CABLE ADDRESS: NEWLANDIN

THE NEW ENGLAND INDUSTRIES, INC.
120 WALL STREET
NEW YORK 5, N. Y.
WHITEHALL 3-1600

Dmea-2773

IN REPLY REFER TO:

November 6th, 1952

United States Department of the Interior
Defense Minerals Exploration Administration
Washington 25, D. C.

Gentlemen:

Enclosed please find application in quadruplicate of a DMEA project for the recovery of substantial quantities of columbite, tantalite, tin, mica, etc., and in order to further clarify this application, a even more detailed report is already in the hands of Mr. Mittendorf.

The application is made in the name of the New England Industries, Inc., and it will be noted that our lease states that New England Industries is the parent corporation of the Lincoln Mining Corporation, a wholly owned subsidiary. All payments with regard to this property, its up-keep, taxes, etc., have been omitted from all calculations and will be taken care of one hundred percent by our corporation without any Government assistance being requested. The lease is a 99-year lease with an option to buy.

Our original folder contains the original U.S. Geological Survey Bulletin 936J, which fully describes the property, and Plate 41 which shows the improvements on the property, fully proven ore bodies, drill holes, dykes, shafts, etc., etc.- Unfortunately we were unable to procure additional copies and therefore can only submit a copy drawing of this map with this folder.

Regarding additional improvements on the property, description of which is contained in our lease and drawn into our maps, the extent of the piece of realestate is of approximately 1000 acres. Our original folder with Mr. Mittendorf again contains photographs taken by the undersigned within the last few weeks, showing improved roads, buildings, fully timbered shafts, power stations, headframes, and list transformers, motors, hoist, incline shafts, drill holes, etc., also a great number of experimental pits which have been dug in the past.

-Over-

A great deal of additional material is contained in the original folder, referring to our application for the erection of a plant and all preliminary work has already been done, such as test work, calculation for installation, flow-sheets, etc. - At this particular point such information would only be of secondary importance in conjunction with the RFCA loan and has therefore been omitted.

Very sincerely yours,

THE NEW ENGLAND INDUSTRIES, INC.

Howard S. Strouth

HSS/lew
Encls.

MF-103
(Revised April 1952)

UNITED STATES DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION

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

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
NOV 12 1952

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-2772
Metal or Mineral
Date Received 11-12-52
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: Lincoln Mining Corporation -- See Attachment

(*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

(*b*) State any mine name by which the property is known.

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

(*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.

(*e*) If you own the land, describe any liens or encumbrances on it

(*f*) If the land consists of unpatented claims, add to the description above, the book and page numbers for each recorded location notice.

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.

(*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.

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

5. *The exploration project.*—(*a*) State the mineral or minerals for which you wish to explore .....

(*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.

(*c*) The work will start within ..... days and be completed within ..... 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.

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 [ ] Use of equipment owned by you [ ] 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 November 6th, 1952

Lincoln Mining Corporation
(Applicant)

By Howard Steven Strouth, Executive Vice-President

120 Wall Street

New York 5, New York

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

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

1.— Lincoln Mining Corporation, Depositors' National Bank Building, Durham, North Carolina. — All correspondence to be addressed to our main office, 120 Wall Street, Room 2805, attention Mr. H. S. Strouth, Executive Vice-President.

2. - - -

3.— a) "SITUATE, lying and being in Lincolnton Township, Lincoln County, North Carolina, about two miles south of the Town of Lincolnton on both sides of U. S. Highway No. 321, and being that certain boundary of land known as the Tin Mine Property", being the identical boundary containing about 650 acres (about 240 acres in fee and the mineral rights on the remaining 410) acres, conveyed by A. L. Quickel, Trustee, to Lessor by deed dated September 4, 1937, and registered in Book 191 at Page 527 in the Lincoln County Public Registry, and being the identical boundary fully described in a deed of trust, now cancelled, dated April 18, 1932, from American Consolidated Tin Mine Corporation, to A.L. Quickel, Trustee, registered in Book 166 at Page 686 in Lincoln County, and also described in a deed from D. E. Rhyne to American Consolidated Tin Mine Corporation dated April 18, 1932, registered in Book 166 at Page 683 in Lincoln County, to all of which conveyances and descriptions specific reference is hereby made for a more particular description of the properties herein leased."

See Enclosed Lease Contract.

b) Ka-Mi-Tin Mine and American Consolidated Tin Mine.

c) 99-year lease with option to purchase.

d) Lease in quadruplicate.

4.— a) The property presently has two timbered shafts extending to the 90 ft. level with cross-cuts, an incline shaft extending 50 ft. at a 45° angle, drill holes - one extending to 1400 ft., approximately 18 exploration pits dug to various depths to 40 ft., various buildings, power lines, hoists, head assemblies, motors, pumps and other improvements, including a power installation capable of running a 250-ton mill with various transformers. The workings are fully accessible.

b.&c.)
Ore reserves, qualities and grade of ore are estimated up to two million tons with proven ore in excess of 500,000 tons, grades as per included assays, reports by Dr. Heron, report by H. S. Strouth, by Mr. St. Clair, and other references. Property fully described and mapped in Bulletin 936J.

d) Access roads as per enclosed photographs. Nearest railroad station 1 mile. Supply and residence points no problem because property is within 2 miles from Lincolnton, county seat of Lincoln County.

e) Sufficient man-power available; same applies to material, supplies, equipment, water and power, as previously stated.

5.— a) Tin, columbite, tantalite, lithium, beryllium, quartz, mica.

b) Maps as enclosed. - It is proposed that during the initial period, diamond drilling be done on the Jake dyke as per enclosed drawing and other preliminary work in accordance with attached statement.

c) Within 15 days the work can be started and a period no exceeding four months is considered necessary from the day of commencement of the work.

d) The applicant and its associate firms have successfully operated coal mines in the United States, with a production capacity of 10,000 tons of coal a day, ~~an~~ operating lead-zinc properties in Mexico and has operated at various times tungsten properties in Montana, manganese properties in Arkansas, uranium properties in Utah and Colorado and has managed all operations, which were conducted in miner-like manner and most of them are known to the Government. The work will be done under the supervision of Mr. William A. Wooten, mining engineer, and Dr. S. D. Heron, Jr., geologist, and other qualified engineers and geologists as may be required.

6.— Estimate of cost is enclosed.

7.— a) Yes.

b) In money.

October 10, 1952

KA-MI-TIN, NORTH CAROLINA * Estimate at Re-opening Mine for Lithium, Tin, Columbite, etc. Production.

STAGE 1. - Development Work

Road clearance and bulldozing to level and upgrade existing roads	$ 1,500.00
Diamond drilling at dyke 2, six drill holes to intercept 2 at 100 and 400 ft. levels and also intercept continuation of dyke 3 at corresponding levels. 45 degree angle at 100 ft. level - 1200 ft. at 400 ft. level - 2400 ft. at $3.00 per ft. Total 3600 ft.	10,800.00
Two crosscuts at swamp shafts 1 and 3 on dyke 3 40 ft. each, total 80 ft. crosscuts at $40.00 per ft. . .	3,200.00
Transport of drilling equipment	500.00
Retimbering and extension of shafts at dyke 3 at no. 1 shaft 40 ft. two-compartments at no. 3 shaft 20 ft. two-compartments Total 60 ft. at $140. per ft.	8,400.00
Timber	200.00
Weatherproofing of existing buildings to protect equipment and tools	300.00
Surfacr stripping at incline shaft on dyke 2 5000 cu. yds. at 40¢ per yd.	2,000.00
Reconditioning of existing hoist and power equipment . . .	1,000.00
Cable 1" 1000 ft. at 25¢ per ft.	250.00
Two small pumps with motors plus hose for dewatering . . . . shafts $500.00 ea.	1,000.00
3 days labor for dewatering	300.00
Handtools	100.00
Engineering	1,500.00
Assays, flowsheets, etc.	1,000.00
TOTAL	$32,050.00

NORTH CAROLINA

DURHAM COUNTY

THIS CONTRACT, AND AGREEMENT, Made and entered into this the 25th day of October, 1952, by and between:

KA-MI-TIN CONCENTRATING CORPORATION, hereinafter called "LESSOR",

and

LINCOLN MINING CORPORATION, hereinafter called "LESSEE",

W I T N E S S E T H:

That for and in consideration of the mutual promises and covenants, the parties do hereby covenant, promise, agree and declare on behalf of themselves, their successors and assigns:

1. LESSOR hereby grants unto LESSEE an option for the period of six (6) months from the date hereof to lease that certain mine located and situate in Lincoln County, North Carolina, more fully described as follows, to wit:

SITUATE, lying and being in Lincolnton Township, Lincoln County, North Carolina, about two miles south of the Town of Lincolnton on both sides of U. S. Highway No. 321, and being that certain boundary of land known as the "Tin Mine Property", being the identical boundary containing about 650 acres (about 240 acres in fee and the mineral rights on the remaining 410) acres, conveyed by A. L. Quickel, Trustee, to LESSOR by deed dated September 4, 1937, and registered in Book 191 at Page 527 in the Lincoln County Public Registry, and being the identical boundary fully described in a deed of trust, now cancelled, dated April 18, 1932, from American Consolidated Tin Mine Corporation, to A. L. Quickel, Trustee, registered in Book 166 at Page 686 in Lincoln County, and also described in a deed from D. E. Rhyne to American Consolidated Tin Mine Corporation dated April 18, 1932, registered in Book 166 at Page 683 in Lincoln County, to all of which conveyances and descriptions specific reference is hereby made for a more particular description of the properties herein leased.

2. During the term of said option, and as one of the considerations therefor, LESSEE agrees to pay to LESSOR the sum of FIVE HUNDRED ($500.00) DOLLARS per month, the first monthly payment being made in advance and

simultaneously with the execution of this contract, and each subsequent payment being due and payable on the 25th day of each month thereafter so long as LESSEE desires said option to continue. In the event that during said six-month option period the LESSEE should notify LESSOR that it no longer desires to continue said option, then upon payment of all monthly payments due up to the effective date of said notification, the parties shall be relieved of any and all further obligation from one to the other.

3. During said option period, LESSEE shall have the right to enter upon the aforementioned premises and to have its engineers, geologists, executives and workmen enter upon said premises for the purpose of making surveys, drillings, and taking samples, and to make whatever preparations are deemed necessary by LESSEE for the commencement of mining operations. Further, during said option period, LESSEE shall have the right to use all of the equipment presently located on the premises, all of the buildings, power, installations, machinery, timber, rights-of-way, access roads and all other improvements as more fully set forth in the attached schedule, and it is further understood and agreed by and between the parties that the monthly option payment of $500.00 shall include any and all rentals for said items. There is specifically excluded from the provisions of this paragraph three (3) Allis Chalmers motors which are individually owned by J. N. Brenizer and which are located upon the premises. LESSOR reserves the right for Mr. Brenizer to remove these motors from the premises at any time he so desires. The serial numbers of said motors are as follows: Gen. Elec. 30 H.P. No. 1508797, Allis Ch. 90 H.P. No. 172-18/46/17, Allis Chalmers 50 H.P. No. 20B5-25-4303-1

4. In the event LESSEE elects to exercise the option herein granted to enter into a lease for said premises along with all mineral rights thereto, it shall notify LESSOR in writing before the expiration of the said six-months period, and shall pay to LESSOR at the time of the exercise of its said option, the sum of SEVEN THOUSAND DOLLARS ($7,000.00), and upon such notification and payment the following lease between KA-MI-TIN CONCENTRATING

CORPORATION as LESSOR and LINCOLN MINING CORPORATION as LESSEE, on the aforementioned property, shall become effective upon the following terms and conditions:

A. This lease shall commence on the date of the exercise of the option above referred to and the payment of $7,000.00 by LESSEE to LESSOR, and shall continue for a period of ten (10) years from said date provided LESSEE performs and complies with all of the covenants and agreements set forth herein on its part to be performed and complied with.

B. As rent and royalty for said lease, LESSEE shall pay to LESSOR and to its successors and assigns seven (7%) percent of the gross sales of all minerals and metals mined and shipped from the aforementioned premises, provided that in the event the market prices of the products mined under this lease shall fall below the average market prices of the first year's total sales average of said products, then the 7% gross sales royalty above mentioned shall be reduced directly in proportion to such price fall; example: Average market or par prices of products mined under said lease the first year equal 100; average market or par prices of products mined under said lease any subsequent year equal 90; fall in price would equal 10% and the royalty would therefore be reduced to 6.3% for said year. It is understood that an accounting shall be made of all sales at the end of each three months during the period of the lease and that payment of said royalties and rents shall be made in the following manner:

1. On the 20th day of each calendar month, LESSEE shall pay to LESSOR an average of seventy-five (75%) percent of the royalties and rents due to LESSOR based upon the 7% of gross sales made during the preceding calendar month.

2. Thereafter, at the end of each three calendar months, an accounting and adjustment shall be made by LESSEE for obligations during the preceding three months and any balance shown to be due LESSOR by LESSEE to bring the rents and royalties paid up to 7% of gross sales shall promptly be paid by LESSEE to LESSOR.

C. LESSEE agrees that at the earliest possible date after the effective date of said lease that it will install a concentration mill o n the aforesaid premises of 100 Tons or more daily capacity. It is understood and agreed that title in and to said mill shall at all times remain in LESSEE whether or not same is affixed to the realty. It is further agreed that during the term of this lease, any and all equipment and machinery that may be placed upon the premises by LESSEE shall remain the property of the LESSEE, whether affixed to the realty or not, and at the termination of the lease the LESSEE shall have the right to remove the same within a period of ninety (90) days from the termination of the lease, PROVIDED that LESSEE shall in moving said property shall do no permanent damage to the realty.

D. If all obligations of LESSEE under this lease shall have been fully complied with, the option is hereby granted unto LESSEE to renew this lease for an additional term of ten (10) years following the expiration of the first 10-year period upon the same terms and conditions as are set forth in this lease appertaining to the first 10-year period. If LESSEE exercises this option to renew, it must give written notice to LESSOR of its intention to renew not later than ninety (90) days prior to the termination of the first 10-year period. It is understood that this lease might be renewed for any number of successive 10-year periods at the option of the LESSEE.

E. LESSEE shall have the right to assign this lease or to sub-lease the property, PROVIDED LESSEE at all times remains fully liable for the performance of all conditions and obligations herein set forth on its part to be performed.

F. It is understood and agreed that the LESSEE, from and after the date of exercise of the option to lease the premises herein mentioned, shall pay all property taxes upon the real and personal property belonging to LESSOR and herein included in this lease to LESSEE. LESSEE shall carry Workmen's Compensation and other insurance in order to fully indemnify and protect LESSOR against any liability for any injuries which may be received by any persons in connection with LESSEE'S operations. It is understood that

LESSOR hereby assumes to pay all taxes accrued to the date that the option is exercised.

G. The LESSOR, through any representatives it may designate, shall have the right at reasonable intervals, but not more often than quarter-annually, to examine LESSEE'S books, records, accounts as to production, shipments and sales of ores and minerals from the leased property, and to inspect the leased property, including the underground workings, the mills and other equipment, and to draw samples of ores, concentrates and tailing from the operation. In addition, LESSEE shall arrange for duplicate copies of all return sheets from smelters, chemical plants or other concerns to which LESSEE ships products from the leased premises, direct to LESSOR.

H. LESSEE does hereby covenant with LESSOR that it will pay the rents and royalties as provided for in this lease when the same shall become due; that if it exercises its option to enter upon the lease of the premises it will thereafter proceed with mining operations in the manner necessary for good and economical mining in a workman like manner.

