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THE L. W. KING HYDROCHLORIC ACID LEACHING PROCESS FOR NICKELIFEROUS MANGANESE ORES

Preliminary Report

On Monday August 1, 1955 P. M. Ambrose and John E. Conley of the Division of Mineral-Technology of Region V, of the Eastern Experiment Station, College Park, Maryland, having previously arranged to meet Mr. E. H. Rose, chemical engineer of the Materials Advisory Board of the National Academy of Sciences and National Research Council, at the Bureau of Mines Station at Pittsburgh, Pennsylvania, proceeded to Salem, Ohio by official automobile. The party arrived at the pilot plant at 10th Street and Ellesworth Ave., at 1:15 p.m. where a demonstration of the King hydrochloric acid leaching process for treating the low-grade nickeliferous manganese ore from the White Oak Mountain area of Tennessee, had been prearranged by General Services Administration. The purpose of such demonstration was to illustrate the feasibility of the process and to supply technical data for evaluation of the operations.

During the demonstration, discussions and conversations were carried on between the following individuals:

Person	Title and Affiliation
L. W. King, M.D.	Contractor and process sponsor, Salem, Ohio
Roland King	Son of Dr. King, operations supervisor, Salem, Ohio
Willard L. Yengling	Plant foreman-mechanic, Salem, Ohio
E. H. Rose	Chemical Engineer, National Academy of Sciences and National Research Council, Washington, D. C.
P. M. Ambrose	Superintendent, Eastern Experiment Station, Division of Mineral-Technology, Region V, College Park, Maryland
John E. Conley	Supervisory Chemical Engineer, Division of Mineral-Technology, Region V, College Park, Maryland

Two laborers assisted Roland King and W. L. Yengling in making the pilot-plant demonstration test.

Immediately on our arrival at the plant, previously crushed unscreened ore of approximately minus 3/8-inch was charged to an elevating conveyor discharging into the feed hopper of the roasting kiln which in turn discharged directly to the leaching tank through an enclosed flattened vibrating chute designed to effect some minor cooling of the roasted product.

Approximately 2,118 pounds of ore admixed with about 5 percent of minus 1/4-inch coke breeze were fed to the roaster and in turn to the leaching operation which was conducted in a 4' x 4' redwood tank containing 30 gallons of 20° HCl and 30 gallons of water. The roasting and leaching operations consumed the remainder of the afternoon. At the completion of the leaching test, the charge was left to settle overnight and the supernatant liquor removed the following morning. The leached ore was then repeatedly washed by spraying water from a hose provided with a nozzle, prefunctorily stirring the leach residue in the leaching tank by means of a cultivating hand-hoe and draining off the washings by tilting the leach tank until the liquid would flow into a wooden tray provided with a coarse-mesh screen to catch the solid particles carried out with the washings. All washings were pumped to and collected in the same tank with the strong leach liquor.

It was planned to treat this extract liquor and combined washings to precipitate the iron as hydroxide and precipitate the combined nickel and cobalt as sulfides. However, these latter phases of the process were demonstrated several times on the afternoon of the first day, while the leaching of the 2,118 pound charge of ore was in progress.

Therefore, only the roasting, leaching and washing steps of the proposed process were demonstrated on the pilot scale. The procedures and equipment devised and used for the iron, cobalt and nickel precipitation steps were, as previously stated, demonstrated on combined extract and wash liquors on hand from previous operations.

Outline of Leaching and Recovery Process

As described by Dr. L. W. King, the major steps of the process are as follows:

1. Mine and crush ore to minus 1/4 or 3/8-inch.

2. Admix ore with approximately 100 lb. coke breeze per ton of ore, and fire with fuel-oil in small (24 in. by 12 ft.) rotary kiln at 1200° - 1450° F to reduce manganese to MnO.

3. Treat with 1 to 1 20° Be muriatic acid with mechanical agitation to a final solution pH of 2.0 - 2.5.

4. Decant extract liquor and wash residue approximately four times by stirring and decanting the resulting wash solutions.

5. Aerate to agitate the liquor and oxidize the iron to assure precipitation by means of Na_2CO_3 added to a pH of 3.9. The iron-hydroxide is allowed to settle approximately 2 days and supernatant solution is removed by decantation.

6. The iron-free solution is then treated with a solution of sodium hydrosulfide (NaHS) to a minimum pH, (usually 2.2 - 2.8) and a subsequent slight increase to 3.0+, whereupon the nickel and cobalt precipitate as their respective sulfides. To accelerate coagulation and settling of the sulfide precipitate, a small quantity of Dow Chemical Company's flocculating compound, #2510 Separan, is added as a dilute solution. All liquid-solid separations and recovery of precipitates are accomplished by decantation washing procedures. An alternate procedure to assure complete nickel-cobalt precipitation is to add excess NaHS solution then add a small quantity of dilute muriatic acid which dissolves co-precipitated sulfides other than cobalt and nickel.

7. Excess sulfide is removed by raising the pH to 5.2 and adding a small quantity of iron chloride, under which conditions manganese also should begin to precipitate. Resulting precipitate is removed after decanting the supernatant liquor.

8. The nickel and cobalt-free solution is then treated with additional sodium-carbonate solution to a pH of 9.2 to precipitate the manganese as carbonate which is recovered by decantation procedures.

9. The precipitate of combined Ni-and Co-sulfides is to be roasted and separated by converting to carbonyls under controlled conditions according to the Mond process.

During the inspection visit on August 1, and 2, 1955, requests were made to Dr. L. W. King for quantitative data on tests made in the pilot plant as batch runs. Also a balanced quantitative flowsheet of the process was requested. Dr. King has agreed to supply the flowsheet, but the general impression of the writer and which is believed to be the sentiment of the other inspectors, was the quantitative data on individual test runs are not available. Presumably, much emphasis in the control work was qualitative in nature. Considerable attention however, has been given to the control of the pH conditions best suited for precipitation of the iron, cobalt and nickel, and of the manganese in their respective precipitating steps.

When and if, the quantitative flowsheet data are received, evaluating of the recoveries of the cobalt-nickel, and manganese values will be possible. Likewise, the calculation of the consumption of chemical reagents comprising sulfuric and hydrochloric acids, soda ash, and sodium hydrogen sulfide will be made. Until more reliable figures can be obtained for the coke and fuel-oil requirements, those given by Dr. King, as 100 pounds of coke and approximately 5 gallons of fuel-oil per ton of ore roasted, must be accepted.

Because of the lack of chemical analyses of the ores used and of the products made, an evaluation of the process will be difficult if not impossible.

However, if Dr. King submits a balanced materials flowsheet, then the consumption of acids and other reagents can be determined and their costs estimated.

Comments on Pilot-plant Operations

In spite of a proposal by Mr. C. B. Larson of the Emergency Procurement Service of General Services Administration, after an inspection trip, that a systematic sampling procedure be followed, the absence of analyses and quantitative data indicates that the sampling procedures as outlined were not followed to any appreciable extent. The use of the various special qualitative tests has merely served to control the operations but does not procure the quantitative data that are essential for process evaluation.

The plant is replete with numerous novel and ingenuous instruments and pieces of equipment. However, the absence of any efficient filters has been a serious deficiency. The filters constructed to collect the various solids and precipitates were merely continuous belts of Saran filter cloth constructed as endless belts about 32 inches wide and approximately 12 feet long, mounted in a frame and supported by rollers at each end and provided with a chain and sprocket drive to convey the solids to one end for discharging. Liquid separation was effected merely by draining through the cloth. With the gelatinous iron-hydroxide and nickel-cobalt sulfide and manganese carbonate precipitates, such drainage would be extremely slow and unsatisfactory. The lack of effective filtration equipment has no doubt, seriously handicapped and retarded the development of the process.

Conclusions and Recommendations

With the present set-up and operating procedures, there is no sound basis for evaluating the process as to grade of ore treated, recoveries possible, costs of chemical reagents and estimated total production costs. Cost estimates are further complicated by the proposed plan to manufacture the hydrochloric acid by the salt-coke process using salt and sulfuric acid.

The sulfuric acid is in turn to be produced by a special patented process developed by a Mr. Kershikov and refined by Dr. Garachi, head of the chemistry department of Genoa University in Italy, and who was retained by Kershikov's widow to exploit the process. Allegedly the process was used by Kershikov in a chemical plant in the Balearic Islands about 1939. Presumably, the process uses gypsum and coke to generate the SO_2 needed for manufacturing the sulfuric acid.

No acid plants are currently using this process in the United States, but there are several installations in Europe in which by-product portland cement is made by admixing coke and the required proportions of alumina and silica. However, cost data available in the literature, indicate that after taking credit for the cement, the acid cost is still higher than that produced by the

conventional contact or lead-chamber processes. However, full details and cost data for Kershikov's process are not presently at hand. On August 2 Dr. King stated that he would abandon the proposed use of Kershikov's process and would produce sulfuric acid by burning sulfur.

Analysis of the grab samples of the head sample, leached residue and resulting leach liquors and washings, taken on this inspection trip, would give a rough idea of the efficiency of the leaching step of the process as practiced by Dr. L. W. King. A better and much more satisfactory picture of the feasibility of the process would necessitate the monitoring of all of the essential steps by a qualified chemical or metallurgical engineer. A minimum of two batch tests would be necessary. Possibly, the presence of a monitor for ten days to possibly two weeks would be needed to procure the essential samples to determine the results obtainable in the various steps of the process. Careful chemical analyses of these samples would then provide a basis for preparing a balanced material flowsheet as a basis for evaluating the process.

Samples of the crushed ore, leach tails, leach solution, and leach solution plus washings were brought to College Park. Dr. King agreed to send samples of the iron precipitate, cobalt-nickel precipitate, manganese precipitate and all liquors other than those sampled on August 2. These samples are to be provided from the batch test started on August 1. Whether they will be analysed at College Park will depend on the desires of General Services Administration.

Respectfully Submitted

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

KING HYDROCHLORIC ACID PROCESS FOR EXTRACTION

of

MANGANESE, NICKEL, AND COBALT FROM

WHITE OAK MOUNTAIN, TENNESSEE, MANGANESE ORE

Contract DMP-103

Pilot-Plant Inspection and Monitoring of L. W. King Facilities,
Salem, Ohio, from August 30 to September 9, 1955

Report No. 2

FOR GOV'T USE ONLY

EASTERN EXPERIMENT STATION
COLLEGE PARK, MARYLAND
NOVEMBER 3, 1955

SUMMARY

At the request of the General Services Administration - Interior Joint Operating Committee, a chemical engineer from the Bureau of Mines station at College Park, Maryland, was present at the Salem, Ohio facilities of Dr. L. W. King from August 30 to September 9, 1955, to monitor and observe the pilot-plant operations. These tests were made as part of the general project being conducted in the development of the hydrochloric-acid leaching process for recovering manganese, nickel, and cobalt compounds from the White Oak Mountain, Tennessee ore; the operations are covered by G.S.A. Contract DMP-103.

During the monitored period, three complete and two abbreviated tests were made according to the process as then proposed by Dr. King. To avoid unnecessary expense, only two of the complete and one of the abbreviated tests were studied and evaluated in detail.

In the reduction and leaching operation, the three tests yielded manganese percentage extractions of 22, 14, and 10, respectively; nickel and cobalt extractions were in the same range. To improve the operation, the ore should be ground finer, much more efficient mechanical agitation should be provided during the leach and more acid should be used, more nearly approaching the theoretical amount needed to dissolve the acid-soluble components of the ore.

To use efficiently the acid added to the leach, all of it should be expended on the ore rather than neutralizing a portion with soda ash. Over half of the acid entering these tests was used to dissolve aluminum which Dr. King states comes mainly from overburden included in his ore stock pile by error.

Eliminating the precipitation of the $Fe(OH)_3$ as a separate step, a procedure which was demonstrated in tests 4 and 5, is a great improvement on the length of the time required for the process.

The settling-and-decantation step used for all solids-liquid separations is very inefficient and should be replaced where at all possible with filter presses or countercurrent decantation thickeners.

Over half of the dissolved nickel and cobalt reported in the final $MnCO_3$ product rather than in the (Ni,Co)S precipitate which is supposedly where a selective precipitation occurs. If this step cannot be controlled,, the merit of the entire process is questionable, regardless of acid-consumption efficiency, a minor constituent of the ore, zinc, concentrates in the (Ni,Co)S giving rise to an additional operation problem.

General Considerations

During the two-week period between August 30 and September 9, 1955, five pilot-plant tests were monitored at the King facilities in Salem, Ohio. In addition to observing the operations, all sampling at the various stages of the process was done by the Bureau of Mines engineer.

Since the nature of the process as it was carried out in the pilot plant required considerable time for settling and subsequent decantation of solutions, the tests were run concurrently. The original number of monitored tests had been set at two or three, depending on operating conditions. When Dr. King realized the extreme length of time that was being taken to conduct each of the first

three tests, he decided to run two more tests in a revised and abbreviated manner in order to show the best possible time-wise results for the monitored period. By this modified procedure, tests 4 and 5 were completed on the same day as test 3. No extra time was required at Salem to observe these two tests.

The essential flowsheet for tests 1, 2, and 3 is shown in figure 1, and that for tests 4 and 5 in figure 2.

The flowsheet in figure 1 shows the following main steps of the process as demonstrated in tests 1, 2 and 3:

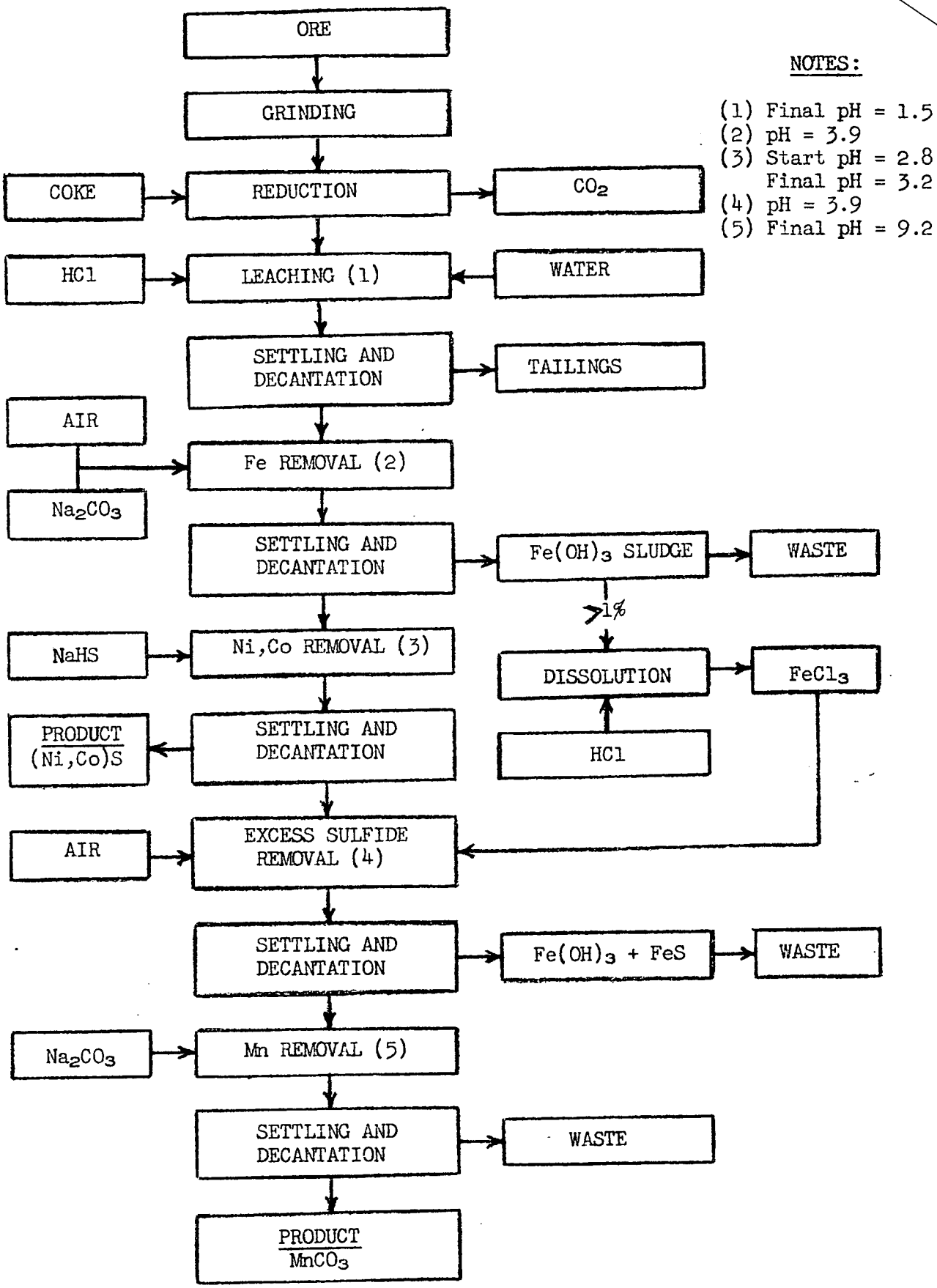
1. Mine and crush the ore to minus 3/8-inch.

2. Feed the crushed ore at the rate of approximately 1/2-ton per hour with a simultaneous feed of approximately 33 pounds of coke per hour to reduce the manganese to MnO in a small, rotary kiln fired with No. 2 fuel oil to a temperature of approximately 1,250°F.

3. Leach the hot ore as discharged from the rotary kiln in a solution containing approximately 8.5 percent by weight of HCl to a final solution pH of 1.5 to 1.75. A small amount of mechanical agitation is provided by air forced upward from a coiled, perforated "Saran" hose fastened to the bottom of the tank.

4. After cooling overnight, decant extraction liquor and wash residue approximately four times by passing water upward through leached ore by means of the perforated hose coil on the tank bottom; decant resulting wash solutions and combine them with extraction liquor.

5. To the combined extraction liquor and washes add Na_2CO_3 solution to a pH of 3.9 and aerate the solution to precipitate the iron



NOTES:

(1) Final pH = 1.5
(2) pH = 3.9
(3) Start pH = 2.8
Final pH = 3.2
(4) pH = 3.9
(5) Final pH = 9.2

Figure 1. Flowsheet for tests 1, 2, and 3.

as $Fe(OH)_3$. The slimy iron hydroxide-tailings precipitate takes roughly four days to settle as demonstrated; the supernatant solution was then decanted off. The iron sludge is washed at least once, resettled, and the wash is siphoned off and added to the first decantate.

6. Add a slight quantity of HCl to lower the pH of the iron-free solution to 2.8. Add NaHS solution to precipitate both nickel and cobalt as their respective sulfides; the NaHS is added to pH of 3.2. It is stated that since this is measured with their conductance-measuring controllers, there is very little excess sulfide solution added. Dow Chemical company's flocculating agent, Separan 2610, is used to accelerate the settling of the extremely finely divided sulfide precipitate. After settling approximately one day, the supernatant liquid is decanted.

7. In test 2, the solution from the nickel-cobalt precipitation was decanted back onto the iron sludge to which had been added one-half gallon of 20° Bé HCl to produce $FeCl_3$. In test 3, one-half gallon of $FeCl_3$ solution was added to the decantate from step 6. Both procedures are essentially the same; tank utilization in the pilot plant being the governing factor. After adjusting the pH to 3.9 with Na_2CO_3 solution, the solution is aerated. Any excess sulfide from step 6 is precipitated as FeS and the solution is again made iron-free by precipitating dissolved iron as $Fe(OH)_3$. After settling overnight, the supernatant solution is decanted.

8. The decantate is then treated with Na_2CO_3 solution to a pH of 9.2 to precipitate the manganese. After settling, the supernatant liquid is decanted to waste and the product is washed, drained and stored.

The flowsheet in figure 2 shows the following modifications used in tests 4 and 5:

1. After cooling overnight, Na_2CO_3 solution was added directly to the leach tank containing the extraction liquor and leached ore residue to give the solution a pH of 3.9. The slurry was then aerated to precipitate the iron as $Fe(OH)_3$. After settling overnight, the iron-free extraction liquor was decanted, and the leached ore containing $Fe(OH)_3$ was washed five times with relatively small quantities of water. Settling and decantation was used to remove each wash from the residue. The combined solution comprising the extraction liquor and washes was allowed to stand overnight in order to give leached ore slimes that had been carried over with the decantates a chance to settle.

2. This clear, iron-free solution was then treated with Na_2CO_3 solution to a pH of 9.2 to precipitate not only the manganese but also the nickel and cobalt in a combined product.

In a step instituted after the monitored period, the $MnCO_3$ product is calcined to produce an oxide which is presumed to be a Mn_3O_4 product physically satisfactory for blast-furnace feed.

Because of the large amount of work necessary to perform the desired analyses of the various samples taken during each test, only three of the five tests, 2, 3, and 5, were studied completely. Test 1 was essentially the same as test 2, and test 4 was similar to test 5.

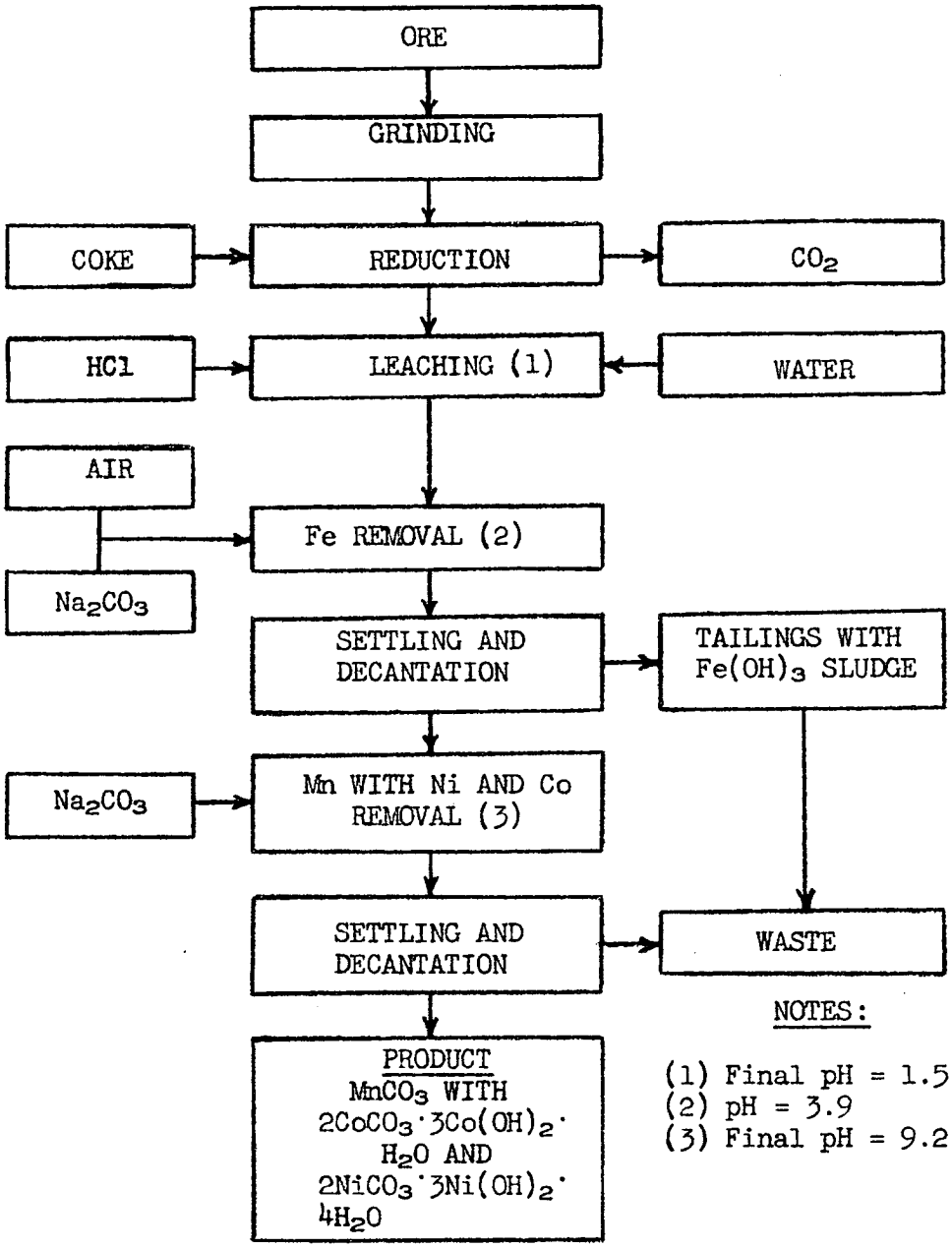


Figure 2. Flowsheet for tests 4 and 5.

While it was understood that the monitored tests were to be made in a manner similar to previous tests, it was evident that some operational changes were made in the first three tests. Instead of adding a set quantity of ore, approximately 2,100 lbs. to the system to provide an excess to "kill" the unused acid, the addition of ore to the leaching tanks was stopped as soon as the conductance of the leaching solution reached a point said to be equivalent to a pH of 1.5. While acid values were being thrown away by this procedure, Dr. King felt that this would give the best possible extraction of manganese for demonstration purposes. The acid that would otherwise have been leaching some manganese from the excess ore had to be neutralized with soda ash before the dissolved iron could be precipitated as $Fe(OH)_3$.

To facilitate the precipitation and settling of $Fe(OH)_3$, much larger quantities of water were added to the decanted combined extraction solution and washes from the leached ore. This had not been tried before since the step required at least four days in each test. No systematic study had been made to find the optimum conditions for the precipitation and/or settling of $Fe(OH)_3$.

The rotary kiln used in the reduction step was made from a ten-foot section of standard 20-inch pipe with a 3/8-inch wall. Excessive scaling was not noted on the exterior of the kiln, and the interior was said to be clean metal showing no signs of scaling. The hot reduced ore was introduced into the leach tank by means of a vibrating closed chute attached to the sealed exit of the kiln. While some

cooling of the hot reduced ore was effected during transit from kiln to leaching tank, the solids entering were hot enough to heat the leaching solution to near boiling. Some acid is necessarily lost in its gaseous form even though the leach tank is covered with a single sheet of plywood.

There are two leaching tanks mounted side by side at the end of the kiln so that two successive runs can be made in the pilot plant on any one day. These are nominal 4- x 4-foot redwood tanks mounted on trunions to facilitate the removal of the leached ore residue. All other steps of the process are performed in redwood tanks, either 6- x 6-feet or 4- x 4-feet in size. All plant activities are governed by the efficient utilization of these tanks since they naturally are limited in number.

Filters have been fabricated, but the poor design proscribed their general use in the plant. Each of these consisted of an endless belt of Saran cloth that acted merely to drain by gravity some of the liquid from precipitates that would not blind the cloth. In actual practice only an extremely wet slurry of the manganese carbonate could be worked on this equipment, and then merely to drain off some of the water to produce a thickened product. No other precipitate from the process could be worked on this equipment, necessitating the settling and decantation procedure used. Some form of filter or filter press would have been a great help to the plant.

Control of the various steps was carried out by qualitative tests for iron, nickel, or manganese, by measurement of the pH, or

by measurement of the conductance as it approached a predetermined control point for the solutions involved.

The conductance was measured on surplus equipment fabricated by Dr. King into controllers that operated at a predetermined value. These predetermined values were equivalent to pH's that had been obtained by measuring known solutions of acid and water.

Data in the literature[1/] show that for the precipitation of iron from solution as ferric hydroxide less than 20 percent comes down at a pH of 3.9. Over 95 percent is precipitated at 5.0 without bringing down more than 2 percent of the manganese in solution. This indicates that a more complete consideration of the quantitative aspects of each step of the process would have been well advised.

Test Results

The results of tests 2, 3, and 5 are discussed in the following section. The complete data of the results, including the analyses of the various samples, are given in the table following the discussion. The items of this log-type table are numbered and will be referred to by number when necessary in the discussion. Each test will be covered as a complete unit rather than as parts of the succeeding steps of the process.

The volumes of the contents of the various tanks were obtained by measuring the outage (vertical distance between top of tank and top of liquid) to find the difference between the known capacity of the tank and the volume not occupied with solution.

1/ Ketzlach, Norman. Production of Manganese Oxides and Ammonium Sulfate. AIME Transactions, vol. 187, March 1950, pp.392.

In order to cut down the cost of the chemical analysis, aluminum was not determined directly. Since the titanium content is negligible, the samples were analyzed for Fe and R_2O_3 (R contains Fe, Ti, and Al), and the aluminum content calculated by difference.

Because of the extremely poor results of the tests, no attempt was made to carry out a material balance on the acid.

Test 2

The ore fed to test 2, as for all tests, was sampled with a "thief" taking at least three random samples from each wheelbarrow load of approximately 250 pounds. As the pH of the leaching solution approached the desired point, the kiln was allowed to run clear and increments of 50 pounds of ore were added. These increments were also sampled with the "thief", taking from each increment only one sample about half the size of the samples taken from the wheelbarrow loads.

The weight of coke fed was obtained only approximately. The coke feed bin had been filled with one wheelbarrow load before the monitored period. At the end of test 3, the coke remaining in the bin was removed and weighed; one wheelbarrow of coke was weighed, and the difference in weights was divided by the total weight of ore fed during the three tests to obtain the average ore-to-coke ratio (item 9).

The fuel oil used was measured in much the same way. Assuming the feed tanks of the oil burner was full at the start, its contents were measured (approximately) at the end of the first three tests, the difference being the oil consumed during the total operating period of those tests. From this, the fuel oil consumption in gallons per hour (item 10) was obtained.

The estimated reduction temperature (item 11) was given by Dr. King from past measurements.

The ore stockpile for the plant was exposed to the weather. The ore for this and the other tests had been washed before the monitored period and stored under cover in an opensided shed.

Two carboys of 126 pounds net weight each of 20° Baumé HCl were added directly to the leaching tank. More water than had been used in tests before the monitored period was added in order to cover carbon electrodes that had been introduced in opposite sides of the tank to measure the conductance of the liquid contents.

Items 16 through 19 show the theoretical amount of acid to dissolve the constituents in the ore fed into the process. The acid used was considerably below the theoretical figure, even neglecting the aluminum. Dr. King had stated that the manganese content of the ore was only 4 percent, if that high. Actually, the manganese content was closer to 8 percent (item 2). This high figure coupled with the aluminum that he had thought absent probably caused the use of too little acid in the leach.

Very little cooling of the reduced ore is accomplished before it falls into the leach tank as is indicated by the charred condition of the upper walls of the leaching tanks and the extremely high temperature of the slurry at the end of the reduction.

After the extraction liquor and subsequent washes had been decanted from the leached ore residue, the remaining thick sludge was sampled with the "thief". In order to have as uniform a residue as possible,

the leaching tank was rocked back and forth on its trunions for several minutes before sampling. Grab samples were taken through the surface's center and the center of each quadrant of the surface of the sludge to obtain a representative sample. Given the volume of the sludge and the sample's total volume, wet weight, and dry weight (washed on filter first), an attempt was made to calculate the weight of the leached ore residue (item 37). Assuming no silica is dissolved, the weight of the leached ore residue was calculated knowing the weight and silica content of the ore fed and the silica content of the leached ore (item 36). The comparison of these two items for the other tests, as well as this one, shows that while it obtains a representative sample of solids in a slurry, the thief is a poor sampling tool for the determination of the liquid content of solids.

The percent extractions of the major constituents of the ore are given in item 38. Because the weight of the tailings could not be obtained accurately, the extractions are based on the silica contents as shown in the item in the table. No reason is immediately apparent for the fact that the ore residue seems to contain more iron than the ore feed.

Item 39 gives the weights of the materials leached from the ore that was fed. Item 30 gives the weights of the materials recovered in solution. The difference is due to extremely poor washing of the leached ore residue; the coiled hose on the tank bottom came loose during the leach and was found in a vertical position when the residue was thrown out.

It was stated by Dr. King that by adding more water than they had done in the past, the $Fe(OH)_3$ precipitation and settling steps would be accelerated. Just the opposite was the case.

To sample the iron sludge and (Ni,Co)S precipitate slurries, the total volume of the slurry was measured first. Then a sample of known volume was taken and weighed. After weighing, it was filtered and the filter cake washed. The filter cake was then dried on a hot plate and weighed. Knowing the weight of precipitate in a given volume, the total weight of precipitate in the slurry was calculated.

To precipitate (Ni,Co)S in the iron sludge decantate a solution of NaHS was metered in, using a pump controlled by a device measuring the conductance. The pH was also measured with a portable pH meter. Knowing the starting volume and concentration of NaHS, the amount added was found from the unused volume.

At least 800 gallons of concentrated soda and solution was already made up in the plant for use in the process. One sample was taken of this to find its Na_2CO_3 concentration. When used, the volume was measured and later converted to weight of Na_2CO_3 added for the iron and manganese precipitation steps.