I. It is specifically understood and agreed that if LESSEE, after once entering upon the lease, abandons the property and discontinues operations altogether, the lease shall thereupon terminate and LESSEE shall promptly pay LESSOR all rents and royalties due to the date of termination. If, after the mining has gotten underway on the leased premises, and royalties and rental payments have become due under the terms of this lease, if thereafter LESSEE ceases or suspends operations of the mine or mines for a continuous period of ninety (90) days, excepting through strikes, acts of God, or circumstances beyond control of LESSEE, but does not exercise its right to abandon the property and cause a termination of the lease, then it is agreed that LESSEE shall pay to LESSOR a minimum rental at the rate of SIX THOUSAND ($6000.00) DOLLARS per year, payable quarter-annually and during the period when operations are suspended.

J. In consideration of the sum of ONE DOLLAR ($1.00) in hand paid to LESSOR by LESSEE, the receipt of which is hereby acknowledged, and in further consideration of the covenants and mutual agreements herein contained, LESSOR does hereby grant unto LESSEE, its successors and assigns, an option to purchase the aforementioned property at any time during the term of the option period, and the term of the lease, or any renewal or extension thereof, for the purchase price as follows: If the LESSEE shall exercise the option given herein within two years from the date of said lease, purchase price shall be THREE HUNDRED THOUSAND ($300,000.00) DOLLARS; if the LESSEE SHALL exercise the option given herein within the first ten (10) years from the date of said lease, purchase price shall be FOUR HUNDRED FIFTY THOUSAND ($450,000.00) DOLLARS; if the LESSEE shall exercise the option given herein within subsequent years from the date of said lease, purchase price shall be SIX HUNDRED THOUSAND ($600,000.00) DOLLARS. All royalties and rental payments made during the terms of the lease, as well as payments made during the option period, shall be credited and applied to the purchase price. Upon the notification by LESSEE of its desire to exercise this option to purchase, LESSOR contracts to tender to LESSEE a warranty deed which will convey the said property without encumbrances to LESSEE or its successors and assigns. Taxes and any other apportionable charges shall be apportioned as of the date of conveyance.

K. If LESSEE shall for any reason default in the payment of any rent or royalty payment due LESSOR as provided for in this lease, or if LESSEE shall default in the performance of any other duty or obligation herein required to be performed by it, and if any of such defaults continue for a period of 90 days after written notice by registered mail of said default is given LESSEE by LESSOR, the lease and option to lease shall, at the option of LESSOR, be terminated; and LESSOR shall th reupon have the right, without any further notice, and with or without legal process, to enter upon the leased premises and dispossess the LESSEE therefrom, and these rights shall not be exclusive but the LESSOR specifically reserves any and all legal rights and remedies now or hereafter authorized and granted

by the State of North Carolina to LESSORS to cancel and terminate leases upon default and to recover possession of leased property.

L. Written notice of any matter requiring notice shall be given LESSEE by LESSOR by depositing such notice in the United States mail, Registered, and addressed to LESSEE, General Delivery, Lincolnton, N. C., and any written notice to LESSOR by LESSEE shall be given by depositing same in the United States mail, Registered, and addressed to LESSEE, at 120 Wall Street, New York, N. Y., and proof of the depositing of such written notice in such manner shall be deemed conclusive upon all concerned.

M. The within agreement shall be binding upon the parties hereto, and their successors and assigns.

N. In the event that any dispute should arise out of the within agreement, same shall be submitted to arbitration to be held in Washington, District of Columbia, in accordance with the rules of the American Arbitration Association then pertaining, and the decision of such arbitration may be entered as a final judgment in any court of record having jurisdiction.

IN TESTIMONY WHEREOF, said LESSOR has caused this contract to be signed in its corporate name by its President and attested by its Secretary and its corporate seal to be hereunto affixed the day and year first above written; and said LESSEE has caused this contract to be signed in its corporate name by its President and attested by its Secretary and its corporate seal to be hereunto affixed the day and year first above written.

KA-MI-TIN CONCENTRATING CORPORATION

ATTEST:

By J. B. Bunger
President

Joseph R. Jarvis
Secretary

LINCOLN MINING CORPORATION

ATTEST:

By _____
President

_____
Secretary

NORTH CAROLINA

Lincoln COUNTY

I, Martha P. Bailey, a Notary Public in and for the County of Lincoln, and State of North Carolina, do hereby certify that Joseph Davis, Secretary of KA-MI-TIN CONCENTRATING CORPORATION, personally appeared before me this day and acknowledged that he is Secretary of KA-MI-TIN CONCENTRATING CORPORATION, a Corporation, and that by authority duly given and as the act of the Corporation, the foregoing instrument was signed in its name by its President J. N. Benziger, sealed with its corporate seal and attested by himself as its Secretary.

WITNESS my hand and Notarial Seal this the 25th day of ~~November,~~ October 1952.

Martha P. Bailey
NOTARY PUBLIC

My Com. Expires:
Sept 12, 1953

NORTH CAROLINA

_____ COUNTY

I, _____, a Notary Public in and for the County of _____, and State of North Carolina, do hereby certify that _____, Secretary of LINCOLN MINING CORPORATION, personally appeared before me this day and acknowledged that he is Secretary of LINCOLN MINING CORPORATION, a Corporation, and that by authority duly given and as the act of the Corporation, the foregoing instrument was signed in its name by its President _____, sealed with its corporate seal and attested by himself as its Secretary.

WITNESS my hand and Notarial Seal this the ____ day of November, 1952.

_____
Notary Public

My Com. Expires:

_____

ABSTRACT ON APPLICATION FOR EXPLORATION DEVELOPMENT AND PRODUCTION LOAN AT LINCOLNTON, NORTH CAROLINA, PROPERTY OF LINCOLN MINING CORPORATION ALSO CALLED THE KA-MI-TIN-PROPERTY.

SUMMARY:

For a considerable period of time certain minerals in short supply have been on the strategic list for Government stockpiling, and this abstract, containing an application for Government loan, will attempt to prove that with such loan and on a proven property, the stockpiling program will be assured of a quantity of estimated -

60,000 tons Mica	estimated value $60.00/ton		$ 3,600,000.—
200,000 lbs.)Columbite			
lbs.)Tantalite		4.00/lb.	800,000.—
5,000 tons Tin		2400.00/ton	12,000,000.—
180,000 tons Lithium		50.00/ton	9,000,000.—
50,000 tons Quartz		15.00/ton	750,000.—
	TOTAL estimated value		$26,150,000.—

plus other minerals of importance and incidental to the production.

Repayment to the Government should therefore not present any problems. The property in question is an improved property, well-known and previously inspected, mapped and commented upon by Government geologists and engineers, as well as engineers of good reputation, working for private companies.

LEGAL STATUS:

The property known as the Ka-Mi-Tin mine, is under 10-year renewable lease to the LINCOLN MINING CORPORATION, an associate of THE NEW ENGLAND INDUSTRIES, INC. which have demonstrated through past mining operations in the United States and abroad, that their organization and mining engineers are well-qualified to schedule, plan and to successfully conduct an operation such as outlined. — Attachment No. 1 - Lease contract between owners of the Ka-Mi-Tin property and the

GEOLOGY:

This property is well-known and described in literature, such as the report of Mr. St. Clair — attachment No. 3; Mr. T. J. Kessler — attachment No. 4 and

in back folder, called "U.S. Geological Bulletin 936 J", which shows the different deposits on the property; reports of the American Consolidated Tin Mines Corporation, which used to have a tin smelter on the property, shipping a tin-columbite-tantalite concentrate to England and Germany, - see attachment No. 5: the Ka-Mi-Tin Corporation which last operated the property in 1936; reports of Government geologist, Mr. Hess, as well as 21 other references listed in attachment No. 6, (and others in back folder).

We believe that these attachments, as well as a complete report by Dr. S. D. Heron, Jr., Vice-Chairman of Duke University, geologist, who visited the property twice during the last month, and whose report forms attachment No. 2, fully documents the type of mineralization and the extent of the ore bodies beyond any reasonable doubt. We also wish to refer to a publication called, "Resources for Freedom", a report to the President, published in June 1952, which stresses the importance of the minerals which we wish to mine, including lithium, their particular application to the defense effort, and the obvious shortage of these strategic minerals existing in the United States at the present time. Excerpts - attachment No. 7 enclosed.

DEVELOPMENT OF PROPERTY:

As evident from attachments submitted, this is a developed property, which has been previously in operation, with roads, housing, shafts, hoists, underground development, diamond drill holes and other improvements in place, including power installations and transformers for a substantial plant and mining operation. Attachment No. 8, report of recent visit of the undersigned to the location with geologist, Dr. Heron. (Pictures, maps).

EXCERPTS FROM REPORTS ON PROPERTY:

T. H. Kessler, U. S. Geological Survey

... the pegmatite bodies are straight, tabular and nearly uniform in thickness .... Speaking of the Ka-Mi-Tin Concentrating Company, Mr. Kessler states, the remaining tin bodies of ore, 1 ft. or more thick, have an average grade of possibly 1.5% tin, an average thickness of 3 ft. and an average length of 100 ft., are assumed giving a calculated reserve of 12,500 tons of ore .... an average of 0.375 ton of tin per ft. of depth on each deposit. The eight deposits of mineable width which have been mined to or below the water level may contain ore of equal or even higher tin

content .... The tin spodumene belt contains an enormous amount of spodumene .... it may contain from 10 to 50% spodumene .... Possible by-product minerals include, cassiterite, columbite, tantalite, beryl, fine grained muscovite, feldspar and possibly ambligonite.....

F. L. Hess, "Economic Geology"

States that hand-cobbed ore mined southwest of Kings Mountain contains more than 50% spodumene. He estimates that the pegmatite bodies of the entire belt may contain an average of 15% spodumene. He estimates 3.7 million tons of possible ore.

Edwards & Barbour

The map of the Ka-Mi-Tin property, made by Edwards & Barbour, Plate 41, Bulletin 936-J, shows 21 tin showings and can be increased to about 50 tin showings according to stripwork. It contains some two dozen spodumene pegmatite bodies of which the longest, as drawn, is 525 ft. in length with an average 40 ft. width. This body is taken as a basis for our calculation. Actually this ore body is almost 300 ft. longer and the one running parallel and starting from the Swamp shafts, is almost twice that length.

Mr. V. J. Hampton, Manager of the Patino Mine and his assistant

.. estimated the total in four dykes as representing 1.5 million tons of ore to the 500 ft. level.

Banks, McDaniel & Sales

The Banks, McDaniel & Sales report on concentration methods for North Carolina spodumene ores is self-explanatory as to the percentages of the various mineral values contained and ample proof of recovery.

W. R. Hudspeth, Chief Engineer - Foote Minerals Plant, Kings Mountain.

Article by W. R. Hudspeth in Mining and Engineering, August 1952, again proves composition of ore and process of recovery.

H. D. Heron, Jr., Professor of Geology, Vice-Chairman, Duke University.

Professor Heron, Jr. in his report of September 9th, speaks of this property as the most promising in the region. According to his findings, sampling the shafts, yielded spodumene alone with a rather high percentage of cassiterite. He mentions the presence of quartz, mica, columbite and tantalite.... I personally believe this prospect is better than any one single part in the belt, with the exception of Foote's holdings near the town of Kings Mountain..... The possible reserve here might well approach those of Foote's, but let me emphasize again that there is only one way of telling, that is by a diamond drilling program.... The other by-products could be columbite, tantalite.... I believe that spodumene will be found in almost each and everyone in the pegmatite dykes located on the entire property.

Mr. St. Clair, Geologist & Consulting Engineer & Formerly with the War Minerals Administration, Washington, D.C.

In his 1937 report states, tin exists in the form of cassiterite with metallic tin content of 60 - 70%, as shown in numerous analyses. The cassiterite occurs as fine disseminations throughout the pegmatite..... He proves the presence and percentage of mica, columbite, spodumene, which he states makes up 20% of the volume,

and quartz.... channel samples taken on the hanging wall side, give assays running from .657 to .921% metallic content, as determined by fire assay. He quotes many series of samples showing such assays and higher, taken by Dr. Banks, Dr. Pryson, Dr. Nelson, and others. He took 6.714 lbs. of samples and states that a composite sample showed .65% metallic content. Mica will be found scattered throughout the pegmatite.... the mica is high grade and should command a good price, especially when ground... The quarts will be found intimately mixed through the pegmatite, but chiefly in the Greison area. In 1935 nearly a 100,000 tons of material were moved, 1200 ft. of drifting was done... on the incline dyke.... Aside from proving another commercial body of.... mica, tin values run from 1/4 of 1% to 2%.... (The main interest of the Ka-Mi-Tin Corporation was of course solely in the tin.)

. . . .

Dr. Heron in his report of July 30th, again shows on camparison level, the Kings Mountain Lithium Corporation property in operation producing from an ore with an average of 21% spodumene, showing the columbite, tantalite, quarts and mica values as set forth by us at the beginning of this expose. However, in our particular case, the amount of tin oxide accrueing would be much greater as set forth in Mr. St. Clair's report.

Dr. Heron in his final conclusive report of October 11th, gives figures far in excess of those claimed by us, due to our effort to make our estimates as conservative as possible. He states the average quarts percentage of 35%, whereas we have merely figured 5% in our application. He states a tonnage on the property of 2 million tons, whereas we have given a figure of one million tons as an estimate, and stated as our first objective that we would endeavor to block out 537,000 tons. Otherwise the report confirms our plan of action and the findings of every eminent geologist and mining engineer, who have inspected the property.

ORE:

The ore has been sufficiently described in many of the publications and assays of past operations, which are attachment No. 9, as well as assays taken recently on the property. It has been clearly established which average values exist in the tin-spodumene belt and even though our assays show considerable higher values than the averages for the entire belt, we have taken as a basis for our calculations, the basic figures given by the Bureau of Mines, showing 18% spodumene, containing 7 - 8% Li_2O, 1/2 of 1% tin in form of cassiterite, 6% mica, 1/100 of 1% combined columbite and tantalite, 6% quarts, plus a substantial percentage of feldspar, kaolin, etc., and some beryllium which was found on our last investigation trip.

The strong mineralization, starting below the weathered zone of 100 feet and extending to a depth beyond the 500 ft. level, in strong dykes, shown by enclosed drawing, attachment No. 10, demonstrates clearly a quantity of ore far in excess of a million tons of mineable ore, but for the sake of our initial phase of operation and

to show clearly the presence of sufficient ore, we have merely assumed a 400 ft. block of ore on dyke No. 2, extending over 525 ft. with 40 ft. in width and showing with a specific weight of 2.72, an ore body of 537,000 tons, which breaks down to the following quantities of minerals which can be recovered:

96,600 tons Spodumene
2,685 tons Tin
32,220 tons Mica
107,400 lbs. Columbium and Tantalum
26,850 tons Quartz, etc. -

Dr. Heron's exposé clearly demonstrates that while proving the 537,000 tons in dyke 2, we intercept by diamond drills dyke 3 at the same time thereby establishing possibly twice the tonnage, not counting the swamp dyke extension and other ore bodies. His estimate of the entire property 2,000,000 tons.

COST:

As per attachment No. 11, the first phase of development and diamond drilling to increase the true tonnage estimate, prove the assays and open up the mine sufficiently for a mining operation, is shown at $32,050.- during the initial phase as per attachment No. 12, while the cost of erecting a 250-ton mill and starting operations at 250 tons daily production, is shown with a cost of $686,600.- as per attachment No. 13. - It is our understanding that in view of the strategic importance of the minerals which will be produced, the Government will grant us a loan amounting to 90% of the moneys to be invested and we will submit clear and sufficient proof that we are capable of contributing our share of such moneys and accounting for all amounts spent, until such time when repayment will be made out of production to the Government.

PROCESSING:

Please find in attachment No. 14, a description of the machinery which we expect to use to set up a concentration plant, which equipment roughly corresponds to similar equipment being presently used on the Kings Mountain operation of Foote Minerals and also proven for mica separation on the property of the Kings Mountain Mica Corporation. Also find in attachment No. 15, a complete flow-sheet, worked out

for the separation of the ores, as prepared for these specific ores by Mr. Banks and others for the Tennessee Valley Authority, Foote Minerals Corporation, and other Government agencies interested in such separation.

Finally we can procure the services of Mr. Ralph Adarr, an ore dressing expert, who built the addition to the Solway and Foote plants, processing these ores.

CONCLUSION:

We again wish to emphasise the proven merit of these properties and deposits, the proof of our qualifications, the complete details which have been worked out to assure proper results and our firm belief that such operations will increase the Government stockpile on mica, columbite, tantalite, tin and lithium to a considerable extent.

Further documentations will be gladly submitted and we respectfully request early action on this request.

Howard Steven Strouth

HSS/lew

REPORT ON THE KA-MI-TIN CONCENTRATING CORPORATION SPODUMENE PROSPECT NEAR LINCOLNTON, LINCOLN COUNTY, NORTH CAROLINA.

By

S. Duncan Heron, Jr.

October 11, 1952.

The Ka-Mi-Tin Concentrating Corporation spodumene prospect is located at the extreme northern end of the tin-spodumene belt of the Carolinas. Mr. Howard S. Strouth of the Standard Ore and Alloys Corporation requested the writer to examine this property and other parts of the belt. Field work was done during parts of August, September and October. The Ka-Mi-Tin property was examined on September 6 and 7 and again on October 6 and 7.

LOCATION, SIZE AND PHYSICAL PROPERTIES

The tin-spodumene belt extends from Grover, North Carolina, in a northeast direction for 25 miles to Lincolnton, North Carolina. The Ka-Mi-Tin property forms the northern portion of the belt and is located two miles southeast of the Lincolnton town limit.

The land is about 2½ miles long, approximately ½ mile wide at the greatest width, and trends in a northeast direction. The property contains about 650 acres, of which 250 acres are owned in fee and the balance in deeded mineral rights. U. S. Highway 321 cuts the property so that most of the land owned in fee is in the northeast portion. This report concerns this section of about 200 acres, because it has the better mineral occurrences. (See accompanying map).

The nearest railway station is 4 miles away in Lincolnton. A metal surfaced road serves the southern portion of the area under discussion and there are several unimproved roads on the property.

The area has gently rolling topography of moderate relief. There is no suitable timber on this property. There are some small pine trees, a few deciduous trees, and undergrowth of honeysuckle vines, kudzu, etc. The annual rainfall is about 47 inches.

GENERAL GEOLOGY

Country rock - The major rocks of this area, like those in the rest of the tin-spodumene belt, are mostly mica schist, hornblende gneiss and mixtures of the two. In general they are well weathered to an average depth of about 100 feet. The mica schists are more thoroughly weathered.

Pegmatites - Throughout the tin-spodumene belt are numerous massive pegmatite dikes that apparently filled fissures aligned with the general northeast trend of the foliation and schistosity of the country rock; however, some of the pegmatites filled joints or fissures formed at right angles to the general structure and, therefore, strike northwest. A few pegmatites are irregular in outline.

Most of the pegmatites of the belt show little, if any, weathering, but the pegmatites of the Ka-Mi-Tin property are almost completely weathered to a depth of between 70 and 100 feet. Some of these pegmatites are very irregular in form while others, like the Inclined Dike and the Jake Dike (named for the Inclined Shaft and the Jake Drift), are tabular.

It is important to note that pegmatite dikes are characterized by changing form and mineral content at different depths.

Minerals - A variety of minerals have been found in the pegmatites of the tin-spodumene belt, but feldspar and quartz make up the bulk of the mass. In most of the pegmatites, mica and spodumene occur in association with minerals like cassiterite, columbite-tantalite, beryl, etc.

The only unweathered pegmatite on the Ka-Mi-Tin property is found on two very small dumps adjacent to Swamp Shafts 1 and 3. The following minerals have been identified by the writer and are listed in order of abundance, according to earlier reports.[1]

Feldspar) Albite)	40%
Quartz	35%
Spodumene	18%
Mica	6%
Cassiterite	0.25%
Columbite-) tantalite)	0.01%
Beryl	?

The percentages listed have not been determined by accurate sampling or assaying and should serve only as a guide.

Spodumene occurs as lath-shaped crystals that are usually fractured and veined with quartz and feldspar. It is not distributed evenly throughout the dikes, nor are the crystals of uniform size. The largest observed crystal was about 18 inches long. The average length appears to be around one or two inches.

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[1]Stuart St. Clair and J. N. Brenizer

Cassiterite is not directly associated with the spodumene but usually occurs as small, irregular grains embedded in masses of muscovite mica and quartz called greisen. The greisen occur as small pockets within the pegmatite. Also cassiterite and columbite-tantalite are found throughout the spodumene pegmatite as very small grains of less than 1 mm in diameter.

ESTIMATED TONNAGE

It is possible to calculate a rough estimate of the tonnage of spodumene-bearing pegmatite within the northern part of the Ka-Mi-Tin property. The following tonnage is based on a pegmatite specific gravity of 2.72 and on the assumptions that the pegmatites have no splits or inclusions of country rock or change in shape to a depth of 500 feet. Since the pegmatites are weathered to an approximate depth of 100 feet, these calculations will apply to the area between the 100 and 500 foot level.

Inclined Dike	430,000 tons
Jake Dike	445,000 tons
Fourteen dikes located near the Condon Shaft	1,170,000 tons
Total	2,045,000 tons

DESCRIPTION OF PREVIOUS WORKINGS

Over the past fifty years the weathered pegmatite has been worked unsuccessfully by a number of companies for the mineral cassiterite. The present owners have sunk two shafts, made several open cuts and worked some in the Condon Shaft. (See map). The most successful work from the standpoint of spodumene was in Swamp Shafts 1 and 5, both of which are now filled with water.

Swamp Shaft 1 is a one-compartment hole about 70 feet deep. Good cassiterite grains occur within the greisen reportedly found in a drift off the 30' level. Some spodumene was also found on the dump. No assays are available from this shaft.

Swamp Shaft 3 is a two-compartment shaft about 90 feet deep. The unweathered pegmatite was reported at about 60 feet. Excellent specimens of spodumene pegmatites can be found on the dump next to this shaft.

Two diamond drill holes have been drilled on the property but no record other than hearsay is available. It has been reported that four dikes averaging 10 feet thick each were encountered in a 1300 foot, 45° inclined hole located near the Bungalow Shaft and drilled in a general eastward direction.

No records, assays, or written report are available for any of the previous workings.

EQUIPMENT ON HAND

A power line with two single-phase, 75 KVA transformers serves the Swamp Area and several small wooden buildings are located here. At least three of these buildings are in usable condition. Three electric motors of 50, 30, and 20 horsepower appear to be in working condition. One pneumatic hoist of undetermined capacity could be placed in operation without much expense.

MINING COST

Mr. H. Jardin of Waxhaw, North Carolina, for ten years superintendent of the Teck Hughes Mine in Canada, was kind enough to supply the following figures for a 100 ton and 250 ton mine:[2]

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[2] A breakdown of these figures is in the hands of Mr. Strouth.

100 ton

Equipment Total	$46,625.00
Building and Structures	35,150.00
Workmen Compensation, Insurance, Social Security, etc.	8,197.50
Total	$90,172.50

250 ton

Equipment Total	$70,475.00
Building and Structures	63,650.00
Workmen Compensation, Insurance, Social Security, etc.	13,137.50
	$148,137.50

Mine development costs as estimated by Mr. Jardin are $140 per foot for two-compartment vertical shafts, $200 for three-compartment shafts, and $30.00 per foot for drifts and crosscuts 5 X 7 feet.

No estimates are available for milling and concentration costs.

RECOMMENDATIONS

Before any large amounts of money are invested in a mine and concentration plant, it will be necessary to block out at least 300,000 tons of ore. Since all of the pegmatites are completely weathered at the surface, sampling can only be accomplished by diamond drilling. In order to prove the desired tonnage, at least one of the larger dikes must be adequately drilled.

Both the Jake Dike and the Inclined Dike offer theoritical tonnage that would justify proof by drilling. It would seem wiser to drill the Inclined Dike because of the possibility of discovering the reported pegmatites adjacent to this dike (said to be encountered in the 1300' drill hole).

Six holes drilled from three positions would be the most economical way of exploring this dike. These drill holes should be located on the

east side of the dike and drilled so that the first hole will intersect the dike at the 125 foot level and the second hole at the 500 foot level. The first hole should continue on past the dike for a horizontal distance of at least 400 feet. This will provide for exploration of the pegmatites reported from the old diamond drill hole.

It should be emphasized that careful drilling and interpretation of cores will be invaluable to the development of this prospect. Care should be taken during drilling so that adequate cores and sludge may be collected for assays.

Swamp Shaft No. 3 should be pumped out and cleaned so that the pegmatites may be examined and sampled. A small drift would serve to determine the width of the dike and to guide in drilling so as to determine its exact size.

CONCLUSION

The Ka-Mi-Tin Concentrating Corporation property has all the possibilities of developing into a successful spodumene-producing mine. Cassiterite, and to some extent columbite-tantalite, should be very important by-products. A carefully planned drilling program should prove the necessary tonnage and the tenor of the ore.

Respectfully submitted,

S. Duncan Heron, Jr.

S. Duncan Heron, Jr.

Durham, North Carolina

October 11, 1952.

REPORT ON THE KA-MI-TIN CONCENTRATING CORPORATION

SPODUMENE PROSPECT.

Location and Size:

The KA-MI-Tin Concentrating Corporation's property is located about two miles southeast of Lincolnton, North Carolina; U. S. Highway No. 321 cuts the property, slightly north of the middle section. The Southern Railroad crosses the extreme lower end of the property adjacent to the South Fork River. There are approximately 650 acres of which 250 is owned in fee, and the balance in deeded mineral rights. The land is about two-and-a-half miles long, approximately one half mile at the greatest width and trends in a northeast direction. For convenience in this report, we shall divide the property in two parts. The boundary between the northern portion and the southern portion will be represented by U. S. Highway No. 321.

General Comments on the Pegmatites:

The pegmatites of the KA-MI-Tin Concentrating Corporation differ from the pegmatites of the balance of the North Carolina Spodumene belt in that they are more completely weathered. There is no visible hard rock at the surface, and none is reached until a depth of approximately 80 to 90 feet. The upper weathered zone consists of completely kaolinized feldspar and spodumene, along with quartz and minor mines of mica, tin and other accessory minerals such as columbite-tantalite. This is in contrast to the unweathered pegmatites as exemplified in Foote's holdings near Kings Mountain.

At no place on the property of the KA-MI-Tin Concentrating Corporation was spodumene observed on the surface outcrops. However, it was found upon the dumps of the old workings.

North End of the Prospect:

Enclosed with this report is a map made by the U. S. Geological Survey that represents most of the area north of the U. S. Highway No. 321. Most of this property is owned in fee by the KA-MI-Tin Concentrating Corporation.

Condon Shaft Area: In and around the Condon Shaft area several open cuts (10 to 20 ft deep) and old water-filled shafts. The pegmatite exposed here are very difficult to follow along the original surface. They can be followed, however, in the old cuts and they outcrop originally as illustrated on the accompanying map. No spodumene was observed because of the thoroughly weathered nature of the rocks.

Swamp Area: The swamp area is that portion of the map located in and around Swamp Shaft No. 1, 2, and 3. As indicated on the USGS map no recognizable pegmatite is exposed on the surface. As reported in Mr. Stuart St. Clair's report, a rich tin strike was made at a depth of 30 ft. in Swamp Shaft No. 1.

Between the 30 and 70 ft. level of this shaft the hard pegmatite had been encountered and this pegmatite bears spodumene. I have collected several specimens off the dump near Shaft No. 1 that contains spodumene along with a rather high percentage of cassiterite (tin oxide).

Off the dum of Swamp No. 2, more spodumen-cassiterite pegmatite was collected.

Swamp Shaft No. 3 is a two-compartment shaft 14 ft X 6 ft. Spodumene pegmatite samples were collected from the dump near the shaft. One sample weighs approximately 150 lbs. and appears to contain a relatively high percentage of spodumene. It is available for analysis. Another 50 lb. block collected from this dump may run as high as 40% spodumene. These samples were reported to have been removed between the 60 and 90 ft. level. The shaft is down to 90 feet; the hard unweathered pegmatite was encountered below 60 feet.

The Jake Area: The Jake Dike is exposed in an open cut approximately 350 ft long. Here again the pegmatite is completely weathered so that naturally no spodumene would be recognized.

The South End of the Prospect:

Near the lower end of the property approximately 1000 feet from the South Fork River were found two very old hydraulic cuts. One runs approximately north-south and the other tends in a northeast direction. No pegmatite was observed in the former, but the weathered pegmatite was seen in the northwest wall of the latter. It, too, was completely kaolinized and there was no recognizable spodumene.

Other shafts in this southern portion did not go down to sufficient depth to reveal the unweathered pegmatite.

Ownership and History:

The history of this particular portion of the spodumene tin belt of the Carolinas is rather sad. The properties and mineral rights were acquired as early as 1900. There was originally some 6000 acres under lease and was eventually cut down to the present size - mostly under the actions of a Mr. Rhyne. It was in those days a tin prospect. A considerable amount of money was spent by various companies in trying to develop a working tin mine. At least two tin concentrate mills have been erected in the northern portion of the property. It is my opinion that a lot of the money was wasted and pocketed by speculators. Mr. J. N. Brenizer of New York City, between 1930 and 1935 lent to the old American Tin Concentrate Company approximately $75,000.00. When the company went broke he foreclosed, took over the property and formed the KAMI-Tin Concentrating Corporation. He issued stock to the stockholders of the old company at the rate of one share for every two shares. He and his wife owned 55% of the new corporation. Most of the other owners live in New York City. Mr. Brenizer

tried to develop the property as a tin-producing mine. Because of either poor tin, or most probably because of lack of capital, the venture failed. With the advent of spodumene in the district, he had been interested in seeing that the property was developed as a spodumene producer.

Mr. Brenizer is eighty years old and he has a bad heart. He is a very likeable old gentleman, and I believe that he is completely honest. He has told me that his sole interest is to see the property in operation, and that he is willing to sell the property outright, or else to lease it. He has been approached by the Lithium Corporation of America, but he knows the history of that corporation and he does not believe that they have the money or the gumption to actually go into production. In plain words, he doesn't like the company, their methods of operation, or their president. He said that he would give the Standard Ore & Alloys Corporation twice a better deal than he would the Lithium Corporation of America. He is a fine gentleman whom I believe is primarily interested in seeing his property developed and working.

Conclusions and Recommendations:

I personally believe that this prospect is better than any one single area within the belt, with the exception of Foote's holdings near the town of Kings Mountain. The big difference between the two is that you can see what you have at Kings Mountain, because the pegmatites are unweathered and you can't see what you have at Lincolnton because of the weathered nature of the pegmatites. The possible reserves here might well approach those of Footes, but let me emphasize that there is only one way of telling, and that is by a rather extensive diamond drilling program.

All of the removal of spodumene ore will have to be done underground. This will, of course, raise the cost of mining, but I believe that it will be offset by the rather high percentage of the recovery of cassiterite. Then too a very selective type of mining would be possible. The very conservative Hess, principal mineralogist of the Bureau of Mines, told Mr. Brenizer that he believed the whole property would average one-quarter of one percent cassiterite. At today's prices this should be over $5.00 a ton, and would certainly pay most of the cost of mining.

The other by-products would be columbite-tantalite — and possibly feldspar. The weathered pegmatites also contain a very high grade of kaolin.

It would be quite possible to start mining the spodumene ore almost immediately. Swamp Shaft No. 3, could be drained and cleaned with a minimum of expense. There is one pneumatic hoist near the shaft, a few electric motors and enough power and water on the land to operate at least a 100-ton concentrate plant.