The nickel and cobalt were precipitated in 4- x 4-foot tanks, requiring the solution to be split three ways. Due to washes of the iron sludge, these three fractions were not of the same concentration. In order to take only one sample rather than three, the sample of (Ni,Co)S decantate was taken after these three fractions had been

recombined. Again, to cut down on samples, the solution was sampled only once between (Ni,Co)S and $MnCO_3$ precipitations. As a result, it was sampled after the removal of the excess sulfide. This is the only source of explanation for the lack of balance between the weights of nickel and cobalt in their precipitate (item 56) and the weights of these removed from solution (difference of items 50 and 60). One plausible explanation is that nickel and cobalt are precipitated during the excess sulfide removal.

It should be noted that the ore contains a small amount of zinc. This zinc is concentrated in the (Ni,Co)S precipitate, where it is reported spectrographically as greater than 5 percent (item 55). The spectroscopist has reported orally that it is probably close to 10 percent. This would mean more zinc than nickel in a by-product that already contains more manganese than nickel (item 54).

From item 54 it is also seen that slightly over 40 percent of the (Ni,Co)S precipitate weight is lost on ignition at 1000°C. for one hour. Since oxygen would replace the sulfur in the compounds, it can be assumed that this figure is equal to approximately the weight of Separan 2610 that was used to flocculate the precipitate. This is exceedingly high if it were to be expected on the plant scale. A closer study of the proper use of the flocculating agent should be made. The writer feels that the Separan 2610 is added in entirely too concentrated a solution for efficient results; this opinion is based on reading the directions for recommended usage issued by Dow Chemical for their product.

The manganese precipitation step was effected in more than one 4- x 4-foot redwood tank, but since the solution entering the step was all of one concentration, it was considered sufficient to take only one sample of the manganese-free decantate. The precipitate of $MnCO_3$ was free-settling, allowing the decantation of the supernatant liquid to take place in less than an hour. The product was then bucketed onto one of the drainer-type filters to be washed and further de-watered. The uliginous product is then stored in cardboard boxes for complete draining to a moist but compact, shape-retaining mass.

Item 65 shows that the supposedly nickel- and cobalt-free manganese carbonate contains exceedingly high percentages of these elements. Half of the nickel and cobalt recovered in solution is found here (items 30 and 67). Items 72, 73, and 74 show the manganese, nickel, and cobalt balances respectively for the test. Only 21.8 percent of the manganese was extracted from the ore. Of this, only 33.2 percent was precipitated as $MnCO_3$; 7.2 percent of the available manganese was all that was recovered.

Test 3

The reduction and leaching steps for test 3 were run in the same manner as test 2. For some reason, 38 percent more ore than test 2 was added to the system before the conductance of the leaching solution reached the same desired point. Even so, the actual amount of manganese extracted from the ore (item 39) was less than for test 2.

In this test the two calculated tailings weights (items 36 and 37) are in satisfactory agreement.

A much more satisfactory washing of the tailings was obtained since the perforated hose coil remained in place on the tank bottom during the run.

To precipitate and settle the $Fe(OH)_3$ from the extraction liquor and washes took five days, one day longer than for test 2 (item 42). The final volume of liquid from which the $Fe(OH)_3$ was precipitated was the same for both tests (item 28). No log or other written record was kept by the operators so that there is no way of knowing the amount of air used during the aeration of the solutions. The $Fe(OH)_3$ was completely settled in this test only after resorting to the use of a small amount of Separan 2610.

All the statements made under test 2 on the precipitation and settling of (Ni,Co)S are equally applicable for test 3. The analysis of the precipitate does vary though, as can be seen under item 54. The slight variance in the procedure for removing the excess sulfide in solution has already been discussed under the general considerations.

The procedure followed for the precipitation of the final $MnCO_3$ product was the same for test 3 as for test 2. Again almost half of the nickel and cobalt recovered in solution from the ore is found in this product (items 30 and 67). From the manganese balance of item 72, it is seen that only 14 percent of the manganese was extracted from the ore, and 45 percent of this was recovered in the $MnCO_3$. This gives an overall recovery of the available manganese of 6.3 percent.

Test 5

As has been mentioned in the section on general considerations, an abbreviated version of the process was inaugurated during the monitored period. The innovation was the precipitation and settling of $Fe(OH)_3$ from the extraction solution upon the leached ore residue. This worked quite well, shortening the time for the iron removal step from 6 days to 2 days. As an expedient, in order to finish the test during the monitored period, the selective nickel-cobalt precipitation step was omitted, and these elements were precipitated with the manganese.

The reduction and leaching steps were the same as for the other tests. After letting the extraction liquor-tailings slurry cool overnight in the leaching tanks, soda ash solution was added to bring the pH up to 3.9. The tank was then aerated all day. After settling overnight, the iron-free mother liquor was decanted off. After a number of washes using a small volume of water had been made and added to the extraction liquor, the tailings containing $Fe(OH)_3$ were discarded. In this test, as in test 2, the two calculated tailings weights were not in agreement (items 36 and 37).

An unexpectedly large amount of soda ash solution was required to complete the precipitation of manganese at a pH of 9.2. The precipitate itself did not settle readily. As a consequence, a large volume of this slurry had to be worked on the drainer-type filters. Even then the de-watering did not approach that of tests 2 and 3. Item 65 indicates that the manganese was probably not present in the form of $MnCO_3$.

From the manganese balance (item 72) it can be seen that only 12.69 pounds out of 130.8, or 9.7 percent of the available manganese was extracted from the ore. Virtually all of this was recovered in the final product.

An effort should be made to find the nature of the manganese compound precipitated as the product in this test and to find what caused it. The $MnCO_3$ recovery portion of the project is predicated on the free-settling quality of the product. Such a product as was obtained in this test would only aggravate already difficult operations on a plant scale.

TABLE OF TEST RESULTS

	Test No.	2	3	5
1.	Date	8/30-9/8	8/31-9/9	9/6-9/9/55
	Ore Analyses:			
2.	Chemical, percentages			
	Mn	7.19	7.59	8.05
	Fe	2.48	2.83	2.06
	Ni	0.45	0.46	0.44
	Co	0.18	0.21	0.23
	R_2O_3	14.6	14.7	12.4
	Al 1/	5.85	5.64	5.00
	SiO_2	65.4	64.4	67.4
	Insoluble	66.3	65.6	68.6
3.	Spectrographic, percentages			
	Mn	>5	>5	>5
	Fe	.8-8	.8-8	.8-8
	Ni	.08-.8	.05-.5	.05-.5
	Co	.05-.5	.05-.5	.05-.5
	Al	.5-5	.8-8	.5-5
	Mg	.08-.8	.08-.8	.08-.8
	Ca	.008-.08	.008-.08	008-.08
	Na	.01-.1	.05-.5	.01-.1
	K	.1-1	.1-1	.1-1
	Si	>10	>10	>10
	Ti	.01-.1	.01-.1	.01-.1
	Zn	.08-.8	.08-.8	.08-.8
4.	Sieve, Tyler series, percentages			
	-3/8" + 4-mesh	3.7	4.5	5.5
	-4 + 8-mesh	27.6	30.1	32.5
	-8 + 14-mesh	20.7	22.3	20.2
	-14 + 28-mesh	16.4	16.1	14.3
	-28 + 48-mesh	12.8	11.3	10.6
	-48 + 100-mesh	9.0	7.5	7.7
	-100 + 200-mesh	4.4	3.8	4.1
	-200-mesh	5.4	4.4	5.1
	Reduction:			
5.	Ore fed, dry basis, lbs.	1,195	1,512	1,625
6.	Wt. of various constituents fed, lbs.			
	Mn	85.9	114.8	130.8
	Fe	29.6	42.8	33.48
	Ni	5.38	6.96	7.15
	Co	2.15	3.18	3.74
	Al	69.9	85.3	81.25
	SiO_2	781.5	973.7	1,095.

1/ Al calculated from R_2O_3 and Fe, neglecting Ti.

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
Date	8/30-9/8	8/31-9/9	9/6-9/9/55
7. Moisture content of ore, percent	10.9	9.9	4.4
8. Approx. ore feed rate, (moist basis), lbs./hr.	1,000	1,000	1,000
9. Approx. ore-to-coke ratio	30:1	30:1	30:1
10. Approx. fuel oil consumption, gal./hr.	6	6	6
11. Estimated reduction temp., °F.	1,250	1,250	1,250
Leaching solution:			
12. 20° Bé HCl, lbs.	252	252	252
13. 20° Bé HCl, gal.	26	26	26
14. HCl, 100 percent, lbs.	79.25	79.25	79.25
15. Total vol. of leaching solution, gal.	112	107	141
Theoretical acid:			
16. HCl needed to dissolve all major acid soluble constituents, (Mn,Fe,Ni,Co,Al), 100%, lbs.	445.6	566.9	560.5
17. Percent of theoretical acid to dissolve all major acid soluble constituents used.	17.8	14.0	14.1
18. HCl needed to dissolve only Mn, Fe, Ni, and Co, 100%, lbs.	162.1	220.9	230.9
19. Percent of theoretical acid to dissolve Mn, Fe, Ni, and Co used	48.9	23.9	34.3

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
Date	8/30-9/8	8/31-9/9	9/6-9/9-55
Leach:			
20. Vol. after addition of hot ore to leaching solution, gal.	184	--	--
21. Vol. following addition of water to hot slurry, gal.	247	255	--
22. Na_2CO_3 (100%) added to bring pH to 3.9 to ppt.$Fe(OH)_3$ during aeration, lbs.	--	--	22.7
23. After cooling overnight, slurry volume, gal.	230	244	--
24. Vol. of extraction liquor decanted from leached solids, gal.	99	70	70
25. Analysis of extraction liquor, constituents in gpl.			
Mn	7.92	11.4	16.4
Fe	2.50	2.92	0.12
Ni	0.54	0.74	1.10
Co	0.17	0.24	0.41
R_2O_3	9.83	13.4	14.2
Al 1/	3.31	4.88	7.42
Cl	38.2	39.8	53.1
Specific gravity	1.045	1.050	1.070
26. Wt. of various constituents decanted in extraction liquor, lbs.			
Mn	6.83	6.99	10.25
Fe	2.16	1.79	0.08
Ni	0.47	0.45	0.69
Co	0.15	0.15	0.26
Al	2.86	2.99	4.64
Cl	32.98	24.41	33.19
27. Number of washes of leached solids	4	6	5
28. Vol. of extraction liquor plus washes decanted from leached solids, gal.	627	630	340

1/ Al calculated from R_2O_3 and Fe, neglecting Ti.

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
Date	8/30-9/8	8/31-9/9	9/6-9/9-55
29. Analysis of extraction liquor plus washes, constituents in gpl.			
Mn	2.22	2.93	4.65
Fe	0.68	0.57	0.046
Ni	0.14	0.17	0.32
Co	0.046	0.066	0.13
R_2O_3	2.65	3.13	3.31
Al 1/	0.89	1.23	1.71
Cl	9.50	10.1	16.7
Specific gravity	1.020	1.015	1.025
30. Wt. of various constituents decanted in extraction liquor + washes, lbs.			
Mn	11.85	15.63	13.52
Fe	3.63	3.04	0.134
Ni	0.74	0.907	0.931
Co	0.24	0.352	0.378
Al	4.75	6.56	4.97
Cl	50.69	53.89	48.56
31. Cl entering leach as HCl, lbs.	77.0	77.0	77.0
32. Cl unaccounted for, lbs.	27.3	23.1	28.4
Leached Ore Analyses:			
33. Chemical, percentages			
Mn	5.79	6.61	7.27
Fe	2.94	2.40	2.24
Ni	0.37	0.40	0.42
Co	0.16	0.20	0.21
R_2O_3	12.0	11.4	11.3
Al 1/	4.13	4.22	4.29
SiO_2	67.1	65.1	67.6
Insoluble	68.4	66.4	69.0
34. Spectrographic, percentages			
Mn	1-10	>5	>5
Fe	.8-8	.8-8	.8-8
Ni	.08-.8	.05-.5	.05-.5
Co	.05-.5	.05-.5	.05-.5
Al	.5-5	.5-5	.5-5
Mg	.05-.5	.05-.5	.05-.5
Ca	.008-.08	.008-.08	.008-.08

1/ Al calculated from R_2O_3 and Fe, neglecting Ti.

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
Date	8/30-9/8	8/31-9/9	9/6-9/55
34 (Cont'd.)			
Na	.008-.08	.01-.1	.01-.1
K	.08-.8	.08-.8	.08-.8
Si	>10	>10	>10
Ti	.008-.08	.008-.08	.008-.08
Zn	.08-.8	.08-.8	.08-.8
Leached Ore Analyses (Cont'd.)			
35. Sieve, Tyler series, percentages			
-3/8" + 4-mesh	--	3.8	1.5
-4 + 8-mesh	--	35.7	33.4
-8 +14-mesh	--	22.3	30.5
-14 +28-mesh	--	14.5	14.8
-28 +48-mesh	--	9.9	9.9
-48 +100-mesh	--	6.5	5.0
-100 +200-mesh	--	3.9	2.2
-200-mesh		3.4	2.7
36. Wt. of leached ore based on wet and dry wts. of known vol. of tailings slurry, lbs.	975	1,530	1,825
37. Wt. of leached ore based on SiO_2 in ore and in leached ore, lbs.	1,165	1,496	1,620
38. Percent extractions, calculated by formula:			
Percentage M extracted = $\left(1 - \frac{M:SiO_2 \text{ ratio of tailings}}{M:SiO_2 \text{ ratio of heads}}\right) \times 100$,			
where M represents:			
Mn	21.8	14.0	9.7
Fe	2/ -16.0	6.6	3/ -0.1
Ni	16.7	14.0	4.6
Co	11.1	5.8	8.8
Al	30.3	26.0	14.6
39. Wts. of constituents extracted from solids, lbs. (basis = $M:SiO_2$ ratios and wt. of feed)			
Mn	18.73	16.07	12.69
Fe	--	2.82	--
Ni	0.90	0.97	0.329
Co	0.24	0.184	0.33
Al	21.18	22.18	11.86

2/ Probably due to poor sample.
3/ $Fe(OH)_3$ pptd. in leach tank before decantation of extraction liquor.

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
40. Wt. of Na_2CO_3 added to extraction soln. + washes to raise pH to 3.9 during aeration to ppt. $Fe(OH)_3$, lbs.	45.4	36.7	3/22.7
41. Wt. of HCl equivalent to Na_2CO_3 used in $Fe(OH)_3$ pptn., lbs.	31.2	25.3	15.62
42. Time required to ppt. and settle $Fe(OH)_3$, days	4	5	1
43. Time required to wash and re-settle $Fe(OH)_3$, days	1	1	1
44. Wt. of $Fe(OH)_3$ sludge (inc. slimes from leached ore), lbs.	47.7	50.6	Inc. in leached solids residue
$Fe(OH)_3$ sludge analyses:			
45. Chemical, percentages			
Mn	1.02	3.15	3/
Fe	7.06	6.24	
Ni	0.22	0.32	
Co	0.06	0.12	
46. Spectrographic, percentages			
Mn	.5-5	.8-8	
Fe	>5	>5	
Ni	.05-.5	.05-.5	
Co	.008-.08	.01-.1	
Ti	.05-.5	.01-.1	
Zn	.08-.8	.03-.3	
Al	.8-8	.8-8	
47. Wt. of constituents pptd. in $Fe(OH)_3$ sludge, lbs.			
Mn	0.51	1.59	
Fe	3.37	3.16	
Ni	0.105	0.162	
Co	0.029	0.061	
48. Vol. of $Fe(OH)_3$ sludge decanted + wash, gallons	692	665	

3/ $Fe(OH)_3$ pptd. in leach tank before decantation of extraction liquor.

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
49. Analysis of $Fe(OH)_3$ sludge decantate + wash, constituents in gpl.			
Mn	1.93	2.68	
Fe	<0.001	<0.001	
Ni	0.11	0.15	
Co	0.039	0.053	
Specific gravity	1.015	1.013	
50. Wt. of various constiuents decanted from $Fe(OH)_3$ sludge, lbs.			
Mn	11.32	15.06	
Fe	<0.006	<0.006	
Ni	0.645	0.843	
Co	0.228	0.298	
51. Wt. of NaHS added to $Fe(OH)_3$ sludge decantate + washes to ppt.(Ni,Co)S,lbs.	1.25	1.0	4/
52. Time required to ppt. & settle (Ni,Co)S, days	1	1	
53. Wt. of (Ni,Co)S, lbs.	0.73	0.80	
54. (Ni,Co)S ppt. analyses: Chemical, percentages			
Mn	5.87	3.86	
Fe	0.86	1.52	
Ni	5.31	2.91	
Co	1.70	1.96	
Loss on ignition 5/	41.1	35.9	
55. Spectrographic, percentages			
Mn	>5	1-10	
Fe	.3-3	.3-3	
Ni	>5	1-10	
Co	1-10	1-10	
Al	.3-3	.5-5	
Si	1-10	1-10	
Ti	.008-.08	.008-.08	
Zn	>5	>5	
56. Wt. of constituent pptd. in (Ni,Co)S,lbs.			
Mn	0.043	0.031	
Fe	0.006	0.012	
Ni	0.039	0.023	
Co	0.012	0.016	

4/ Ni and Co pptd. with Mn.

5/ Represents approx. the floc. agent, Dow Separan 2610, used to settle the (Ni, Co)S ppt. prior to decantation.

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
57. Vol. of (Ni,Co)S ppt. decantate + $Fe(OH)_3$ sludge slurry, gals	810		
58. Vol. of (Ni,Co)S ppt. decantate (inc.1/4 gal. $FeCl_3$ soln. for excess S removal		492	
59. Analysis of (Ni,Co)S ppt. decantate, constituents in gpl.			
Mn	1.37	2.13	
Fe	0.002	0.01	
Ni	0.072	0.12	
Co	0.023	0.043	
Specific gravity	1.015	1.015	
60. Wt. of various constituents decantated from (Ni,Co)S ppt., lbs.			
Mn	9.40	8.88	
Fe	0.014	0.042	
Ni	0.494	0.500	
Co	0.157	0.179	
61. Wt. of Na_2CO_3 added to (Ni,Co)S ppt. decantate to ppt. $MnCO_3$,lbs.	34.9	36.7	
62. Wt. of Na_2CO_3 added to Fe-free extraction soln. to ppt. Ni,Co, and Mn, lbs.			122.2
63 Wt. of HCl equivalent to Na_2CO_3 used in Mn ppt. lbs.	24.0	25.2	84.1
64 Wt. of $MnCO_3$, lbs.	20.0	21.2	56.6
65. $MnCO_3$ analyses: Chemical, percentages			
Mn	31.1	34.3	22.8
Fe	0.41	0.17	0.31
Ni	1.81	1.92	1.42
Co	0.66	0.76	0.60

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
66. $MnCO_3$ analyses: (Cont'd.)			
Spectrographic, percentages			
Mn	>10	>10	>10
Fe	.1-1	.01.1	.03-.3
Ni	.1-1	.3-3	.08-.8
Co	.5-5	.5-5	.5-5
Ti	<.01	<.01	<.01
Zn	.03-.3	.01-.1	.08-.8
Al	.3-3	.1-1	.8-8
67. Wt. of constituents pptd. in $MnCO_3$, lbs. -			
Mn	6.22	7.27	12.90
Fe	0.082	0.036	0.175
Ni	0.362	0.407	0.804
Co	0.132	0.161	0.340
68. Vol. of $MnCO_3$ decantate, gals.	679	527	450
69. Analysis of $MnCO_3$ decantate, constituents in gpl.			
Mn	<.001	<0.001	<.001
Fe	<.001	<.001	<.001
Ni	<.01	<.01	<.01
Co	0.001	0.002	0.001
Specific gravity	1.015	1.015	1.035
70. Wt. of various constituents decanted to waste from $MnCO_3$, lbs.			
Mn	<.006	0.004	<.004
Fe	<.006	<.004	<.004
Ni	<.06	<.046	<.04
Co	0.006	0.009	0.004
71. Analysis of calcined $MnCO_3$, percents 6/			
Mn	53.8	56.0	7/61.0

6/ Samples not taken under supervision of Bureau of Mines personnel.
7/ Sample referred to by Dr. King as calcination product of carbonate mixture. It has been assumed that this is a mixture of the manganese carbonate products from tests 4 and 5.

TABLE OF TEST RESULTS (Cont'd.)

Test No.	2	3	5
72. Manganese balance:			
Mn content of various solids and liquids given in lbs.			
Ore in	85.9	114.8	130.8
Ore residue out	67.17	98.73	118.11
Extracted from ore	18.73	16.07	12.69
Recovered in extraction solution and washes	11.85	15.63	13.52
Recovered in $Fe(OH)_3$ sludge decantate and washes	11.32	15.06	--
Recovered in (Ni,Co)S ppt. decantate	9.40	8.88	
Recovered in $MnCO_3$ ppt.	6.22	7.27	12.90
73. Nickel balance:			
Ni content of various solids and liquids given in lbs.			
Ore in	5.38	6.96	7.15
Ore residue out	4.48	5.99	6.82
Extracted from ore	0.90	0.97	0.329
Recovered in extraction soln. and washes	0.74	0.907	0.931
Recovered in $Fe(OH)_3$ sludge decantate and washes	0.645	0.843	--
Recovered in (Ni,Co)S ppt. decantate.	0.494	0.500	
Recovered in $MnCO_3$ ppt.	0.362	0.407	0.804
74. Cobalt balance:			
Co content of various solids and liquids given in lbs.			
Ore in	2.15	3.18	3.74
Ore residue out	1.91	3.00	3.41
Extracted from ore	0.24	0.184	0.33
Recovered in extraction, soln. and washes	0.24	0.352	0.38
Recovered in $Fe(OH)_3$ sludge decantate and washes	0.228	0.298	--
Recovered in (Ni,Co)S ppt.	0.157	0.179	--
Recovered in $MnCO_3$ ppt.	0.132	0.161	0.340

COMMENTS

Poor results are not necessarily inherent in this process. Some of the reasons for them, together with suggestions for their improvement, are listed below:

1. The ore has not been ground to a sufficiently fine size. It should be ground to at least minus 10-mesh and probably finer rather than crushed to only minus 3/8-inch for efficient reducing and leaching.

For an operation on the scale of the one in Salem, the writer would recommend that the operators have one large batch of ore (enough to last for the projected pilot-plant demonstration period) custom ground and mixed. The advantage of this would be a known feed that would not vary; the purchase of crushing and grinding equipment for the pilot plant would be unnecessary, and time would not be spent on this known unit operation that could better be spent studying the process as a whole.

2. The retention time of the charge in the reducing kiln is too short, especially if the minus 3/8-inch ore is used as feed. The slope of the kiln should be decreased to lengthen the retention time. When the reducing kiln was constructed, provision should have been made to vary the slope of the kiln.

3. The hot ore from the reducing kiln should be cooled more before entering the leaching tank; this would suppress the loss of HCl that is now lost when the hot ore heats the leaching solution to the boiling point.

4. Efficient mechanical agitation of the leaching ore should be provided by mixing equipment. The coiled perforated hose fastened to the tank bottom provides some agitation and is excellent for washing the leached ore residues as the step is now run, but the air providing the agitation must also re-oxidize some of the hot ore. Item 34 of the table shows that the best manganese extraction was had in test 2 during which the hose coil came loose and got into a vertical position on one side of the tank.

5. A closer check should be kept on the analysis of the ore entering the process. This applies not only to the manganese, but also to all the acid soluble constituents. In no test during the monitored period was more than 18 percent of the theoretical acid used. This no doubt contributed more to the poor leaching than any other single factor.

6. The use of countercurrent thickeners should be investigated for efficient solids-liquid separation and washing of the tailings following the leaching step. In the pilot plant a large filter press would have sufficed.

7. The innovation started in tests 4 and 5 for the precipitation of $Fe(OH)_3$ showed what could be done to shorten the operating time of the process. This is certainly the recommended procedure rather than that demonstrated during tests 1, 2, and 3.

8. The results of tests 2 and 3 showed that nickel and cobalt could not be selectively precipitated as had been claimed. In addition, a minor constituent of the ore, zinc, was concentrated in the supposed (Ni,Co)S precipitate. It is suggested that further

work on this step be done in the laboratory. This is especially true because Dr. King states that the profit of the operation will come from the nickel and cobalt obtained. As the process stands now, a speciallized market must be found for the nickel- and cobalt-contaminated manganese product. Since it appears that most of the nickel and cobalt is removed from solution during the excess sulfide removal step (pH=3.9) rather than the addition of NaHS (pH=3.2), the desirability of carrying out the sulfide precipitation at a higher pH should be investigated.

9. Filter presses should be used for the various solids-liquid separations in the pilot plant rather than the inefficient settling-decantation procedure now used.

Submitted by: Ralph C. Kirby
Chemical Engineer

John E. Conley
Supervising Chemical Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

KING HYDROCHLORIC ACID PROCESS FOR EXTRACTION of MANGANESE, NICKEL, AND COBALT FROM WHITE OAK MOUNTAIN, TENNESSEE, MANGANESE ORE

Contract DMP-103

Supplementary Laboratory Investigation Following Pilot-Plant Inspection and Monitoring of L. W. King Facilities, Salem, Ohio

from August 30 to September 9, 1955

Report No. 3

FOR GOV'T USE ONLY

EASTERN EXPERIMENT STATION
COLLEGE PARK, MARYLAND
NOVEMBER 21, 1955

SUMMARY

As instructed by Mr. C. B. Larson of the General Services Administration, supplementary tests have been made to determine if improved results could be obtained with the L. W. King hydrochloric-acid leaching process by slight modifications. These changes involved: (1) precipitation of the nickel-cobalt sulfides at higher pH to effect higher recovery of an improved product and, (2) preliminary leaching tests on the extracted ore residues with additional acid proportioned to supply theoretical quantities equivalent to the soluble constituents.

The products resulting from the tests proposed by Dr. L. W. King have not been received yet at College Park. Therefore it is assumed that some complications have been encountered to delay the samples from the King pilot-plant. The proposed leaching tests have been completed by the Bureau and the results are given in this report.

This supplementary laboratory work on materials from the monitored tests showed that: (1) the pilot-plant reduction did not completely reduce the manganese from its tetravalent form; (2) the coarse ore residue when ground finer and leached with agitation and the theoretical acid equivalent to the unreacted manganese, iron, nickel, cobalt and aluminum, gave increased extractions which raised the indicated recoveries on monitored tests 2, 3 and 5 to the following range of percentages: Mn, 61 - 80; Fe, 70 - 80; Ni, 50 - 65; and Co, 43 - 59. With hydrochloric acid equivalent to the Mn, Fe, Ni and Co only, the total combined pilot-plant and laboratory recoveries as percentages were: 47.1, 57.5, 44.0, and 35.9, respectively. A sample of the raw ore when reduced with carbon and

extracted with 74 percent of the stoichiometric quantity of hydrochloric acid for the Mn, Fe, Ni, Co and Al, yielded percentage recoveries of: 59.2, 29.4, 79.1, 32.4 and 36.9, respectively. The nickel recovery of 79.1 percent is the best obtained in any of the tests. However, additional tests will be needed to fix the optimum conditions.

GENERAL CONSIDERATIONS

Supplementary laboratory investigations were undertaken at the Eastern Experiment Station to determine the reason or reasons for the extremely poor extractions that were obtained by Dr. King during the monitored tests. In Report No. 2, previously submitted, some possible explanations for the poor test results were given in the section on comments (pp. 28-30). The ones that dealt with the extraction of the various constituents from the ore were:

1. Insufficient size reduction of the ore entering the process.
2. Probable incomplete reduction of the ore due to its coarse size and the short retention time in the reducing kiln.
3. Almost complete lack of mechanical agitation during the leaching period.
4. Insufficient acid to meet the theroretical requirements of the major acid-soluble components of the ore.

Five experiments were made to determine the effect of these variables on the extraction of the acid-soluble constituents of the ore. All of the solids used were ground fine enough to pass through a 100-mesh screen.

These were leached in each instance with 8-percent hydrochloric acid solutions at a constant temperature of 80°C. (176°F.) for two hours. Vacuum filtration was used to separate the re-worked solids from the extraction solution to which was added the subsequent washings of the filter cake. Only the combined extraction solution and washes were analyzed for the major acid-soluble constituents. Knowing the chemical analysis of the starting solids, this was sufficient to obtain the percentage recoveries of the various constituents from the ore.

In experiments 1, 2 and 3, samples of the tailings from each of the monitored tests evaluated in Report No. 2, were leached with the stoichiometric amount of HCl required for dissolution of the Mn, Fe, Ni, Co and Al remaining in the solids. In experiment 4, another sample of the tailings from monitored test No. 3 was leached with the stoichiometric quantity of HCl required for the dissolution of the Mn, Fe, Ni and Co, neglecting the aluminum present. In experiment 5, a sample of the heads for monitored test 3 was mixed with 5-percent charcoal and reduced in a closed graphite crucible for two hours at 700°C. (1,292°F.). The weight loss of the ore on reduction was 7.5 percent. A sample of the reduced ore was then leached with approximately 75 percent of the stoichiometric acid needed to dissolve all the Mn, Fe, Ni, Co and Al present.

EXPERIMENTAL RESULTS

The results of these experiments and comparisons with the corresponding monitored tests are given in table 1.

TABLE 1.-Experimental results

Experiment No.	1	2	3	4	5
Supplementing King monitored test No.	2	3	5	3	3
1. Solids re-worked with stoichiometric HCl for Mn, Fe, Ni, Co and Al	Tailings	Tailings	Tailings	1/Tailings	2/Heads
2. Percentage composition of solids leached:					
Mn	5.79	6.61	7.27	6.61	7.59
Fe	2.94	2.40	2.24	2.40	2.83
Ni	0.37	0.40	0.42	0.40	0.46
Co	0.16	0.20	0.21	0.20	0.21
R_2O_3	12.0	11.4	11.3	11.4	14.7
Al 3/	4.13	4.22	4.29	4.22	5.64
Leaching Conditions					
3. Weight of solids, gms. 4/	25	25	25	25	25
4. Nominal size of solids, mesh	-100	-100	-100	-100	-100
5. Weight of 8% HCl leaching acid, gms.	94	94	94	40.6	94
6. Theoretical HCl:solids ratio 5/ (lbs. 100% HCl:lbs. solids)	0.291	0.301	0.308	1/ 0.130	0.375
7. Actual HCl:solids ratio used	0.30	0.30	0.30	0.13	0.278

1/ Stoichiometric HCl for Mn, Fe, Ni, Co, only.
2/ Head sample reduced for 2 hours at approx. 700°C. in graphite crucible using ore:C ratio of 20:1 Weight loss of heads on reduction = 7.5%.
3/ Al calculated from R_2O_3 and Fe, neglecting Ti.
4/ Leached for 2 hours at 80°C. with rapid mechanical agitation.
5/ Stoichiometric ratio for soluble constituents.

TABLE 1.-Experimental results (cont'd.)

Experiment No.	1	2	3	4	5
Recoveries					
8. Weights of various constituents removed during leach of 25 g. of starting solids, gms.					
Mn	1.08	1.21	1.035	0.635	1.22
Fe	0.45	0.46	0.415	0.365	0.225
Ni	0.055	0.06	0.05	0.035	0.095
Co	0.022	0.02	0.022	0.016	0.0185
R_2O_3	1.735	1.715	1.765	1.185	1.30
Al 3/	0.575	0.56	0.62	0.35	0.52
9. Percentage of various starting constituents recovered in combined extraction liquor and washes					
Mn	74.5	73.3	56.9	38.5	59.2
Fe	61.2	76.0	74.1	60.8	29.4
Ni	59.7	60.0	47.6	35.0	79.1
Co	55.0	40.0	42.3	32.0	32.4
R_2O_3	57.8	60.1	62.5	41.5	32.7
Al 3/	55.6	54.0	57.8	33.1	36.9
10. Weight of constituents remaining after leaching 25 g. of starting solids, gms.					
Mn	0.37	0.44	0.785	1.015	0.84
Fe	0.285	0.14	0.145	0.235	0.54
Ni	0.037	0.040	0.055	0.065	0.025
Co	0.018	0.030	0.030	0.034	0.038
Al 3/	0.457	0.498	0.452	0.708	1.00

3/ Al calculated from R_2O_3 and Fe, neglecting Ti.

TABLE 1.-Experimental results (cont'd.)