I would recommend an extensive drilling program before any large-scale concentrate plant is erected. Mr. Stuart St. Clair on page 29 of his report mentions a thirteen hundred drill hole that cuts four pegmatites, each 10 to 20 feet thick. The red pencilled lines on the enclosed map were copied from Mr. Brenizer's map. These red pencilled lines represent pegmatites, and they were put on by Mr. Stuart St. Clair. I believe that the pegmatite extending from Shaft No. 1 through Shafts Nos. 2 and 3 to the first open cut northeast of Swamp

Shaft No. 3 is accurately portrayed. It is possible that this may represent several pegmatites pinched and swelling along the strike. But it seems reasonable to conclude the existence of the pegmatite at least to the open cut. The thickness of this pegmatite is unknown. I could see no evidence of the pegmatite extending on approximately 1000 ft to the northeast, but then it is quite possible to be standing on top of these dikes and never know it. I believe that spodumene will be found in almost each and every one of the pegmatite dikes located on the entire property. The only reason you can't find it now is because of the extensive weathering. The northern portion of the property is by far the best, but drilling on the lower end may reveal more pegmatites. It seems advisable to obtain all of the property because of the railroad and the large quantity of water that could be obtained from South Fork River.

According to Mr. Brenizer, the percentage of spodumene as determined by one analysis is 18.

S. D. Heron Jr.

S. D. Heron, Jr.

GEOLOGICAL NOTES

on the

NORTH CAROLINA TIN BELT

U. S. A.

By

Stuart St. Clair

Consulting Geologist

New York, N.Y.

June 1, 1957

These geological notes are principally on the north end of the Tin Belt, North Carolina, as the writer has made a more careful study of this section. Also, the southern end, from Kings Mountain south into South Carolina, has been reported on in the U. S. Geological Survey Folio 222 and Bulletin 660 D.

GENERAL GEOLOGY

The general area lies in the Piedmont Province, an eastward-sloping plateau extending from the Blue Ridge Mountains on the west to the Coastal Plain on the east.

The general topography is a gently sloping surface eastward, dissected by the rivers and streams that flow over the surface.

The rocks are both igneous and sedimentary, most of which have been metamorphosed to varying degrees and now appearing as schists and gneisses. This is especially true in the Pre-Cambrian rocks whereas in some of the later intrusives unaltered facies are common.

The oldest rocks of the area are the Carolina gneiss and schist which primarily were sedimentary, igneous and volcanic rocks but which were highly metamorphosed in Pre-Cambrian time.

The rocks that now make up the Roan gneiss and schist were intruded into the Carolina formation. The Roan rocks are determined chiefly by the amount of associated hornblende. They are metamorphosed along with the Carolina and in places they are

hard to separate. Both of these formations are deeply weathered and make up a large part of the country rock of the area.

Included in the Pre-Cambrian complex is a series of basic rocks intrusive into the Carolina and Roan formations and also occurring as isolated bodies in the Bessemer granite.

The Bessemer granite is a light-colored, schistose granite which is intrusive into the rocks of the Carolina and Roan formations. It has an extensive outcropping in Gaston County and to the south. It occupies chiefly a belt running northeast through Bessemer City, Gaston County. Some pegmatite is associated with the Bessemer granite.

A series of schists, generally dark in color, probably Algonkian in age, and narrow outcrops of Cambrian rocks made up chiefly of dark schists, conglomerates, quartzites, all of which are highly altered, outcrop in bands which extend in a general north-northeast direction. These rocks are often faulted and folded into the older rocks and, therefore, form a most complex series of outcrops. All the outstanding topographic features in the area are the result of differential weathering and erosion of these various rocks.

At a much later time, presumably late Carboniferous, there was intruded into the older rocks granites of light color made up largely of quartz, feldspars and muscovite mica in varying quantities. A large batholithic intrusion of this granite is found in the Cherryville area to the southwest of

Lincolnton.

The younger granites are considered of economic importance as the pegmatite which is found in dikes and which carries tin is probably an early end product of the differentiation of the granite magma, and the quartz and mica which occur as veins and in replacements are probably the final product in the cooling of the granite batholith. The pegmatite will be discussed in detail later.

Younger than any of the intrusives and cutting all other rock formations is a series of diabase dikes which run in a general northwest direction. The dikes vary in width from a few inches to 200 feet and extend for long distances, relatively. They evidently occupy tension cracks that probably resulted from vertical uplift of the area. The dikes are of Triassic age or younger. What economic effect they may have exercised is not known.

The general structure of the region was produced by compressive stresses acting from the southeast, thereby producing folds, faults and schistosity which trend in a general north-northeast direction. Most mineralization should follow this general trend although some may occur nearly perpendicular to it as there would be secondary stress relief in a general northwest direction. Such topographic features as Kings Mountain range, Crowders Mountain and Pasour Mountain have the north-northeast structural trend.

The dips in the Pre-Cambrian rocks are usually steep, but are variable. Long plunging anticlinal and synclinal folds include most of the formations. There has been both normal and thrust faulting, the movement of some being as much as several thousand feet.

One special structural feature should be spoken of as it may have economic significance. Near Beaverdam Creek in Cherryville Township, Gaston County, the general trend of formations, which is north-northeast, including the Tin Belt, has been offset to the east a mile or more. The writer has not worked this change out in the field and is not prepared to say whether this phenomenon is due to a bend in the general strike or to a fault. Probably both conditions exist.

The Pegmatite

The country rock at the north end of the Tin Belt, and, more particularly on the property of Ma-Mi-Tin Concentrating Corporation, is gneiss and schist. Near the surface the schist is soft, but below the weathered zone and near the contacts with pegmatite dikes the schist is highly indurated. The schist has been cut by a paralleling series of pegmatite dikes which are much younger in age and which have undergone no intense metamorphism such as has the earlier enclosing rock.

The pegmatite dikes are in places massive and in other places more in the nature of veins. Such are probably

apophyses which extend into the country rock from the main dikes.

The pegmatite was injected into the schists at depth, as, due to the high degree of crystallization, the cooling was slow. The inclusion of bodies of schist in the pegmatite would indicate that the pegmatite, although probably filling some fault planes or fissures, also stoped its way through and into the schist. We would, therefore, expect irregular masses as well as dike-like bodies of pegmatite between regular inclosing walls.

The primary pegmatite is composed chiefly of quartz, feldspar and mica, the feldspar in many places predominating. A few minor minerals such as spodumene, tourmaline and others may occur in the pegmatite. Cassiterite is found sparingly disseminated throughout the pegmatite, but where in commercial quantities it is found in lenses and pockets throughout the pegmatite mass and along the foot-wall and hanging-wall. The occurrence of the cassiterite and its gangue minerals would indicate that deposition had taken place largely through replacement.

The order of events in the deposition of the pegmatites and the tin ore may be briefly summarized as follows:-

1. Intrusion of a granite magma in the form of a batholith in the west part of the area at or about the time that earth stresses were accumulating and which later caused the great Appalachian revolution.

2. Cooling at depth of this magma and the separation therefrom of aqueo-igneous solutions rich in mineralizers.

3. The expulsion of this highly-mineralized solution into the country rock of schist and gneiss along and filling fault planes and fissures which had been caused by earth movements.

4. Slow crystallization of the pegmatite solutions at depth allowing growth of large crystals of feldspar, quartz and mica. It may be found at depth that primarily the pegmatite is composed chiefly of feldspars.

5. With the cooling of the pegmatite, the formation of shrinkage cracks chiefly at and near the contacts with the walls, around inclusions of country rock that had floated off into the pegmatite, and within the main mass of the dike.

6. Injection into these shrinkage cracks of even a later phase of differentiation of the granitic magma, aqueous solutions rich in silica, fluorine, tin and other minerals and mineralizers. These solutions would replace the feldspars first with quartz and mica and cassiterite as well as crystallize out as primary minerals. The cassiterite would thus be found in greisen, quartz and mica chiefly, the characteristic gangue of tin.

7. The final step in the cooling and crystallization of the granite magma is the giving off of fumaroles, or vapors, rich in mineralizers which would find their way throughout the pegmatite mass wherever porous and replace the feldspars and deposit by crystallization quartz, micas, cassiterite,

[illegible] probably such minerals as to rutile, fluorite, axinite, topaz, and metals, should they be present in the original magma or be absorbed from the enclosing country rock.

4. The final step is the action of supergene agents so that the pegmatite is exposed at the surface through erosion and to alter through weathering those minerals susceptible to change such as the feldspars. Thus we have exposed at the surface now kaolin, as the result of weathering of the feldspars; and quartz and mica, the reison, with which is associated the cassiterite. Below the zone of weathering there should be the primary rocks, pegmatite which should be made up of feldspars, micas and quartz, with the greisen veins, pockets and lenses, formed as outlined above, in which will be found the cassiterite in minable quantities.

The main pegmatite dikes vary in width from a few inches to as much as 200 feet. The 200-foot thickness is found at Hanseur Hill, western Gaston County, and probably represents a joining of several of the dikes into one main dike.

As exposed at the present surface, the dikes represent the filling of faults and fissures many of which may join at depth to form a main dike of pegmatite.

The dikes are not continuous in length, but as they die out others continue at a short offset distance, thus indicating the filling of fissures. However, the dikes must extend to depth as the pegmatite injection came from below and the rock cooled at depth, as indicated by the degree

[illegible]

[illegible]

[illegible] cassiterite.

[illegible] due to which the [illegible] which marking the [illegible] perfect [illegible] between the pegmatite dikes and the faults and [illegible] lower sedimentary [illegible] adjoining. The batholith [illegible] intense pressure due to [illegible] during the Appalachian revolution kept the [illegible] lower than the other parts [illegible] greater degree of differentiation and pro- [illegible] necessary [illegible] through which the aqueo-igneous [illegible] were squeezed. The pegmatite should extend at least [illegible] at which mining of this character would be [illegible].

In the Wescalf and adjoining section, five miles [illegible] of the Lincolnton area, the pegmatite is more [illegible] of veins of quartz and mica in diorite country rock, the latter being of the Roan series. The veins at the surface are narrow, that is up to three feet, and only slightly weathered, and carry cassiterite.

Economic Factors. From the facts above given, it may be well to present at this point the factors which should largely influence the economic value of the pegmatites. Primarily, the area into which the pegmatite is injected should be broken up by faults and fissures so that there should be large and continuous bodies of pegmatite. There should also be irregular walls and there should be numerous embayments and kidney-shaped areas where there may be a segregation of the cassiterite upon crystallization from the original pegmatite or into which the later injections may find their way. Numerous fissures in the country rock will lead to the formation of apophyses running out from the main pegmatite dike, and these should contain some of the richest cassiterite deposits.

The more cooling surfaces to which the solutions are exposed, the more rapid the crystallization with the resulting shrinkage cracks which act as channels for later aqueous solutions and fumaroles to move and replace the feldspars and deposit their mineral content.

In prospecting the area, where one finds where there has been excessive earth stressing in association with the pegmatite, it is a fair assumption that rich pockets or veins of cassiterite may be found. Also where there are a number of paralleling dikes of pegmatite with numerous apophyses or stringers outcropping parallel to the main dikes, one may conclude that earth movements have been severe and there should be some rich cassiterite deposits in the area.

ECONOMIC GEOLOGY

The "Tin Belt" extends from Lincolnton, North Carolina to Gaffney, South Carolina, a distance of some 3[illegible] miles. Many other minerals are found in belts paralleling the above and include gold, iron, barite, manganese, lead, mica, monosite, garnet, graphite, corundum, emerald, beryl, pyrite, clay, limestone, furnace rock, and building stone. In this report, only the tin and its by-product minerals will be discussed.

Ore Minerals

The ore minerals on the property of Ka-Mi-Tin Concentrating Corporation are cassiterite, the oxide of tin, theoretically 78.6% metallic tin but usually around 65-70% due to associated metals and impurities; kaolin, the weathered product of the feldspars; mica, a primary constituent of the pegmatite but enriched in the greisen to commercial proportions; feldspar, when unweathered, primary constituent of the pegmatite; silica, primary constituent of the pegmatite and one of the replacement minerals of the feldspar in greisen veins and lenses; spodumene, a mineral that is found in quantities in the east series of dikes and valuable as a source of lithium; columbite, a mineral found in appreciable quantities in certain sections of the tin-bearing parts of the dikes.

The tin and columbite are recoverable through concentration, the kaolin by washing, the mica by crushing and water separation, the feldspar will be recovered, as a market is developed, by hand picking when mining is in the primary pegmatite, the silica or quartz will be the waste material from the mill and will be intimately mixed with the crushed feldspar rock. Unless the quartz can be mechanically separated from the feldspar, probably the only use for the material will be for road surfacing. The spodumene can be separated on the tables or by decrepitation.

Tin. Cassiterite, the dioxide of tin, SnO_2, is dark brown to black in color, has a specific gravity of 6-7, i.e., seven times as heavy as water, equal volume, and has a metallic tin content in these deposits of 60-70%, as shown by numerous analyses. The cassiterite occurs as fine disseminations throughout the pegmatite and as well-formed crystals of varying size in greisen veins and replacements.

Kaolin. This is a secondary product resulting from the weathering of the feldspars. Primarily, it should be pure and generally white with a composition chiefly of silica and alumina. Small amounts of soda and potash may be present as well as calcium and magnesium. A little iron impurity would probably come from inclosing beds and the color of the kaolin affected to a degree dependent upon the amount of iron oxide washed into it. A large part of the iron can be removed in the processing of the kaolin.

Chemical and refractory tests of the kaolin show it to be very high grade. The uses will be governed by the degree of preness and the color when processed and ready for market. Reference is made to the report of R. J. Bryson for the kaolin tests.

Mica. The mica is a mechanical separation and is a byproduct. It is chiefly muscovite or margarite mica and has a brilliant lustre. When ground and screened it should bring a good price and there should be a ready market for mica of this grade.

Feldspar. The mining of feldspar will come when the primary pegmatite is reached below the zone of weathering. In selective mining for the cassiterite, it will be necessary to line some feldspar also. Where it can be separated by hand-picking, it can be saved in chunks and ground separately and prepared for market. There should be some rich bodies of feldspar in the pegmatite dikes, and, when a market is developed, selective mining of feldspar can be carried on to a degree to meet requirements. As a rule, the cassiterite does not occur in quantity associated with the feldspar but more in greisen lenses and veins, the minerals of which have largely replaced the feldspars.

Silica. If it were practical to separate the quartz and feldspar after crushing at the mill, the quartz could be used in glass manufacture. However, the specific

gravities of quartz and feldspar are so nearly the same, about 2.6, that their separation does not appear possible and economical. Any separation must be made by hand-sorting before crushing. The tailings, therefore, from the mill run can be used only for road building and probably for concrete mixtures.

Columbite. There is a growing demand for this mineral as it has a valuable use in the metallurgy of Steel. Separation from the cassiterite can be effected.

Spodumene. The eastern series of dikes at the north end of the Tin Belt carry up to 20% of spodumene in the pegmatite mass. The U. S. Bureau of Mines has been carrying on experiments in the beneficiation of spodumene and find a method of separation from the associated feldspar by by decrepitation. Further work is being done at this time and the experimental results will soon be available. The lithium salts are finding increasing uses.

Accessory minerals. No ilmenite, magnetite, wolframite, arsenopyrite or other metallics have been found associated with the cassiterite on this property except as traces. Some ilmenite and magnetite are found in placer deposits with the cassiterite but their source must be outside the tin-bearing pegmatites.

Such fumarole minerals as tourmaline, apatite, beryl, garnet, topaz, fluorite, axinite, lithiophylite, etcetera that might be found in the greisen veins or in the

pegmatite, or at the contacts in the enclosing schists, would mechanically separate from the cassiterite in the milling operation.

Ore Occurrence

All the ores on the property of the Ka-Mi-Tin Consolidated Corporation occurs in and associated with the pegmatite. The pegmatite has been tested by a series of pits, shafts and tunnels from the north end of the property southward for 2½ miles to Sour Dough Fork River. There are at least four parallelling dikes at the north end and several paralleling stringers or apophyses. The present surface outcropping aggregates a width of about 120 feet of pegmatite, and the upper part of each dike has been weathered to kaolin, in some places to a depth of 50 to 70 feet.