Experiment No.	1	2	3	4	5
Recoveries (cont'd.)					
11. Calculated percentage composition of re-worked tailings (assuming only listed constituents are removed by leach)					
Mn	1.62	1.94	3.43	4.31	3.76
Fe	1.20	0.64	0.63	0.99	2.35
Ni	0.16	0.18	0.24	0.28	0.11
Co	0.08	0.13	0.13	0.14	0.17
Al	2.00	2.14	1.98	2.99	4.36
12. Weight of leached ore from monitored test, lbs. (See Item 37, Table of Test Results, Report No.2)	1,165	1,496	1,620	1,496	5/1,512 6/1,400
13. Additional recoverable wt. in lbs. of various constituents from leached ore on the basis of small-scale re-working tests.					
Mn	50.2	72.5	66.9	38.00	--
Fe	21.4	27.2	26.9	21.8	--
Ni	2.58	3.59	3.24	2.09	--
Co	1.03	1.20	1.44	0.96	--
Al	26.8	34.1	40.2	42.1	--
14. Total recoverable weights in lbs. of various constituents from leached ore; based on weights recovered in monitored test. (See Item 39, Table of Test Results, Report No.2) and additional recoverable weights found in re-working tests 7/					
Mn	68.9	88.6	79.6	54.1	68.3
Fe	21.4	30.0	26.9	24.6	12.6
Ni	3.48	4.56	3.57	3.06	5.31
Co	1.27	1.38	1.77	1.14	1.04
Al	57.1	56.3	52.1	64.3	31.5

5/ Weight of ore fed to monitored test No.3
6/ Reduced weight of ore fed to monitored test No. 3 on basis of small-scale reduction.
7/ Recoverable weights in pounds of various constituents based on extrapolation of data of small-scale

TABLE 1. Experimental results (cont'd.)

Experiment No.	1	2	3	4	5
15. Total percentage of constituents recoverable from ore					
Mn	80.2	77.2	60.9	47.1	59.2
Fe	72.3	70.1	80.4	57.5	29.4
Ni	64.7	65.5	50.0	44.0	79.1
Co	59.0	43.4	47.3	35.9	32.4
Al	81.7	67.6	64.1	75.4	36.9
16. Percentage extractions of monitored tests (same as Item 38, Table of Test Results, Report No.2)					
Mn	21.8	14.0	9.7	14.0	14.0
Fe	--	6.6	--	6.6	6.6
Ni	16.7	14.0	4.6	14.0	14.0
Co	11.1	5.8	8.8	5.8	5.8
Al	30.3	26.0	14.6	26.0	26.0

The assumption that the ore had been only partially reduced during the monitored tests was substantiated during the first four experiments. In these, the tailings from the monitored tests after having been ground to minus 100-mesh, were leached with hydrochloric acid. Unreduced manganese would be present in the tetravalent state as MnO_2 which would react with HCl to form chlorine. This is the now commercially abandoned Weldon process for chlorine production by the oxidation of HCl, following the equation:

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2$$

Such a reaction during the leaching step of the proposed King process would be unprofitable because of the complete waste of acid in producing virtually unrecoverable chlorine. This reaction took place during the first four experiments, being evidenced by the evaluation of obnoxious amounts of chlorine from the 25-gram samples of solids being leached.

There is no way to evaluate the individual effect of the size reduction and mechanical agitation of the variables tested by these experiments. The collective effects of reduction to small particle size, ample mechanical agitation, and use of the theoretically required acid are demonstrated by items 9, 15, and 16 in the table. The use of enough acid is the most important single factor. The difference between experiments 2 and 4 was the quantity of acid used for the leach; in experiment 3 enough acid was used for all the acid-soluble constituents,

while in experiment 4, acid for the dissolution of the aluminum present was not provided. The use of the full quantity of theoretical acid in experiment 2 yielded a manganese recovery twice that of experiment 4. Had 100 percent of the theoretical acid been used for the leach of experiment 5 instead of 75 percent, the recoveries would no doube have increased correspondingly.

In experiment 5, a sample of the heads from monitored test 3 was reduced after having been ground to minus 100-mesh. The results of the leach as given in items 9 and 15 show that while the manganese recovery is down as compared to experiment 2, the iron recovery has been definitely suppressed and the nickel recovery is higher than would have been expected. The cobalt recovery is lower in experiment 5 following the trend indicated by the manganese recovery.

COMMENTS AND RECOMMENDATIONS

The results of these tests substantiate the opinions expressed in Report No. 2. Most of the acid-soluble components can be leached from the ore. Their selective recoveries will depend on modification of the King process as demonstrated during the monitored period.

The ore was not reduced enough to obtain only MnO. Finer grinding and efficient agitation during the leach would help increase the recoveries.

Careful attention must be given to the analysis of the ore-feed to the process in order to use enough acid to dissolve most of the Mn, Ni, and Co. If the main ore body does not contain aluminum-bearing minerals, then caution must be used during the mining to keep clay overburden out of the ore.

Respectfully submitted: Ralph C. Kirby
Chemical Engineer

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Docket

L. W. King
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GENERAL SERVICES ADMINISTRATION

EMERGENCY PROCUREMENT SERVICE

MATERIALS DIVISION

STATUS OF RESEARCH PROJECTS

FOR

UPGRADING SUB-METALLURGICAL MANGANESE ORES AND SLAGS

P. 9

January 3, 1955

GSA-WASH DC 55-6021

The critical shortage of metallurgical grade manganese ores for stockpiling and consumption, during the recent Korean campaign, focused attention more sharply than ever on the large reserves of low grade manganese ores and manganiferous slags in this country. As a result the Government commenced several programs for the purchase of low grade ores, and simultaneously began various research projects looking to the development and testing of processes for upgrading these ores to usable products.

At the time these programs were started, it was felt that the urgency of the manganese situation was such that, in processing the ores, low recoveries and high costs could be tolerated, if necessary. However, in the intervening period the urgency of converting these ores to usable products at any cost has decreased. Hence experimental work is now being continued not only with the objective of merely finding processes for treating the various types of ores, but also of finding the most practical and economic processes for doing this.

In the course of these investigations EPS has given careful consideration to nearly a score of different new or unproven processes for extracting manganese from slags and various types of submetallurgical ores and slags. As a result, a half dozen of these processes have been deemed promising enough to justify financial assistance by the Government for further research, development and test work.

In each of these cases, before deciding finally as to whether, or to what degree, financial assistance of the Government should be given, EPS has requested the Materials Advisory Board of the National Academy of Sciences to investigate, study and report upon the technical merits of the process. Also, in the general consideration of these matters and in certain specific cases, EPS has sought technical information and counsel in other offices of Government, including principally the Bureau of Mines.

Actual research and testing work was begun over a year ago on two new metallurgical processes for winning manganese from low grade sources. Since then test work on other new processes has been commenced. Others are about to be commenced.

Here follows a brief description of the work done to date on the various projects:

FLOTATION

Studies Regarding Upgrading of Government Stockpiled Sub-Metallurgical Ores

The Bureau of Mines has for a number of years been experimenting with the so-called "oil-emulsion" process which, in the case of low grade ores, would need to be followed by

nodulizing or other means of agglomerating the product and eliminating base-metal impurities. The Bureau has at times and on selected specific types of low grade ores, secured in the laboratory fair to good recoveries of manganese, but has indicated that a full scale mill test on mixed ores as stockpiled would as yet be ill-advised and premature;

(a) In early 1954 an idle lead and zinc flotation mill at Deming (peru Mining Company) was offered for use in upgrading low grade stockpiled ores. Bureau of Mines metallurgists examined the plant as a possible site for making mill-scale tests and reported not only that the mill was not suited to the purpose but that it would be "premature" and "utter folly" to undertake mill-scale tests without further extensive laboratory and pilot plant testing of the process.

(b) In 1949-1950 the Domestic Manganese and Development Company of Butte operated a Government-owned flotation mill and a nodulizing plant on low grade Butte district ores. Forty-one thousand (41,000) tons of ore (22.11% Mn) were treated, producing 7301.5 tons of nodules (46.19% Mn). The overall recovery of manganese, however, was only 37.22% and the base metal (zinc and lead) content of the nodules was so high that they were unusable by industry and rejected for stockpiling.

Recently the former plant operator proposed that a mill test of the oil-emulsion flotation process be made in that plant. In reply to this proposal the Bureau stated, "It is the consensus of interested Bureau personnel that large-scale mill runs would be premature at this time. Although the method is considered to be technically feasible, it is believed that small pilot plant testing and probably additional laboratory and other work will be necessary before an undertaking of the magnitude proposed by Mr. Cole can be justified."

If the need for conversion were immediate and urgent, the "oil-emulsion" flotation and nodulizing as now developed could be employed to obtain from these ores some manganese suitable for metallurgical use. Under present circumstances, however, the present costs and losses to the Government in that procedure cannot be justified, and large-scale mill testing should be deferred until the Bureau is ready to recommend it. In the meantime some more feasible and economical process may be developed.

Southwestern Engineering Company (Sweco)

In 1952 Sweco, under contract to DMPA, obtained large working samples of wad and other low grade manganese ores from Virginia, Tennessee, Arkansas, Maine, Arizona and New Mexico. They performed extensive analyses and ore tests upon each ore. Flotation possibilities were principally studied, but tests were also made by employing gravity and sink-float methods. Also, a few tests, employing leaching, were performed.

Sweco reported that none of the sample ores were amenable to upgrading to metallurgical grade, by physical methods alone. More research, using chemical (leaching) methods, was indicated. It was found in some instances that preconcentration by physical methods would be practical for preparing the material for leaching.

PYROMETALLURGY

Mangaslag Inc.

A contract was signed between DMPA and Mangaslag on December 31, 1952, whereby the latter was to test out in a large pilot plant a new process devised by Bureau of Mines metallurgists for recovering manganese from open hearth slags, and possibly Aroostook ores.

The contract, as amended, provided that the pilot plant construction was to be completed by April 1954; and that prior to December 31, 1955, the process would be proven feasible or not. The project, situated at Pittston, Pennsylvania, was largely financed by Government funds.

The process is pyrometallurgical, entailing the reduction of ore in a vertical blast furnace, possibly using anthracite coal instead of coke, to produce a spiegeleisen; then selective oxidation of the molten spiegeleisen in a special converter to produce a cinder containing the manganese, and a molten metal containing the iron and phosphorous; then reduction of the cinder in the blast furnace to produce ferromanganese; and blowing of the molten metal in a second converter to produce de-phosphorized steel melting scrap.

The construction of the pilot plant was completed in May 1954. Since then furnace operations have been commenced a number of times and each time have soon been stopped

because of defects of one kind or another in the furnace and accessory equipment.

Mangaslag Inc., assisted by Bureau of Mines and other Government engineers, has continued to work on the project, making improvements as indicated after each new testing operation. To date the furnace has never functioned satisfactorily, and operations have never progressed to the point of selective oxidation of molten spiegeleisen in the converters, which is the crux of the process.

Evidently much additional development and testing will be required to prove or disprove the feasibility of the process.

At the time of this writing there is some possibility that Mangaslag Inc. may drop out of the project. In such case, EPS, believing that the process should be tested out to a final conclusion, expects to find some satisfactory arrangement for continuing with the pilot plant testing.

Blast Furnace Reduction

The Bureau of Mines has informally suggested that the most feasible way to upgrade the low grade manganese ores in the Government stockpiles in the southwest might be direct reduction in the blast furnace to obtain a product intermediate in manganese content between standard spiegeleisen and ferromanganese. A product of that nature has little utilization at present in the steel industry but this procedure would have the virtue of recovering a fairly high percentage of the manganese in ore as a product that could be consumed by the steel industry in an emergency when higher grade materials were in short supply.

(a) The Colorado Fuel and Iron Co. with blast furnaces at Pueblo, Colorado, was a possible candidate for this type of conversion, since the plant is so located that ores from El Paso and Deming could be freighted to Pueblo for a cost of about $7.00 per ton. (Separate arrangements would have to be made for the Wenden ores, probably at furnaces in the Los Angeles area).

C.F. and I. suggested a test run of about 20,000 tons of El Paso and Deming ore in one of their 750-ton furnaces which is now making a run of ferromanganese, the object being to determine costs of

the operation, and quality and potential utility of the product. Upon closer examination, however, the company has lost interest at the present time because, (a) the furnace that they planned to use has developed a hot spot and must be relined immediately, after which it will be returned to production of pig-iron, and (b) the operating people are afraid of the lead-zinc content of the ores, which might destroy a good furnace lining, plus (c) a lack of knowledge as to whether sintering the ore ahead of furnacing would reduce the base metal content to proportions harmless to the blast furnace lining.

(b) It has recently been learned that the Sheffield Steel Company (subsidiary of Armco) a few years ago purchased a small (75-ton) blast furnace at Rusk, Texas, with a small sintering plant, blowing engines and other accessories. Inquiries are now under way to determine whether that plant is still in existence and operable. If so, a study will be made of the possibility of utilizing these facilities for a test run on a comparatively small amount of El Paso and Deming ore, to determine feasibility of costs. The Rusk plant is south of Dallas, within a reasonable freighting distance of El Paso and Deming. Lone Star and Sheffield also have other furnaces in Texas which conceivably could be made available for this purpose under certain conditions.

The problem of finding a suitable process, whereby the sub-metallurgical grade ores in the Government stockpiles can be upgraded to some readily usable form, continues to receive active consideration in EPS. As soon as more conclusive data is available concerning some of the processes, which are now being tested, it may be that one of these processes, or a combination of them, can be selected for upgrading these ores.

COMBINED ROASTING - LEACHING

Manganese Chemical Corp. (M.C.C.)
(Carbamate Process)

A contract was signed August 7, 1952, between DMPA and MCC, which provided that the company build a pilot plant and test the new Carbamate (Dean-Leute) Process for extracting manganese from the manganiferous iron ores of the Cuyuna Range, Minnesota. The pilot plant, having

capacity to treat 200 tons per day of ore, is situated at Riverton, Minnesota. The project has been financed largely by Government funds. The contract, as amended, provides that pilot plant production is to commence by January 1, 1955.

The new process combines roasting and leaching of the ore, using an ammonia solution, with the aid of CO_2 gas; and the recycling of ammonia. The final basic product is manganese carbonate which can be readily converted to manganese oxide in nodules for use in the steel-making industry; also the manganese carbonate, which is in a very pure state, can be used to good advantage in the chemical industry. It can be also used as basic material for producing electrolytic manganese dioxide.

The construction and tuning-up of the pilot plant has required over a year more than was originally anticipated. However, MCC now reports that the plant finally is in good working condition and will be in production on a regular basis by January 1, 1955.

When the plant has been in regular production for a few months, data may then be available concerning the economic feasibility.

It now seems reasonable to suppose that the pilot plant operation will prove the new process to be technically sound for the treatment of the Cuyuna low grade manganiferous iron ores, of which there are extensive reserves. Indications are that the operation will show the process to be economically feasible, as well. However, final conclusions concerning these points must, of course, await definite proof which can be obtained only after the plant has been in regular operation for at least a few months.

Nossen Laboratories, Inc. (N.L.I.)

DMPA and N.L.I. entered into a contract June 30, 1953, whereby the latter was to construct and operate a pilot plant for the purpose of testing their new process for extracting manganese from low grade manganese ores. The contract, as amended, expired on November 15, 1954. The project was financed entirely by Government funds.

The new process begins with a reducing roast (omitted in the case of some ores.) A nitric acid solution is employed to dissolve the manganese in the raw or roasted material.

The pregnant solution is decomposed by heat in a specially designed equipment, thereby producing a solid product containing the manganese, and a vapor containing the nitrous fumes. The solid product is then treated by grinding and washing to give a high grade manganese dioxide concentrate. The nitrous fumes are recovered in the form of nitric acid for recycling in the process.

Construction of the plant, at Paterson, New Jersey, required over half a year and the plant was then operated for several months. It was shut down last October upon expiration of the contract period and exhaustion of allotted funds. As a result of pilot plant operations, the general opinion in Government offices is that the metallurgy of the new process was proven to be technically sound.

However, certain difficulties were encountered in connection with the mechanical operations of some of the equipment which had been selected or developed for use in the pilot plant. At the conclusion of the contract period when the plant was shut down these difficulties had not been completely overcome.

The feeling among Government engineers who have been close to the pilot plant work is that, owing to unexpected delays because of late delivery of equipment, and of necessity for solving unforeseen problems, not enough time remained within the contract period for fully developing optimum techniques and for determining which kinds of equipment, in some instances, would give the proper results. The feeling is that with a reasonable amount of further pilot plant experimentation and final testing these operating problems can very probably be solved.

With reference to economics of the process, the data thus far obtained gives some indication that the process can be applied within practical limits of cost; but that definite conclusive opinions upon this aspect must await more complete data obtainable once the equipment problems, just referred to, are solved.

It should be mentioned that, in the pilot plant work, ores from Aroostook County, Maine, were used exclusively. These ores are of low manganese content and furthermore are of a refractory character. The Government insisted that Aroostook ores be used in the pilot plant because the Aroostook deposits are very extensive and, if the Nossen process were proved feasible, these deposits would represent a great source of manganese in a national emergency if imports of foreign ores were cut off.

Undoubtedly some of the country's less refractory ores having a higher manganese content, such as some of the sub-metallurgical grade ores from less extensive deposits in the southwest, could be treated much easier and cheaper, per unit of manganese recovered, than the Aroostook ores.

Since being shut down, the pilot plant, which is property of the Government, has been kept intact, with the thought that possibly pilot plant operations may be soon renewed. It is the expectation of EPS that arrangements to this end may be made with some private company which may become interested in the matter.

Bruce Williams Laboratories (B.W.L.)

EPS has concluded negotiations with B.W.L., and a contract is now being prepared whereby the latter will build and operate a small metallurgical pilot plant, at Joplin, Missouri. The project is to be wholly financed by Government funds.

The purpose of the pilot plant is that of testing a new process, developed by B.W.L., for extracting manganese from practically any type of low grade, manganiferous ore or slag, to produce a high grade MnO_2 concentrate.

In general, the process, upon which B.W.L. has applied for a patent, involves a roasting procedure followed by leaching and precipitation, with recycling of the principal reagents, and from this point of view is, of course, not new. It does involve, however, certain distinctive procedures and the novel use of certain reagents which sets it apart from being merely a duplication of some other already known process.

Various Government engineers have examined and studied the the theory of the process, and some have visited the premises of B.W.L. for a firsthand laboratory demonstration of it. All are of the opinion that the process holds much promise.

The contract schedule of pilot plant construction and operation covers a period of 15 months, thus if there are no delays in signing the contract, and in carrying out the construction and operations, the process should be proved or disproved by April 1956.

L. W. King

On September 3, 1954, EPS signed a contract with Dr. L. W. King. The contract provides that he is to erect and operate a small-scale pilot plant for the purpose of testing a process devised by him for recovering manganese, cobalt, and nickel, separately, from low grade, natural deposits which exist in widely scattered places in the United States.

The raw ore to be used in the pilot plant is being shipped from a mineral property in Tennessee, controlled by Dr. King.

Dr. King has been conducting his own laboratory experiments for several years for the purpose of developing a process for treating satisfactorily that type of ore. The process is not patented.

The King process employes roasting and leaching, using hydrochloric acid as the leaching agent. The manganese, cobalt and nickel are recovered separately, as oxides, by a series of chemical operations involving the changing of the degree of acidity of the solution by the addition of reagents, and by changes in solution temperatures.

For the economic success of the process Dr. King relies to some extent upon recycling a portion of the hydrochloric acid, but principally he relies upon manufacturing the acid very cheaply from low cost raw materials by means of a special European process upon which he holds certain rights.

The present contract provides only for testing the process to recover the manganese, cobalt and nickel from the ores. If the pilot plant demonstrates success in this, the intention of EPS would be to assist Dr. King with funds to erect additional facilities to test his process for manufacturing cheap hydrochloric acid.

The pilot plant is now being erected in Salem, Ohio where Dr. King already owns premises and some equipment which he is loaning to the project. The cost of additional equipment, and of erecting and operating the pilot plant, is to be paid by the Government.

The present contract is to expire in May 1955 by which time it is contemplated that the feasibility of the extraction process will have been proved or disproved.

If the extraction process is proved feasible, another period running possibly into 1956, would be required for setting up and testing the acid manufacturing facilities.

At present, the installation of equipment at the pilot plant is progressing according to contract schedule, and the expectation is that the construction will be complete and that operations on a tune-up basis will be commenced early in February.

COMBINED ROASTING - MAGNETIC SEPARATION

Diamond Alkali Co. (D.A.C.)
(Sylvester Process)

Negotiations are now in progress between EPS and D.A.C. with a view to making a contract whereby the latter will test, at its plant at Painesville, Ohio, the Sylvester Process for recovering manganese from slags and low grade ores of Aroostook County, Maine.

This testing project is to be financed by Government funds, but with D.A.C. doing the work on a cost basis, that is, a non-profit basis, with expectations of possible gain later on if the process is proved successful and is used commercially.

The Sylvester Process, developed within recent years in the laboratory of Sylvester & Co., Cleveland, Ohio, is a roasting process whereby manganiferous slags and ores of the types above named are converted pyro-chemically from a refractory state to a state amenable to concentration by magnetic separation. It is expected that the concentrate thus produced will permit of successful further treatment either by leaching or by smelting to produce manganese products for use in the steel industry.

The contemplated program, including the work of designing the necessary facilities, of installing equipment additional to that already available in the D.A.C. plant, and of performing shakedown operations and final demonstrations, will cover a period of 15 months.

This means that if a contract is soon signed, and if no great delays are experienced in getting the facilities ready, or in operating them, the whole project should be completed, and the process proved or disproved by May 1956.

TABLE NO. 1

DISTRIBUTION OF MANGANESE RESEARCH AND DEVELOPMENT UNDER EMERGENCY PROCUREMENT SERVICE
(By Regions and Types of Projects)

CONTRACTOR	Southwestern Engineering Company	Bureau of Mines	Manganese Chemical Corp.	Nossen Laboratories Inc.	Mangaslag Inc.	L. W. King	Bruce Williams Laboratories	Diamond Alkali
TYPE OF PROCESS:	Gravity and Flotation	Flotation	Ammonia CO_2 Leach (Dean-Leute "Carbamate" process)	Nitric Acid Leach (Nossen Process)	Special Blast Furnace (Royster), and Selective separation of Mn in converter (Buehl)	Hydro-chloric Acid Leach	Special Roasting and Leaching	Lime Roast followed by Magnetic Separation
SOURCE MATERIAL:								
Slags, Open Hearth					X		X	X
Cuyuna Iron Range, Minn.			X					
Aroostook County, Maine	X			X	X		X	X
Artillery Peak, Ariz.	X							
Batesville, Ark.	X							
Va-Tenn-Ala (S.Appalachian Region)	X						X	
Low-Grade Mn-Ni-Co Ores Tennessee and elsewhere						X		
Govt. Stockpiles, sub-metallurgical ores, at El Paso-Deming-Wenden-Butte	X	X	X	X			X	

SUMMARY:

The following tabulations and remarks are presented as a summary of the scope and status of manganese research and development under EPS:

TABLE NO. 2 - Status of Research and Development work

PROJECTS	ESTIMATED DATES FOR CONCLUSION OF TEST WORK	REMARKS
A. Finished		
SWECO Flotation; various ores in different states	Concluded	SWECO found that some ores, including the important Aroostook County ores, could be preconcentrated to advantage for possible subsequent treatment by other processes such as maybe Nossen, Mangaslag and Sylvester processes.
B. In Progress		
MANGANESE CHEMICAL CO. Leaching process for Cuyuna ores & possibly Sylvester concentrates	May 1955	Work to date indicates favorable results by date here indicated.
NOSSEN LABORATORIES, INC. Leaching process for Aroostook ores & Govt. stockpiles of sub-metallurgical ores.	December 1955	Work to date indicates favorable results if project is continued till date here indicated.
L. W. KING Leaching process for low grade Mn, Ni, Co ores	June 1955 (extraction process) Jan. 1956 (acid process)	Pilot plant now under construction.
MANGASLAG, INC. Pyrometallurgical process for slags	At least 6 mos., but maybe a year from now (Jan. 1956)	Pilot plant operation has not yet developed any definite data.
C. Under Negotiation or Study		
BRUCE WILLIAMS Roasting-leaching process; all ores and slags	April 1956	Pilot Plant construction to be commenced soon.
DIAMOND ALKALI (Sylvester) Pyrochemical process followed by magnetic separation, or leaching, or blast furnace reduction.	June 1956	Negotiations for testing of process now in progress
UPGRADING GOVT. STOCKPILES OF SUB-METALLURGICAL MANGANESE ORES	After all above processes have been tested, the one best suited for treating stockpile ores can be selected by late 1956	Project is of importance but the quantity of manganese contained in the low grade stockpiles is of much less strategic importance than that contained in the extensive deposits, Aroostook, Cuyuna and Slags.

Emergency Procurement Service feels that in this work a good degree of progress has thus far been made. Naturally, as might be expected in research work of this kind, unforeseen problems and delays have come up in each of the different projects. However, these problems are being met and solved as they come up, and on the whole the prospects for bringing forth some practical means of utilizing the nation's low-grade manganese deposits, at least as an emergency supply, are good.

Because the characteristics of the material from the different low-grade sources of manganese differ so greatly, it is not expected that any one process will be satisfactorily applicable to all. In some cases a combination of processes may prove desirable, as for example the Aroostook ores may be best pre-treated by flotation prior to leaching, or prior to the lime clinker-magnetic separation (Sylvester) process; or possibly the Sylvester process may be employed to good advantage to pre-treat open hearth slags or Aroostook type ores, producing a concentrate which would be amenable to further treatment by the Carbamate, Nossen, Bruce Williams or some other process. These are possibilities to which Emergency Procurement Service plans to give attention as soon as more data on each of these processes are available.

The three largest, known potential sources of domestic manganese are the Open Hearth Slags, the ores in Aroostook County, Maine and the manganiferous low-grade iron ores of the Cuyuna Iron Range, Minnesota. Consequently, from the viewpoint of national expediency, Emergency Procurement Service has naturally been more interested in testing processes which would treat material from these large sources.

With reference to these the project of the Manganese Chemicals Co. at Riverton, Minnesota, for testing the Carbamate process for treating Cuyuna ores, is furthest advanced, and at this writing the belief is that this project will soon have demonstrated the practicability of that process for those ores.

However, Emergency Procurement Service is also giving attention to the possibilities of treating ores from some of the lesser sources such as (1) the Government stockpiles of sub-metallurgical ores at El Paso, Texas; Deming, New Mexico; Wenden, Arizona; and Butte-Philipsburg, Montana; (2) Artillery Peak, Arizona; (3) the Virginia-Tennessee-Georgia-Alabama Region; (4) the Arkansas Region. Three years ago as a Korean War expedient a large plant was partly constructed for treating ores of the Batesville district on a commercial basis. This project, however, ran into difficulties resulting in litigation and a cessation of operations.

With the aid of Government, through Emergency Procurement Service, plants for extracting manganese from ores have already been established and are now in operation at Henderson, Three Kids and Pioche, Nevada.

Table No. 1 shows the distribution of manganese projects under Emergency Procurement Service by Regions and by type of projects.

From Table 2 it is seen that only one research and development project - Sweco - has been completed; and that the other seven are in various stages of progress - some soon to be finished, some still to be continued for the better part of a year or more, and others just about to be started.

The present estimate is that the last of the individual projects may be completed by mid 1956.

When all of the data from the different pilot plants have finally been obtained, some relatively little additional time will be required for making comparisons of the different processes with a view to selecting the process, or combination of processes, which will give the best over-all results in the case of each different source material.

With this in view Emergency Procurement Service recommends that, unless some national emergency dictates otherwise, no full scale or commercial upgrading of the government's stockpiles of sub-metallurgical ores be undertaken, and that no full scale plant be established by the government for beneficiating any of the extensive natural deposits of domestic low-grade ores till all of the processes now being investigated have been fully appraised.

Thus, the thorough and proper completion of the manganese research and development work as a whole may well require some 18 or 20 months more or, say, till the latter part of 1956.

In this connection it should be borne in mind, however, that research and development work is naturally fraught with many uncertainties, and that consequently some of these projects may require more time than is now estimated. Also, there is the possibility that other new processes may yet be proposed, and that one or another of them may be worthy of pilot plant testing. This possibility, however, seems slight inasmuch as there does not appear to be any other worthy process in the offing, and it is doubtful that in the immediate future any will be brought forth.

The great importance to the nation of being prepared in an emergency to extract manganese for the steel industry from the extensive domestic deposits of low-grade ores and slags in a practical and economic, large scale manner, is well known. A good start in this direction has been made by launching and working upon the research and development projects here discussed. It now remains to finish the job in a proper, thorough manner.

The matter is of such vital importance to the nation that support of these projects should be continued for at least the 18 or 20 months above mentioned.

GSA-WASH DC 55 55-6640

AUG 24 1956

Mr. Robert A. Laurence, Executive Officer
DMEA Field Team, Region V
Room 13, Post Office Building
Knoxville 2, Tennessee

Re: Docket No. DMEA 274h, Manganese-
Nickel-Cobalt
J. H. Arts land
Bradley and Hamilton Counties,
Tennessee

Dear Mr. Laurence:

Reference is made to the last paragraph of your letter of August 17, 1956, wherein you ask to borrow, if available, a copy of Dr. King's report to GSA on the results of his metallurgical research work on the manganiferous chert from the above-captioned land.

We have not seen any report by Dr. King on his work, but have been afforded an opportunity to consult three reports prepared for GSA by Bureau of Mines employees. We concluded therefrom that metallurgical tests have not indicated that the greater proportion of the material in question can be economically treated to yield a satisfactory product.

Inasmuch as the reports in question were not made either by or for DMEA, it seems inappropriate for us to comment further.

Sincerely yours,

George C. Selfridge

Chairman, Operating Committee

APPROVED:

FRANK D. LAMB

Member, Bureau of Mines

N. E. Nelson

Member, Geological Survey

SPHolt/foc 8/22/56
cc to: Docket
Code 400
Admr. Read. File
Oper. Comm.
FT. REG. V
T. Kiilsgaard, USGS
H. T. Reno, USBM

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C.
ROOM 13 POST OFFICE BLDG.
KNOXVILLE 2, TENN.

406

August 17, 1956

WSM

Memorandum

To: Operating Committee, DMEA, Washington, D. C.

From: Field Team, DMEA, Region V, Knoxville, Tennessee

Subject: DMEA-2744 (Manganese-nicket-cobalt)
L. W. King, M. D., Salem, Ohio
J. H. Artz land, Bradley and Hamilton Counties, Tennessee

Reference is made to Mr. Mittendorf's letter of August 2 to the Applicant, denying the application. We infer from this that the results of Dr. King's research under a GSA contract were negative.

We have been unable to learn what was done in the way of metallurgical research by Dr. King, though we understand that he built a small mill at Salem and shipped a few truckloads of manganiferous chert from White Oak Mountain to it.

Is there a copy of Dr. King's report to GSA which could be loaned to us? Although the application has been denied, we would be interested to know just what has been accomplished.

Robert A. Laurence
Executive Officer

V. J. Lynch
Member, Bureau of Mines

RAL?MG
CC * Operating Committee (2)
Lynch
files

Millar says he wouldn't send Laurence copies of Kerr reports; but would tell him anything we wanted to about what was in the reports, with the stipulation that information he gave was for use in Govt or DMEA only.

S.P.H.
8.22.56

SPH :- Sugest that you see if Millar is willing to have us tell Laurence about those reports that Millar lent to us. This is a good thing to clear by phone with College Park before we write any letters

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D.C.
ROOM 15 POST OFFICE BLDG.
KNOXVILLE 2, TENN.

August 17, 1956

Memorandum

To: Operating Committee, DMEA, Washington, D. C.

From: Field Team, DMEA, Region V, Knoxville, Tennessee

Subject: DMEA-2744 (Manganese-nicket-cobalt)
L. W. Wing, M. D., Salem, Ohio
J. H. Arts land, Bradley and Hamilton Counties, Tennessee

Reference is made to Mr. Mittendorf's letter of August 2 to the Applicant, denying the application. We infer from this that the results of Dr. King's research under a GSA contract were negative.

We have been unable to learn what was done in the way of metallurgical research by Dr. King, though we understand that he built a small mill at Salem and shipped a few truckloads of manganiferous chert from White Oak Mountain to it.

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Robert A. Laurence
Executive Officer

V. J. Lynch
Member, Bureau of Mines

RAL?MG
CC * Operating Committee (2)
Lynch
files

RECEIVED AUG 20 1956

400

1956

Dr. L. W. King
470 E. State Street
Salem, Ohio

Re: Docket No. DMEA-2744,
Manganese-Nickel-Cobalt
J. H. Artz land
Bradley and Hamilton Counties,
Tennessee

Dear Doctor King:

Reference is made to your letter of August 3, 1956, calling our attention to items with which you disagreed in our letter of August 2 regarding the subject project.