The strike of the dikes is N. 20 to 25E. and the general dip is to the northwest. In the major dikes the dip is 70-80 degrees; in the stringers or apophyses the dip may be from 45 degrees up indicating that they probably join the larger dikes at varying and minor depths.

The hanging and foot walls of the dikes and apophyses are not regular. There are numerous bays in which kidney-shaped bodies of pegmatite have formed. Should there have been much cassiterite disseminated in the pegmatite magma and being an original constituent of the magma, we should expect to find segregations of cassiterite, both by magmatic and mechanical separation, in the embayments and pockets which branch off from the dikes and the apophyses.

[illegible] the deposits [illegible] have [illegible] to determine if there are [illegible] types of [illegible] which are free and distinct from the [illegible] reisen [illegible] are [illegible] bodies, but I should expect to find some. [illegible], there should be more feldspar associated with the cassiterite than in the greisen veins and replacement deposits.

In many places where thin quartz veins strike [illegible] the pegmatite, above and below the quartz there are rich areas of cassiterite associated with quartz and mica [illegible]. This would indicate an aqueo-igneous solution injected along a fissure or fracture in the already partly solidified pegmatite mass, the deposits being replacements of the feldspar by quartz, mica and cassiterite. What I term "Tin Reefs" are greisen rock rich in cassiterite which occurs in the hard, primary pegmatite and which is a fissure filling and replacement. Such a reef is typically shown in Swamp shaft number one on the Ka-Mi-Tin property.

The richest greisen should be near the hanging and foot walls, the former being the more favorable for rich areas of cassiterite. Another favorable place is around inclusions and horses of country rock found within the pegmatite. These are caused by stoping action of the pegmatite, the country rock or schist being broken off and floated out into the solidifying magma.

From what has been said, thin apophyses extending into the schists should be very favorable places for circulation of the aqueo-igneous and aqueous solutions as well as the fumaroles, and for replacement of the feldspar by greisen minerals and cassiterite, as well as primary deposition of them.

No evidence of typical vein filling such as banded or ribbon structure was noted. Without doubt there has been vein filling but the walls were at the same time attacked by the solutions and the feldspar replaced by greisen minerals for varying distances back from the fissures, thus giving the appearance of replacement deposits entirely, except where there is a quartz stringer more or less in the center.

Within the pegmatite where shrinkage cracks had developed at the time of crystallization and solidification, greisen minerals and cassiterite are found. Thus when the primary rocks are reached at the base of and below the weathered zone, a selective mining system will be called for.

Where there is a change in the regional direction of the pegmatite dikes, we may look for such fracturing and fissuring as to form favorable areas for the deposition of cassiterite. At the south end of the Ka-Mi-Tin property near South Fork River, the strike of the pegmatite is N. 45-60 W. Approximately at this point, the pegmatite series has been offset to the west. The pegmatite has not been traced over

this offset distance but in the southerly trend again numerous pits have been opened and several mines developed to a point beyond Kings Mountain town.

Examination of the turn in the dike at the southern end of the property, disclosed a much shattered area and very irregular bodies of pegmatite. Channel samples taken on the hanging-wall side gave assays running from 0.587% to 0.921% metallic tin, as determined by fire assay. The association is typical greisen and quartz stringers. The contacts are extremely irregular.

Nineteen samples were taken from the northern part of the property by Dr. John H. Banks and two composite samples milled and assayed. No. 1 gave a return of 1.36% metallic tin; No. 2 gave 0.59% tin, or an average of nearly 1.00% tin from all samples. The reports of Dr. Banks and G. S. James are available for verification and for a full description of the method of procedure.

Dr. E. J. Bryson, State Geologist of North Carolina, took a series of samples in which cassiterite ran from 0.21% to 6.80%, an average he considered of about 1.00% tin. Report on file for verification.

Dr. Wilbur Nelson took seven samples at random from the 50 and 70 foot levels of the old Condon shaft. Four ran from 0.30% to 0.85%; three, trace only of tin.

The values of cassiterite in the pegmatite are extremely variable. Some assays show only a trace, others

show up to 50% in some rich shoots. The average for the full thickness of the pegmatite is problematic. In mining the weathered zone, probably all the dike material will be removed. The cost of both mining and milling will be so small that an average of considerably less than 1.00% cassiterite or 0.65% metallic tin will be profitable as the kaolin and mica will also be saved. It would appear safe to say that the average recovery should be at least 0.25% tin for all material mined to the base of the weathered zone. If we take 100 feet for the aggregate thickness of the several dikes, an average depth of 75 feet for the weathered zone, 15 cu. ft. per ton, for a length of 3000 feet along the strike, there would be 1,500,000 tons of minable material.

Below the weathered zone in the primary pegmatite, selective mining can raise the percentage of cassiterite to whatever degree is economically required.

Assays were made on an average of many samples of the surface material or residuum. To a depth of three feet, the average of 70 pits, 6714 lbs. samples, the recovery was 3.6 lbs. of metallic tin per ton, or 0.18%. From a series of pits varying in depth from 8 to 21 feet, and averaging 14½ feet, a composite sample gave 0.50% metallic tin. Map and report of this work are on file.

Kaolin.

The kaolin deposit will be found only in the weathered zone of the pegmatites as they are formed by the complete break-down of the feldspars. The high-grade white kaolin comes from the weathering of pure masses of the feldspar. Where found in such pockets, the kaolin should be mined separately. The depth to which the kaolin deposits will extend will not greatly exceed 75 feet.

The upper part of the weathered pegmatite will be more oxidized in varying degrees but much of the discoloration should wash out in the milling operation.

The kaolin is all high-grade and runs nearly theoretically pure. The white has little or no iron impurity. Analyses by Dr. Tryson on ten samples show an average kaolin recovery of 48.90%. W. S. James found 31.7% by weight to be clay, all of which can be saved.

The amount of mica in the weathered zone of pegmatite was estimated from one to five percent of the material by Dr. Tryson. In two tests made by W. S. James, the mica recovery was 8.22% and 7.40% respectively.

The mica will be found scattered through the pegmatite and concentrated in the greisen areas with the cassiterite. When the primary rocks are reached, probably the only mica that can be profitably mined will be that associated with the greisen. The mica is high-grade and should command a good price, especially when ground.

Feldspar can be mined and saved only when operations [illegible] the primary pegmatite [illegible] the zone of weathering. There would be bodies of pure feldspar which can be mined and hand picked, if necessary. The only milling operation would be to crush to commercial mesh. The high-grade feldspar would extend to about [illegible] feet.

The quartz will be found intimately mixed through the pegmatite, but chiefly in the [illegible] enclosure. If a method of separation is worked out, the quartz may be used for purposes more valuable than just road material.

Developments

The developments on the Lincolnton property, prior to the fall of 1935 when the Ka-Mi-Tin Concentrating Corporation began operations, are ancient history. Suffice to say that the ten or more shafts and the several thousand feet of underground work were confined almost exclusively to the weathered or soft zone which extends to a maximum depth of about 80 feet. Large bodies of kaolin containing commercial quantities of muscovite mica were proved and good tin values in many places were found. A mill was built, ore milled, and concentrates shipped. Very little work was carried into the hard, primary pegmatite.

From a tin standpoint, there was proved for the Condon area a tin reef six to twelve feet wide for a horizontal length of 149 feet. This was on a 70-foot level. On the Jake dike, promising tin enrichments were found but never carried to depth in the hard rock. The same can be said for the Incline dike and for the Carpenter dike. These are all on the north end of the property.

One mile to the south the Henry shaft was sunk and good tin ore taken from the 65-foot level. Many test pits were sunk over the entire length of the property, a distance of $2\frac{1}{3}$ miles. At the southern end there was some hydraulic work and open-cutting. Assay values are given in the preceding pages, the highest being 0.921 metallic tin.

On the strength of all the early work and following a report on the area by St. Clair, Ka-Mi-Tin began steam shovel operation late in 1935. Cross-cuts and pits were dug and nearly 100,000 tons of material moved. Supplementing this about 1200 feet of drifting was done in the pegmatite dikes in the weathered zone at depths of 20 to 40 feet below the surface, this work being done in 1936.

To conserve space a resume of the 1936 developments as printed in January 1937 is here inserted.

" Progress reports have been made regularly during the year 1936 covering the work done on the property of the American Consolidated Tin Mines Corporation in Lincoln County, North Carolina, by the operating Company, Ka-Mi-Tin Concentrating Corporation. The Management believes that at this time a short recapitulation of these operations will be of interest.

Primarily, it should be understood and appreciated that the work which has been done and which is progressing systematically and continuously will, if successful, add a chapter to American mining. A new enterprise must encounter many problems, some unique, which must be analyzed and safely and successfully overcome before rapid progress can be made. No bridge is built until plans and specifications are drawn, foundations tested, and stresses of materials calculated. No mining project can be successful unless just as careful geological and engineering theory and practice are considered and plans and calculations made.

With no written records or accurate maps available on previous work done on the property, operations under the supervision of Ka-Mi-Tin Concentrating Corporation were begun in the Condon area, for it was known that rich tin ore had been mined and milled from this section.

Three long cross-cuts of the mineralized area were made by steam shovel which gave an excellent picture of the form and character of the pegmatite dikes. Three large pits were dragged, each to a depth of about 40 feet. From the cuts and pits drifts were run into and through the pegmatite dikes to determine contacts and enrichments. All this work was done in the soft, weathered zone, the depth of which extends to about 60 feet where hard-pan is encountered.

The work was made very hazardous and difficult by the continual unexpected encountering of old workings from which large volumes of water and muck would break in upon the new workings.

Without further detailing the work done in the old areas, we may briefly summarize the results. In the Condon area, the management has established the fact that a rich tin-bearing reef rock is near or at the hanging wall of the west pegmatite dike, and the top of the reef is at a depth of about 50 feet from the surface. Later, this will be mined by a shaft to be sunk west of all the old workings and to a depth of at least 150 feet so as to get underneath all the old water and muck-filled drifts. Diamond drilling will first outline the shape and extent of the tin reef.

The work in the Condon area has also established the fact that the company has a large deposit of high-grade Kaolin and Mica which when milling and treating facilities are available should prove a source of income. Other tin enrichments at the several contacts, hanging-and foot-walls of the dikes, will be followed down and should develop into valuable ore bodies at depth.

In the Jake Mine, a high-grade deposit of Kaolin and Mica and several enrichments of tin have been proved, none of which have been carried to a depth of more than 20 feet all in the soft weathered zone.

On the Incline dike, a good part of the old workings were cleaned out and extended. All work was in the soft, weathered rock; at no place to a depth of more than 30 feet. Aside from proving another commercial body of Kaolin and Mica, tin values run from ¼ of one percent to two percent, the richer bodies being at the foot-wall contact of the main dike. No work was done in the old Carpenter area.

Work in the Swamp section, which lies about 1,000 feet south of the Incline area, was started early in September 1936. In a cross-cut from Swamp Shaft Number 1 at a depth of only 30 feet from the surface a rich tin

strike was made, assays running up to sever 1 percent tin over a reef width of four to six feet. A drift was run north a distance of 85 feet paralleling the reef but in the soft, weathered rock and above the harder reef rock. An incline or slope the full width of the reef has been run for a distance of 33 feet and attaining a depth of 40 feet in the reef. Milling ore is being hoisted to the surface and stored.

Swamp Shaft Number 2 was sunk to a depth of 45 feet, cross-cut made to connect with the north entry from Shaft Number 1, and is now being used for ventilation and drainage of the workings in Number 1. Later it will be deepened and used for both mining and hoisting.

Swamp Number 3 is a two-compartment shaft with pipe and ladder-way and is 14 feet x 6 feet. The present depth is 65 feet and sinking is continuing. Progress has been slow due to the rock being very hard and highly silicified. Earth mechanics and water have also retarded the expected progress. All these are being overcome and the Shaft will be carried to depth. A level will be established within the next 15 to 30 feet where drifting will be done to reach the foot-wall and the hanging-wall. From this level only one compartment of the Shaft will be carried deeper and the sinking will be more rapid.

Very encouraging values for such highly silicified

rock, both in tin and columbite, have been followed down in Number 3 Shaft. It is anticipated that the hanging-wall or foot-wall contact, where the rock should not be so hard, should have tin-bearing rock similar in character to what was found at the hanging wall in Number 1 which is only 300 feet to the south. The formations appear similar.

Practically all work is being concentrated in the Swamp area at this time. There are 27 men on the pay-roll and day and night shifts are [illegible] Shaft Number 3.

The steam shovel is being used as a hoist and stacker for Number 3 Shaft. Hand winches are used on the others. A compressor plant was installed in November and furnishes power for four air drills and one pump. Two gasoline engines and pumps are in Shaft Number 3. A generator plant furnishes Electric current for surface and underground work. There are eight buildings in the Swamp Shaft enclosure including the office and two bunk houses. An ore bin 30 feet by 80 feet is being constructed.

A recent development has added color to the picture. A mile to the south at the Henry Shaft, a recent work has opened a tin reef similar to the strike in Swamp Number 1. Sufficient depth has not yet been reached to determine the full width of the reef.

The work in the Henry is on the 30-foot level. Years ago limited mining was done on a 60-foot level where good ore

values were reported. To mine at this depth now would require the installation of a new unit, including pump, compressor and air drills as well as a hoist. The Company is fully occupied in its development at the Swamp Shafts and nothing more than exploratory work is planned for the Henry area for the moment. Probably by Spring when the weather conditions are more favorable, plans will be made to open up this new area.

In conclusion, the year 1936 has seen the Company develop into a smoothly functioning organization and a well-trained and experienced personnel. Local labor conditions have caused delays in the past but this is being overcome by importing miners from other districts. In Canada the saying is "five years to develop a mine." We hope that the year 1937 will see developed a tin-producing mining and milling company, and later an installation to handle the Mica and Kaolin, and the Feldspar and spodumene (source of lithium).

In all, the year 1936 has seen satisfactory progress and results in the development of this new project. The work is under the supervision of L.H. Hepp, resident superintendent and the consulting geological advice of Stuart St. Clair of New York.//

Since this report, the number three shaft has been carried down to 80 feet and number one shaft has reached 70 feet. A cross-cut from shaft number one on the 30-foot level struck a rich tin reef. A cross-cut is now being driven on the 65-foot level to reach the same reef. Assay results on careful sampling of the Swamp number one reef give the following results: Cut number one, width 8 feet, roof channel 3.24% metallic tin, floor channel 2.74% tin. Cut number two, 16 feet north, width 5 feet, roof channel 4.92% metallic tin, floor channel, 5.66% tin. Assays by John H. Banks Laboratories, New York City.

Of some interest, - in sinking Swamp shaft number one and driving 65-foot level cross-cut, considerable iron sulphide was encountered in the gneiss. Assay by Banks gives gold per ton 0.05 oz.; silver per ton 0.12 oz.; copper 0.03%.

After the above report was made, further drifting from the Henry shaft on a 30-foot level struck 5 feet of weathered greisen which panned 3% cassiterite; second sample 1.25% cassiterite. Hard greisen reef, 2 feet in width, uncovered, estimated 2.5% cassiterite.

Early diamond drill holes should be mentioned. Unfortunately, no record is now available except from word of mouth of people who worked on the drill. One hole 450

feet in depth, angle 45° in the Condon area, passed through 10 feet of dike, good tin values. This would be about 60 feet horizontal thickness. This checks with known widths of this dike.

A drill hole west of the Incline area and north 1000 feet from Swamp shafts went to a depth of 1300 feet on a 45 angle. Four dikes were cut ranging from 10 to 20 feet in thickness, tin assays averaging 1.5 to 2.0%. This length of drill hole would give 920 feet on a horizontal and vertical projection. The findings check with known dikes. A few cores picked up around the collars of the holes are of hard gneiss and schist, the country rock.

LIST OF REPORTS

AND GOVERNMENT PUBLICATIONS ON THE GENERAL AREA.