From the copy which you enclosed of your letter of August 2 to Mr. Clarence A. Fredell, Emergency Procurement Service, General Services Administration, we note that you plan further discussions of your process with that Agency. We have consulted the report which you called to our attention. Your information is appreciated.

In accordance with your request, the above-mentioned correspondence is being made a part of Docket No. DMEA-2744.

Sincerely yours,

G. O. Mitteudorf

Administrator

cc: Docket
Code 400
Adm. Read. File
Oper. Comm.
T. Killsgaard, USGS
H. T. Reno, USBM
FT, Reg. 5
WSMartin/ls 8/15/56

Reports on

King Hydrocholoric Acid Process for Extraction of Manganese, Nickel, and Cobalt

(1) Preliminary Report, The L. W. King Hydrochloric Acid Leaching Process for Nickeliferous Manganese Ores, dated August 10, 1955, by P. M. Ambrose and J. E. Conley.

Extract from "Conclusions and Recommendations": (pp.4-5)

"With the present set-up and operating procedures, there is no sound basis for evaluating the process as to grade of ore treated, recoveries possible, costs of chemical reagents and estimated total production costs. Cost estimates are further complicated by the proposed plan to manufacture the hydrochloric acid by the salt-cake process using salt and sulfuric acid.

" * * * .

(2) Report No. 2, King Hydrochloric Acid Process for Extraction of Manganese, Nickel, and Cobalt from White Oak Mountain, Tennessee, Manganese Ore Contract DMP-103, Pilot-Plant Inspection and Monitoring of L. W. King Facilities, Salem, Ohio, from August 30 to September 9, 1955. Report dated November 3, 1955, written by Ralph C. Kirly, and John E. Conley, Eastern Experiment Station, College Park, Md.

Extract from "Comments": (pp. 28-30)

"Poor results are not necessarily inherent in this process. Some of the reasons for them, together with suggestions for their improvement, are listed below:

" (9 practical suggestions followed). * * *."

(3) Report No. 3, Supplementary Laboratory Investigation Following Pilot-Plant Inspection and Monitoring of L. W. King Facilities, Salem, Ohio, from August 30 to September 9, 1955. Report dated November 21, 1955, written by Ralph C. Kirly and John E. Conley.

Extract from "Comments and Recommendations": (pp. 9-10)

"The results of these tests substantiate the opinions expressed in Report No. 2. Most of the acid-soluble components can be leached from the ore. Their selective recoveries will depend on modification of the King process as demonstrated during the monitored period.

"The ore was not reduced enough to obtain only MnO. Finer grinding and efficient agitation during the leach would help increase the recoveries. Careful attention must be given to the analysis of the ore-feed to the process in order to use enough acid to dissolve most of the Mn, Ni, and Co. If the main ore body does not contain aluminum-bearing minerals, then caution must be used during the mining to keep clay overburden out of the ore."

400

C O P Y

L. W. KING, M. D.
470 E. State Street
Salem, Ohio

August 3, 1956

Mr. C. O. Mittendorf
D.M.E.A. Administration
Dept. of Interior Bldg.
Washington 25, D. C.

Dear Mr. Mittendorf:

I was surprised to receive your letter in reference to Docket D.M.E.A.-2744.

It contains some inaccuracies that I wish to correct by calling them to your attention, so that this statement which I will mail registered may come to your personal attention.

The second and third paragraphs suggest that as "indicated that the greater portion of such material etc."--- cannot be classed as ore by present standards" - is untrue as a perusal of Bureau of Mines report # 3 on DMP Contract # 103 of which all copies except the file copy were collected from them; will corroborate. I presume this report was not made available to you in reference to this application. I think you personally can see it at the Bureau at College Park on request.

I will enclose my last application for pilot plant assistance which will bring you up to date on our work.

Will you please make this letter a part of Docket # D.M.E.A.-2744?

Sincerely yours,

/s/ L. W. King, M. D.

L. W. King, M.D.
470 E. State St.
Salem, Ohio

LWK/mg

AUG - 2 1956

Dr. L. W. King
470 E. State Street
Salem, Ohio

Re: Docket No. DMEA-2744,
Manganese-Nickel-Cobalt
J. H. Artz land
Bradley and Hamilton Counties,
Tennessee

Dear Doctor King:

Reference is made to the subject application dated October 22, 1952, and our subsequent discussions with you. As you are aware, that application has been held in abeyance in consideration of the information and correspondence which you have had with the General Services Administration, and other agencies of the Government, relative to the problem of beneficiating the particular type of mineralized material occurring on the captioned property.

Exploration already completed on the same property under Contract No. Idm-E83, our Docket No. DMA-176X, has indicated the presence of appreciable tonnages of material containing cobalt and manganese, but does not show that your property has definite promise of yielding products of acceptable grade in quantities that will significantly improve the mineral supply position for the National Defense Program. The subject request was for exploration assistance in extending the explored areas. The new work might indicate additional tonnages similar in character to the deposits already explored.

It is our understanding, however, that metallurgical tests have not indicated that the greater proportion of such material can be economically treated to yield a satisfactory product. Consequently, unless further tests produce a satisfactory metallurgical process, additional exploration by the Government would be unwarranted in any area where we could expect to find only similar deposits of material which cannot be classed as ore by present standards.

We have held final action on your request for additional exploration assistance in abeyance for more than two years in order to allow ample time for completion of your metallurgical tests. The DMEA cannot indefinitely postpone action on applications under such circumstances. We therefore regret to advise that your application for additional exploration assistance is denied. However, if at some future time the metallurgy of cobalt-manganese deposits of this type is satisfactorily solved, we shall be glad to consider a revised application for additional exploration assistance.

We wish to thank you for your interest in the DMEA program and for bringing your property to our attention.

Sincerely yours,

G. O. Mittendorf

Administrator

cc: Docket
Code 400
Adm. Read. File
Oper. Committee
T. Kiilsgaard, USGS
W. McInnis, USBM
Field Team, Region V

WSMartin/FEJohnson/ls
7/26/56

Copy for Bill Martin

UNITED
DEPARTMENT
OFFICE OF
WASHIN

RMS 6696

July 6, 1956

My dear Dr. King

Your letters of June 1, 1956, making formal application for the construction of a pilot plant for the recovery of cobalt, nickel, and manganese using South Appalachian ore, and requesting an interview, have received my attention.

Neither the Department of the Interior, nor any agency thereof, is authorized to construct pilot plants outside Government laboratories, unless specifically instructed to do so by the Congress. Accordingly, an interview with me and members of the Department's staff could not further your request for assistance in constructing a plant to treat South Appalachian ore.

The Emergency Procurement Service, General Services Administration, Seventh and D Streets, S. W., Washington 25, D. C., under specific circumstances set forth in the Defense Production Act of 1950 and subsequent amendments, is authorized to encourage and give certain assistance to producers of strategic metals. I suggest, therefore, that you present your application to that agency.

Please be assured that I will direct that data pertinent to your application, now held by the Department of the Interior, will be made freely available to the engineering staff of General Services Administration.

Sincerely yours,

(Signed) Fred A. Seaton

Secretary of the Interior

Dr. L. W. King
[illegible] East State Street
Salem, Ohio

Prepared 6/26/56

Copy to: Secretary's Reading File
Assistant Secretary Barrow
Office of Secretary Files
Bureau of Mines Files
Director's Reading File (Mines)
Division of Minerals
Ferrous Metals (4)
BMRA Files

6-19-4

OFFICE OF THE
ASSISTANT SECRETARY OF THE INTERIOR
WASHINGTON

July 6, 1956

To. Bill Martin
DMEA

From: Gladys McCarthy

Please hold these copies of letters to Dr. King and give them to Mr. Martin upon his return from his vacation.

G. McC.

Copy for Bill Martin

June 20, 1956

My dear Dr. King:

Your letter of May 31, addressed to the President regarding "confidential and restricted" classifications of certain Government data, has been referred to the Department of the Interior for reply.

We note your concern that valuable data collected by the Government is not published in textbooks or magazines.

The policy of this Department is, and has been, to make known the findings of its technical bureaus when such information contributes to scientific knowledge and is deemed to be of value to the public. Hence, significant results of scientific research and technical investigation are published by the Department or outside press, or otherwise made available to taxpayers. You understand, of course, that in certain types of work, however, officials are prohibited by law, or in the interest of proper administrative procedure, from publicizing information. One such category consists of data collected on privately-owned properties, which are obtained with the owner's consent and an explicit understanding that such data will be treated in confidence by the Government.

Your interest in this matter is appreciated, and if we can be of further assistance to you please let me know.

Sincerely yours,

(Signed) F. E. Wormser

Secretary of the Interior

Dr. L. W. King
470 East State Street
Salem, Ohio

Prepared 6/15/56

HOIverson:jbr/rk

CC: Secretary's Reading File
Asst. Secretary-Mineral Resources
Office of Secretary Files
Director's Reading File
Bureau of Mines Files
Division of Minerals
Br. of Ferrous Metals

(- 5 - 7

W. S. Martin

DRAFT

for reply by Mr. Miller

Dear Dr. King:

Your letter of January 7, 1956, addressed to Mr. Liebert, has been referred to us for reply since it mentions Mr. Melcher who was at the time you specify, working in our Washington office.

Your letter does not make clear to us what report you desire to examine. Possibly you refer to a final report of Field Team prepared for the Defense Minerals Exploration Administration in 1951 and ~~completed as of~~ dated January 9, 1952, for Exploration Project Contract Idm-E83 (Docket No. DMA-176X), entitled: "Artz Cobalt-Manganese Property, Operator: L. W. King, M.D., Cecil K. Scott, and Lowell R. King, a Partnership; White Oak Mountain, Bradley County, Tennessee."

Such Field Team reports are for Government use only, but under certain circumstances certain factual parts thereof can be discussed with the land owner or his legal representative. Your request should, therefore, be addressed to Mr. C. O. Mittendorf, Administrator, Defense Minerals Exploration Administration, Department of the Interior, Washington 25, D. C.

CC: Mr. Mittendorf (with a copy of incoming)
Mr. Clarence A. Fredell (" " " ")
EPS - GSA Regional Office Building, Room 5008, 7th & D Sts

402

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C.
ROOM 13 POST OFFICE BLDG.
KNOXVILLE 2, TENN.

RECEIVED
JUN 24 1955

June 22, 1955

Mr. Sigmund J. Sadow
Emergency Procurement Service
General Services Administration
c/o Cramet, P. O. Box 8157
Chattanooga, Tennessee

Copy [illegible]

Re: Docket No. DMEA-2744
(Manganese-nickel-cobalt)
L. W. King, applicant
J. H. Artz land, Bradley and
Hamilton Counties, Tennessee

Dear Mr. Sadow:

Some time ago, Dr. L. W. King of Salem, Ohio, filed an application for aid in further exploration of cobalt-bearing manganese deposits on White Oak Mountain in Bradley and Hamilton Counties, Tennessee. We did not recommend approval, because it could not be demonstrated that the known deposits were of commercial grade. However, the application was kept open while Dr. King continued his research.

It is my understanding that his pilot plant, financed under a research contract with General Services Administration is about to go into operation. Because the results of that project will to a very large extent influence any decision as to further action on Dr. King's exploration application, I would greatly appreciate it if you could keep this office advised as to the progress of the research project. Also, if any considerable amount of material is being mined for this project, it is probably that we will want to inspect the mine workings. Any information you can provide will be helpful to us.

Very truly yours,

Robert A. Laurence
Executive Officer
DMEA Field Team, Region V

RAL/mg
cc - Operating Committee (2)
Lynch
Allsman
Clemmons
Pavlides

JUN 17 1955

400

Mr. Robert A. Laurence, Executive Officer
DMEA Field Team, Region V
Room 13, Post Office Building
Knoxville 2, Tennessee

Re: Docket No. DMEA 2744 (Manganese-Nickel-Cobalt)
L. W. King
J. H. Artz land
Bradley & Hamilton Counties, Tennessee

Dear Mr. Laurence:

Reference is made to your letter of June 10, 1955, inquiring about the status of the subject application.

From conversations with the staff of the Materials Division, Emergency Procurement Service, General Services Administration, we have learned that the plant built for the research project on Mr. King's process is about to go into operation. In another three months, the preliminary work in that plant should be completed and we should be able to draw some conclusions about the merits of the proposed process.

It is suggested that you arrange to be kept advised of the progress of this same research project by the local GSA representative: Mr. Sigmund J. Sadow, Emergency Procurement Service, General Services Administration, c/o Cramet, P. O. Box 8157, Chattanooga, Tennessee.

Please let us know if our suggestion is feasible.

Sincerely yours,

George C. Selfridge
Chairman, Operating Committee

Approved:

J. H. Hedges
Member, Bureau of Mines

Thor H. Kiilsgaard
Member, Geological Survey

cc: Docket
Adm. Read. File
Oper. Committee
Code 400
Thor Kiilsgaard, USGS
G. DeHuff, USBM
FT, Reg. V

WSMartin:(--)
6/17/55

400

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C.
ROOM POST OFFICE BLDG.
KNOXVILLE 2, TENN.
June 10, 1955

RECEIVED
JUN 1 0 1955

Memorandum

To: Operating Committee, DMEA - Washington

From: Executive Officer, DMEA Field Team, Region V

Subject: DMEA-2744 (Cabolt-Manganese-Nickel) L. W. King, et al. Salem, Ohio. J. H. Artz Land, Bradley-Hamilton Counties, Tennessee.

We are still carrying the subject application in our active files, although there has been no correspondence, or other activity, since October 23, 1953.

Is this application still active, or has it been withdrawn?

Robert A. Laurence

RAL/xm

Copy retained 400
W. S. Martin

FAR
5-3-55

Not used
File 5-4-55

Doctor L. W. King
470 East State Street
Salem, Ohio

Re: Docket No. 2744 - Manganese, cobalt, and Nickel
L. W. King, C. K. Scott, & L. R. King, partners
The J. H. Artz land
Bradley and Hamilton Counties, Tenn.

Dear Dr. King:

Your application for additional exploration assistance on the above-referenced property and other data available to us in Washington have been carefully reviewed.

Projects approved by the Defense Minerals Exploration Administration must, in its judgment, show definite promise of yielding materials of acceptable grade in quantities that will significantly improve the mineral supply position for the National Defense Program.

Exploration already completed on the subject property under Contract No. Idm-E83, our Docket No. DMA 176X, has indicated the presence of appreciable tonnages of cobalt-bearing manganese mineralization. The subject request was for exploration assistance in extending the explored areas; the new work might indicate additional reserves similar in character to those contained in the deposits already explored.

~~The~~ Such results ~~of~~ metallurgical tests ~~to date~~ as ~~that~~ have been brought to our attention ~~have~~ do not indicate that any ~~that the~~ greater proportion of such material can be economically treated to yield a satisfactory product. Therefore until we receive evidence that further testing has demonstrated a satisfactory metallurgical process for the treatment

MF-201
(Revised February 1953)

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
SUBORDINATION AGREEMENT

KNOW ALL MEN BY THESE PRESENTS:

WHEREAS, the undersigned is the holder of a mortgage, claim, lien, or encumbrance identified and described as follows*:

.....

.....

upon that certain parcel of ground described in a proposed Exploration Project Contract

between .....

.....

and the United States of America;

NOW, THEREFORE, the undersigned, in consideration of said contract and as an inducement to the Government to enter into same, does by these presents subordinate all of his right, title, and interest in said mortgage, claim, lien, or encumbrance to the right, title, and interest of the United States of America under the provisions of said Exploration Project Contract, and any amendments thereof, and agrees that the lien and claim of the United States of America under the provisions of said Exploration Project Contract, and any amendments thereof, shall be prior to the undersigned's rights under the provisions of said mortgage, claim, lien, or encumbrance; and

The undersigned agrees to commit no act nor assert any right, title, or interest under said mortgage, claim, lien, or encumbrance that might contravene or conflict with the prior lien and claim of the United States of America under the provisions of said Exploration Project Contract, and any amendments thereof.

This undertaking and covenant shall be binding upon the heirs, successors, and assigns of the undersigned.

Dated this ..... day of ....., 195...

.....[SEAL]

.....[SEAL]

I, ..., certify that I am the .....

(Secretary, etc.) of the corporation named herein; that .....

who signed this agreement was then ..... (President or Vice-President, etc.) of said corporation; that said agreement was duly signed for and in behalf of said corporation by authority of its governing body, and was within the scope of its corporate powers.

.....

[CORPORATE SEAL]

*Include date of the instrument, and if recorded, book, page, and county of record.

16—68181-1 U. S. GOVERNMENT PRINTING OFFICE

MF-500

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

REFERENCE SLIP

DATE 5-4-55

REFERRED TO:

1. ~~Mr. Martin~~ Rm. 3538
2. ~~Mr. Johnson~~ Rm. ~~4460~~
3. ~~Mr. Mittendorf~~ Rm. ~~4459~~
4. Code 400

FOR:

	Action		Recommendation
	Approval		Record of
	Comment		Referring to
	Conference		Reply for signature of
X	Consideration		Rewriting
	Filing		Signature
	Instructions		Suggestions
	Investigation		Your information
	Initials		
	Mailing		
	Previous correspondence		

REMARKS: If you concur, we will prepare final draft. No rush on this, but Mr. Adams would be glad to see the case taken off our active list after all these months WSM

Check (X) before the items needing attention.

What are GSA & BM doing?

FAR
Initials of sender.

GPO 16—63815-1

indicated

of the cobalt-bearing manganese material, additional exploration by the Government would be unwarranted in any area where we could expect to find only similar deposits of material which cannot be classed as not ore by present standards.

we feel that your application should be included with our current applications, ~~and~~ for administrative reasons ~~your~~ the subject

Under these circumstances, ~~we regret to advise you that at this time we are unable to approve a project for additional exploration of your property~~ doubt is being transferred to our inactive file. However when the results of the pilot plant tests now in progress under your contract with the Materials Division, Emergency Procurement Service, General Services Administration are available, we shall be glad to consider a revised application for assistance to explore for additional reserves of this type of material providing the metallurgicals results are favorable. If such a request is made, please refer to the subject docket.

We wish to thank you for your interest in the Defense Minerals Exploration Program and for bringing this property to our attention.

Sincerely yours,

Administrator

MF-201
(Revised February 1953)

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
SUBORDINATION AGREEMENT

KNOW ALL MEN BY THESE PRESENTS:

WHEREAS, the undersigned is the holder of a mortgage, claim, lien, or encumbrance identified and described as follows*:

.....

.....

upon that certain parcel of ground described in a proposed Exploration Project Contract

between .....

.....

and the United States of America;

NOW, THEREFORE, the undersigned, in consideration of said contract and as an inducement to the Government to enter into same, does by these presents subordinate all of his right, title, and interest in said mortgage, claim, lien, or encumbrance to the right, title, and interest of the United States of America under the provisions of said Exploration Project Contract, and any amendments thereof, and agrees that the lien and claim of the United States of America under the provisions of said Exploration Project Contract, and any amendments thereof, shall be prior to the undersigned's rights under the provisions of said mortgage, claim, lien, or encumbrance; and

The undersigned agrees to commit no act nor assert any right, title, or interest under said mortgage, claim, lien, or encumbrance that might contravene or conflict with the prior lien and claim of the United States of America under the provisions of said Exploration Project Contract, and any amendments thereof.

This undertaking and covenant shall be binding upon the heirs, successors, and assigns of the undersigned.

Dated this ..... day of ....., 195....

.....[SEAL]

.....[SEAL]

I, ..., certify that I am the .....

(Secretary, etc.) of the corporation named herein; that .....

who signed this agreement was then ..... (President or Vice-President, etc.) of said corporation; that said agreement was duly signed for and in behalf of said corporation by authority of its governing body, and was within the scope of its corporate powers.

.....

[CORPORATE SEAL]

*Include date of the instrument, and if recorded, book, page, and county of record.

16—68181-1 U. S. GOVERNMENT PRINTING OFFICE

Not used

Doctor L. W. King
470 East State Street
Salem, Ohio

Re: Docket No. 274A - Manganese, cobalt, and nickel
L. W. King, C. K. Scott, & L. R. King, partners
The J. H. Artz land
Bradley and Hamilton Counties, Tenn.

Dear Dr. King:

Your application for additional exploration assistance on the above-referenced property and other data available to us in Washington have been carefully reviewed.

Projects approved by the Defense Minerals Exploration Administration must, in its judgment, show definite promise of yielding materials of acceptable grade in quantities that will significantly improve the mineral supply position for the National Defense Program.

Exploration already completed on the subject property under Contract No. Idm-883, our Docket No. DMA 176X, has indicated the presence of appreciable tonnages of cobalt-bearing manganese mineralization. The subject request was for exploration assistance in extending the explored areas. The new work might indicate additional reserves similar in character to those contained in the deposits already explored.

Metallurgical tests to date have not indicated that the greater proportion of such material can be economically treated to yield a satisfactory product. Therefore, unless further testing produces a satisfactory metallurgical process, additional exploration by the Government would be unwarranted in any area where we could expect to find only similar deposits of material which cannot be classed as ore by present standards.

Under the circumstances, we regret to advise that we are unable to approve a project for additional exploration of your property. However, if at some future date the metallurgy of cobalt-bearing manganese deposits of this type is satisfactorily solved, we shall be glad to consider a revised application for assistance to explore for additional reserves of this type of material. If such request is made by you, please refer to the subject docket.

We wish to thank you for your interest in the Defense Minerals Exploration Program and for bringing this property to our attention.

Sincerely yours,

Administrator

FARUTLEDGE:foc
6-23-54
cc to: Docket
Code 400
Admr. Reading File
Operating Comm.
FT. Reg. VII
Louis Pavlides, USGS
Gilbert DeHuff, USBM

June 23, 1954

MEMORANDUM

To: Administrator, DMEA

From: Iron and Ferro-Alloys Division, DMEA

Subject: Denial of exploration project in the amount of $25,000.00
Docket No. 2744 - Manganese, cobalt, and nickel
L. W. King, C. K. Scott, & L. R. King, Partners
The J. H. Arts land
Bradley and Hamilton Counties, Tennessee

The denial of the subject application by this Division is based on the following information:

1. Dr. King requested additional exploration assistance to further extend the known reserves delimited under DMEA Contract No. Idm-E83, Docket No. DMA 176X. The mineralized material investigated under this exploration contract was not considered to warrant certification.

2. The property to be explored is the same as that covered by the previous application, Docket No. DMA 176X. The land consists of 963 acres, located partly in Bradley County and partly in Hamilton County, Tennessee, being in the White Oak Mountain area and known as the J. H. Arts land.

3. The ore sought for was a cobalt oxide which was known to occur at shallow depths with the oxides of manganese and iron. The cobalt seems to be either adsorbed on the manganese minerals as a cobalt oxide or to be a constituent of the manganese minerals. Lithiophorite, $Li_2 (Mn, Co, Ni)_2 Al_8 Mn_{10} O_{35} - 14 H_2O$, has been identified as occurring at the White Oak Mountain deposit. The cobalt-manganese deposits are considered to be supergene. In the area explored, the deposits occur as near surface replacements, incrustations, and fracture fillings in the Fort Payne chert.

Exploration under Contract No. Idm-E83 consisted of four trenches varying from 4 to 17 feet in depth, aggregating 1350 feet in length, and two test pits 16 and 38 feet in depth, respectively. The results of this work indicated that there is no continuity in the physical characteristics of the deposits. The cobalt-bearing manganese is erratically distributed along joints, bedding planes,

fractures, and other openings in the chert, and in residual material derived from the cherty beds.

Based upon the results of the exploration and the analyses by the Operator, the Operator calculated that the trenching indicated 9,600,000 tons of material averaging 0.20 percent cobalt, or 38,400,000 pounds of contained cobalt. The DMEA Field Team calculated 557,000 tons averaging 0.16 percent cobalt, or 1,790,000 pounds of contained cobalt.

As there was some doubt of the accuracy of the Operator's analyses, check samples were run. Twenty of the thirty samples rerun by the Operator were also analyzed by the Bureau of Mines. The results follow:

	PERCENT COBALT		
	Operator original	Operator check	Bureau of Mines check
Unweighted average 30 samples	0.387	0.238	
Unweighted average 20 samples	0.491	0.347	0.207

If the grade of the reserves calculated by the Field Team is reduced in proportion to that indicated by the Bureau of Mines check samples, the material would contain (0.16 x 0.42) 0.067 percent cobalt. On this basis, the reserves contain 746,380 pounds of cobalt.

Analyses of twenty of the samples for manganese were made by the Operator and the Bureau of Mines with the following results:

Operator - 6.9 percent

Bureau of Mines - 7.0 percent

The above cited averages contain one high sample of wad from which it is doubtful if commercial recovery could be made. With this sample eliminated, the rest averaged 4.5 and 5.8 percent manganese as determined by the Operator and the Bureau of Mines, respectively.

The metallurgical treatment of this type and grade of ore for the recovery of cobalt, manganese, and nickel has not yet been perfected on a commercial basis. Similar ores of much higher grade may be treated in an electrolytic manganese plant and the residues, principally cobalt, recovered from the cells.

The Applicant has proposed a plant to recover the cobalt, nickel, and manganese. At present there is a possibility that the Government through the Emergency Procurement Service, General Service Administration, may participate in the construction of a small pilot plant. Mr. King's cost data were based on treating an ore, mined by selective stripping, that would contain in excess of 10 percent manganese, 0.4 percent cobalt, 0.4 percent nickel. No appreciable reserves of this grade have been delimited.

4. The anticipated reserves are expected to be similar to those already explored under the prior contract (Contract No. Idm-883). Until it has been proven that such material can be treated to yield satisfactory products, additional exploration for this type of cobalt-bearing manganese deposits is unwarranted.

5. Mr. King has several times been advised during conferences with DMEA that additional exploration assistance will not be granted until the feasibility of his metallurgical plant has been proven.

6. The Commodity Division of the Geological Survey recommends denial.

7. The Commodity Division of the Bureau of Mines has recommended that until satisfactory proof of a feasible process for recovery could be demonstrated, the deposit should be considered noncommercial, and concurs with denial of the subject application.

W. S. Martin, Chief
Iron and Ferro-Alloys Division

FARUTLEDGE:foc
6-23-54
cc to: Docket
Code 400
Adm. Reading File
Operating Comm.

400

See OMEA 2744
L.W. King

GENERAL SERVICES ADMINISTRATION

EMERGENCY PROCUREMENT SERVICE

MATERIALS DIVISION

STATUS OF RESEARCH PROJECTS

FOR

UPGRADING SUB-METALLURGICAL MANGANESE ORES AND SLAGS

January 3, 1955

GSA-WASH DC 55-6021

The critical shortage of metallurgical grade manganese ores for stockpiling and consumption, during the recent Korean campaign, focused attention more sharply than ever on the large reserves of low grade manganese ores and manganiferous slags in this country. As a result the Government commenced several programs for the purchase of low grade ores, and simultaneously began various research projects looking to the development and testing of processes for upgrading these ores to usable products.

At the time these programs were started, it was felt that the urgency of the manganese situation was such that, in processing the ores, low recoveries and high costs could be tolerated, if necessary. However, in the intervening period the urgency of converting these ores to usable products at any cost has decreased. Hence experimental work is now being continued not only with the objective of merely finding processes for treating the various types of ores, but also of finding the most practical and economic processes for doing this.

In the course of these investigations EPS has given careful consideration to nearly a score of different new or unproven processes for extracting manganese from slags and various types of submetallurgical ores and slags. As a result, a half dozen of these processes have been deemed promising enough to justify financial assistance by the Government for further research, development and test work.

In each of these cases, before deciding finally as to whether, or to what degree, financial assistance of the Government should be given, EPS has requested the Materials Advisory Board of the National Academy of Sciences to investigate, study and report upon the technical merits of the process. Also, in the general consideration of these matters and in certain specific cases, EPS has sought technical information and counsel in other offices of Government, including principally the Bureau of Mines.

Actual research and testing work was begun over a year ago on two new metallurgical processes for winning manganese from low grade sources. Since then test work on other new processes has been commenced. Others are about to be commenced.

Here follows a brief description of the work done to date on the various projects:

FLOTATION

Studies Regarding Upgrading of Government Stockpiled Sub-Metallurgical Ores

The Bureau of Mines has for a number of years been experimenting with the so-called "oil-emulsion" process which, in the case of low grade ores, would need to be followed by

nodulizing or other means of agglomerating the product and eliminating base-metal impurities. The Bureau has at times and on selected specific types of low grade ores, secured in the laboratory fair to good recoveries of manganese, but has indicated that a full scale mill test on mixed ores as stockpiled would as yet be ill-advised and premature;

(a) In early 1954 an idle lead and zinc flotation mill at Deming (Peru Mining Company) was offered for use in upgrading low grade stockpiled ores. Bureau of Mines metallurgists examined the plant as a possible site for making mill-scale tests and reported not only that the mill was not suited to the purpose but that it would be "premature" and "utter folly" to undertake mill-scale tests without further extensive laboratory and pilot plant testing of the process.

(b) In 1949-1950 the Domestic Manganese and Development Company of Butte operated a Government-owned flotation mill and a nodulizing plant on low grade Butte district ores. Forty-one thousand (41,000) tons of ore (22.11% Mn) were treated, producing 7301.5 tons of nodules (46.19% Mn). The overall recovery of manganese, however, was only 37.22% and the base metal (zinc and lead) content of the nodules was so high that they were unusable by industry and rejected for stockpiling.

Recently the former plant operator proposed that a mill test of the oil-emulsion flotation process be made in that plant. In reply to this proposal the Bureau stated, "It is the consensus of interested Bureau personnel that large-scale mill runs would be premature at this time. Although the method is considered to be technically feasible, it is believed that small pilot plant testing and probably additional laboratory and other work will be necessary before an undertaking of the magnitude proposed by Mr. Cole can be justified."

If the need for conversion were immediate and urgent, the "oil-emulsion" flotation and nodulizing as now developed could be employed to obtain from these ores some manganese suitable for metallurgical use. Under present circumstances, however, the present costs and losses to the Government in that procedure cannot be justified, and large-scale mill testing should be deferred until the Bureau is ready to recommend it. In the meantime some more feasible and economical process may be developed.

Southwestern Engineering Company (Sweco)

In 1952 Sweco, under contract to DMPA, obtained large working samples of wad and other low grade manganese ores from Virginia, Tennessee, Arkansas, Maine, Arizona and New Mexico. They performed extensive analyses and ore tests upon each ore. Flotation possibilities were principally studied, but tests were also made by employing gravity and sink-float methods. Also, a few tests, employing leaching, were performed.

Sweco reported that none of the sample ores were amenable to upgrading to metallurgical grade, by physical methods alone. More research, using chemical (leaching) methods, was indicated. It was found in some instances that preconcentration by physical methods would be practical for preparing the material for leaching.

PYROMETALLURGY

Mangaslag Inc.

A contract was signed between DMPA and Mangaslag on December 31, 1952, whereby the latter was to test out in a large pilot plant a new process devised by Bureau of Mines metallurgists for recovering manganese from open hearth slags, and possibly Aroostook ores.

The contract, as amended, provided that the pilot plant construction was to be completed by April 1954; and that prior to December 31, 1955, the process would be proven feasible or not. The project, situated at Pittston, Pennsylvania, was largely financed by Government funds.

The process is pyrometallurgical, entailing the reduction of ore in a vertical blast furnace, possibly using anthracite coal instead of coke, to produce a spiegeleisen; then selective oxidation of the molten spiegeleisen in a special converter to produce a cinder containing the manganese, and a molten metal containing the iron and phosphorous; then reduction of the cinder in the blast furnace to produce ferromanganese; and blowing of the molten metal in a second converter to produce de-phosphorized steel melting scrap.

The construction of the pilot plant was completed in May 1954. Since then furnace operations have been commenced a number of times and each time have soon been stopped

because of defects of one kind or another in the furnace and accessory equipment.

Mangaslag Inc., assisted by Bureau of Mines and other Government engineers, has continued to work on the project, making improvements as indicated after each new testing operation. To date the furnace has never functioned satisfactorily, and operations have never progressed to the point of selective oxidation of molten spiegeleisen in the converters, which is the crux of the process.

Evidently much additional development and testing will be required to prove or disprove the feasibility of the process.

At the time of this writing there is some possibility that Mangaslag Inc. may drop out of the project. In such case, EPS, believing that the process should be tested out to a final conclusion, expects to find some satisfactory arrangement for continuing with the pilot plant testing.

Blast Furnace Reduction

The Bureau of Mines has informally suggested that the most feasible way to upgrade the low grade manganese ores in the Government stockpiles in the southwest might be direct reduction in the blast furnace to obtain a product intermediate in manganese content between standard spiegeleisen and ferromanganese. A product of that nature has little utilization at present in the steel industry but this procedure would have the virtue of recovering a fairly high percentage of the manganese in ore as a product that could be consumed by the steel industry in an emergency when higher grade materials were in short supply.

(a) The Colorado Fuel and Iron Co. with blast furnaces at Pueblo, Colorado, was a possible candidate for this type of conversion, since the plant is so located that ores from El Paso and Deming could be freighted to Pueblo for a cost of about 7.00 per ton. (Separate arrangements would have to be made for the Wenden ores, probably at furnaces in the Los Angeles area).

30 - 50¢ / unit for freight alone

C.F. and I. suggested a test run of about 20,000 tons of El Paso and Deming ore in one of their 750-ton furnaces which is now making a run of ferromanganese, the object being to determine costs of

the operation, and quality and potential utility of the product. Upon closer examination, however, the company has lost interest at the present time because, (a) the furnace that they planned to use has developed a hot spot and must be relined immediately, after which it will be returned to production of pig-iron, and (b) the operating people are afraid of the lead-zinc content of the ores, which might destroy a good furnace lining, plus (c) a lack of knowledge as to whether sintering the ore ahead of furnacing would reduce the base metal content to proportions harmless to the blast furnace lining.

(b) It has recently been learned that the Sheffield Steel Company (subsidiary of Armco) a few years ago purchased a small (75-ton) blast furnace at Rusk, Texas, with a small sintering plant, blowing engines and other accessories. Inquiries are now under way to determine whether that plant is still in existence and operable. If so, a study will be made of the possibility of utilizing these facilities for a test run on a comparatively small amount of El Paso and Deming ore, to determine feasibility of costs. The Rusk plant is south of Dallas, within a reasonable freighting distance of El Paso and Deming. Lone Star and Sheffield also have other furnaces in Texas which conceivably could be made available for this purpose under certain conditions.

The problem of finding a suitable process, whereby the sub-metallurgical grade ores in the Government stockpiles can be upgraded to some readily usable form, continues to receive active consideration in EPS. As soon as more conclusive data is available concerning some of the processes, which are now being tested, it may be that one of these processes, or a combination of them, can be selected for upgrading these ores.

COMBINED ROASTING - LEACHING

Manganese Chemical Corp. (M.C.C.)
(Carbamate Process)

A contract was signed August 7, 1952, between DMPA and MCC, which provided that the company build a pilot plant and test the new Carbamate (Dean-Leute) Process for extracting manganese from the manganiferous iron ores of the Cuyuna Range, Minnesota. The pilot plant, having

capacity to treat 200 tons per day of ore, is situated at Riverton, Minnesota. The project has been financed largely by Government funds. The contract, as amended, provides that pilot plant production is to commence by January 1, 1955.

The new process combines roasting and leaching of the ore, using an ammonia solution, with the aid of CO_2 gas; and the recycling of ammonia. The final basic product is manganese carbonate which can be readily converted to manganese oxide in nodules for use in the steel-making industry; also the manganese carbonate, which is in a very pure state, can be used to good advantage in the chemical industry. It can be also used as basic material for producing electrolytic manganese dioxide.

The construction and tuning-up of the pilot plant has required over a year more than was originally anticipated. However, MCC now reports that the plant finally is in good working condition and will be in production on a regular basis by January 1, 1955.

When the plant has been in regular production for a few months, data may then be available concerning the economic feasibility.

It now seems reasonable to suppose that the pilot plant operation will prove the new process to be technically sound for the treatment of the Cuyuna low grade manganiferous iron ores, of which there are extensive reserves. Indications are that the operation will show the process to be economically feasible, as well. However, final conclusions concerning these points must, of course, await definite proof which can be obtained only after the plant has been in regular operation for at least a few months.

Nossen Laboratories, Inc. (N.L.I.)

DMPA and N.L.I. entered into a contract June 30, 1953, whereby the latter was to construct and operate a pilot plant for the purpose of testing their new process for extracting manganese from low grade manganese ores. The contract, as amended, expired on November 15, 1954. The project was financed entirely by Government funds.

The new process begins with a reducing roast (omitted in the case of some ores.) A nitric acid solution is employed to dissolve the manganese in the raw or roasted material.

The pregnant solution is decomposed by heat in a specially designed equipment, thereby producing a solid product containing the manganese, and a vapor containing the nitrous fumes. The solid product is then treated by grinding and washing to give a high grade manganese dioxide concentrate. The nitrous fumes are recovered in the form of nitric acid for recycling in the process.

Construction of the plant, at Paterson, New Jersey, required over half a year and the plant was then operated for several months. It was shut down last October upon expiration of the contract period and exhaustion of allotted funds. As a result of pilot plant operations, the general opinion in Government offices is that the metallurgy of the new process was proven to be technically sound.

However, certain difficulties were encountered in connection with the mechanical operations of some of the equipment which had been selected or developed for use in the pilot plant. At the conclusion of the contract period when the plant was shut down these difficulties had not been completely overcome.

The feeling among Government engineers who have been close to the pilot plant work is that, owing to unexpected delays because of late delivery of equipment, and of necessity for solving unforeseen problems, not enough time remained within the contract period for fully developing optimum techniques and for determining which kinds of equipment, in some instances, would give the proper results. The feeling is that with a reasonable amount of further pilot plant experimentation and final testing these operating problems can very probably be solved.

With reference to economics of the process, the data thus far obtained gives some indication that the process can be applied within practical limits of cost; but that definite conclusive opinions upon this aspect must await more complete data obtainable once the equipment problems, just referred to, are solved.

It should be mentioned that, in the pilot plant work, ores from Aroostook County, Maine, were used exclusively. These ores are of low manganese content and furthermore are of a refractory character. The Government insisted that Aroostook ores be used in the pilot plant because the Aroostook deposits are very extensive and, if the Nossen process were proved feasible, these deposits would represent a great source of manganese in a national emergency if imports of foreign ores were cut off.

Undoubtedly some of the country's less refractory ores having a higher manganese content, such as some of the sub-metallurgical grade ores from less extensive deposits in the southwest, could be treated much easier and cheaper, per unit of manganese recovered, than the Aroostook ores.

Since being shut down, the pilot plant, which is property of the Government, has been kept intact, with the thought that possibly pilot plant operations may be soon renewed. It is the expectation of EPS that arrangements to this end may be made with some private company which may become interested in the matter.

Bruce Williams Laboratories (B.W.L.)

EPS has concluded negotiations with B.W.L., and a contract is now being prepared whereby the latter will build and operate a small metallurgical pilot plant, at Joplin, Missouri. The project is to be wholly financed by Government funds.

The purpose of the pilot plant is that of testing a new process, developed by B.W.L., for extracting manganese from practically any type of low grade, manganiferous ore or slag, to produce a high grade MnO_2 concentrate.

In general, the process, upon which B.W.L. has applied for a patent, involves a roasting procedure followed by leaching and precipitation, with recycling of the principal reagents, and from this point of view is, of course, not new. It does involve, however, certain distinctive procedures and the novel use of certain reagents which sets it apart from being merely a duplication of some other already known process.

Various Government engineers have examined and studied the the theory of the process, and some have visited the premises of B.W.L. for a firsthand laboratory demonstration of it. All are of the opinion that the process holds much promise.

The contract schedule of pilot plant construction and operation covers a period of 15 months, thus if there are no delays in signing the contract, and in carrying out the construction and operations, the process should be proved or disproved by April 1956.

L. W. King

On September 3, 1954, EPS signed a contract with Dr. L. W. King. The contract provides that he is to erect and operate a small-scale pilot plant for the purpose of testing a process devised by him for recovering manganese, cobalt, and nickel, separately, from low grade, natural deposits which exist in widely scattered places in the United States.

The raw ore to be used in the pilot plant is being shipped from a mineral property in Tennessee, controlled by Dr. King.

Dr. King has been conducting his own laboratory experiments for several years for the purpose of developing a process for treating satisfactorily that type of ore. The process is not patented.

The King process employes roasting and leaching, using hydrochloric acid as the leaching agent. The manganese, cobalt and nickel are recovered separately, as oxides, by a series of chemical operations involving the changing of the degree of acidity of the solution by the addition of reagents, and by changes in solution temperatures.

For the economic success of the process Dr. King relies to some extent upon recycling a portion of the hydrochloric acid, but principally he relies upon manufacturing the acid very cheaply from low cost raw materials by means of a special European process upon which he holds certain rights.

The present contract provides only for testing the process to recover the manganese, cobalt and nickel from the ores. If the pilot plant demonstrates success in this, the intention of EPS would be to assist Dr. King with funds to erect additional facilities to test his process for manufacturing cheap hydrochloric acid.

The pilot plant is now being erected in Salem, Ohio where Dr. King already owns premises and some equipment which he is loaning to the project. The cost of additional equipment, and of erecting and operating the pilot plant, is to be paid by the Government.

The present contract is to expire in May 1955 by which time it is contemplated that the feasibility of the extraction process will have been proved or disproved.

If the extraction process is proved feasible, another period running possibly into 1956, would be required for setting up and testing the acid manufacturing facilities.

At present, the installation of equipment at the pilot plant is progressing according to contract schedule, and the expectation is that the construction will be complete and that operations on a tune-up basis will be commenced early in February.

COMBINED ROASTING - MAGNETIC SEPARATION

Diamond Alkali Co. (D.A.C.)
(Sylvester Process)

Negotiations are now in progress between EPS and D.A.C. with a view to making a contract whereby the latter will test, at its plant at Painesville, Ohio, the Sylvester Process for recovering manganese from slags and low grade ores of Aroostook County, Maine.

This testing project is to be financed by Government funds, but with D.A.C. doing the work on a cost basis, that is, a non-profit basis, with expectations of possible gain later on if the process is proved successful and is used commercially.

The Sylvester Process, developed within recent years in the laboratory of Sylvester & Co., Cleveland, Ohio, is a roasting process whereby manganiferous slags and ores of the types above named are converted pyro-chemically from a refractory state to a state amenable to concentration by magnetic separation. It is expected that the concentrate thus produced will permit of successful further treatment either by leaching or by smelting to produce manganese products for use in the steel industry.

The contemplated program, including the work of designing the necessary facilities, of installing equipment additional to that already available in the D.A.C. plant, and of performing shakedown operations and final demonstrations, will cover a period of 15 months.

This means that if a contract is soon signed, and if no great delays are experienced in getting the facilities ready, or in operating them, the whole project should be completed, and the process proved or disproved by May 1956.

TABLE NO. 1

DISTRIBUTION OF MANGANESE RESEARCH AND DEVELOPMENT UNDER EMERGENCY PROCUREMENT SERVICE
(By Regions and Types of Projects)

CONTRACTOR	Southwestern Engineering Company	Bureau of Mines	Manganese Chemical Corp.	Nossen Laboratories Inc.	Mangaslag Inc.	L. W. King	Bruce Williams Laboratories	Diamond Alkali
TYPE OF PROCESS:	Gravity and Flotation	Flotation	Ammonia CO_2 Leach (Dean-Leute "Carbamate" process)	Nitric Acid Leach (Nossen Process)	Special Blast Furnace (Royster), and Selective separation of Mn in converter (Buehl)	Hydro-chloric Acid Leach	Special Roasting and Leaching	Lime Roast followed by Magnetic Separation
SOURCE MATERIAL:								
Slags, Open Hearth					X		X	X
Cuyuna Iron Range, Minn.			X					
Aroostook County, Maine	X			X	X		X	X
Artillery Peak, Ariz.	X							
Batesville, Ark.	X							
Va-Tenn-Ala (S.Appalachian Region)	X						X	
Low-Grade Mn-Ni-Co Ores Tennessee and elsewhere						X		
Govt. Stockpiles, sub-metallurgical ores, at El Paso-Deming-Wenden-Butte	X	X	X	X			X	

SUMMARY:

The following tabulations and remarks are presented as a summary of the scope and status of manganese research and development under EPS:

TABLE NO. 2 - Status of Research and Development work

PROJECTS	ESTIMATED DATES FOR CONCLUSION OF TEST WORK	REMARKS
A. Finished		
SWECO Flotation; various ores in different states	Concluded	SWECO found that some ores, including the important Aroostook County ores, could be preconcentrated to advantage for possible subsequent treatment by other processes such as maybe Nossen, Mangaslag and Sylvester processes.
B. In Progress		
MANGANESE CHEMICAL CO. Leaching process for Cuyuna ores & possibly Sylvester concentrates	May 1955	Work to date indicates favorable results by date here indicated.
NOSSEN LABORATORIES, INC. Leaching process for Aroostook ores & Govt. stockpiles of sub-metallurgical ores.	December 1955	Work to date indicates favorable results if project is continued till date here indicated.
L. W. KING Leaching process for low grade Mn, Ni, Co ores	June 1955 (extraction process) Jan. 1956 (acid process)	Pilot plant now under construction.
MANGASLAG, INC. Pyrometallurgical process for slags	At least 6 mos., but maybe a year from now (Jan. 1956)	Pilot plant operation has not yet developed any definite data.
C. Under Negotiation or Study		
BRUCE WILLIAMS Roasting-leaching process; all ores and slags	April 1956	Pilot Plant construction to be commenced soon.
DIAMOND ALKALI (Sylvester) Pyrochemical process followed by magnetic separation, or leaching, or blast furnace reduction.	June 1956	Negotiations for testing of process now in progress
UPGRADING GOVT. STOCKPILES OF SUB-METALLURGICAL MANGANESE ORES	After all above processes have been tested, the one best suited for treating stockpile ores can be selected by late 1956	Project is of importance but the quantity of manganese contained in the low grade stockpiles is of much less strategic importance than that contained in the extensive deposits, Aroostook, Cuyuna and Slags.

Emergency Procurement Service feels that in this work a good degree of progress has thus far been made. Naturally, as might be expected in research work of this kind, unforeseen problems and delays have come up in each of the different projects. However, these problems are being met and solved as they come up, and on the whole the prospects for bringing forth some practical means of utilizing the nation's low-grade manganese deposits, at least as an emergency supply, are good.

Because the characteristics of the material from the different low-grade sources of manganese differ so greatly, it is not expected that any one process will be satisfactorily applicable to all. In some cases a combination of processes may prove desirable, as for example the Aroostook ores may be best pre-treated by flotation prior to leaching, or prior to the lime clinker-magnetic separation (Sylvester) process; or possibly the Sylvester process may be employed to good advantage to pre-treat open hearth slags or Aroostook type ores, producing a concentrate which would be amenable to further treatment by the Carbamate, Nossen, Bruce Williams or some other process. These are possibilities to which Emergency Procurement Service plans to give attention as soon as more data on each of these processes are available.

The three largest, known potential sources of domestic manganese are the Open Hearth Slags, the ores in Aroostook County, Maine and the manganiferous low-grade iron ores of the Cuyuna Iron Range, Minnesota. Consequently, from the viewpoint of national expediency, Emergency Procurement Service has naturally been more interested in testing processes which would treat material from these large sources.

With reference to these the project of the Manganese Chemicals Co. at Riverton, Minnesota, for testing the Carbamate process for treating Cuyuna ores, is furthest advanced, and at this writing the belief is that this project will soon have demonstrated the practicability of that process for those ores.

However, Emergency Procurement Service is also giving attention to the possibilities of treating ores from some of the lesser sources such as (1) the Government stockpiles of sub-metallurgical ores at El Paso, Texas; Deming, New Mexico; Wenden, Arizona; and Butte-Philipsburg, Montana; (2) Artillery Peak, Arizona; (3) the Virginia-Tennessee-Georgia-Alabama Region; (4) the Arkansas Region. Three years ago as a Korean War expedient a large plant was partly constructed for treating ores of the Batesville district on a commercial basis. This project, however, ran into difficulties resulting in litigation and a cessation of operations.

With the aid of Government, through Emergency Procurement Service, plants for extracting manganese from ores have already been established and are now in operation at Henderson, Three Kids and Pioche, Nevada.

Table No. 1 shows the distribution of manganese projects under Emergency Procurement Service by Regions and by type of projects.

From Table 2 it is seen that only one research and development project - Sweco - has been completed; and that the other seven are in various stages of progress - some soon to be finished, some still to be continued for the better part of a year or more, and others just about to be started.

The present estimate is that the last of the individual projects may be completed by mid 1956.

When all of the data from the different pilot plants have finally been obtained, some relatively little additional time will be required for making comparisons of the different processes with a view to selecting the process, or combination of processes, which will give the best over-all results in the case of each different source material.

With this in view Emergency Procurement Service recommends that, unless some national emergency dictates otherwise, no full scale or commercial upgrading of the government's stockpiles of sub-metallurgical ores be undertaken, and that no full scale plant be established by the government for beneficiating any of the extensive natural deposits of domestic low-grade ores till all of the processes now being investigated have been fully appraised.

Thus, the thorough and proper completion of the manganese research and development work as a whole may well require some 18 or 20 months more or, say, till the latter part of 1956.

In this connection it should be borne in mind, however, that research and development work is naturally fraught with many uncertainties, and that consequently some of these projects may require more time than is now estimated. Also, there is the possibility that other new processes may yet be proposed, and that one or another of them may be worthy of pilot plant testing. This possibility, however, seems slight inasmuch as there does not appear to be any other worthy process in the offing, and it is doubtful that in the immediate future any will be brought forth.

The great importance to the nation of being prepared in an emergency to extract manganese for the steel industry from the extensive domestic deposits of low-grade ores and slags in a practical and economic, large scale manner, is well known. A good start in this direction has been made by launching and working upon the research and development projects here discussed. It now remains to finish the job in a proper, thorough manner.

The matter is of such vital importance to the nation that support of these projects should be continued for at least the 18 or 20 months above mentioned.

GSA-WASH DC 55 55-6640

C O P Y of letter transmitted by Mr. D. H. Schnee, Executive Director, Minerals and Metals Advisory Board, to Mr. Irving Gumbel, Acting Director, Materials Division, EPS, GSA. (Transcribed from telephone dictation.)

January 19, 1954

Mr. D. H. Schnee, Executive Director
Minerals and Metals Advisory Board
National Research Council
2101 Constitution Avenue
Washington 25, D. C.

Dear Mr. Schnee:

The proposal of Dr. L. W. King for the recovery of cobalt, nickel, and manganese from White Oak Mountain ores in Tennessee has been circulated amongst the Manganese Panel. Additional information concerning the proposal made available by Dr. King through Mr. Long's visit to the King laboratory and the various visits of Dr. King to the M.M.A.B. offices was also circulated along with the proposal.

Comments from the members of the Panel were not favorable to the proposal and Mr. Critchett, Chairman of the Cobalt Panel, likewise commented unfavorably.

The Manganese Panel is of the opinion that the White Oak Mountain ore deposits have not been adequately explored to determine the quantity of ore available, nor has the grade of the deposit been sufficiently established to predict the success of this exploration. The Panel is also of the opinion that the chemical operations involved in Dr. King's proposal, although cleverly conceived and fitted together, are nevertheless very complex and quite involved. On the limited scale of operations proposed for this plan, it is believed that it would be cheaper and certainly much simpler to purchase the necessary chemicals rather than to build up chemical plants, the operation and coordination of which would needlessly complicate the main purpose of recovering the nickel, cobalt, and manganese from the ores. In addition, it is believed that the chemical separations proposed would be less sharp, and hence less perfect, than Dr. King performed, and that to attain the recoveries anticipated would involve multiple precipitation in handling at great expense. The Panel also expressed doubt that the potential production of these metals available from the ores was of sufficient size to be of national importance.

In view of these comments, it is suggested that Mr. Gumbel be informed that the Manganese Panel does not recommend that the King proposal be given Government support.

Very truly yours,

Signed: M. J. DAY

Chairman, Manganese Panel

Jan 19 1954 Covering letter giving report

V.H. Schnee Jan 19, 1954
Ex Dir
Min & Metals Adv Bd
Nat Res
2101 Const Av
Washington 25, D.C.

The propn of Co Ni & Mn White Oak Mt in Tenn has been Cir among the Mn panel note dr dil MMAB

Critchett chm.
Co panel likewise comment unfavor

The Mn panel is of the opinion that not enough expl no grade chem clever conceived & fitted together are quite involved. Cheaper & much simpler to push

Multiple precipit in handling of grt exp

SW has rept'd on SF without ~~determin~~ favorable

Now try Photo Conv.

NOV 5 1953

Mr. Robert A. Laurence, Executive Officer
DMEA Field Team, Region VII
Room 13, Post Office Building
Knoxville 2, Tennessee

Re: Docket No. DMEA 2744 -
Manganese and Cobalt
[illegible] King et al.
The J. H. Artz land
Bradley and Hamilton Counties,
Tennessee

Dear Mr. Laurence:

For your information we are enclosing two copies of a reply to our letter of October 23, 1953, from Clarence A. Fredell, Acting Chief, Expansion Branch, Materials Division, Emergency Procurement Service, General Services Administration.

Sincerely yours,

George C. Selfridge

Chairman, Operating Committee

Enclosure

APPROVED:

J. H. Hedges

Member, Bureau of Mines

A. R. Kinkel, Jr.

Member, Geological Survey

cc: DOCKET
FT, REG. VII
CODE 400
OPER. COMM.
ADM. HEAD. FILE
LOUIS PAVLIDES, USGS
GILBERT DE HUFF, USBM

FARutledge/ls
11/3/53

COPY

GENERAL SERVICES ADMINISTRATION

EMERGENCY PROCUREMENT SERVICE

Washington 25, D. C.

October 28, 1953

In Reply Refer to: EDE

Mr. Frank E. Johnson
Acting Administrator
Defense Minerals Exploration
Administration
Department of the Interior
Washington 25, D. C.

Re: Docket No. DMEA 2744
King, Scott & King

Dear Mr. Johnson:

Reference is made to your letter of October 23, 1953, addressed to Mr. Irving Gumbel, Director, Materials Division, requesting a copy of the field report on this application.

In connection with the determination of the economic treatment of the mineral, the field investigation is being conducted by the Minerals and Metals Advisory Board of the National Academy of Sciences. When their recommendations of this entity are made to this Agency, we shall be glad to pass them on to you for your consideration.

Very truly yours,

Signed: Clarence A. Fredell

Acting Chief
Expansion Branch

400

OCT 23 1953

Mr. Irving Gumbel, Director
Materials Division
Emergency Procurement Service
General Services Administration
Washington 25, D. C.

Re: Docket No. DMEA 274 - Manganese
and Cobalt
L. W. King et al.
The J. H. Arts land
Bradley and Hamilton Counties, Tenn.

Dear Mr. Gumbel:

Reference is made to the subject application for exploration assistance from Mr. King who previously completed an exploration project on the same property under Contract No. Idm-E83, Docket No. DMA 176X.

We were aware that Mr. King also had a related production application on file with the Defense Materials Procurement Administration, now the Materials Division, Emergency Procurement Service, General Services Administration, and we have been holding the referenced exploration application in abeyance until it could be determined whether the "ore" might be economically treated.

It has recently been called to our attention that GSA has requested a field examination. Therefore, when your field report has been completed, it would be appreciated if you would furnish us with copies for our consideration.

Sincerely yours,

Frank E. Johnson

ACTING Administrator

FARutledge:foc
10-23-53
cc: Docket
Code 400
MT. REG. 7
Admr. Reading File
Operating Comm.
H. W. Davis, USBM
Phillip Guild, USGS

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C.

Mr. Robert A. Laurence, Executive Officer
DMEA Field Team, Region VII
Room 13
Post Office Building
Knoxville 2, Tennessee

Re: Docket No. DMEA 2744 - Cobalt and Manganese
L. W. King et al.
The J. H. Artz land
Bradley and Hamilton Counties, Tenn.

Dear Mr. Laurence:

Reference is made to the subject application covering the same property upon which Mr. King previously completed an exploration project under Contract No. Idm-E83.

We have been holding the referenced exploration application in abeyance until it could be determined whether the "ore" might be economically treated. Mr. King had a related production application on file with the Defense Materials Procurement Administration, now the Materials Division, Emergency Procurement Service, General Services Administration. We have been informed that GSA has recently requested a field examination of the same property. It would be appreciated if you would also furnish us with copies of your report for our consideration.

Sincerely yours,

Chairman, Operating Committee

APPROVED:

Member, Bureau of Mines

Member, Geological Survey

402

Mr. C. O. Mittendorf, Administrator, DMEA October 31, 1952

Iron and Ferro-Alloy Division, DMEA

Metallurgy
Dockets Nos. 176 and 2744 (Cobalt-Nickel-Manganese)
Dr. J. W. King, et al.
The J. H. Artz land
Bradley and Hamilton Counties, Tennessee

The writer met with Mr. O. C. Ralston, Chief Metallurgist of the Bureau of Mines, and Messrs. Mann and Brussolo of DMPA, on the morning of October 30 to discuss the metallurgical problems set forth in our letter of October 15 to Mr. Ralston, copies of which were sent to Mr. Howard Young on the same date.

After discussion of the entire matter for some time it was learned that the Signal Corp was buying part of the manganese production of a subsidized 1-ton chemical plant at 20 cents a pound for batteries. This compares to 5 cents a pound for African ore. Industry is also buying part of the product. The plant is being enlarged to 10 tons and uses from 10 to 30 percent crude ore. Other projected manganese chemical plants were also mentioned.

With regard to King's process, it appears feasible. There is a market for a mixed nickel-cobalt product. The iron and manganese can be separated, the iron precipitating at a Ph of 4. The magnesium content is not known and should be a minimum as it comes down with the $MnCO_3$. The amount of acid is O.K.

Mr. Ralston spoke of other smaller but richer cobalt-manganese deposits that might ship to such a plant. The U. S. Geological Survey has a list. DMPA made tentative arrangements to have a small representative lot beneficiated by the Bureau of Mines at Tuscaloosa to learn if a richer feed could be obtained for the chemical plant.

Our problem regarding further exploration was explained. Mr. Mann's office is studying the matter of the proposed chemical plant. If the grade of the "ore" promises possible economic feasibility (possibly with subsidies), the DMPA will so advise us. If its report is favorable, it will then be up to DMEA to provide for further exploration to increase the now indicated tonnage to a figure sufficiently large to warrant the proposed plant.

George C. Selfridge

G. C. Selfridge, Chief
Iron and Ferro-Alloy Division

GCSelfridge:ls
cc: Docket
Admn. Read. File

cc: G. C. Selfridge

IN REPLY REFER TO:

G-MD-CF

40-C

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

October 28, 1952

Memorandum

To: George C. Selfridge

From: T. P. Thayer

Subject: DMEA 2744 - Cobalt-manganese
L. W. King
470 E. State St.
Salem, O.
Arts Mountain deposits, Tennessee

Dr. King proposes to spend $25,000 more exploring the cobaltiferous manganese deposits which were partly explored by DMA Project 176. The Field Team estimated reserves of 557,000 short tons of material containing 1,790,800 lbs. of cobalt, or averaging 0.16 percent cobalt metal. Later, Bureau of Mines check assays and applicants recheck showed the original assays were somewhere between 50 percent and 250 percent too high. If the original assays are discounted by half, the "reserve" of contained metal drops to about 900,000 lbs. or .08 percent.

The Bureau of Mines assays show a definite correlation between Mn and Co in samples. The ratio of Mn:Co in the 20 check samples ranges from 7:1 to 115:1, probably averaging about 40:1. If it were possible to produce a concentrate averaging 20 percent Mn, which seems doubtful by ordinary methods, it would average only about 0.5% Co or one pound per ton, if all the cobalt is in the manganese oxides. Samples of "the one high-grade pocket" showed no ore above 25 percent Mn, and a sample from a small wad deposit assayed 31.1 percent Mn and 0.51 percent Co. One pound of cobalt metal per ton, at $2.50 per pound, would allow only $2.50 for recovery by chemical methods, assuming that the manganese would carry mining and milling costs. The economics of recovering either the manganese or cobalt seem to be far from known, and extremely doubtful.

Two of the criteria for DMEA exploration projects are the availability of a feasible method of treatment, and probability of a significant contribution to the national supply. In this case the general grade of material likely to be found has been demonstrated, and the cobalt content is very low. The Geological Survey sees no point in seeking more material until a method of recovery has been developed.

Action recommended:

Deny the application on the grounds that metallurgical problems should be solved before more money is spent on exploration.

T. P. Thayer

TPThayer:gt

Copies to: Dir's reading file-4212
Branch reading file
N.B.Melcher - Int. 3513
Hugh Davis - Int. 3519

Mr. C. C. Mittendorf, Administrator, DMEA October 31, 1952

Iron and Ferro-Alloy Division, DMEA

Metallurgy
Dockets Nos. 176 and 2744 (Cobalt-Nickel-Manganese)
Dr. I. W. King, et al.
The J. W. Arts land
Bradley and Hamilton Counties, Tennessee

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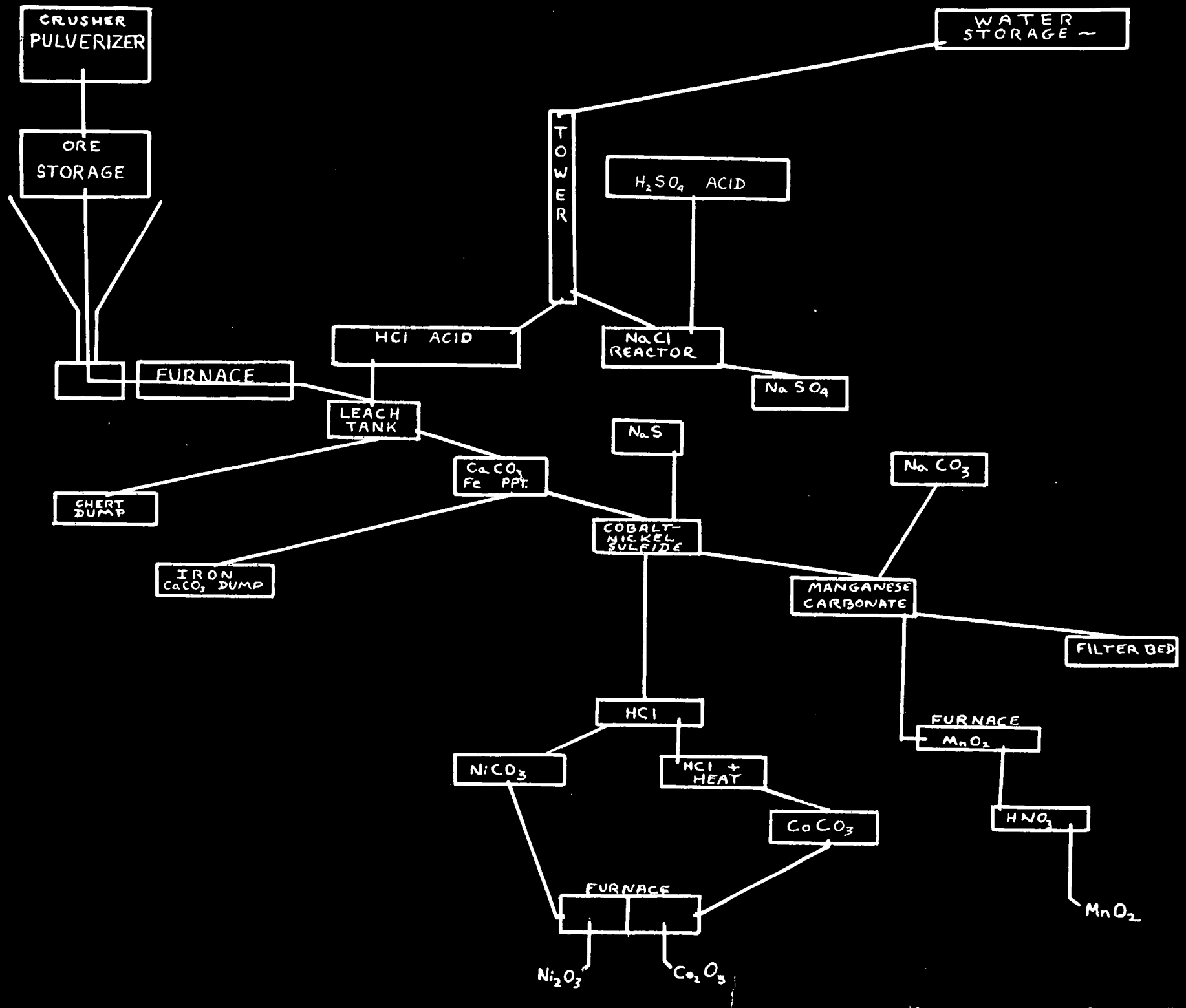
G. C. Selfridge, Chief
Iron and Ferro-Alloy Division

GCSelfridge:ls
cc: Docket
Admn. Read. File

cc: G. C. Selfridge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IRON
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CARBONATE
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FURNACE
MnO_2
$NiCO_3$
HCl +
HEAT
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FURNACE
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Ni_2O_3
Co_2O_3

MF-103
(Revised April 1952)

UNITED STATES DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION

Form Approved.
Budget Bureau No. 42-R1035.2.