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" " " " " 1903, p. 337.
" " " Bulletin 260, page 163, page 188.
" " " " 293.
" " " " 660d.
" " " Geologic Folio 222.
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Dr. John H. Banks, New York City, Assay Reports.
C. S. James, Newark, N.J., Mill and Mill runs.
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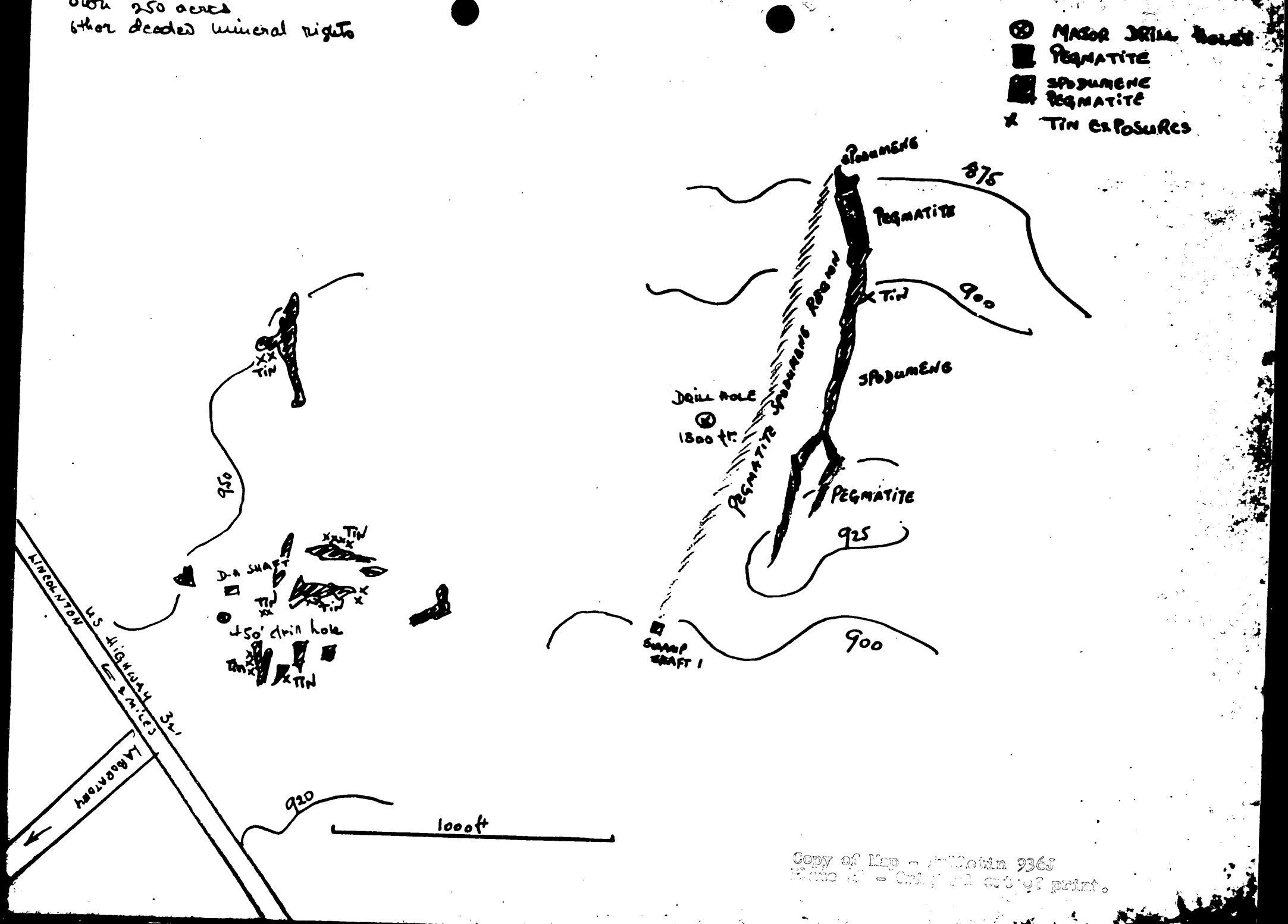
Stuart St. Clair, New York City, Consulting Geologist.
V. J. Hampton, Patino Mines, Bolivia. Mining Engineer.
Mr. Bennett, before the Tin Investigation Committee, Foreign Relations Comm. Samuel McReynolds Chairman. Washington.

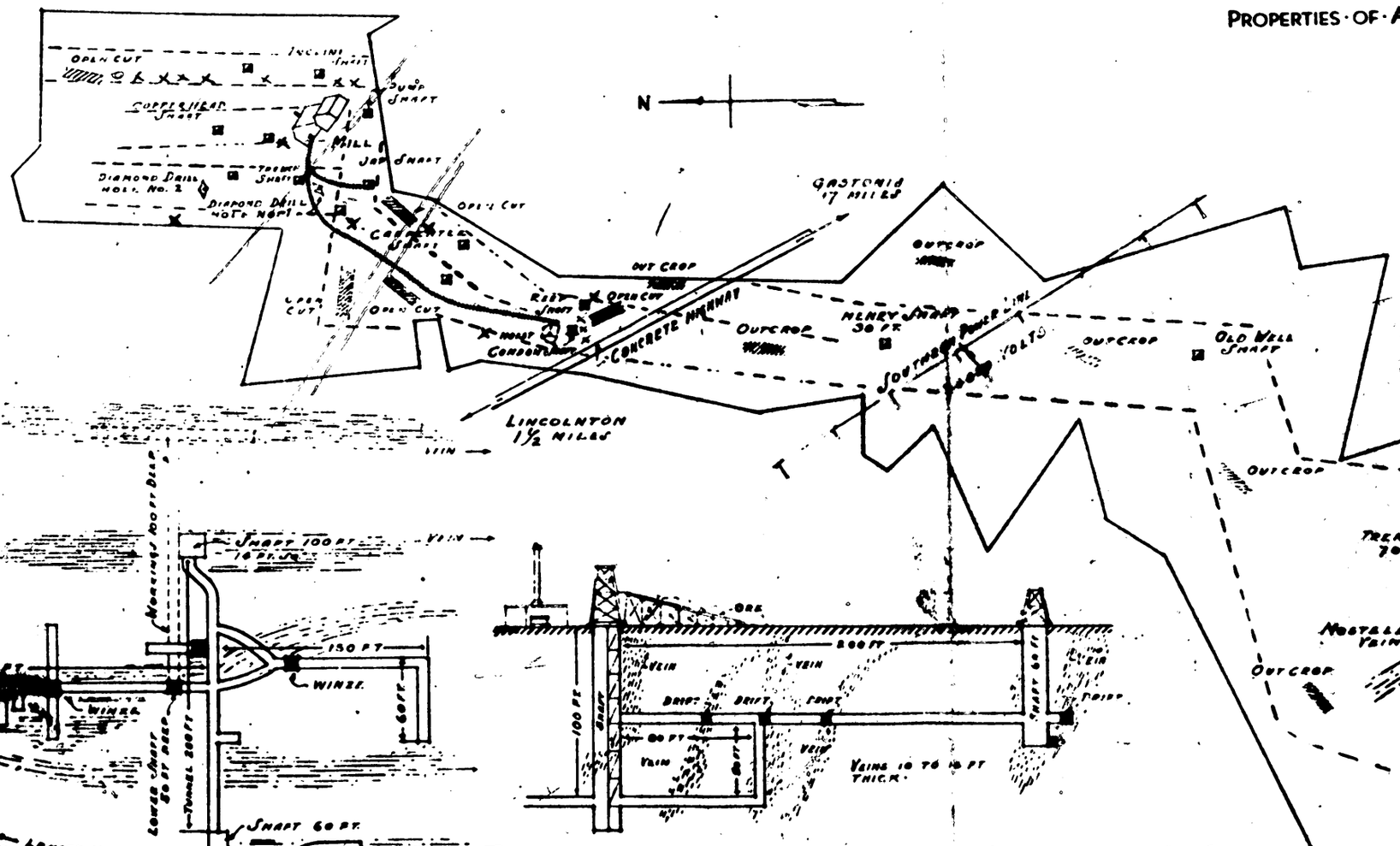
other 250 acres
other deeded mineral rights

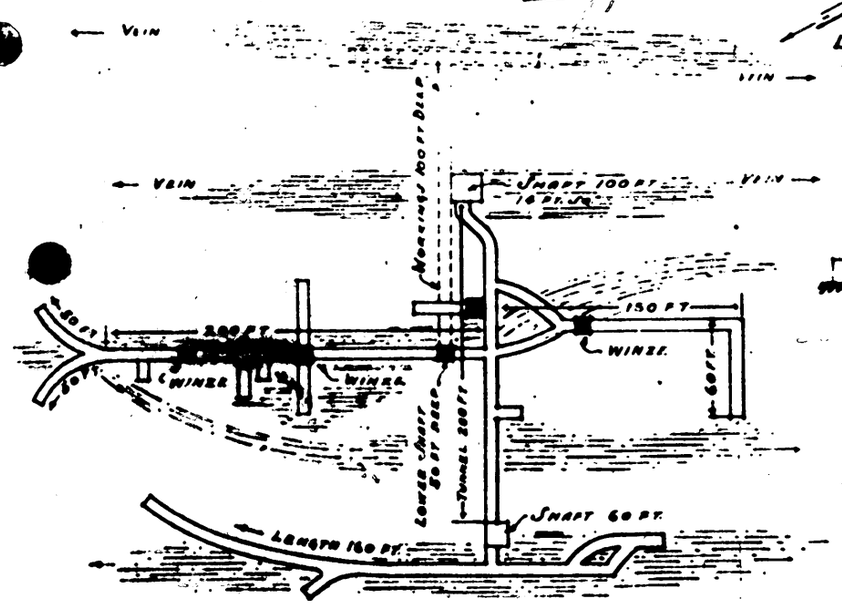


Copy of Map - Bulletin 936J
Photo [illegible] - Original [illegible] print.

PROPERTIES · OF · AMERICAN · CONSOLIDATED · TIN · MINES · CORP ·

ORE ZONES.
DIAMOND DRILL HOLES.
SHAFTS.
OUTCROP OF VEINS
OPEN CUT WORKINGS ON VEINS.
TRENCHES ON VEINS.
COMPANY'S RAIL TRAMWAY
LOCATIONS APPROXIMATE.
AREA - 600 ACRES - 2½ MILES BY ½ MI.
X SAMPLE ASSAYS





DETAIL PLAN OF WORKINGS ESTABLISHED FIFTY FEET BELOW THE SURFACE, SHOWING THE FIVE LARGE VEINS. THE DOTTED LINES INDICATE WORKINGS 100 FEET BELOW THE SURFACE.

SECTIONAL VIEW OF THE CONDON SHAFT WORKINGS, SHOWING SHAFTS 50, 60 AND 100 FEET DEEP, ALSO THE LEVELS ESTABLISHED 50 AND 100 FEET BELOW THE SURFACE.

ENGINEERS
INSPECTIONS and TESTS

CHEMISTS
INDUSTRIAL and ANALYTICAL

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806 Valley Drive
Telephone [illegible] 3224

October 28, 195[illegible]

St[illegible]ard [illegible] lloys Corporation
120 [illegible]ll Street
New York 5, New York

Attn: Mr. Howard [illegible]. [illegible]routh

628355 Sample [illegible]-[illegible] I

Tin	Sn	0.77%	Cassiterite	SnO_2	0.98%
Beryllium	Be	0.12%	The Metal Beryllium	Be	0.12%
Lithium	Li	0.26%	Spodumene	$LiAl(SiO_3)_2$	0.47%
Columbium	Cb)				
Tantalum	Ta)		Combined as the oxides	Cb_2O_5) Ta_2O_5)	0.145%

It was necessary to grind the entire sample in order to have a representative pulp. Mica or feldspar, or any other rock, should be determined on a separate sample.

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WHITEHALL 3-1600

SIMPSON COAL & CHEMICAL CORPORATION
120 WALL STREET
NEW YORK 5, N.Y.

October 27, 1952

A N A L Y S I S

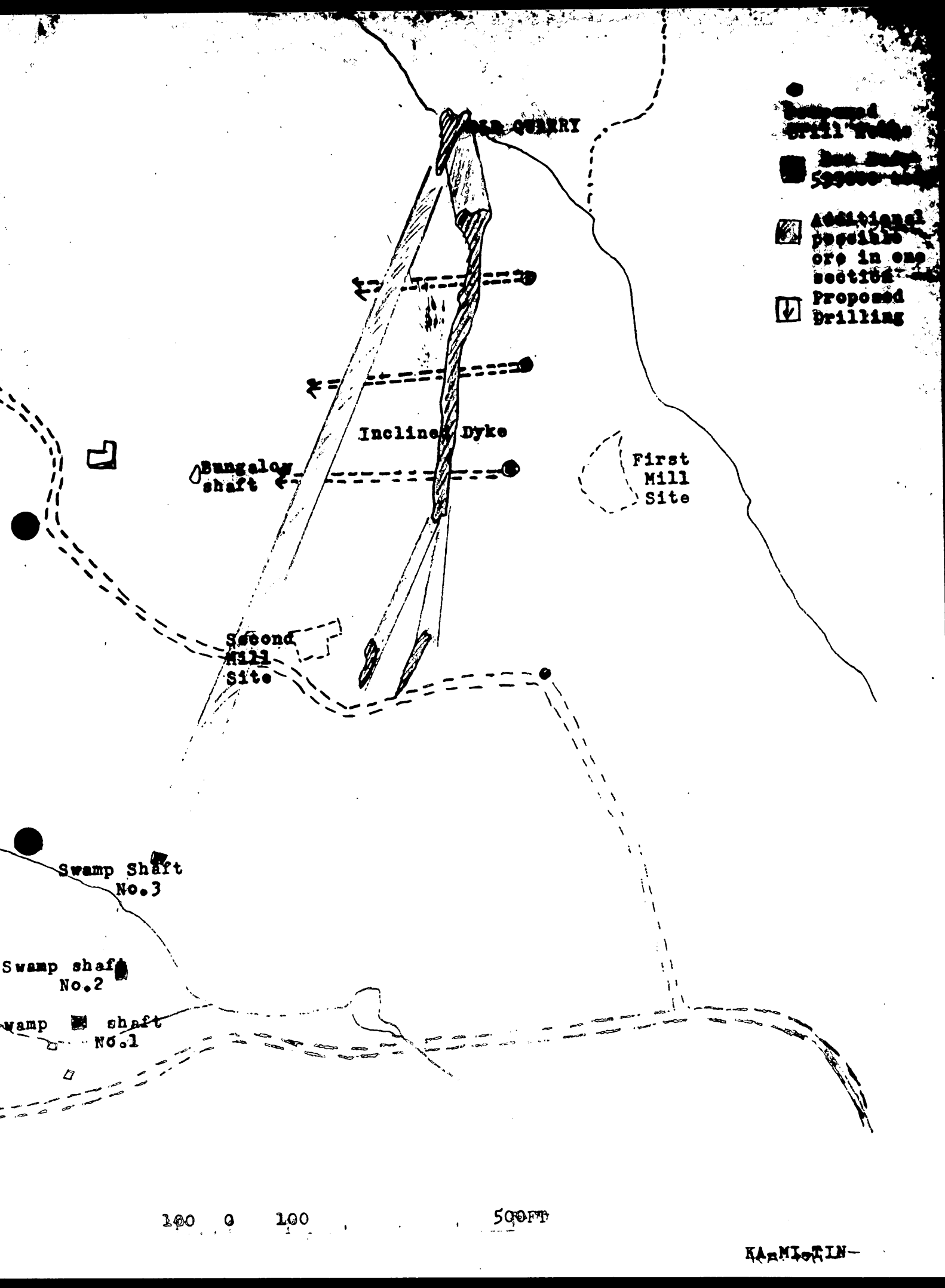
Pegmatite Ore - Composite Sample K M T

	% Present
Spodumene (Lithia content 7% Li_2O)	18
Quartz	35
Mica	6
Tin (In form of Cassiderite)	.5
Columbium-Tantalum Comb.	.015
Beryllium	Trace
Iron	2.0
Feldspar	30.5
Alumina	6
Moisture	Balance
	100 %

SIMPSON COAL & CHEMICAL CORPORATION

D. Shenkin

D. Shenkin, Chemist


Additional possible ore in one section
Proposed Drilling
Inclined Dyke
Bungalow shaft
First Mill Site
Second Mill Site
Swamp Shaft No.3
Swamp shaft No.2
Swamp shaft No.1
100 0 100 500FT

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Please [illegible] of this manuscript by returning it to the [illegible] with your comment and recommendations at your earliest convenience.

NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING

OF THE

UNIVERSITY OF NORTH CAROLINA

MINERALS RESEARCH LABORATORY
Asheville, North Carolina

March, 1952

A METHOD FOR CONCENTRATION

OF

NORTH CAROLINA SPODUMENE ORES

By

Mason E. Banks, William T. McDaniel and Philip N. Sales

Report prepared in cooperation with the North Carolina Department of Conservation and Development and the Tennessee Valley Authority

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ABSTRACT

Studies of a froth flotation process for concentration of spodumene from ores obtained in the vicinity of Kings Mountain, North Carolina were made on both batch and pilot plant scales. A process was developed for the production of concentrates which assayed 6.0% Li_2O and 0.45% Fe_2O_3 with 70-75% recovery of spodumene. The process requires two flotation separations, i.e., (1) a procedure whereby mica, feldspar, and quartz are simultaneously removed as a froth product with a cationic collector, and (2) the subsequent removal of iron-bearing minerals as a froth product while spodumene is depressed as a tailing. The process is the reverse of the usual procedure of collecting spodumene as a froth product with anionic collectors.

The investigation was undertaken by North Carolina State College Minerals Research Laboratory of Asheville, North Carolina at the request of Foote Mineral Company of Philadelphia, Pennsylvania. Parts of the process are now being used on a commercial scale at the Foote Mineral Company plant near Kings Mountain, North Carolina

Introduction

During the 1942-45 period of World War II, Solvay Process Company operated a flotation plant with a daily capacity of 300 tons of ore for the production of spodumene concentrate near Kings Mountain, North Carolina. The operation was shut down upon cessation of wartime demand for lithium chemicals and, until recently, there has been no production from the Carolinas.

In April, 1950 an investigation of the problem of spodumene flotation from North Carolina ores was begun at N. C. State College Minerals Research Laboratory at Asheville, N. C. This laboratory, operating under the combined auspices of N. C. State College, N. C. Department of Conservation and Development, and Tennessee Valley Authority undertook the spodumene project at the request of Foote Mineral Company of Philadelphia, Pennsylvania. The work, involving a period of fifteen months of intensive batch and pilot plant investigation, was completed in June, 1951, and resulted in development of a process for concentration of spodumene by flotation which has been hereto unrecorded in the literature. A similar approach has been used before on iron, ilmenite, and other minerals, but the literature shows no record of its having been applied to spodumene. Parts of the process are now being used on a commercial scale at the Foote Mineral Company plant near Kings Mountain, N. C., which has been in production since July, 1951. It is the purpose of this paper to describe some of the results of the investigation.

Acknowledgements

The authors would like to acknowledge with sincere appreciation the assistance of the following people and organizations in connection with this investigation: Dr. J. L. Stuckey, State Geologist of North Carolina and his assistant, Sam D. Broadhurst; Charles E. Hunter, former TVA Geologist, for field sampling and geological assistance; Carolina Mineral Company; United Feldspar and Mineral Company; Research and Development Division, Foote Mineral Company for furnishing checks on analytical control samples, and for part of the pilot plant equipment; W. H. Powell, R. B. Terrell, and W. R. Hedgpeth for assistance in carrying out laboratory tests.

The Ore Bodies

According to statements judged to be conservative the tin-spodumene belt of the Carolinas contains an estimated 4,300,000 tons of pegmatite ore averaging 15% spodumene. This amounts to "a reserve of at least 650,000 tons of spodumene (more than 20,000 tons of metallic lithium) to a depth of 100 feet." (1)

Spodumene-bearing pegmatites occur in a narrow belt 24.5 miles long and 1.8 miles wide extending southwestward from Lincolnton to Grover, N. C. There are hundreds of pegmatites in the belt most of which are less than 10 feet wide, however, there are sufficient larger bodies to permit the establishment of the reserves figure of 4,300,000 tons of ore. This figure includes only bodies having an average thickness of 35 feet and length of 550 feet. The largest pegmatite in the area has a maximum thickness of 395 feet and maximum length of 3250 feet. (1)

These larger pegmatites are composed principally of albite and microcline feldspars (albite predominating), quartz, spodumene, and muscovite. There are many accessory minerals, but the important ones are cassiterite and beryl, and possibly columbite-tantalite. Approximate composition of ores from the belt which were used in this investigation is as follows:

Table I

Ore	Sampled by	Spodumene	Feldspar	Quartz	Mica	Others
Lab. No. 808	Laboratory Staff	[illegible]	36%	[illegible]	3%	2%
Lab. No. 837-A	Foote Mineral Co.	36	33	26	3	2
Lab. No. 971	Consolidated Feldspar Corp.	23	41	27	5	4
Lab. No. 943	Foote Mineral Co.	19	45	25	4	7
Lab. No. 969	Foote Mineral Co.	22	42	25	4	6
Lab. No. 985	Foote Mineral Co.	13	56	22	4	5

Notes: 1. "Others includes hornblende gneiss and sericite schist particles from wall rock and inclusions, as well as beryl, cassiterite, and numbers of accessory pegmatite minerals present in trace quantities.

2. The Foote samples contained 0.03-0.05% Sn, or approximately 1.8 pound Sn per ton of ore. These came from the old Selvey quarry about 1 mile SW of Kings Mountain.

Table I shows that quartz and muscovite content remain fairly constant in all the ores, while feldspar content increases when spodumene content decreases, and vice versa. This is interesting because feldspar is potentially an important by-product.

The Spodumene

According to Boyd,(3) the following analysis is typical of the Carolina spodumene:

SiO_2	Al_2O_3	Li_2O	Fe_2O_3	CaO	MnO	BeO	MgO	Ignition loss
63.84	28.61	7.26	0.39	0.04	Trace	Nil	Nil	0.16

Spectrographic analysis shows the presence of minor amounts of Fe_2O_3, MnO, TiO_2, SnO_2, Ga_2O_3, NaO and KO in the spodumene. One sample contained Nb_2O. Petrographic and X-ray studies indicated that these impurities are probably isomorphous replacements in the crystal structure of the spodumene.(5)

The molecular dispersion of the iron within the spodumene crystal has been substantiated by acid-leaching and magnetic separation tests in which the Fe_2O_3 content of spodumene crystals remained from 0.15-0.40% after magnetic separation and acid leaching.(2)

The iron content of the spodumene crystals is usually reflected in the color of the crystals, the colorless to white variety containing from 0.08-0.20% Fe_2O_3, the buff or cream variety containing 0.20-0.40% Fe_2O_3 and the yellow or greenish-yellow variety containing up to 0.6% Fe_2O_3, etc. The darker the color the higher the iron content of the spodumene.

The amount of iron dispersed in the spodumene crystals is a significant factor since it effects the use to which the concentrates may be put. For use in ceramics the spodumene concentrate should contain less than 0.5% Fe_2O_3, but for use in extraction of lithia for chemical purposes the presence of iron presents no special problem. None of the samples handled from the Carolina belt contained spodumene with low enough isomorphous iron content to yield a product with less than 0.2% Fe_2O_3. The average iron content of spodumene concentrates prepared from these ores was 0.40-0.50%.

The Carolina spodumene is somewhat variable in Li_2O content, but apparently averages approximately 7.0% or slightly in excess of this figure, although, the textbook gives 8.03% theoretical Li_2O. Some variation is caused by weathering for it has been established that Li_2O is lost by leaching when the rock undergoes weathering, just as the Na_2O and K_2O are lost in kaolinization of feldspar.

Since the close of World War II there have been numerous developments which have tended to increase the use of lithium by industry. Notable among these has been the development of an industrial lubricant based on lithium stearate. The lubricant is fluid at low temperatures, stable at high temperature, and insoluble in water. A new bleaching agent, lithium hypochlorite, has also been developed recently.[11] Other well-known uses are listed below:

1. Lithium oxide in ceramics reduces firing time, lowers melting temperatures, lowers thermal expansion, raises refractive index, and improves chemical resistivity.
2. Lithium carbonate and lithium stronitium nitrate are used in pyrotechnics for their brilliant red color.[10]
3. Lithium chlorides and fluorides are used as fluxes for welding aluminum and magnesium.[10]
4. The affinity of lithium for nitrogen is the basis for a process used in purifying helium.[10]
5. Lithium chlorides and bromides are used in air conditioning for their powers to absorb organic amines, ammonia, and smoke.[11]
6. Lithium hydride has been used as a source of hydrogen to inflate life rafts and balloons used by the Air Forces and Navy.[11]
7. Lithium metal and lithium hydride are useful in the atomic energy program in connection with the production of the isotopes of hydrogen.[7]

Review of Concentration Methods

The literature reveals the following methods which have been used for production of spodumene concentrates: 1. The spodumene of the Black Hills of South Dakota was present in such large crystals that it was easily concentrated by selective mining and hand sorting. 2. The Bureau of Mines developed a method by which alpha spodumene was decrepitated at a temperature between 1000°C and 1100°C, changing its form to beta spodumene, a soft pulverulent material, which could be recovered from the harder gangue minerals by differential grinding following the decrepitation.[6] 3. Froth flotation of spodumene using anionic collectors (fatty acids) in an alkaline circuit was worked out by the Bureau of Mines, and enlarged upon by Norman and Gieseke.[2] This method was utilized by Solvay Process Company at Kings Mountain, N. C. during its wartime operation. 4. Froth flotation with sulfonated oils in an acid circuit was also shown to be feasible, as well as a method of producing a feldspar-spodumene mixture by using cationic collectors in an HF circuit.[2] 5. A mill at Keystone, South Dakota operated by Lithium Corp. of America has been utilizing the heavy media method, treating 15 tons of minus 1½-in. ore per hour, and producing a concentrate of 4 to 5% Li_2O.[7]

All of the methods above have their advantages and disadvantages. The method described on the following pages is presented merely as a different approach and is acknowledged also to have both advantages and disadvantages.

The Flotation Process

The final process developed for spodumene concentration of North Carolina ores revolves around two primary flotation separations, i.e., 1. a process whereby mica, feldspar and quarts are simultaneously removed as a froth product while spodumene and iron-bearing minerals are depressed as a tailing; and, 2. the subsequent removal of iron-bearing minerals as a froth product while spodumene is depressed as a tailing. The removal of silicate gangue minerals in Step 1 is accomplished in an alkaline circuit, using a long-chain amine as collector, and a colloidal depressant, such as starch or dextrine as selective depressant for the spodumene and iron-minerals. The iron minerals are removed in an acid circuit, using sodium resinate as collector and hydrofluoric acid as controller for prevention of spodumene flotation. Suitable frothers are used in both floats.

The gangue froth product containing mica, feldspar, and quarts may be split into its component parts for recovery of a feldspar by-product. Since approximately one-third of the feed is generally recoverable as a feldspar concentrate, it was felt that efforts to recover it should be made. The general procedure for feldspar recovery would be to dewater the gangue froth product, and then treat it in the conventional manner for feldspar ores which consists of removal of mica with sulfuric acid and amine, washing by classification, then flotation of other iron-bearing silicates with sulfonated oil or fatty acid collectors, and finally flotation of feldspar from quarts with the conventional hydrofluoric acid-amine process.

The final process which breaks the ore into its component parts is described generally as follows:

1. Grinding. The ore as received was ground in a batch rod mill at 25 percent solids to pass a 28 mesh screen. The plus 28 mesh fraction, consisting almost entirely of mica, was removed. The minus 28 mesh fraction, was deslimed by decanting over a 325 mesh screen. Approximately 0.5 pound caustic per ton of feed was used in the mill to keep the pulp dispersed for desliming. The oversize product consisted of about 1.0 percent weight of the feed, while slime loss amounted to 12-18 percent weight of the feed. Separations were obtained with feed as coarse as 20 mesh, and the general range of 20-28 mesh was satisfactory. The feed should be sized by screening or classification, with oversize returning to the mill in practice. The rod mill is preferred to the ball mill, because it produces a coarser, more ganular, feed with much closer size distribution. It is believed that ball milling would produce excessive slimes and a long particle size range, both of which have been shown to be undesirable in this process.

2. Rougher Gangue Flotation. The deslimed minus 28 mesh plus 325 mesh pulp was placed in a Denver 2000 gram laboratory flotation machine and brought to 20-25 percent solids. The following reagents* were added: 1.0 lb/T Lime, 0.5 lb/T dextrine, 0.4-0.7 lb/T Armac T, and 0.4 lb/T B-23. The pulp was conditioned for one minute, then floated for four minutes, with the quarts, feldspar, and mica being simultaneously removed as a froth product. The spodumene and iron-bearing minerals were selectively depressed and removed as a tailing. Most of the froth was removed in two minutes. The float is heavy and fast if sufficient frother is used. The rougher is more selective if little or no frother is used, but requires more collector (Armac T) and an excessive float time. Lime

*Calculated in pounds per ton of dry mill feed.

and dextrine are more selective and cheaper than caustic and dextrine, although either may be used. If dextrine is not available, causticized-starch may be used, although dextrine is preferable. An excess of starch or dextrine does not break down the separation, but merely causes an increase in collector required. Approximately 0.5 lb/T dextrine or causticized-starch is generally sufficient to depress the spodumene. An excess of caustic or lime can cause complete break-down of the separation as the amine collector is unstable when the pH is above 11.5.

3. Cleaner Gangue Flotation. The rougher gangue froth was next placed in the cell at 15-20 percent solids with 0.5 lb/T Lime, 0.5 lb/T Dextrine, and 0.2 lb/T B-23. It was conditioned 15 seconds, then floated four minutes. This is practically a repetition of the rougher, for the purpose of dropping out fine spodumene particles which were mechanically entrained in the heavy rougher froth. It requires no additional collector. If sufficient frother is used, the cleaner tailing or middling is a high-grade spodumene concentrate and may be combined with the rougher tailing.

4. Iron Mineral Flotation. The combined rougher tailing and cleaner tailing, consisting of a high-grade spodumene concentrate with substantially all of the iron-bearing minerals present, was then washed by decantation, thickened to 65-75 percent solids, and conditioned for ten minutes with 0.35 lb/T HF (100 percent), 2.0 lb/T sodium resinate, 0.1 lb/T B-24. The pulp was transferred to the cell and floated four minutes at 25 percent solids, with iron-bearing minerals being removed as a froth product, and relatively iron-free (except for molecularly contained iron) spodumene discharged as a tailing. The tailing is the finished spodumene concentrate, which may be thickened, filtered, and dried in conventional manner. The sodium resinate collector was chosen over sulfonated oils as iron-mineral collector because it tends to concentrate the spodumene by floating mica and feldspar impurities along with the iron minerals, whereas the sulfonated oils tend to float pure spodumene along with the iron minerals. It is most important to maintain pulp density in the conditioner as high as possible before flotation of iron minerals.

5. Mica Flotation. The cleaner gangue froth was next conditioned for three minutes with 1.0 lb/T H_2SO_4, 0.1 lb/T B-23, and 0.05 lb/T Armac T at 35 percent solids. Mica was then removed as a froth product.

6. Feldspar Flotation. The quartz-feldspar tailing from the mica float was washed by decantation, then conditioned six minutes at 50 percent solids with 1.5 lb/T HF (100 percent). It was then placed in the cell, diluted to 25 percent solids, and 0.05-0.20 lb/T Armac T and 0.3 lb/T B-23 were added before flotation. Feldspar was removed as a froth product and quartz was discharged as a tailing.