APPLICATION FOR AID IN AN EXPLORATION PROJECT, PURSUANT TO DMEA ORDER 1, UNDER THE DEFENSE PRODUCTION ACT OF 1950, AS AMENDED

Not to be filled in by applicant

Docket No. dmea 2744
Metal or Mineral
Date Received 10-23-52
Estimated Cost
Participation (Government %)

INSTRUCTIONS

1. *Name of applicant.*—(*a*) State here your full legal name, in the form in which you will wish to contract, and your mailing address: L. W. King, M. D.
870 E. State Street
Salem, Ohio.
A partnership. Partners: Cecil K. Scott, Lowell R. King - Address as above.

(*b*) If other than an individual, add to your name above whether a corporation, partnership, etc., and the name of the State in which incorporated or otherwise organized.

(*c*) If a corporation, add to above statement, titles, names and addresses of officers.

(*d*) If a partnership, add to the above statement the names and addresses of all partners.

2. *General.*—Read DMEA Order 1, "Government Aid in Defense Exploration Projects," before completing this application. Submit this application and all accompanying papers in quadruplicate (four copies), with your name and address on each sheet of the application and on all accompanying papers. Where sufficient space is not provided on the form for all required information, state it on an accompanying paper, with a reference in each case to the instruction to which it refers by number. Comply with all applicable instructions; or, if not applicable, so state. File the application with Defense Minerals Exploration Administration, Department of the Interior, Washington 25, D. C., or with the nearest field executive officer thereof.

3. *Applicant's property rights.*—(*a*) State the legal description of the land upon which you wish to explore, including all land which you possess or control that may be benefited by the exploration, and excluding any land or interest in land which is not to be included in the exploration project contract Previously and completely stated. See Docket DMA 176.

(*b*) State any mine name by which the property is known. None

(*c*) State your interest in the land, whether owner, lessee, purchaser under contract, or otherwise Lessee

(*d*) If you are not the owner, submit with this application a copy of the lease, contract, or other document under which you control the property. See Docket DMA 176.

(*e*) If you own the land, describe any liens or encumbrances on it Not applicable

(*f*) If the land consists of unpatented claims, add to the description above, the book and page numbers for each recorded location notice. None

4. *Physical description.*—(*a*) Describe in detail any mining or exploration operations which have been or now are being conducted upon the land, including existing mine workings and production facilities. State your interest, if any, in such operations. Also describe accessibility of mine workings for examination purposes. See Docket 176 Above.

(*b*) State past and current production, and ore reserves, if any, giving quantities and grades.

(*c*) Describe the geologic features of the property, including mineralization, type of deposit (vein, bedded, etc.), and your reasons for wishing to explore. Illustrate with maps or sketches. Send with your application (but not necessarily as a part of it) any geologic or engineering report, assay maps, or other technologic information you may have, indicating on each whether you require its return to you.

(*d*) State the facts with respect to the accessibility of the project: Access roads, distances to shipping, supply and residence points. Above.

(*e*) State the availability of manpower, materials, supplies, equipment, water, and power.

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
OCT 23 1952

16—66551-1

5. *The exploration project.*—State the mineral or minerals for which you wish to explore Cobalt, Nickel, Tungsten.

(*b*) Describe fully the proposed work, including a map or sketch of the property showing a plan (and cross sections if needed) of any present mine workings, and the location of the proposed exploration work as related to such features as contacts, veins, ore-bearing beds, etc. Eco EA Docket 176

(*c*) The work will start within 30 days and be completed within Four months from the date of an exploration project contract.

(*d*) State the operating experience and background of the applicant with relation to the ability to carry out such exploration project, and also that of the person or persons who will supervise the operations. Previous exploration project contract EA 176. Personnel unchanged.

6. *Estimate of costs.*—Furnish a detailed estimate of the costs of the proposed work (you will have to use a separate sheet), under the following headings. Add the totals under all headings to give the estimated total cost of the project:

(*a*) *Independent contracts.*—(Note.—If the applicant does not intend to let any of the work to contractors, write "none" after this item. To the extent that the work is to be contracted, do not repeat the cost of the contract-work in subsequent items.) State the cost of any proposed independent contracts for the performance of all or any part of the work, expressed in terms of units of work (such as per foot of drilling, per foot of drifting, per hour of bulldozer operations, per cubic yard of material moved, etc.).

(*b*) *Labor, supervision, consultants.*—Include an itemized schedule of numbers, classes and rates of wages, salaries or fees for necessary labor, supervision and engineering and geological consultants.

(*c*) *Operating materials and supplies.*—Furnish an itemized list, including items of equipment costing less than $50 each, and power, water and fuel.

(*d*) *Operating equipment.*—Furnish an itemized list of any operating equipment to be rented, purchased, or which is owned and will be furnished by the Operator, with the estimated rental, purchase price, or suggested use-allowance based on present value, as the case may be.

(*e*) *Rehabilitation and repairs.*—Furnish a detailed list showing the cost of any necessary initial rehabilitation or repairs of existing buildings, installations, fixtures, and movable operating equipment, now owned by the Operator and which will be devoted to the exploration project.

(*f*) *New buildings, improvements, installations.*—Furnish a detailed list showing the cost of any necessary buildings, fixed improvements, or installations to be purchased, installed or constructed for the benefit of the exploration project.

(*g*) *Miscellaneous.*—Furnish a detailed list showing the cost of repairs to and maintenance of operating equipment (not including initial rehabilitation or repairs of the Operator's equipment), analytical work, accounting, workmen's compensation and employers' liability insurance, and payroll taxes.

(*h*) *Contingencies.*—Give an estimate of any necessary allowances for contingencies not included in the costs stated above.

NOTE.—No items of general overhead, corporate management, interest, taxes (other than payroll and sales taxes), or any other indirect costs, or work performed or costs incurred before the date of the contract, should be included in the estimate of costs.

7. (*a*) Are you prepared to furnish your share of the cost of the proposed project in accordance with the regulations on Government participation (Sec. 7, DMEA No. 1)? Yes

(*b*) How do you propose to furnish your share of the costs?

[X] Money [X] Use of equipment owned by you [X] Other

Explain in detail on acompanying paper.

CERTIFICATION

The undersigned, whether as an individual, corporate officer, partner, or otherwise, both in his own behalf and acting for the applicant, certifies that the information set forth in this form and accompanying papers is correct and complete, to the best of his knowledge and belief.

Dated October 22, 2., 195--

(Applicant)

By

Title 18, U. S. Code (Crimes), Section 1001, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U. S. GOVERNMENT PRINTING OFFICE 16—66551-1

L. W. King, M.D.
470 E. State St.
Salem, Ohio.

(To accompany MF-103)

5(b) Proposed work: Purpose of this project is to extend the previous work described in DMA Docket 176 which indicated that ore of commercial grade might exist on the property. This project is to establish definitely that ore does exist on the property, that the ore occurs in more than one area, and also, by trenching methods described in DMA 176, would establish a tonnage measurement of over 1,000,000 tons material.

Maps, sketches of the property, location of the project are shown in Docket DMA 176.

This project would consist of trenching to an aggregate depth of 18 feet and 3 feet wide, to a total lineal length of 5000 feet. Individual trenches to average 300 feet in length to be placed at any location on the property in order to explore for ore between the two areas described "North" and "Middle" on maps in Docket DMA 176.

6. Estimate of Costs:

(a) No work is to be let under contract.

(b) Labor is included in rental of equipment. This includes workman's compensation, liability insurance. One laborer to drill shot holes, load, and shoot dynamite, maintain air compressor; includes wages, transportation to project and workman's compensation. $1.75 hr.
Supervision: One general supervisor.....$800.00

(c) Operating materials: Drill steel, rock bits, dynamite caps, lead wire, battery box, fuel for air compressor..... 500.00

(d) Operating Equipment:

1. One TD 14 International Tractor with bull dozing blade; operator, oiler, fuel, lubrication, maintenance to be rented for total of $12.00 per hour.

2. One 1/2 yard Insley Deisel powered shovel with 1/2 yard back hoe attachment; operator, oiler, fuel lubrication, and maintenance to be rented at $12.00 per hour.

3. One Ingersol-Rand 105 Air compressor, 85 Jack Hammer $125.00 per month.

4. One four-wheel drive Universal Willys Jeep $100 per month. Owned by operator. Includes fuel, oil, insurance.

(e) Rehabilitation of existing 10' x 14' building for the storage of dynamite and caps, drill steel and rock bits, air hose, fuel, oil, repair parts, maps, etc.....150.00

Rehabilitation of existing access roads within the property...120.00

CONCLUSION: The total 5000 lineal feet of trenching can be accomplished at a total cost of $5.00 per lineal foot which includes all equipment, personnel, materials, etc. Thus the entire project is estimated not to cost over $25,000.00.

Mr. Homer Mann, Chief
Minor and Light Metals Branch
Defense Materials Procurement Agency
Washington, D. C.

Re: Docket No. DMA 176X - Manganese-Cobalt-Nickel
The J. H. Artz Land
Bradley and Hamilton Counties, Tennessee
Contract No. Idm-8-83

Dear Mr. Mann:

Attached hereto for your information is a copy of a letter dated October 17, 1952, by O. C. Ralston, Chief Metallurgist, Bureau of Mines, which embodies his comments on a metallurgical process for the recovery of cobalt which was recently submitted by Dr. L. W. King.

Copies of our letter to Mr. Ralston and King's process were sent Mr. Howard Young under date of October 15, 1952.

Sincerely yours,

C. O. Mittendorf

Administrator

Enclosure

GCSelfridge'lm
10/22/52

cc: Admn. Reading File
Docket
G. C. Selfridge

COPY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON 25, D. C.

October 17, 1952

Mr. C. O. Mittendorf
Administrator, D.M.E.A.
General Services Building
Washington 25, D. C.

Re: Docket No. DMA-176X -
Manganese-Cobalt-Nickel
The J. H. Artz land
Bradley and Hamilton Counties,
Tennessee. Contract Idm-E-83

Dear Mr. Mittendorf:

Responding to your letter of October 15, 1952, on the extractive process proposed by Dr. L. W. King for treatment in a pilot plant of 10 tons daily of ore from the J. H. Artz land in Tennessee. I have read the material and comment as follows:

1. The chemistry of his proposed process appears sound, and, although I do not expect his separation between nickel and cobalt to be clean, there is a market for a considerable amount of mixed nickel and cobalt in the permanent magnet industry. King has used as reducing furnace for converting manganese to acid-soluble MnO, a design he found at work in a Baltimore plant making manganese chloride as a commercial product. He is also copying the dissolution in hydrochloric acid, which he proposed to make from salt and sulphuric acid by well-known methods. His precipitation of cobalt and nickel as sulphide by hydrogen sulphides is also something that is well known. Precipitation of manganese carbonate and calcination of MnO_2 is also well known and has produced MnO_2 of battery grade by the steps he describes.

2. As to whether Dr. King can be rated as a competent operator, I have some doubt. I know of no competent operators in his employ. His presentation has been that of an amateur.

3. Construction costs give details of first cost of equipment, but appear not to provide for erection and housing. I have tried to extend his operating costs to a larger plant, but find few economies that would result with larger tonnage. Also, he has not calculated operating capital needed. I therefore am at a loss to check his figures on amortization and interest.

4. Dr. King's early operation will be based on loading of selected material without concentration. Whether he knows how to concentrate his lean ore I do not know. From his description of the undeveloped area it would appear that more trenches might well turn up much more ore, but he stated to me that you had called a halt on exploration until you knew more about what he could do with the ore he has already uncovered.

5. This deposit appears to have more cobaltiferous manganese than in the usual southern deposits, and I would like to see it in more competent hands and given a better examination. It could provide a plant to which the small lots of ore from elsewhere could be shipped. The nickel content is small in terms of national needs, but acceptable for what it is worth. The market for battery grade manganese ore is small, but not too small to take the output from this operation if Dr. King can show that he can make an acceptable product.

Sincerely yours,

/s/ O. C. Ralston

O. C. Ralston
Chief Metallurgist

cc: Mr. Paul Zinner
Mr. N. B. Melcher
Extra copy to Mr. Mittendorf

COPY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON 25, D. C.

October 17, 1952

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Administrator, D.M.E.A.
General Services Building
Washington 25, D. C.

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XC

C O P Y of letter transmitted by Mr. D. H. Schnee, Executive Director, Minerals and Metals Advisory Board, to Mr. Irving Gumbel, Acting Director, Materials Division, EPS, GSA. (Transcribed from telephone dictation.)

January 19, 1954

Mr. D. H. Schnee, Executive Director
Minerals and Metals Advisory Board
National Research Council
2101 Constitution Avenue
Washington 25, D. C.

Dear Mr. Schnee:

The proposal of Dr. L. W. King for the recovery of cobalt, nickel, and manganese from White Oak Mountain ores in Tennessee has been circulated amongst the Manganese Panel. Additional information concerning the proposal made available by Dr. King through Mr. Long's visit to the King laboratory and the various visits of Dr. King to the M.M.A.B. offices was also circulated along with the proposal.

Comments from the members of the Panel were not favorable to the proposal and Mr. Critchett, Chairman of the Cobalt Panel, likewise commented unfavorably.

The Manganese Panel is of the opinion that the White Oak Mountain ore deposits have not been adequately explored to determine the quantity of ore available, nor has the grade of the deposit been sufficiently established to predict the success of this exploration. The Panel is also of the opinion that the chemical operations involved in Dr. King's proposal, although cleverly conceived and fitted together, are nevertheless very complex and quite involved. On the limited scale of operations proposed for this plan, it is believed that it would be cheaper and certainly much simpler to purchase the necessary chemicals rather than to build up chemical plants, the operation and coordination of which would needlessly complicate the main purpose of recovering the nickel, cobalt, and manganese from the ores. In addition, it is believed that the chemical separations proposed would be less sharp, and hence less perfect, than Dr. King performed, and that to attain the recoveries anticipated would involve multiple precipitation in handling at great expense. The Panel also expressed doubt that the potential production of these metals available from the ores was of sufficient size to be of national importance.

In view of these comments, it is suggested that Mr. Gumbel be informed that the Manganese Panel does not recommend that the King proposal be given Government support.

Very truly yours,

Signed: M. J. DAY

Chairman, Manganese Panel

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C O P Y of letter transmitted by Mr. D. H. Sehnes, Executive Director, Minerals and Metals Advisory Board, to Mr. Irving Gumbel, Acting Director, Materials Division, RFS, GSA. (Transcribed from telephone dictation.)

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Chairman, Manganese Panel

DRAFT
WSM/FEJ
7/9/56

Dr. L. W. King
470 E. State Street
Salem, Ohio

Re: Docket No. DMEA-2744
Manganese-Nickel-Cobalt
J. H. Artz land
Bradley & Hamilton Counties, Tenn.

Dear Doctor King:

Reference is made to the subject application dated October 22, 1952, and our subsequent discussions with you. As you are aware, that application has been held in abeyance in consideration of the information and correspondence which you have had with the General Services Administration, and other agencies of the Government relative to the problem of beneficiating the particular type of mineralization occurring on the captioned property.

Although exploration already completed on the subject property under Contract No. Idm-E83, our Docket No. DMA-176X, has indicated the presence of appreciable tonnages of cobalt-bearing manganese mineralization, it does not show that your property has definite promise of yielding materials of acceptable grade in quantities that will significantly improve the mineral supply position for the National Defense Program. The subject request was for exploration assistance in extending the explored areas. The new work might indicate additional reserves similar in character to those contained in the deposits already explored.

It is our understanding that metallurgical tests to date have not indicated that the greater proportion of such material can be economically treated to yield a satisfactory product. If that is the case, unless

MF-500

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

REFERENCE SLIP

DATE 6/28/56

REFERRED TO:

1. ~~Mr. Selfridge~~
2. ~~Mr. Johnson~~
3. ~~Mr. Mittendorf~~
4. ~~Mr. Martin~~

FOR:

---- Action	---- Recommendation
XX Approval	---- Record of ----
---- Comment	---- Referring to ----
---- Conference	---- Reply for signature of ----
---- Consideration	---- Rewriting
---- Filing	---- Signature
---- Instructions	XX Suggestions
---- Investigation	---- Your information
---- Initials	
---- Mailing	
---- Previous correspondence	

REMARKS: ----

Check (X) before the items needing attention.

WSMartin/ls

Initials of sender.

GPO 16—63815-1

further tests produce a satisfactory metallurgical process, additional exploration by the Government would be unwarranted in any area where we could expect to find only similar deposits of material which cannot be classed as ore by present standards.

We have held final action on your request for additional exploration assistance in abeyance for more than two years pending satisfactory completion of the metallurgical testings. The DMEA cannot indefinitely postpone action on applications, and we feel sufficient time has been allowed to complete the tests. Under the circumstances, therefore, we regret to advise that your application for additional exploration assistance is denied. However, if at some future time the metallurgy of cobalt-manganese deposits of this type is satisfactorily solved, we shall be glad to consider a revised application for additional exploration assistance.

We wish to thank you for your interest in the DMEA program and for bringing your property to our attention.

Sincerely yours,

Administrator

WSM

The attached draft is intended to combine Mr. Liebert's suggested reply (see attachment) and our unused letter of June 23, 1954, which passed the Operating Committee at that time but was noted as follows by the Administrator:

"(1) Should we hold in abeyance until GSA takes firm and formal position?
(2) Or - Knock off list, awaiting such action by GSA?

"I prefer (1) unless Dr. King brings pressure on us.

"(Johnson concurs.)" ?

WSM

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Salem, Ohio

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Dear Doctor King:

Reference is made to the subject application dated October 22, 1952, and our subsequent discussions with you. As you are aware, that application has been held in abeyance in consideration of the information and correspondence which you have had with ~~has passed between you,~~ the General Services Administration, and other agencies of the Government relative to the problem of beneficiating the particular type of mineralization occurring on the captioned property.

~~Projects approved by the Defense Minerals Exploration Administration must, in its judgment, show~~ definite promise of yielding materials of acceptable grade in quantities that will significantly improve the mineral supply position for the National Defense Program.

Although Exploration already completed on the subject property under Contract No. Idm-E83, our Docket No. DMA 176X, has indicated the presence of appreciable tonnages of cobalt-bearing manganese mineralization, it does not show that your property The subject request was for exploration assistance in extending the explored areas. The new work might indicate additional reserves similar in character to those contained in the deposits already explored.

It is our understanding that metallurgical tests to date have not indicated that the greater proportion of such material can be conomically treated to yield a satisfactory product. If that is the case, unless further tests produce a satisfactory metallurgical process, additional exploration by the Government would be unwarranted in any area where we could expect to find only similar deposits of material which cannot be classed as ore by present standards.

If no satisfactory treatment process has yet been developed but you believe that your future research will result in a satisfactory process, you may wish to withdraw the subject application with the idea of submitting a revised application for assistance to explore for additional reserves of whatever proportion of this type of material you subsequently find ~~available for~~ amenable to treatment. In that event, please refer to the captioned docket.

We have held final action on your request for additional exploration and time in abeyance for more than two years pending satisfactory completion of the metallurgical tests. The Department cannot indefinitely postpone action on applications, and we feel that there has been ample time to complete the tests. Under the existing basis, therefore, the request to withdraw your application for additional exploration assistance is denied. However, if at some future time the metallurgy of cobalt-manganese deposits of this type is satisfactorily solved, you should be glad to consider a revised application.

Administrator

WSMartin/ls
6/28/56

for additional appreciation 400 in lieu,

We wish to thank you for your interest in the DMSD program and for bringing your property to our attention.

Sincerely yours

[illegible]

Rough ~~Rough~~ draft

By phone from Mr. Liekert
6/28/56

Re: L. W. King

We have in our pending file your application No. DMEA-2744, for manganese _____.
It has not been acted upon in view of the information and correspondence which has passed between yourself, the General Services Administration, and other agencies of the Government relative to the problem of beneficiating the ores. We now would like to find out from you whether or not you desire to keep this application in a pending status or carry through your original ideas of exploration. Please advise us of your desires either to go forward with this project or to close it out.

DOCKET
SURNAME

Holt
Martin
Selfridge
Ryman
Mattendorf

400

AUG 24 1956

Mr. Robert A. Laurence, Executive Officer
DMEA Field Team, Region V
Room 13, Post Office Building
Knoxville 2, Tennessee

Re: Docket No. DMEA 274, Manganese-Nickel-Cobalt, L. W. King, et al.
J. N. Arts land
Bradley and Hamilton Counties,
Tennessee

Dear Mr. Laurence:

Reference is made to the last paragraph of your letter of August 17, 1956, wherein you ask to borrow, if available, a copy of Dr. King's report to GSA on the results of his metallurgical research work on the manganiferous chert from the above-captioned land.

We have not seen any report by Dr. King on his work, but have been afforded an opportunity to consult three reports prepared for GSA by Bureau of Mines employees. We concluded therefrom that metallurgical tests have not indicated that the greater proportion of the material in question can be economically treated to yield a satisfactory product.

Inasmuch as the reports in question were not made either by or for DMEA, it seems inappropriate for us to comment further.

Sincerely yours,

George C. Selfridge
Chairman, Operating Committee (GCS)

APPROVED:

FRANK D. LAMB (FDL)
Member, Bureau of Mines

N. E. Nelson (NEN)
Member, Geological Survey

SPHolt/foc 8/22/56
cc to: Docket
Code 400
Admr. Read. File
Oper. Comm.
FT. REG. V
T. Kiilsgaard, USGS
H. T. Reno, USBM

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C.
ROOM 13 POST OFFICE BLDG.
KNOXVILLE 2, TENN.

August 17, 1956

Memorandum

To: Operating Committee, DMEA, Washington, D. C.

From: Field Team, DMEA, Region V, Knoxville, Tennessee

Subject: DMEA-2744 (Manganese-nicket-cobalt)
L. W. King, M. D., Salem, Ohio
J. H. Artz land, Bradley and Hamilton Counties, Tennessee

Reference is made to Mr. Mittendorf's letter of August 2 to the Applicant, denying the application. We infer from this that the results of Dr. King's research under a GSA contract were negative.

We have been unable to learn what was done in the way of metallurgical research by Dr. King, though we understand that he built a small mill at Salem and shipped a few truckloads of manganiferous chert from White Oak Mountain to it.

Is there a copy of Dr. King's report to GSA which could be loaned to us? Although the application has been denied, we would be interested to know just what has been accomplished.

Robert A. Laurence
Robert A. Laurence
Executive Officer

V. J. Lynch
V. J. Lynch
Member, Bureau of Mines

RECEIVED
AUG 20 1956

Docket
Martin
Selfridge
Johnson

AUG 17 1956

Dr. L. W. King
470 E. State Street
Salem, Ohio

Re: Docket No. DMEA-2744,
Manganese-Nickel-Cobalt
J. H. Artz land
Bradley and Hamilton Counties,
Tennessee

Dear Doctor King:

Reference is made to your letter of August 3, 1956, calling our attention to items with which you disagreed in our letter of August 2 regarding the subject project.

From the copy which you enclosed of your letter of August 2 to Mr. Clarence A. Fredell, Emergency Procurement Service, General Services Administration, we note that you plan further discussions of your process with that Agency. We have consulted the report which you called to our attention. Your information is appreciated.

In accordance with your request, the above-mentioned correspondence is being made a part of Docket No. DMEA-2744.

Sincerely yours,

C. O. Mittendorf

Administrator

cc: Docket
Code 400
Adm. Read. File
Oper. Comm.
T. Kiilsgaard, USGS
H. T. Reno, USBM
FT, Reg. 5
WSMartin/ls 8/15/56

Dmea Docket
DmEa 2744

Reports on

King Hydrocholoric Acid Process for Extraction of Manganese, Nickel, and Cobalt

(1) Preliminary Report, The L. W. King Hydrochloric Acid Leaching Process for Nickeliferous Manganese Ores, dated August 10, 1955, by P. M. Ambrose and J. E. Conley.

Extract from "Conclusions and Recommendations": (pp.4-5)

"With the present set-up and operating procedures, there is no sound basis for evaluating the process as to grade of ore treated, recoveries possible, costs of chemical reagents and estimated total production costs. Cost estimates are further complicated by the proposed plan to manufacture the hydrochloric acid by the salt-cake process using salt and sulfuric acid.

" * * * .

(2) Report No. 2, King Hydrochloric Acid Process for Extraction of Manganese, Nickel, and Cobalt from White Oak Mountain, Tennessee, Manganese Ore Contract DMP-103, Pilot-Plant Inspection and Monitoring of L. W. King Facilities, Salem, Ohio, from August 30 to September 9, 1955. Report dated November 3, 1955, written by Ralph C. Kirly, and John E. Conley, Eastern Experiment Station, College Park, Md.

Extract from "Comments": (pp. 28-30)

"Poor results are not necessarily inherent in this process. Some of the reasons for them, together with suggestions for their improvement, are listed below:

" (9 practical suggestions followed). * * *."

(3) Report No. 3, Supplementary Laboratory Investigation Following Pilot-Plant Inspection and Monitoring of L. W. King Facilities, Salem, Ohio, from August 30 to September 9, 1955. Report dated November 21, 1955, written by Ralph C. Kirly and John E. Conley.

Extract from "Comments and Recommendations": (pp. 9-10)

"The results of these tests substantiate the opinions expressed in Report No. 2. Most of the acid-soluble components can be leached from the ore. Their selective recoveries will depend on modification of the King process as demonstrated during the monitored period.

"The ore was not reduced enough to obtain only MnO. Finer grinding and efficient agitation during the leach would help increase the recoveries. Careful attention must be given to the analysis of the ore-feed to the process in order to use enough acid to dissolve most of the Mn, Ni, and Co. If the main ore body does not contain aluminum-bearing minerals, then caution must be used during the mining to keep clay overburden out of the ore."

L. W. KING, M. D.
470 E. State Street
Salem, Ohio

Docket

RECEIVED
AUG - 6 1956

August 3, 1956

File 80.4486

WSM

Mr. C. O. Mittendorf
D.M.E.A. Administration
Dept. of Interior Bldg.
Washington 25, D. C.

Dear Mr. Mittendorf:

I was surprised to receive your letter in reference to Docket D.M.E.A.-2744.

It contains some inaccuries that I wish to correct by calling them to your attention, so that this statement which I will mail registered may come to your personal attention.

The second and third paragraphs suggest that as "indicated that the greater portion of such material etc."--- cannot be classed as ore by present standards" - is untrue as a perusal of Bureau of Mines report # 3 on DMP Contract # 103 of which copies except the file copy were collected from them; will corroborate. I presume this report was not made available to you in reference to this application. I think you personally can see it at the Bureau at College Park on request.

I will enclose my last application for pilot plant assistance which will bring you up to date on our work.

Will you please make this letter a part of Docket # D.M.E.A.-2744?

Sincerely yours,

L. W. King M.D.

L. W. King, M. D.
470 E. State St.
Salem, Ohio.

LWK/mg

made +
Copy retained 400
1 ls 8/15/56

L. W. KING, M. D.
470 E. State Street
Salem, Ohio

RECEIVED
AUG - 6 1956

August 2, 1956

Clarence A. Fredell
Acting Chief
Expansion Branch
Emergancy Procurement Service
General Services Administration
Washington 25, D. C.

I wish to make a formal application for the construction of a pilot plant for the recovery of Cobalt, Nickel and Manganese using South Appalachian ore which exists in "immense" quantity on our "White Oak Mountain" Tennessee deposit.

The size of this deposit can be verified by consulting a "White Oak" file seen by me previously to 1952 in the office of Mr. Norwood Melchior and the subsequent file covering work done under DMPA trenching and DMP Contract #103 (a hydrochloric acid process developed by me and built at Salem Ohio to check this process.)

During this contract we worked under a mistaken belief that our poorest ore contained an average of 3% for Mn plus Co, and Ni. This error led to an overfeed of ore that; on our supervised run during which we weighed all input of ore, wasted over 50% of our contained Mn, Co and Ni because not enough acid was used. It was later shown (see Bureau of Mines report # 3) that the method, itself was entirely workable.

This mistake was made through a faulty method of analysis that gave us a uniformly 4 % low reading for Mn. This was not caught by us, or anyone else to our knowledge prior to our supervised run. Our original method will work on many types of United States and Stockpile ores -- and at a profit. This error caused us to carefully re-examine all our data and all procedual methods, we proposed using.

Because our original method involved the manufacture of our own H_2SO_4 and Hcl, in order to keep costs down; we obtained a license for the use of a patented successful H_2SO_4 process in operation in Italy and England since 1952. Work with this process suggested that our ore, itself, contained catylitic material that should theoretically oxidize SO_2 (our starting point) to SO_3 -- H_2SO_4 at a temperature not over 50°C. We decided to investigate this possibility.

Six months ago we started work on this investigation and found that with our ore ground to -50 Me. the results were extremely good. As this newly found method made our process very much less costly in plant construction, and operation costs; we re-checked, six weeks ago, with the Pittsburgh Bureau of Mines, where we had gotten all the literature available five years previously, and found that a very good

L. W. KING, M. D.
470 E. State Street
Salem, Ohio

piece of work had been done and released for publication in 1954 on SO_2 leaching on some Western Ores, some few of these ores did not work as well as ours, due to their different make up. This process works best with oxide ores such as found in our, and most other, South Appalachian ores.

We believe we can develop a successful pilot plant for the recovery of Nickel, Cobalt and Manganese with good purity of end products with this method, and at low cost for operation and plant construction.

We think such a pilot plant would be of distinct value, to the country, as it would make available a worthwhile contribution to the Cobalt and Nickel stockpile of the Nation using U. S. ores.

(a) It uses a method, in part, that we have been working with for six years.

(b) Our independent laboratory results parallel the Bowlder City published reports.

(c) It will cost us nothing for our plant site and only for stripping the ore in Tennessee, which is an advantage.

(d) I can get an experienced construction man on plant construction; he has just finished the construction of two limestone mining and processing plants which, through necessity, must be very efficient plants to operate profitably.

(e) I can get the design services of a recently retired top flight experienced engineer who has designed among many other large projects, over a dozen SO_2 burners that have been used successfully in the paper industry over the last twenty years.

(f) We have built, and have in operation improved controls for automatically controlling all critical steps of the process.

(g) We have a lot of experience in this work and have come up with some independently found methods that we have found later have been in use in the world somewhere, as well as some new methods of worth of our own. One of these is the carbonyl separation of Nickel used in Germany in World War II but marked "Restricted and Confidential" here. Pilot plant work on this Nickel separation definitely should be done in this country. (See our reports for the last five years in conformation of our work on this process).

(h) Such a pilot plant should be built to actually run about ten to twenty tons per day, each day, this is the way you correct faults and work out bugs found in operation.

L. W. KING, M. D.
470 E. State Street
Salem, Ohio

(i) I think we are familiar with pilot plant construction, as to records, methods of procedure, and can really save money on such an operation.

(j) We are not attempting to develop a patented procedure where anyone would have to be licensed to use it. This in itself I think, merits consideration of our proposal.

(k) We can complete this work in about a year and a Half if we get a reasonable "go ahead" date to utilize the summer and fall seasons for construction.

Will you, at your convenience, set up an interview with me on this project? Many questions will probably occur to you, and your board that I can possibly answer and document, and you will have plenty of them; in view of your familiarity with the work done through the department covering the Mn, CO and Ni projects to date, and our work on DMP#103.

I have a signed letter from the Secretary "that data pertinent to your application, now held by the Department of The Interior, will be made freely available to the engineering staff of General Services Administration".

This together with material we personally have developed in the last six years will be worth going over.

A personal reply that you have seen this request will be appreciated.

Yours truly,

L. W. King, M. D.
470 E. State St.
Salem, Ohio.

LWK/mg

CW

400

DOCKET
Surname:
Martin
Chapman
Reno
Nelson
Gleason
Kylmen

AUG - 2 1956

Dr. L. W. King
470 E. State Street
Salem, Ohio

Re: Docket No. DMEA-2744,
Manganese-Nickel-Cobalt
J. H. Artz land
Bradley and Hamilton Counties,
Tennessee

Dear Doctor King:

Reference is made to the subject application dated October 22, 1952, and our subsequent discussions with you. As you are aware, that application has been held in abeyance in consideration of the information and correspondence which you have had with the General Services Administration, and other agencies of the Government, relative to the problem of beneficiating the particular type of mineralized material occurring on the captioned property.

Exploration already completed on the same property under Contract No. Idm-E83, our Docket No. DMA-176X, has indicated the presence of appreciable tonnages of material containing cobalt and manganese, but does not show that your property has definite promise of yielding products of acceptable grade in quantities that will significantly improve the mineral supply position for the National Defense Program. The subject request was for exploration assistance in extending the explored areas. The new work might indicate additional tonnages similar in character to the deposits already explored.

It is our understanding, however, that metallurgical tests have not indicated that the greater proportion of such material can be economically treated to yield a satisfactory product. Consequently, unless further tests produce a satisfactory metallurgical process, additional exploration by the Government would be unwarranted in any area where we could expect to find only similar deposits of material which cannot be classed as ore by present standards.

A.C.K.

We have held final action on your request for additional exploration assistance in abeyance for more than two years in order to allow ample time for completion of your metallurgical tests. The DMEA cannot indefinitely postpone action on applications under such circumstances. We therefore regret to advise that your application for additional exploration assistance is denied. However, if at some future time the metallurgy of cobalt-manganese deposits of this type is satisfactorily solved, we shall be glad to consider a revised application for additional exploration assistance.

We wish to thank you for your interest in the DMEA program and for bringing your property to our attention.

Sincerely yours,

G. O. Mittendorf

Administrator

cc: Docket
Code 400
Adm. Read. File
Oper. Committee
T. Kiilsgaard, USGS
W. McInnis, USBM
Field Team, Region V

WSMartin/FEJohnson/ls
7/26/56

Docket
Chapman
Davis
Dethloff
Lurson
Kilgaard
Grated Yoyes

Dr. L. W. King
470 E. State Street
Salem, Ohio

Re: Docket No. DMEA-2744,
Manganese-Nickel-Cobalt
J. H. Artz land
Bradley and Hamilton Counties,
Tennessee

Dear Doctor King:

Reference is made to the subject application dated October 22, 1952, and our subsequent discussions with you. As you are aware, that application has been held in abeyance in consideration of the information and correspondence which you have had with the General Services Administration, and other agencies of the Government, relative to the problem of beneficiating the particular type of mineralization occurring on the captioned property.

Although exploration already completed on the subject property under Contract No. Idm-E83, our Docket No. DMEA-176X, has indicated the presence of appreciable tonnages of cobalt-bearing manganese mineralization, it does not show that your property has definite promise of yielding materials of acceptable grade in quantities that will significantly improve the mineral supply position for the National Defense Program. The subject request was for exploration assistance in extending the explored areas. The new work might indicate additional reserves similar in character to those contained in the deposits already explored.

It is our understanding that metallurgical tests to date have not indicated that the greater proportion of such material can be economically treated to yield a satisfactory product. If that is the case, unless further tests produce a satisfactory metallurgical process, additional exploration by the Government would be unwarranted in any area where we could expect to find only similar deposits of material which cannot be classed as ore by present standards.

Reviewed
Place for file

We have held final action on your request for additional exploration assistance in abeyance for more than two years pending satisfactory completion of the metallurgical testings. The DMEA cannot indefinitely postpone action on applications, and we feel sufficient time has been allowed to complete the tests. Under the circumstances, therefore, we regret to advise that your application for additional exploration assistance is denied. However, if at some future time the metallurgy of cobalt-manganese deposits of this type is satisfactorily solved, we shall be glad to consider a revised application for additional exploration assistance.

We wish to thank you for your interest in the DMEA program and for bringing your property to our attention.

Sincerely yours,

Administrator

cc: Docket
Code 400
Adm. Read. File
Oper. Committee
T. Kiilsgaard, USGS
W. McInnis, USBM
Field Team, Region V

WSMartin/FEJohnson/ls
7/9/56

Mr. DeHuff – 3523
Mr. Davis – 3523
Mr. Kilsgaard – 5222

6/22/56

M B Mumford
Mrs J R Strange

They were in here to ask if King would be a dependable source of supply for Mu.
Told them that was not the sort of question we could answer but that it was not certified and we had a current (4 yrs old) application

W. S. Martin

DRAFT

for reply by Mr. Miller

not used

Dear Dr. King:

Your letter of January 7, 1956, addressed to Mr. Liebert, has been referred to us for reply since it mentions Mr. Melcher who was at the time you specify, working in our Washington office.

Your letter does not make clear to us what report you desire to examine. Possibly you refer to a final report of Field Team prepared for the Defense Minerals Exploration Administration in 1951 and ~~completed as of~~ dated January 9, 1952, for Exploration Project Contract Idm-E83 (Docket No. DMA-176X), entitled: "Artz Cobalt-Manganese Property, Operator: L. W. King, M.D., Cecil K. Scott, and Lowell R. King, a Partnership; White Oak Mountain, Bradley County, Tennessee."

Such Field Team reports are for Government use only, but under certain circumstances certain factual parts thereof can be discussed with the land owner or his legal representative. Your request should, therefore, be addressed to Mr. C. O. Mittendorf, Administrator, Defense Minerals Exploration Administration, Department of the Interior, Washington 25, D. C.

cc: Mr. Mittendorf (with a copy of incoming)
Mr. Clarence A. Fredell (with a copy of incoming)
EPS - GSA Regional Office Building, Room 5008, 7th & D SW

OFFICE OF THE
ASSISTANT SECRETARY OF THE INTERIOR
WASHINGTON

1/31/56

To: Mr. Mittendorf
Room 4459

(For your information)

From: Mr. Liebert

~~Johnson~~
~~Seaborg~~
Max Tao (for file)

Rec'd 1/31/56 #2372 (Register No)
#5

L. W. King, M. D.
470 E. State Street
Salem, Ohio

January 27, 1956

REGISTERED MAIL (No 2372)

WSM

Mr. Arthur Sherman
General Services Administration
7th & D Sts.
Washington 25, D. C.

Re: DMPA Contract-105

Dear Mr. Sherman:

Since our last report following the Bureau of Mines report we have been busy.

Since finding that our ore is much richer in Manganese than tests showed, owing to basic errors in analysis, due to type of ore as contrasted with a satisfactory steel analysis method; we have been re-examining all of our "major premises."

One - Our White Oak deposit is one of the richest in combined Mn, Co and Ni in reported literature, considering ease of mining and recovery, and that the amount of ore available is "immense".

Two - Our outlined method of recovery will make money. On a re-examination of every step, we have come up with a real improvement in cost of operation and cost of installation, that has proved out on a laboratory scale - we are stepping it up to some hundred pound runs, and so far have run into no difficulties. In the next couple weeks, after analysis has been checked by a commercial laboratory, think we will have something that will be of interest.

We are rebuilding all our automatic controls to incorporate inbuilt check points on operation. Such things should have been built in originals and then no question of reliability of information would have arisen and there will be no stupid refusals to believe indicated results. (Ore richness for example will be recognized).

Four - Our nation needs Nickel and Cobalt and can use Manganese. Our work in nickel and cobalt separation is progressing well. One commercial firm has approached us on buying our combined precipitate, so our success in this work is only of financial interest to us - not to the feasibility of our installation.

Will call you soon and make arrangements to go over this latest work with you.

Yours truly,

(Signed) L. W. King
L. W. King, M.D.
470 E. State St.
Salem, Ohio.

to Mr. Fredell
" Mr. Leibhart

LK/mg

10/12/55

DMEA 2744 _L.W.KING

GSA's letter of 7/1/55 from here in DC said King had June, July & August to finish his work re White Oaks Mountain, Tenn., deposit & report expected in September. Perhaps we should now send a follow-up to ask for same.

ls

Will handle by a phone call to Fleming or Fredell about Nov. 1

Mr. Fleming says final report not yet received. Nov. 16, 1955. S.P.H.

DMEA, Washington, ~~D.C.~~

Docket

GENERAL SERVICES ADMINISTRATION

Emergency Procurement Service
Washington 25, D. C.

2744

July 1, 1955

In reply refer to: KHK

RECEIVED
JUL - 5 1955

Mr. Robert A. Laurence
Executive Officer
DMEA Field Team, Region V
Room 13 Post Office Bldg.
Knoxville 2, Tennessee

Re: L. W. King
Docket No. DMEA-2744

Dear Mr. Laurence:

Your letter of June 22 to Mr. S. J. Sadow has been forwarded by him to us for reply.

On September 3, 1954 GSA signed a contract with Dr. L. W. King, whereunder he was to erect and operate, by means of a grant of Government funds, a small-scale pilot plant upon his premises in Salem, Ohio. The objective of this pilot plant project was to test the practicability of a process which he had devised for extracting and separating Mn, Ni and Co contained in low-grade, natural deposits in the United States.

One such deposit is the one situated at White Oaks Mountain, Tennessee, which Dr. King controls. A few months ago he excavated from that deposit, and transported to Salem, about 100 tons of material for use in the pilot plant.

According to original contract terms, the pilot plant work was to have been completed by June of this year. But, because of unforeseen circumstances which delayed the work, GSA granted an extension of three months.

The pilot plant has been in operation since May and the work is now well advanced. It is expected that final reports upon the pilot plant work will be available in September.

Very truly yours,

SIGNED

R. C. Fleming
Acting Chief, Expansion Branch
Materials Division

January 11, 1956

Mr. Martin:

L. W. KING, DMEA 2744

GSA ltr of 7/1/55 said King had through August to finish work at White Oaks Mountain, Tenn., and his report expected in September.

On November 15 when you phoned GSA, you learned that GSA at that time had "no report yet."

When and is GSA expecting a report???

ls

Talked to Laurence about this 1/10/56 No reason to push

WSM

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C.
ROOM 13 POST OFFICE BLDG.
KNOXVILLE 2, TENN.

Docket

RECEIVED
JUN 24 1955

June 22, 1955

WSM

Mr. Sigmund J. Sadow
Emergency Procurement Service
General Services Administration
c/o Cramet, P. O. Box 8157
Chattanooga, Tennessee

Copy retained 200

Re: Docket No. DMEA-2744
(Manganese-nickel-cobalt)
L. W. King, applicant
J. H. Artz land, Bradley and
Hamilton Counties, Tennessee

Dear Mr. Sadow:

Some time ago, Dr. L. W. King of Salem, Ohio, filed an application for aid in further exploration of cobalt-bearing manganese deposits on White Oak Mountain in Bradley and Hamilton Counties, Tennessee. We did not recommend approval, because it could not be demonstrated that the known deposits were of commercial grade. However, the application was kept open while Dr. King continued his research.

It is my understanding that his pilot plant, financed under a research contract with General Services Administration is about to go into operation. Because the results of that project will to a very large extent influence any decision as to further action on Dr. King's exploration application, I would greatly appreciate it if you could keep this office advised as to the progress of the research project. Also, if any considerable amount of material is being mined for this project, it is probable that we will want to inspect the mine workings. Any information you can provide will be helpful to us.

Very truly yours,

Robert A. Laurence
Executive Officer
DMEA Field Team, Region V

RAL/mg
cc - Operating Committee (2)
Lynch
Allsman
Clemmons
Pavlides

400

DOCKET
Surname:
Martin
Selfridge
K Johnson

JUN 17 1955

Mr. Robert A. Laurence, Executive Officer
DMEA Field Team, Region V
Room 13, Post Office Building
Knoxville 2, Tennessee

Re: Docket No. DMEA 2744 (Manganese-Nickel-Cobalt)
L. W. King
J. H. Artz land
Bradley & Hamilton Counties, Tennessee

Dear Mr. Laurence:

Reference is made to your letter of June 10, 1955, inquiring about the status of the subject application.

From conversations with the staff of the Materials Division, Emergency Procurement Service, General Services Administration, we have learned that the plant built for the research project on Mr. King's process is about to go into operation. In another three months, the preliminary work in that plant should be completed and we should be able to draw some conclusions about the merits of the proposed process.

It is suggested that you arrange to be kept advised of the progress of this same research project by the local GSA representative: Mr. Sigmund J. Sadow, Emergency Procurement Service, General Services Administration, c/o Cramet, P. O. Box 8157, Chattanooga, Tennessee.

Please let us know if our suggestion is feasible.

Sincerely yours,

George C. Selfridge

Chairman, Operating Committee (SJB)

Approved:

J. H. Hedges (SJB)
Member, Bureau of Mines

Thor H. Kiilsgaard (SJB)
Member, Geological Survey

cc: Docket
Adm. Read. File
Oper. Committee
Code 400
Thor Kiilsgaard, USGS
G. DeHuff, USBM
FT, Reg. V

WSMartin:(--)
6/17/55

R.G.S.

Docket

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
ROOM 1550 POST OFFICE BLDG.
KNOXVILLE 2, TENN.

June 10, 1955

WSM

Memorandum

To: Operating Committee, DMEA - Washington

From: Executive Officer, DMEA Field Team, Region V

Subject: DMEA-2744 (Cabolt-Manganese-Nickel) L. W. King, et al. Salem, Ohio. J. H. Artz Land, Bradley-Hamilton Counties, Tennessee.

We are still carrying the subject application in our active files, although there has been no correspondence, or other activity, since October 23, 1953.

Is this application still active, or has it been withdrawn?

Robert A. Laurence

Robert A. Laurence

EPS Research Project
Has plant at Salem
30 odd grand
Plant just about to go into operation
June 14, 1955
3 more months should see conclusion
of preliminary work

Called Materials Division, EPS 11-16-54

They executed contract with L. W. King

9/3/54 for construction of pilot plant.

Cost to Government $30,000.00

Supplied by - Metallurgical Dev. - E.P.S.
Report by
Smith Lewis Eng. Co. - Los Angeles,

TENNESSEE SAMPLES, NOS. 373-T AND 374-T, WHITE OAK MOUNTAIN MINE

As noted in our August progress report, determinations for cobalt and nickel were made on the sink products from the heavy media and heavy liquid separation of the -1" +1/4" and -1/4" +35 mesh fractions of samples 373-T and 374-T and also on the concentrates of two preliminary flotation tests. As the results seemed somewhat erratic, those products were re-assayed and determinations also were made on the various other products involved in the tests. The manganese results of these tests were given in our July progress report but for convenience also are included below with those of cobalt and nickel:

Sample 373-T - Combined Results of Heavy Media Separation of -1" +1/4" and Heavy Liquid Separation of -1/4" +35 mesh fractions

	% Wt.	% Mn	% Co	% Ni	% Distribution Mn	Co	Ni
Assayed Head		14.38	0.16	0.78			
Calculated Head	100.00	15.14	0.25	0.76	100.00	100.00	100.00
-1" +1/4" float at 2.389 sp. gr.	27.63	5.51	0.04	0.21	10.06	4.49	7.69
-1" +1/4" sink at 2.389 and 2.670	31.12	21.90	0.41	1.04	45.00	51.80	42.87
-1/4" +35 mesh float at 2.60	7.06	3.91	0.03	0.15	1.73	0.86	1.40
-1/4" +35 mesh sink at 2.60, 2.80, 2.91	16.72	30.04	0.60	1.72	33.17	40.73	38.09
-35 mesh fraction (untreated)	17.47	8.70	0.03	0.43	10.04	2.12	9.95
Combined -1" +35 mesh float	34.69	5.14	0.04	0.20	11.79	5.35	9.09
Combined -1" +35 mesh sink	47.84	24.75	0.48	1.28	78.17	92.53	80.96

Sample 374-T - Combined Results of Heavy Media Separation of -1" +1/4" and Heavy Liquid Separation of -1/4" +35 mesh fractions

	% Wt.	% Mn	% Co	% Ni	% Distribution Mn	Co	Ni
Assayed Head		4.99	0.13	0.21			
Calculated Head	100.00	4.97	0.13	0.21	100.00	100.00	100.00
-1" +1/4" float at 2.30 sp. gr.	21.21	1.84	0.07	0.08	7.85	11.44	8.21
-1" +1/4" sink at 2.30 and 2.56	19.60	7.23	0.38	0.23	28.50	57.39	21.82
-1/4" +35 mesh float at 2.60 sp. gr.	18.62	1.41	0.02	0.09	5.27	3.06	8.23
-1/4" +35 mesh sink at 2.60, 2.80, 2.924	5.27	24.60	0.43	0.80	26.07	17.29	20.37
-35 mesh fraction	35.30	4.55	0.04	0.24	32.31	10.82	41.37
Combined -1" +35 mesh float	39.83	1.64	0.04	0.09	13.12	14.50	16.44
Combined -1" +35 mesh sink	24.87	10.91	0.39	0.35	54.57	74.68	42.19

Flotation Tests on Samples 373-T and 374-T

Determinations for cobalt and nickel were made on the products from the two preliminary flotation tests on samples 373-T and 374-T, the manganese results of which were first given in our July progress report. The manganese, cobalt and nickel determinations are given below:

Sample 373-T - Test No. 2

	% Wt.	% Mn	% Fe	% Co	% Ni	% SiO_2	% Al_2O_3	% Distribution Mn	Co	Ni
Assayed Head		14.38	2.04	0.16	0.78	50.38	11.84			
Calculated Head	100.00	14.75		0.11	0.72			100.00	100.00	100.00
Concentrate	30.16	29.22		0.14	1.49	13.50	17.10	59.76	38.33	62.69
Middling No. 1	8.29)									
Middling No. 2	3.86)									
Middling No. 3	2.36)	6.35		0.10	0.22			6.25	13.17	4.45
Middling No. 4	7.35	22.88		0.12	1.10			11.40	8.01	11.28
Middling No. 5	4.71	23.32		0.12	1.17			7.45	5.13	
Tailing	43.27	5.16		0.09	0.23			15.14	35.36	
Combined Conct. + Midd. No. 4 & No. 5	42.22	27.46		0.13	1.37			78.61	39.97	81.66

Sample 374-T - Test No. 1

	% Wt.	% Mn	% Fe	% Co	% Ni	% SiO_2	% Al_2O_3	% Distribution Mn	Co	Ni
Assayed Head		4.99	2.98	0.13	0.21	77.49	4.26			
Calculated Head	100.00	4.55		0.12	0.18			100.00	100.00	100.00
Concentrate	16.99	22.23		0.35	0.97	22.23	6.35	82.64	49.08	89.14
Middling No. 1	19.75)									
Middling No. 2	3.24)									
Middling No. 3	0.58)	1.51		0.06	0.06			7.82	11.67	7.65
Tailing	59.44	0.73		0.08	0.01			9.54	39.25	3.21

For the purpose of obtaining an additional check on the cobalt and nickel content of samples 373-T and 374-T, a flotation test was made on each lot producing only a rougher concentrate and tailing. The products were assayed with the following results:

Sample 373-T, Test No. 22

	% Wt.	% Mn	% Co	% Ni	% SiO2	% Al2O3	% Distribution Mn	Co	Ni
Assayed Head		14.38	0.16	0.78	50.38	11.84			
Calculated Head	100.00	14.03	0.24	0.61			100.00	100.00	100.00
Rougher Concentrate	50.00	22.11	0.34	1.04	*	*	78.82	70.83	85.25
Rougher Tailing	50.00	5.94	0.14	0.18			21.18	29.17	14.75

Sample 374-T, Test No. 27

	% Wt.	% Mn	% Co	% Ni	% SiO2	% Al2O3	% Distribution Mn	Co	Ni
Assayed Head		4.99	0.13	0.21	77.49	4.26			
Calculated Head	100.00	5.07	0.15	0.21			100.00	100.00	100.00
Rougher Concen.	23.23	18.76	0.55	0.61	*	*	85.92	84.73	67.22
Rougher Tailing	76.77	0.93	0.03	0.09			14.08	15.27	32.78

* Determinations for silica and alumina were not made on the rougher concentrates from above tests No. 22 and No. 27 but would be high in both cases.

The foregoing results of determinations for nickel and cobalt, particularly the latter, still seem somewhat erratic. The analyst reports that the low cobalt content adds to the difficulty of the determination. It is noted, however, that less difficulty seems to be experienced with sample 374-T than with 373-T although the cobalt content of the latter is somewhat higher. In general, it appears that the cobalt content of sample 373-T may be on the order of 0.24% rather than 0.16% as indicated by direct assay of the original head sample. In preliminary flotation test No. 2 on sample 373-T, the calculated head is only 0.11% cobalt and re-assay of the concentrate did not alter this result appreciably. As the 0.11% cobalt compares with a calculated head of 0.24% in test No. 22, further investigation will be made of the cobalt analytical results on test No. 2 products.

Additional Flotation Testing on Samples 373-T and 374-T

A number of additional flotation tests were conducted on samples 373-T and 374-T attempting to produce concentrates having higher manganese and lower silica and alumina contents. In general, the results therefrom were not better than in earlier tests which appears due to the close association of a portion of the silica and alumina, particularly the latter, with the manganese.

Flotation of gravity concentrates will be tried.

MF-500

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

REFERENCE SLIP

DATE 6-23-54

REFERRED TO:

1. [redacted]
2. [redacted]
3. ~~Operating Comm.~~ Johnson
4. Administrator
5. Mails & Files

FOR:

..... Action	..... Recommendation
..... Approval	..... Record of .....
..... Comment	..... Referring to .....
..... Conference	..... Reply for signature of .....
..... Consideration	..... Rewriting
..... Filing	X Signature
..... Instructions	..... Suggestions
..... Investigation	..... Your information
X Initials	
X Mailing	
..... Previous correspondence	

REMARKS: Please note that GSA's plans are not yet firm.

Check (X) before the items needing attention.

FARutledge/foc
Initials of sender.

GPO 16—63815-1

One agency says not enough exploration done to establish sufficient reserves to justify subsidized testing.

DMEA says sufficient exploration done, untested metallurgy is worked out. They

1) Should we hold in abeyance until GSA takes firm & formal position?

2) or - knock off list, awaiting such action by GSA?

or I prefer 1 unless King brings pressure on us.

(Johnson concurs)

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C.

Doctor L. W. King
470 East State Street
Salem, Ohio

Re: Docket No. 2744 - Manganese, cobalt, and nickel
L. W. King, C. K. Scott, & L. R. King, partners
The J. H. Artz land
Bradley and Hamilton Counties, Tenn.

Dear Dr. King:

Your application for additional exploration assistance on the above-referenced property and other data available to us in Washington have been carefully reviewed.

Projects approved by the Defense Minerals Exploration Administration must, in its judgment, show definite promise of yielding materials of acceptable grade in quantities that will significantly improve the mineral supply position for the National Defense Program.

Exploration already completed on the subject property under Contract No. Idm-E83, our Docket No. DMA 176X, has indicated the presence of appreciable tonnages of cobalt-bearing manganese mineralization. The subject request was for exploration assistance in extending the explored areas. The new work might indicate additional reserves similar in character to those contained in the deposits already explored.

Metallurgical tests to date have not indicated that the greater proportion of such material can be economically treated to yield a satisfactory product. Therefore, unless further testing produces a satisfactory metallurgical process, additional exploration by the Government would be unwarranted in any area where we could expect to find only similar deposits of material which cannot be classed as ore by present standards.

Under the circumstances, we regret to advise that we are unable to approve a project for additional exploration of your property. However, if at some future date the metallurgy of cobalt-bearing manganese deposits of this type is satisfactorily solved, we shall be glad to consider a revised application for assistance to explore for additional reserves of this type of material. If such request is made by you, please refer to the subject docket.

We wish to thank you for your interest in the Defense Minerals Exploration Program and for bringing this property to our attention.

Sincerely yours,

Administrator

DOCKET
SURNAME

Rutledge
Deckoff
Newcomb
for Publication
Martin
Davis
Faraker
Hedges
Selfridge

Doctor L. W. King
470 East State Street
Salem, Ohio

Re: Docket No. 2744 - Manganese, cobalt, and nickel
L. W. King, C. K. Scott, & L. R. King, partners
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We wish to thank you for your interest in the Defense Minerals Exploration Program and for bringing this property to our attention.

Sincerely yours,

Administrator

FARUTLEDGE:foc
6-23-54
cc to: Docket
Code 400
Admr. Reading File
Operating Comm.
FT. Reg. VII
Louis Pavlides, USGS
Gilbert DeHuff, USBM

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C.

June 23, 1954

MEMORANDUM

To: Administrator, DMEA

From: Iron and Ferro-Alloys Division, DMEA

Subject: Denial of exploration project in the amount of $25,000.00
Docket No. 2744 - Manganese, cobalt, and nickel
L. W. King, C. K. Scott, & L. R. King, Partners
The J. H. Artz land
Bradley and Hamilton Counties, Tennessee

The denial of the subject application by this Division is based on the following information:

1. Dr. King requested additional exploration assistance to further extend the known reserves delimited under DMEA Contract No. Idm-E83, Docket No. DMA 176X. The mineralized material investigated under this exploration contract was not considered to warrant certification.

2. The property to be explored is the same as that covered by the previous application, Docket No. DMA 176X. The land consists of 963 acres, located partly in Bradley County and partly in Hamilton County, Tennessee, being in the White Oak Mountain area and known as the J. H. Artz land.

3. The ore sought for was a cobalt oxide which was known to occur at shallow depths with the oxides of manganese and iron. The cobalt seems to be either adsorbed on the manganese minerals as a cobalt oxide or to be a constituent of the manganese minerals. Lithiophorite, $Li_2 (Mn, Co, Ni)_2 Al_8 Mn_{10} O_{35} - 14 H_2O$, has been identified as occurring at the White Oak Mountain deposit. The cobalt-manganese deposits are considered to be supergene. In the area explored, the deposits occur as near surface replacements, incrustations, and fracture fillings in the Fort Payne chert.

Exploration under Contract No. Idm-E83 consisted of four trenches varying from 4 to 17 feet in depth, aggregating 1350 feet in length, and two test pits 16 and 38 feet in depth, respectively. The results of this work indicated that there is no continuity in the physical characteristics of the deposits. The cobalt-bearing manganese is erratically distributed along joints, bedding planes,

fractures, and other openings in the chert, and in residual material derived from the cherty beds.

Based upon the results of the exploration and the analyses by the Operator, the Operator calculated that the trenching indicated 9,600,000 tons of material averaging 0.20 percent cobalt, or 38,400,000 pounds of contained cobalt. The DMEA Field Team calculated 557,000 tons averaging 0.16 percent cobalt, or 1,790,000 pounds of contained cobalt.

As there was some doubt of the accuracy of the Operator's analyses, check samples were run. Twenty of the thirty samples rerun by the Operator were also analyzed by the Bureau of Mines. The results follow:

	PERCENT COBALT		
	Operator original	Operator check	Bureau of Mines check
Unweighted average 30 samples	0.387	0.238	
Unweighted average 20 samples	0.491	0.347	0.207

If the grade of the reserves calculated by the Field Team is reduced in proportion to that indicated by the Bureau of Mines check samples, the material would contain (0.16 x 0.42) 0.067 percent cobalt. On this basis, the reserves contain 746,380 pounds of cobalt.

Analyses of twenty of the samples for manganese were made by the Operator and the Bureau of Mines with the following results:

Operator - 6.9 percent

Bureau of Mines - 7.0 percent

The above cited averages contain one high sample of wad from which it is doubtful if commercial recovery could be made. With this sample eliminated, the rest averaged 4.5 and 5.8 percent manganese as determined by the Operator and the Bureau of Mines, respectively.

The metallurgical treatment of this type and grade of ore for the recovery of cobalt, manganese, and nickel has not yet been perfected on a commercial basis. Similar ores of much higher grade may be treated in an electrolytic manganese plant and the residues, principally cobalt, recovered from the cells.

The Applicant has proposed a plant to recover the cobalt, nickel, and manganese. At present there is a possibility that the Government through the Emergency Procurement Service, General Service Administration, may participate in the construction of a small pilot plant. Mr. King's cost data were based on treating an ore, mined by selective stripping, that would contain in excess of 10 percent manganese, 0.4 percent cobalt, 0.4 percent nickel. No appreciable reserves of this grade have been delimited.

4. The anticipated reserves are expected to be similar to those already explored under the prior contract (Contract No. Idm-E83). Until it has been proven that such material can be treated to yield satisfactory products, additional exploration for this type of cobalt-bearing manganese deposits is unwarranted.

5. Mr. King has several times been advised during conferences with DMEA that additional exploration assistance will not be granted until the feasibility of his metallurgical plant has been proven.

6. The Commodity Division of the Geological Survey recommends denial.

7. The Commodity Division of the Bureau of Mines has recommended that until satisfactory proof of a feasible process for recovery could be demonstrated, the deposit should be considered noncommercial, and concurs with denial of the subject application.

W S Martin

W. S. Martin, Chief
Iron and Ferro-Alloys Division

Docket
Surname

Ruthley
DeHuff
Martin
David
Newcomb for
Pavelson

June 23, 1954

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W. S. Martin, Chief
Iron and Ferro-Alloys Division

FARUTLEDGE:foc
6-23-54
cc to: Docket
Code 400
Adm. Reading File
Operating Comm.

C O P Y of letter transmitted by Mr. D. H. Schnee, Executive Director, Minerals and Metals Advisory Board, to Mr. Irving Gumbel, Acting Director, Materials Division, EPS, GSA. (Transcribed from telephone dictation.)

January 19, 1954

Mr. D. H. Schnee, Executive Director
Minerals and Metals Advisory Board
National Research Council
2101 Constitution Avenue
Washington 25, D. C.

Dear Mr. Schnee:

The proposal of Dr. L. W. King for the recovery of cobalt, nickel, and manganese from White Oak Mountain ores in Tennessee has been circulated amongst the Manganese Panel. Additional information concerning the proposal made available by Dr. King through Mr. Long's visit to the King laboratory and the various visits of Dr. King to the M.M.A.B. offices was also circulated along with the proposal.

Comments from the members of the Panel were not favorable to the proposal and Mr. Critchett, Chairman of the Cobalt Panel, likewise commented unfavorably.

The Manganese Panel is of the opinion that the White Oak Mountain ore deposits have not been adequately explored to determine the quantity of ore available, nor has the grade of the deposit been sufficiently established to predict the success of this exploration. The Panel is also of the opinion that the chemical operations involved in Dr. King's proposal, although cleverly conceived and fitted together, are nevertheless very complex and quite involved. On the limited scale of operations proposed for this plan, it is believed that it would be cheaper and certainly much simpler to purchase the necessary chemicals rather than to build up chemical plants, the operation and coordination of which would needlessly complicate the main purpose of recovering the nickel, cobalt, and manganese from the ores. In addition, it is believed that the chemical separations proposed would be less sharp, and hence less perfect, than Dr. King performed, and that to attain the recoveries anticipated would involve multiple precipitation in handling at great expense. The Panel also expressed doubt that the potential production of these metals available from the ores was of sufficient size to be of national importance.

MF-500

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

REFERENCE SLIP

DATE 2-24-54

REFERRED TO:

1. ~~Johnson Rm. 4624~~
2. ~~Selfridge Rm. 4631~~
3. Code 400 Rm. 3538
4.

FOR:

	Action		Recommendation
	Approval		Record
	Comment		of
	Conference		Referring
	Consideration		to
	Filing		Reply for signa-
	Instructions		ture of
	Investigation		Rewriting
	Initials		Signature
	Mailing		Suggestions
	Previous correspondence	X	Your information

What about

REMARKS: DMEA 2744 - Mn, Co; L. W. King et al; held in abeyance awaiting action by GSA. Attached letter report by Minerals and Metals Advisory Board of the National Academy of Sciences.

Check (X) before the items needing attention.

WSMartin
Initials of sender.

GPO 16—63815-1

In view of these comments, it is suggested that Mr. Gumbel be informed that the Manganese Panel does not recommend that the King proposal be given Government support.

Very truly yours,

Signed: M. J. DAY

Chairman, Manganese Panel

400

FILE COPY
SURNAME:

Rutledge
Martin
Selfridge
Hedges
Martin

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

NOV 5 1953

Mr. Robert A. Laurence, Executive Officer
DMEA Field Team, Region VII
Room 13, Post Office Building
Knoxville 2, Tennessee

Re: Docket No. DMEA 2744 -
Manganese and Cobalt
L. W. King et al.
The J. H. Artz land
Bradley and Hamilton Counties,
Tennessee

Dear Mr. Laurence:

For your information we are enclosing two copies of a reply to our letter of October 23, 1953, from Clarence A. Fredell, Acting Chief, Expansion Branch, Materials Division, Emergency Procurement Service, General Services Administration.

Sincerely yours,

George C. Selfridge
Chairman, Operating Committee

Enclosure

APPROVED:

J. H. Hedges
Member, Bureau of Mines

A. R. Kinkel, Jr.
Member, Geological Survey

cc: DOCKET
FT, REG. VII
CODE 400
OPER. COMM.
ADM. READ. FILE
LOUIS PAVLIDES, USGS
GILBERT DE HUFF, USBM

FARutledge/ls
11/3/53

R.C.S.
11-5-53

Docket

RECEIVED

GENERAL SERVICES ADMINISTRATION

Emergency Procurement Service
Washington 25, D. C.

October 28, 1953

In Reply Refer To: EDE

WSM

Mr. Frank E. Johnson
Acting Administrator
Defense Minerals Exploration
Administration
Department of the Interior
Washington 25, D. C.

Re: Docket No. DMEA 2744
King, Scott & King

Dear Mr. Johnson:

Reference is made to your letter of October 23, 1953, addressed to Mr. Irving Gumbel, Director, Materials Division, requesting a copy of the field report on this application.

In connection with the determination of the economic treatment of the mineral, the field investigation is being conducted by the Minerals and Metals Advisory Board of the National Academy of Sciences. When their recommendations of this entity are made to this Agency, we shall be glad to pass them on to you for your consideration.

Very truly yours,

Clarence A. Fredell

Clarence A. Fredell
Acting Chief
Expansion Branch

FILE COPY
SURNAME:

400
Rutledge
Martin

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

OCT 23 1953

Mr. Irving Gumbel, Director
Materials Division
Emergency Procurement Service
General Services Administration
Washington 25, D. C.

Re: Docket No. DMEA 2744 - Manganese
and Cobalt
L. W. King et al.
The J. H. Artz land
Bradley and Hamilton Counties, Tenn.

Dear Mr. Gumbel:

Reference is made to the subject application for exploration assistance from Mr. King who previously completed an exploration project on the same property under Contract No. Idm-E83, Docket No. DMA 176X.

We were aware that Mr. King also had a related production application on file with the Defense Materials Procurement Administration, now the Materials Division, Emergency Procurement Service, General Services Administration, and we have been holding the referenced exploration application in abeyance until it could be determined whether the "ore" might be economically treated.

It has recently been called to our attention that GSA has requested a field examination. Therefore, when your field report has been completed, it would be appreciated if you would furnish us with copies for our consideration.

Sincerely yours,

Frank E. Johnson (fw)

ACTING Administrator

FARutledge:foc
10-23-53
cc: Docket
Code 400
RT. REG. 7
Admr. Reading File
Operating Comm.
H. W. Davis, USBM
Phillip Guild, USGS

R.C.B. 10-23-53

IN REPLY REFER

G-MO-CF

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

October 28, 1952

Memorandum

To: George C. Selfridge

From: T. P. Thayer

Subject: DMSA 2744 - Cobalt-manganese
L. W. King
470 E. State St.
Salem, O.
Arts Mountain deposits, Tennessee

Dr. King proposes to spend $25,000 more exploring the cobaltiferous manganese deposits which were partly explored by DMA Project 176. The Field Team estimated reserves of 557,000 short tons of material containing 1,790,800 lbs. of cobalt, or averaging 0.16 percent cobalt metal. Later, Bureau of Mines check assays and applicants recheck showed the original assays were somewhere between 50 percent and 250 percent too high. If the original assays are discounted by half, the "reserve" of contained metal drops to about 900,000 lbs. or .08 percent.

The Bureau of Mines assays show a definite correlation between Mn and Co in samples. The ratio of Mn:Co in the 20 check samples ranges from 7:1 to 115:1, probably averaging about 40:1. If it were possible to produce a concentrate averaging 20 percent Mn, which seems doubtful by ordinary methods, it would average only about 0.5% Co or one pound per ton, if all the cobalt is in the manganese oxides. Samples of "the one high-grade pocket" showed no ore above 25 percent Mn, and a sample from a small wad deposit assayed 31.1 percent Mn and 0.51 percent Co. One pound of cobalt metal per ton, at $2.50 per pound, would allow only $2.50 for recovery by chemical methods, assuming that the manganese would carry mining and milling costs. The economics of recovering either the manganese or cobalt seem to be far from known, and extremely doubtful.

Two of the criteria for DMSA exploration projects are the availability of a feasible method of treatment, and probability of a significant contribution to the national supply. In this case the general grade of material likely to be found has been demonstrated, and the cobalt content is very low. The Geological Survey sees no point in seeking more material until a method of recovery has been developed.

Action recommended:

Deny the application on the grounds that metallurgical problems should be solved before more money is spent on exploration.

T. P. Thayer

TPThayer:gt

Copies to: Dir's reading file-4212
Branch reading file
N.B.Melcher - Int. 3513
Hugh Davis - Int. 3519

IN REPLY REFER TO:

G-MD-CF

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

October 28, 1952

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Hold.
Thayer writing later memo to replace this one.

Dr. L. W. King has come forth with a new proposition. DMPA now investigating. Brussolo says should have a decision in two more weeks.
9-10-53
J.A.R.

10-20-53
Examination by GSA, scheduled to check on process + commitment.

2/5/53

Mr. Martin:
Apparently Mr. Thayer did not write the revised memo as promised last fall. How much longer should this case be held pending - or is there some action brewing on it via personal contacts of Mr. King with this office or DMPA?

ls

Talked to GCS about this - He says wait till we hear from DMPA - Please bring it around again about March 1
WSM

Brussolo, DMPA, reports case still pending.
Southwestern Engineering Company reports Testing to improve grade of ore for DMPA.
Feasibility still questionable -
DMPA doubts if process feasible - will advise DMEA when decision made
Continue Holding
5-11-53

From Brussolo 7/29/5

Co-Ni-Mn
Process works in Lab but is not feasible - Beneficiation tests in progress because process might work on a richer material
South Western making tests

IN REPLY REFER TO:

G-MD-CF

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

October 28, 1952

Memorandum

To: George C. Selfridge

From: T. P. Thayer Thayer

Subject: DMEA 2744 - Cobalt-manganese
L. W. King
470 E. State St.
Salem, O.
Artz Mountain deposits, Tennessee

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Copy retained 400
George C. Selfridge

U.S. G.S.
Recommendations
for
Denial
T. P. Thayer
10/28/52

Action recommended:

Deny the application on the grounds that metallurgical problems should be solved before more money is spent on exploration.

T. P. Thayer

T. P. Thayer

400

COPY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON 25, D. C.

October 17, 1952

2744

Mr. C. O. Mittendorf
Administrator, D.M.E.A.
General Services Building
Washington 25, D. C.

Re: Docket No. DMA-176X -
Manganese-Cobalt-Nickel
The J. H. Artz land
Bradley and Hamilton Counties,
Tennessee. Contract Idm-E-83

Dear Mr. Mittendorf:

Responding to your letter of October 15, 1952, on the extractive process proposed by Dr. L. W. King for treatment in a pilot plant of 10 tons daily of ore from the J. H. Artz land in Tennessee. I have read the material and comment as follows:

1. The chemistry of his proposed process appears sound, and, although I do not expect his separation between nickel and cobalt to be clean, there is a market for a considerable amount of mixed nickel and cobalt in the permanent magnet industry. King has used as reducing furnace for converting manganese to acid-soluble MnO, a design he found at work in a Baltimore plant making manganese chloride as a commercial product. He is also copying the dissolution in hydrochloric acid, which he proposed to make from salt and sulphuric acid by well-known methods. His precipitation of cobalt and nickel as sulphide by hydrogen sulphides is also something that is well known. Precipitation of manganese carbonate and calcination of MnO_2 is also well known and has produced MnO_2 of battery grade by the steps he describes.

2. As to whether Dr. King can be rated as a competent operator, I have some doubt. I know of no competent operators in his employ. His presentation has been that of an amateur.

3. Construction costs give details of first cost of equipment, but appear not to provide for erection and housing. I have tried to extend his operating costs to a larger plant, but find few economies that would result with larger tonnage. Also, he has not calculated operating capital needed. I therefore am at a loss to check his figures on amortization and interest.

4. Dr. King's early operation will be based on loading of selected material without concentration. Whether he knows how to concentrate his lean ore I do not know. From his description of the undeveloped area it would appear that more trenches might well turn up much more ore, but he stated to me that you had called a halt on exploration until you knew more about what he could do with the ore he has already uncovered.

5. This deposit appears to have more cobaltiferous manganese than in the usual southern deposits, and I would like to see it in more competent hands and given a better examination. It could provide a plant to which the small lots of ore from elsewhere could be shipped. The nickel content is small in terms of national needs, but acceptable for what it is worth. The market for battery grade manganese ore is small, but not too small to take the output from this operation if Dr. King can show that he can make an acceptable product.

Sincerely yours,

/s/ O. C. Ralston

O. C. Ralston
Chief Metallurgist

cc: Mr. Paul Zinner
Mr. E. B. Melcher
Extra copy to Mr. Mittendorf

Data on cobalt-bearing manganese deposits

Source: U.S.G.S. Bull. 940-J, Cobalt-bearing manganese deposits of Alabama, Georgia, and Tennessee. by W. G. Pierce, pp. 265-285, 1944.

That the Appalachian manganese ores contained a small amount of cobalt has been known since 1905.

Cobalt-bearing manganese oxide is commonly associated with some variety of siliceous rock and occurs as incrustations and fracture fillings, and some of it partly replaces quartz. The stratified rocks known to contain cobaltiferous manganese deposits range in age from Carboniferous to Lower Cambrian and perhaps pre-Cambrian. The more important deposits are in the Weisner quartzite, in the residual clay of the Shady dolomite, in the Knox dolomite, and the Fort Payne chert. Other deposits occur in the Talladega slate, in the Rome formation, in the residual clay of the Tonoloway limestone, and in the Floyd shale.

Cobalt-bearing manganese oxide also occurs as pellets in colluvium, which is commonly a red clay.

101 manganese mines and prospects were appraised by the U.S.G.S. on their cobalt possibilities. Of these only a few contained appreciable quantities of cobalt. An estimate of 7,900 tons of manganese ores containing 0.75 to 1.5 percent Co is given (165,000 lb. cobalt). Other deposits in which the manganese ores contain 0.2 to 0.3 percent cobalt might supply 25,000 lbs

of manganese oxides containing about 140,000 pounds of cobalt.

Of the 101 prospects, 50 were in Alabama, 25 in Georgia, 14 in Tennessee, 6 in Virginia, 4 in North Carolina, and 2 in South Carolina.

STANDARD FORM NO. 64

Docket

Office Memorandum • UNITED STATES GOVERNMENT

TO : Mr. C. O. Mittendorf, Administrator, DMEA DATE: October 31, 1952

FROM : Iron and Ferro-Alloy Division, DMEA

SUBJECT: Metallurgy
Dockets Nos. 176 and 2744 (Cobalt-Nickel-Manganese)
Dr. L. W. King, et al.
The J. H. Artz land
Bradley and Hamilton Counties, Tennessee

The writer met with Mr. O. C. Ralston, Chief Metallurgist of the Bureau of Mines, and Messrs. Mann and Brussolo of DMPA, on the morning of October 30 to discuss the metallurgical problems set forth in our letter of October 15 to Mr. Ralston, copies of which were sent to Mr. Howard Young on the same date.

After discussion of the entire matter for some time it was learned that the Signal Corp was buying part of the manganese production of a subsidized 1-ton chemical plant at 20 cents a pound for batteries. This compares to 5 cents a pound for African ore. Industry is also buying part of the product. The plant is being enlarged to 10 tons and uses from 10 to 30 percent crude ore. Other projected manganese chemical plants were also mentioned.

With regard to King's process, it appears feasible. There is a market for a mixed nickel-cobalt product. The iron and manganese can be separated, the iron precipitating at a Ph of 4. The magnesium content is not known and should be a minimum as it comes down with the $MnCO_3$. The amount of acid is O.K.

Mr. Ralston spoke of other smaller but richer cobalt-manganese deposits that might ship to such a plant. The U. S. Geological Survey has a list. DMPA made tentative arrangements to have a small representative lot beneficiated by the Bureau of Mines at Tuscaloosa to learn if a richer feed could be obtained for the chemical plant.

Our problem regarding further exploration was explained. Mr. Mann's office is studying the matter of the proposed chemical plant. If the grade of the "ore" promises possible economic feasibility (possibly with subsidies), the DMPA will so advise us. If its report is favorable, it will then be up to DMEA to provide for further exploration to increase the now indicated tonnage to a figure sufficiently large to warrant the proposed plant.

G. C. Selfridge.

G. C. Selfridge, Chief
Iron and Ferro-Alloy Division

1 copy in DMPA 176

October 24, 1952

Doctor L. W. King
470 E. State Street
Salem, Ohio

Subject: DMEA-2744
Re: Exploration Assistance

My dear Doctor King:

The receipt of your application dated October 22, 1952 for exploration assistance under the Defense Production Act of 1950, as amended, is hereby acknowledged.

Your application has been assigned Docket Number DMEA-2744 and referred to the Iron and Ferro-Alloy Division.

Kindly refer to DMEA-2744 in any future correspondence relating to your application.

Sincerely yours,

R. E. ADAMS

Robert E. Adams
Chief, Operation Control
and Statistics Division

25451

Idaho —
Docket in
New Application

MF-103
(Revised April 1952)

UNITED STATES DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION

Form Approved.
Budget Bureau No. 42-R1035.2.

APPLICATION FOR AID IN AN EXPLORATION PROJECT, PURSUANT TO DMEA ORDER 1, UNDER THE DEFENSE PRODUCTION ACT OF 1950, AS AMENDED

Not to be filled in by applicant

Docket No. dmea 2744
Metal or Mineral
Date Received 10-23-52
Estimated Cost
Participation (Government %)

INSTRUCTIONS

1. *Name of applicant.*—(*a*) State here your full legal name, in the form in which you will wish to contract, and your mailing address: L. W. King, M. D.
470 E. State Street
Salem, Ohio.
A partnership. Partners: Cecil K. Scott, Lowell R. King - Address as above.

(*b*) If other than an individual, add to your name above whether a corporation, partnership, etc., and the name of the State in which incorporated or otherwise organized.

(*c*) If a corporation, add to above statement, titles, names and addresses of officers.

(*d*) If a partnership, add to the above statement the names and addresses of all partners.

2. *General.*—Read DMEA Order 1, "Government Aid in Defense Exploration Projects," before completing this application. Submit this application and all accompanying papers in quadruplicate (four copies), with your name and address on each sheet of the application and on all accompanying papers. Where sufficient space is not provided on the form for all required information, state it on an accompanying paper, with a reference in each case to the instruction to which it refers by number. Comply with all applicable instructions; or, if not applicable, so state. File the application with Defense Minerals Exploration Administration, Department of the Interior, Washington 25, D. C., or with the nearest field executive officer thereof.

3. *Applicant's property rights.*—(*a*) State the legal description of the land upon which you wish to explore, including all land which you possess or control that may be benefited by the exploration, and excluding any land or interest in land which is not to be included in the exploration project contract Previously and completely stated. See Docket DMA 176.

(*b*) State any mine name by which the property is known. None

(*c*) State your interest in the land, whether owner, lessee, purchaser under contract, or otherwise Lessee

(*d*) If you are not the owner, submit with this application a copy of the lease, contract, or other document under which you control the property. See Docket DMA 176.

(*e*) If you own the land, describe any liens or encumbrances on it Not applicable

(*f*) If the land consists of unpatented claims, add to the description above, the book and page numbers for each recorded location notice. None

4. *Physical description.*—(*a*) Describe in detail any mining or exploration operations which have been or now are being conducted upon the land, including existing mine workings and production facilities. State your interest, if any, in such operations. Also describe accessibility of mine workings for examination purposes. See DMA Docket 176

(*b*) State past and current production, and ore reserves, if any, giving quantities and grades. Above.

(*c*) Describe the geologic features of the property, including mineralization, type of deposit (vein, bedded, etc.), and your reasons for wishing to explore. Illustrate with maps or sketches. Send with your application (but not necessarily as a part of it) any geologic or engineering report, assay maps, or other technologic information you may have, indicating on each whether you require its return to you.

(*d*) State the facts with respect to the accessibility of the project: Access roads, distances to shipping, supply and residence points.

(*e*) State the availability of manpower, materials, supplies, equipment, water, and power. Above.

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
OCT 23 1952

16—66551-1

5. *The exploration project* (*a*) State the mineral or minerals for which you wish to explore Cobalt, Nickel, Manganese.

(*b*) Describe fully the proposed work, including a map or sketch of the property showing a plan (and cross sections if needed) of any present mine workings, and the location of the proposed exploration work as related to such features as contacts, veins, ore-bearing beds, etc. See DMA Docket 176

(*c*) The work will start within 30 days and be completed within Four months from the date of an exploration project contract.

(*d*) State the operating experience and background of the applicant with relation to the ability to carry out such exploration project, and also that of the person or persons who will supervise the operations. Previous exploration project Contract DMA 176. Personnel unchanged.

6. *Estimate of costs.*—Furnish a detailed estimate of the costs of the proposed work (you will have to use a separate sheet), under the following headings. Add the totals under all headings to give the estimated total cost of the project:

(*a*) *Independent contracts.*—(Note.—If the applicant does not intend to let any of the work to contractors, write "none" after this item. To the extent that the work is to be contracted, do not repeat the cost of the contract-work in subsequent items.) State the cost of any proposed independent contracts for the performance of all or any part of the work, expressed in terms of units of work (such as per foot of drilling, per foot of drifting, per hour of bulldozer operations, per cubic yard of material moved, etc.).

(*b*) *Labor, supervision, consultants.*—Include an itemized schedule of numbers, classes and rates of wages, salaries or fees for necessary labor, supervision and engineering and geological consultants.

(*c*) *Operating materials and supplies.*—Furnish an itemized list, including items of equipment costing less than $50 each, and power, water and fuel.

(*d*) *Operating equipment.*—Furnish an itemized list of any operating equipment to be rented, purchased, or which is owned and will be furnished by the Operator, with the estimated rental, purchase price, or suggested use-allowance based on present value, as the case may be.

(*e*) *Rehabilitation and repairs.*—Furnish a detailed list showing the cost of any necessary initial rehabilitation or repairs of existing buildings, installations, fixtures, and movable operating equipment, now owned by the Operator and which will be devoted to the exploration project.

(*f*) *New buildings, improvements, installations.*—Furnish a detailed list showing the cost of any necessary buildings, fixed improvements, or installations to be purchased, installed or constructed for the benefit of the exploration project.

(*g*) *Miscellaneous.*—Furnish a detailed list showing the cost of repairs to and maintenance of operating equipment (not including initial rehabilitation or repairs of the Operator's equipment), analytical work, accounting, workmen's compensation and employers' liability insurance, and payroll taxes.

(*h*) *Contingencies.*—Give an estimate of any necessary allowances for contingencies not included in the costs stated above. None

NOTE.—No items of general overhead, corporate management, interest, taxes (other than payroll and sales taxes), or any other indirect costs, or work performed or costs incurred before the date of the contract, should be included in the estimate of costs.

7. (*a*) Are you prepared to furnish your share of the cost of the proposed project in accordance with the regulations on Government participation (Sec. 7, DMEA No. 1)? Yes

(*b*) How do you propose to furnish your share of the costs?

[X] Money [X] Use of equipment owned by you [X] Other

Explain in detail on acompanying paper.

CERTIFICATION

The undersigned, whether as an individual, corporate officer, partner, or otherwise, both in his own behalf and acting for the applicant, certifies that the information set forth in this form and accompanying papers is correct and complete, to the best of his knowledge and belief.

Dated October 22, 1952.

(Applicant)

By

Title 18, U. S. Code (Crimes), Section 1001, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U. S. GOVERNMENT PRINTING OFFICE 16—66551-1

L. W. King, M.D.
470 E. State St.
Salem, Ohio.

(To accompany MF-103)

5(b) Proposed work: Purpose of this project is to extend the previous work described in DMA Docket 176 which indicated that ore of commercial grade might exist on the property. This project is to establish definitely that ore does exist on the property, that the ore occurs in more than one area, and also, by trenching methods described in DMA 176, would establish a tonnage measurement of over 1,000,000 tons material.

Maps, sketches of the property, location of the project are shown in Docket DMA 176.

This project would consist of trenching to an aggregate depth of 18 feet and 3 feet wide, to a total lineal length of 5000 feet. Individual trenches to average 300 feet in length to be placed at any location on the property in order to explore for ore between the two areas described "North" and "Middle" on maps in Docket DMA 176.

6. Estimate of Costs:

(a) No work is to be let under contract.

(b) Labor is included in rental of equipment. This includes workmen's compensation, liability insurance. One laborer to drill shot holes, load, and shoot dynamite, maintain air compressor; includes wages, transportation to project and workman's compensation. $1.75 hr.
Supervision: One general supervisor.....$800.00

(c) Operating materials: Dril steel, rock bits, dynamite caps, lead wire, battery box, fuel for air compressor..... 500.00

(d) Operating Equipment:

1. One TD 14 International Tractor with bull dozing blade; operator, oiler, fuel, lubrication, maintenance to be rented for total of $12.00 per hour.

2. One 1/2 yard Insley Deisel powered shovel with 1/2 yard back hoe attachment; operator, oiler, fuel lubrication, and maintenance to be rented at $12.00 per hour.

3. One Ingersol-Rand 105 Air compressor, 85 Jack Hammer, $125.00 per month.

4. One four-wheel drive Universal Willys Jeep $100 per month. Owned by operator. Includes fuel, oil, insurance.

(e) Rehabilitation of existing 10' x 14' building for the storage of dynamite and caps, drill steel and rock bits, air hose, fuel, oil, repair parts, maps, etc.....150.00

Rehabilitation of existing access roads within the property...120.00

CONCLUSION: The total 5000 lineal feet of trenching can be accomplished at a total cost of $5.00 per lineal foot which includes all equipment, personnel, materials, etc. Thus the entire project is estimated not to cost over $25,000.00.

MF-203

OWNER'S CONSENT TO LIEN

WHEREAS, the undersigned, as owner, co-owner, lessor, or seller has an interest in certain property in the State of TENNESSEE, County of BRADLEY-HAMILTON, described as follows:1/

SEE DOCKET DMA 176

which is the subject of a proposed exploration project contract, hereinafter called the "contract", between the United States of America, hereinafter called the "Government", and

2/ L.W. KING, M.D.; CECIL K. SCOTT, and LOWELL R. KING, a partnership

hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said contract which are set forth on the reverse side hereof, the Government is entitled to a percentage royalty on production and to certain other rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said contract and as an inducement to the Government to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to dismantle, sever, take possession of, and remove and dispose of facilities, buildings, fixtures, equipment, or other items as provided in the contract, or any amendment thereof, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned, and the Government is authorized to enter upon the land for such purposes.

2. To secure the payment to the Government of the percentage royalty on production3/ provided for under the terms of said exploration project contract, or any amendment thereof which does not increase the maximum amount of the Government's claim here stated or alter the provisions for repayment, there is hereby granted to the Government a lien upon the land herein described and upon any production of minerals therefrom, until the royalty claim is fully paid in the amount of the Government's contribution, not in excess of 4/$ 25,000, or ten years have elapsed from the date of the contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of said contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

Dated this 22nd day of October, 195 2.

L. Lynn Higginbotham [Seal]

Pauline Higginbotham [Seal]

[Seal]

interest

1/ Either (a) insert the legal description of the land, or (b) strike out the words "as follows" and insert "in a lease [or contract, deed, or other document] dated _____, and recorded in book _____ page _____ official records of said county." If (b) is used, the book and page of recordation cannot be dispensed with. If the space provided is insufficient, use an Annex, and refer to the Annex in the space.

2/ Insert the name of the Operator as it will appear in the exploration project contract.

3/ Mining or production from the land is not required, and in the absence of production there is no obligation to repay the Government.

4/ Insert the maximum amount of the Government's contribution.

RELEVANT CONTRACT PROVISIONS

Repayment by Operator. (a) If, at any time, the Government considers that a discovery or a development from which production may be made has resulted from the exploration work, the Government, at any time not later than six months after the Operator has rendered the required final report and final account, may so certify in writing to the Operator. The certification shall describe broadly or indicate the nature of the discovery or development. In the event of such certification, any minerals mined or produced from the land described in Article 2 within 10 years from the date of this contract, including any mined or produced before the certification, shall be subject to a percentage royalty which the Operator or his successor in interest shall pay to the Government, upon the net smelter returns, the net concentrator returns, or other net amounts realized from the sale or other disposition of any such production, in whatever form disposed of, including ore, concentrates, or metal, until the total amount contributed by the Government, without interest, is fully repaid, or said 10 years have elapsed, whichever occurs first, as follows:

(1) One and one-half (1½) per cent of any such net amounts not in excess of eight dollars ($8.00) per ton.

(2) One and one-half (1½) per cent of any such net amounts, plus one-half (½) per cent such net amounts for each additional full fifty cents ($0.50) by which such net amounts exceed eight dollars ($8.00) per ton, but not in excess of five (5) per cent of such net amounts.

(For instance: the percentage royalty on a net amount of five dollars ($5.00) per ton, would be one and one-half (1½) per cent; on a net amount of ten dollars ($10.00) per ton, three and one-half (3½) per cent.)

(b) As here used, "net smelter returns", "net concentrator returns", and "other net amounts realized from the sale or other disposition", mean gross revenue from sales; or if not sold, the market value, the market value of the material after it is mined in the form in which and the place where it is held. In the case of integrated operations in which the material is not disposed of as such, these terms mean what is or would be gross income from mining operations for percentage depletion purposes in income tax determination.

(c) To secure the payment of its percentage royalty, the Government shall have and is hereby granted a lien upon the land described in Article 2 and upon any production of minerals therefrom, until the royalty claim is extinguished by lapse of time or is fully paid.

(d) This article is not to be construed as imposing any obligation on the Operator or the Operator's successor in interest to engage in any mining or production operations.

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50.00 each, paid for or purchased with funds contributed jointly by the Operator and the Government, although title may be taken in the name of the Operator, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the completion of the work or the termination of the contract shall be disposed of promptly by the Operator for the joint account of the Government and the Operator, either by return to the vendor, by sale to others, or purchase by the Operator at a price at least as high as could otherwise be obtained, as may appear to be for the best interest of the Government, unless the Government, in writing, waives its interest in any such item. If necessary to accomplish such disposition, the Operator shall dismantle, sever from the land, and remove any such item, the cost thereof to be for the joint account of the parties in proportion to their respective interests. If the Operator, within 90 days after the receipt of written notice from the Government, fails, neglects, or refuses to dispose of such property, the Government may itself enter upon the land, take possession of, and remove and dispose of any such property as above provided.

MF-203

OWNER'S CONSENT TO LIEN

WHEREAS, the undersigned, as owner, co-owner, lessor, or seller has an interest in certain property in the State of TENNESSEE, County of BRADLEY - HAMILTON, described as follows:1/

SEE DOCKET DMA 176

which is the subject of a proposed exploration project contract, hereinafter called the "contract", between the United States of America, hereinafter called the "Government", and

2/ L.W. KING, M.D.; CECIL K. SCOTT, and LOWELL R. KING, A PARTNERSHIP

hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said contract which are set forth on the reverse side hereof, the Government is entitled to a percentage royalty on production and to certain other rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said contract and as an inducement to the Government to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to dismantle, sever, take possession of, and remove and dispose of facilities, buildings, fixtures, equipment, or other items as provided in the contract, or any amendment thereof, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned, and the Government is authorized to enter upon the land for such purposes.

2. To secure the payment to the Government of the percentage royalty on production3/ provided for under the terms of said exploration project contract, or any amendment thereof which does not increase the maximum amount of the Government's claim here stated or alter the provisions for repayment, there is hereby granted to the Government a lien upon the land herein described and upon any production of minerals therefrom, until the royalty claim is fully paid in the amount of the Government's contribution, not in excess of 4/$ 25,000, or ten years have elapsed from the date of the contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of said contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

Dated this 22nd day of October, 195 2.

Pauline Hyeringer [Seal]

Pauline Hyeringer [Seal]

[Seal]

1/ Either (a) insert the legal description of the land, or (b) strike out the words "as follows" and insert "in a lease [or contract, deed, or other document] dated _____, and recorded in book _____ page _____ official records of said county." If (b) is used, the book and page of recordation cannot be dispensed with. If the space provided is insufficient, use an Annex, and refer to the Annex in the space.

2/ Insert the name of the Operator as it will appear in the exploration project contract.

3/ Mining or production from the land is not required, and in the absence of production there is no obligation to repay the Government.

4/ Insert the maximum amount of the Government's contribution.

RELEVANT CONTRACT PROVISIONS

Repayment by Operator. (a) If, at any time, the Government considers that a discovery or a development from which production may be made has resulted from the exploration work, the Government, at any time not later than six months after the Operator has rendered the required final report and final account, may so certify in writing to the Operator. The certification shall describe broadly or indicate the nature of the discovery or development. In the event of such certification, any minerals mined or produced from the land described in Article 2 within 10 years from the date of this contract, including any mined or produced before the certification, shall be subject to a percentage royalty which the Operator or his successor in interest shall pay to the Government, upon the net smelter returns, the net concentrator returns, or other net amounts realized from the sale or other disposition of any such production, in whatever form disposed of, including ore, concentrates, or metal, until the total amount contributed by the Government, without interest, is fully repaid, or said 10 years have elapsed, whichever occurs first, as follows:

(1) One and one-half (1½) per cent of any such net amounts not in excess of eight dollars ($8.00) per ton.

(2) One and one-half (1½) per cent of any such net amounts, plus one-half (½) per cent such net amounts for each additional full fifty cents ($0.50) by which such net amounts exceed eight dollars ($8.00) per ton, but not in excess of five (5) per cent of such net amounts.

(For instance: the percentage royalty on a net amount of five dollars ($5.00) per ton, would be one and one-half (1½) per cent; on a net amount of ten dollars ($10.00) per ton, three and one-half (3½) per cent.)

(b) As here used, "net smelter returns", "net concentrator returns", and "other net amounts realized from the sale or other disposition", mean gross revenue from sales; or if not sold, the market value, the market value of the material after it is mined in the form in which and the place where it is held. In the case of integrated operations in which the material is not disposed of as such, these terms mean what is or would be gross income from mining operations for percentage depletion purposes in income tax determination.

(c) To secure the payment of its percentage royalty, the Government shall have and is hereby granted a lien upon the land described in Article 2 and upon any production of minerals therefrom, until the royalty claim is extinguished by lapse of time or is fully paid.

(d) This article is not to be construed as imposing any obligation on the Operator or the Operator's successor in interest to engage in any mining or production operations.

Title to and disposition of property. All facilities, buildings, fixtures, equipment, or other items costing more than $50.00 each, paid for or purchased with funds contributed jointly by the Operator and the Government, although title may be taken in the name of the Operator, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the completion of the work or the termination of the contract shall be disposed of promptly by the Operator for the joint account of the Government and the Operator, either by return to the vendor, by sale to others, or purchase by the Operator at a price at least as high as could otherwise be obtained, as may appear to be for the best interest of the Government, unless the Government, in writing, waives its interest in any such item. If necessary to accomplish such disposition, the Operator shall dismantle, sever from the land, and remove any such item, the cost thereof to be for the joint account of the parties in proportion to their respective interests. If the Operator, within 90 days after the receipt of written notice from the Government, fails, neglects, or refuses to dispose of such property, the Government may itself enter upon the land, take possession of, and remove and dispose of any such property as above provided.

MF-203

OWNER'S CONSENT TO LIEN

WHEREAS, the undersigned, as owner, co-owner, lessor, or seller has an interest in certain property in the State of TENNESSEE, County of BRADLEY-HAMILTON, described as follows:1/

SEE POCKET DMA 176

which is the subject of a proposed exploration project contract, hereinafter called the "contract", between the United States of America, hereinafter called the "Government", and

2/ L.W. KING, M.D.; CECIL K. SCOTT, and LOWELL R. KING, A PARTNERSHIP

hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said contract which are set forth on the reverse side hereof, the Government is entitled to a percentage royalty on production and to certain other rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said contract and as an inducement to the Government to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to dismantle, sever, take possession of, and remove and dispose of facilities, buildings, fixtures, equipment, or other items as provided in the contract, or any amendment thereof, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned, and the Government is authorized to enter upon the land for such purposes.

2. To secure the payment to the Government of the percentage royalty on production3/ provided for under the terms of said exploration project contract, or any amendment thereof which does not increase the maximum amount of the Government's claim here stated or alter the provisions for repayment, there is hereby granted to the Government a lien upon the land herein described and upon any production of minerals therefrom, until the royalty claim is fully paid in the amount of the Government's contribution, not in excess of 4/$ 25,000, or ten years have elapsed from the date of the contract.

3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of said contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

Dated this 22nd day of October, 195 2.

Edgar Kyzinger [Seal]

Pauline Kyzinger [Seal]

[Seal]

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(1) One and one-half (1½) per cent of any such net amounts not in excess of eight dollars ($8.00) per ton.

(2) One and one-half (1½) per cent of any such net amounts, plus one-half (½) per cent such net amounts for each additional full fifty cents ($0.50) by which such net amounts exceed eight dollars ($8.00) per ton, but not in excess of five (5) per cent of such net amounts.

(For instance: the percentage royalty on a net amount of five dollars ($5.00) per ton, would be one and one-half (1½) per cent; on a net amount of ten dollars ($10.00) per ton, three and one-half (3½) per cent.)

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MF-203

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SEE DOCKET DMA 176

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Dated this 22nd day of October, 1952.

Edgar F. Hyninger [Seal]

Pauline Hyninger [Seal]

[Seal]

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