Using the process as outlined, results on batch testing several ores are shown in Table II. Figure I is a flowsheet of the process.

Table II
Batch Test Results

Lab. No. 808 Head Sample: 38% spodumene, 0.24% Fe_2O_3 in spodumene crystals.

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	Fe_2O_3	Al_2O_3	SiO_2	(1) Li_2O	(2) Li_2O
Spodumene Conc.	29.4	91	26.8	70.8	0.26			6.55	
Iron Froth Product	3.2	62	2.0	5.3				4.85	
Mica Froth Product	4.2	4	0.2	0.5				0.45	
Feldspar Froth Product	21.0	14	2.9	7.7	0.07		67.0	1.25	
Quartz Tailing	29.8	8	2.4	6.3	0.04		93.3	0.75	
Slime & Oversize	12.5	29*	3.6*	9.5*					
Total	100.1		37.9	100.1					

Lab. No. 837-A Head Sample: 36% spodumene, 0.43% Fe_2O_3 in spodumene crystals.

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	Fe_2O_3	Al_2O_3	SiO_2	(1) Li_2O	(2) Li_2O
Spodumene Conc.	33.8	89	30.1	83.6	0.44			6.50	6.44
Iron Froth Product	1.9	50	1.0	2.8	8.29			4.05	4.50
Mica Froth Product	1.5	3	0.1	0.3				0.35	0.52
Feldspar Froth Product	27.5	8	2.2	6.1	0.09	19.9	68.4	0.70	0.68
Quartz Tailing	20.9	1	0.2	0.6	0.02		98.0	0.10	0.11
Slime & Oversize	14.4	18*	2.4*	6.7*					
Total	100.0		36.0	100.1					

Lab. No. 943 Head Sample: 19% spodumene, ____% Fe_2O_3 in spodumene crystals.

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	Fe_2O_3	Al_2O_3	SiO_2	(1) Li_2O	(2) Li_2O
Spodumene Conc.	14.3	82	11.7	63	0.86			6.35	6.40
Iron Froth Product	2.6	55	1.4	7				4.35	4.00
Mica Froth Product	6.0	5	0.3	2				0.50	1.19
Feldspar Froth Product	37.9	7	2.6	14	0.26	20.6	66.0	0.70	1.40
Quartz Tailing	20.1	1	0.2	1	0.14		94.1	0.10	0.36
Slime & Oversize	19.1	13*	2.4*	13*					
Total	100.0		18.6	100					

Lab. No. 971 Head Sample: 23% spodumene, 0.47% Fe_2O_3 in spodumene crystals.

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	Fe_2O_3	Al_2O_3	SiO_2	(1) Li_2O	(2) Li_2O
Spodumene Conc.	22.8	84	19.2	83.5	0.56			6.25	
Iron Froth Product	1.0	94	0.9	3.9				6.70	
Mica Froth Product	4.4	1	0.0	0.0				0.10	
Feldspar Froth Product	36.6	4	1.5	6.5	0.12	20.4	68.1	0.40	
Quartz Tailing	20.8	1	0.2	0.9	0.05		96.5	[illegible]	
Slime & Oversize	14.3	8*	1.2*	5.2					
Total	99.9		23.0	100.0					

(1) By using curve showing Li_2O vs. percent sinks in acetylene tetrabromide.
(2) By actual chemical analysis.

*Calculated using head sample analysis.
Distribution of spodumene based on percentage of sinks in acetylene tetrabromide.
Li_2O analyses by Foote Mineral Company.

PROPOSED SPODUMENE FLOTATION PLANT FLOWSHEET

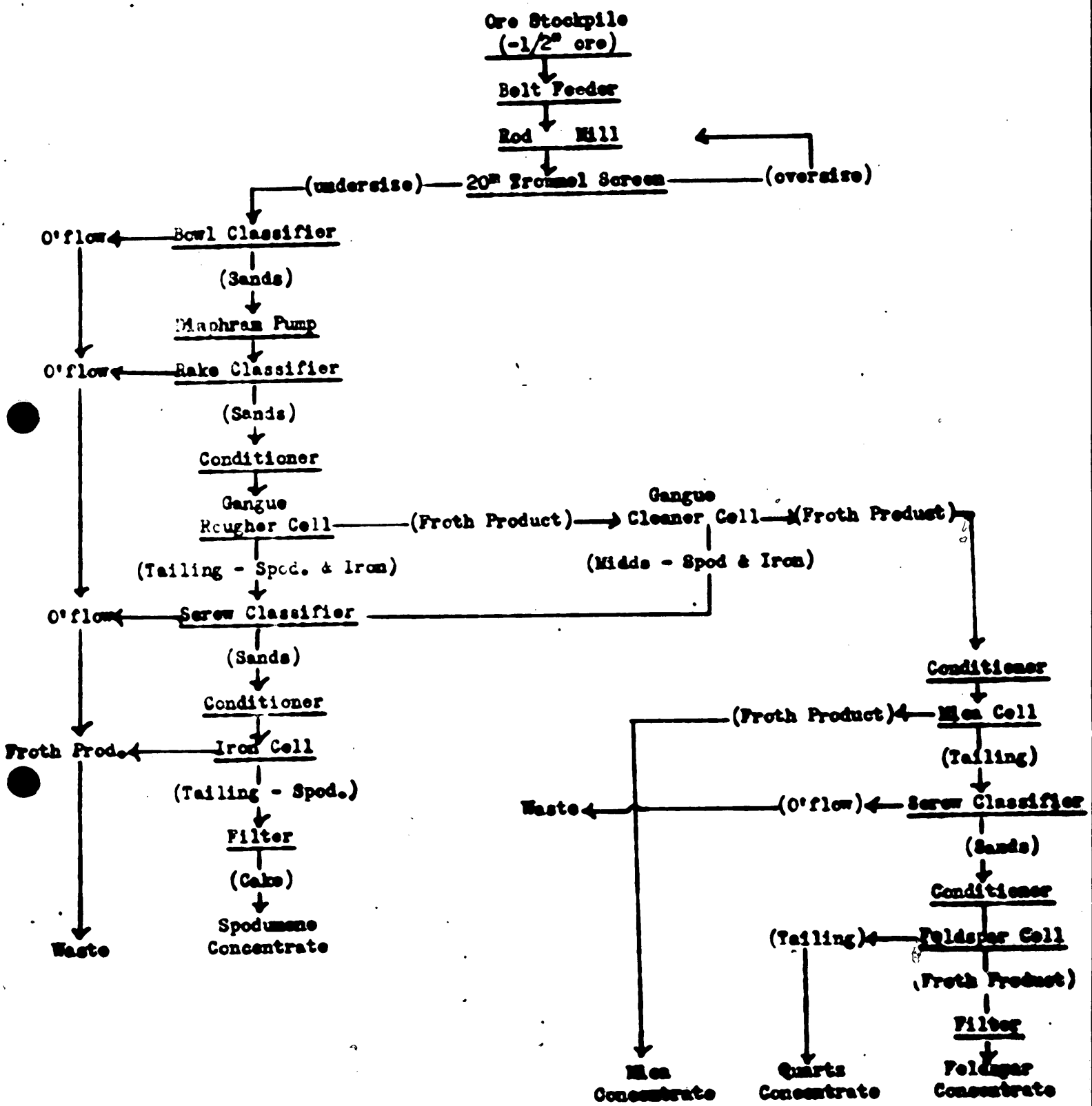

Figure 1

Pretreatment of Weathered Ores

It was found necessary to employ light attrition scrubbing on ore types which were weathered appreciably. Unless alteration products were removed from the mineral particle surfaces, selectivity was rather poor. This condition had been noted previously in application of anionic flotation to these same ores.(2) The main effect of weathering on this cationic float was to inhibit flotation of stained particles of quartz and increase amine consumption. This substantially lowered the grade of concentrates obtained. It was found that conditioning at 65-70 percent solids for 5-10 minutes with 4-5 lb/T of caustic followed by a decantation wash was effective in removing the alteration products on particle surfaces. When the spodumene-gangue separation was performed on weathered ores which had been scrubbed in this manner, selectivity was usually as good as that obtained on fresh, unweathered ore samples.

An alternate method was also found to be effective. This alternate method was to change the grinding pulp density from the normal low percent solids to high percent solids, using 4-5 lbs/T of caustic in the mill, thereby getting a scrubbing action in the mill. This procedure resulted in improved flotation selectivity, but changed the nature of the mill discharge from a rather coarse, uniformly-sized feed, to a finer feed with a much greater range of size.

Of these two methods of handling weathered ores, the one utilizing dilute grinding conditions and a separate scrubbing step has been shown to be the best procedure, although the alternative use of the mill as a scrubbing device may be used if it becomes expedient to do so.

The following three batch test results indicate the beneficial effect of scrubbing on a weathered ore. In each case shown, treatment of the samples was identical except for grinding and scrubbing conditions as indicated. Feed was Lab. No. 969.

Table III

Test 1 - Dilute (25% solids) grind. No scrubbing.

Results:	% Wt.	% Spod.	Units Spod.	Distribution of Spodumene
Spodumene Conc.	20.0	71.0	14.3	65
Gangue Froth	69.3	8.0	5.3	24
Slime Loss	10.7			11
Total	100.0			100

Test 2 - Dilute (25% solids) grind. Scrubbed 6 min. at 75% solids with 5.0 lbs/T NaOH. Washed.

Results:	% Wt.	% Spod.	Units Spod.	Distribution of Spodumene
Spodumene Conc.	16.1	90.7	14.6	66
Gangue Froth	72.9	5.4	3.9	18
Slime Loss	11.0			16
Total	100.0			100

Test 3 - Thick (60% solids) grind with 4.0 lbs/T NaOH in grind.

Results:	% Wt.	% Spod.	Units Spod.	Distribution of Spodumene
Spodumene Conc.	20.2	86.3	17.3	79
Gangue Froth	66.3	5.0	3.3	15
Slime Loss	13.5			6
Total	100.0			100

Pilot Plant Tests

Since the method outlined in the preceding pages represented a rather novel approach to spodumene flotation, it was decided to make pilot plant tests so that the spodumene-gangue and spodumene-iron separations could be studied under continuous operating conditions. Part of the necessary equipment was furnished the laboratory by Foote Mineral Company.

The flowsheet followed was the same as that shown in Fig. 2, except that the gangue froth product was collected as a bulk froth product with no attempt made to separate the mica, feldspar, and quartz. Grinding conditions were set-up to utilize the mill as a scrubbing device, i. e., high density grinding with caustic. Feed rate for most of the tests was 300 lbs/hr of minus 1/2 inch ore and a total of 15 tons of ore were used in these tests. Operating time on the test runs varied from two to eight hours. Two ore samples were studied in this manner. Lab. No. 969 containing 22% spodumene, and Lab. No. 985 containing 12.5% spodumene. Seven complete tests were made on each ore. Variables studied in these fourteen continuous pilot plant tests included amount of caustic used in the mill, pH studies in rougher and cleaner gangue floats, conditioning time and cell retention time in the gangue float section, comparison of pine oil, B-23, and cresylic acid as frothers, determination of optimum dextrine and amine amounts required, studies comparing sulfonated oils with soap as iron mineral collector, conditioning time and cell retention time in the iron float section. A short study was also made of the problem of concentration of the small amount of cassiterite which occurs in the spodumene ores. The cassiterite problem is not considered within the scope of this paper, but is mentioned to indicate that the presence of the mineral in interesting quantities was recognized and a method was evolved to recover it.

Table IV shows the results obtained in pilot plant tests number 2 and number 14.

Table IV

Pilot Plant Test 2

Operating Conditions

Feed: -1/2 inch Lab. No. 969, 22% spodumene, 0.89% Fe_2O_3, fed at 300 lbs/hr. Mill discharge minus 28 mesh.

Equipment	Reagent	Quantity Reagents - lbs/T	pH	Percent Solids
Rod Mill	NaOH	4.34		65
Rougher Cell	NaOH	0.27	10.9	20
	Dextrine	1.15		
	Amine	0.90		
	Pine Oil	1.13		
Cleaner Cell	Dextrine	1.10	10.0	15
	Pine Oil	0.69		
Fe Conditioner	Sodium Resinate	3.20	5.0	65
	HF	0.24		
	Pine Oil	0.76		
Fe Cell			5.4	20

Metallurgical Results

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	% Fe_2O_3	(1) % Li_2O	(2) % Li_2O
Heads	100.0	22.0	22.0	100.0	0.89	1.90	1.30
Oversize	0.1	75.0	0.1	0.5	[illegible]	5.80	5.80
Bowl O'flow	3.8	3.0	0.1	0.5	1.02	0.35	0.74
Rake O'flow	3.2	3.0	0.1	0.5	0.68	0.35	0.87
Gangue Froth	72.0	7.0	5.0	23.0	0.23	0.70	0.64
Iron Froth	1.5	59.0	0.9	4.1	7.08	4.40	3.50
Spodumene Conc.	19.1	81.0	15.5	71.4	0.47	6.10	6.00
Total	99.7		21.7	100.0			

Pilot Plant Test 14

Operating Conditions

Feed: -1/2 inch Lab. No. 985, 12.5% spodumene, 0.35% Fe_2O_3, fed at 325 lbs/hr. Mill discharge minus 28 mesh.

Equipment	Reagent	Quantity-lbs/T	pH	Percent Solids
Rod Mill	NaOH	4.80		65
Rougher Conditioner	NaOH	0.17	11.1	50
	Dextrine	0.98		
	Amine	0.68		
	Pine Oil	0.90		
Rougher Cell	NaOH	0.26	11.0	20
Cleaner Cell	Dextrine	0.98	10.5	15
	Pine Oil	0.46		
Iron Conditioner	Sodium Resinate	2.16		
	HF	0.70		65
	Cresylic Acid	0.52		

Metallurgical Results

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	% Fe_2O_3	(1) % Li_2O	(2) % Li_2O
Heads	100.0	12.7	12.7	100.0	0.35	1.15	1.15
Oversize	0.1	80.0	0.1	0.7		6.05	6.00
Bowl O'flow	7.7	5.0	0.4	2.8	1.64	0.50	0.87
Rake O'flow	2.3	6.0	0.1	0.7	0.96	0.60	0.81
Screw O'flow	0.4	12.0			1.00	1.10	1.00
Gangue Froth	77.0	4.7	3.6	26.0	0.19	0.50	0.42
Iron Froth	0.6	53.3	0.3	2.2	11.00	4.30	3.96
Spodumene Conc.	11.8	80.0	9.3	67.5	0.65	6.05	6.44
	99.9		13.8	99.9			

(1) By using curve showing % Li_2O vs percent sinks in acetylene tetrabromide.

(2) By actual chemical analysis.

Distribution based on percentage of sinks in acetylene tetrabromide.
Chemical analyses by Foote Mineral Company.

Heavy Liquid Control Method

The use of acetylene tetrabromide as a laboratory control aid is worthy of mention here in view of its extensive use in this investigation. The liquid has a specific gravity of 2.96. The only major constituent of the spodumene ores having a specific gravity higher than 2.96 was spodumene itself. It was found that minus 20 mesh ore samples when placed in acetylene tetrabromide, resulted in a sinks product averaging 98 percent spodumene, the remaining 2 percent consisting of traces of cassiterite, horneblende, tourmaline, apatite, pyrite, and numerous others. Therefore, for all practical control purposes, the percentage of sinks in acetylene tetrabromide was the actual percentage of spodumene in the procuct.

A method was evolved in which the test samples were weighed, placed in acetylene tetrabromide contained in centrifuge tubes, and centrifuged for 10 minutes. Centrifuging brought about excellent separation of gangue minerals as floats and spodumene as sinks. Floats and sinks were then easily separated by a simple pouring technique, filtered, washed with benzene to remove excess tetrabromide, dried and weighed.

A graph (Figure 2) was then drawn in which percentage of sinks in a given sample was plotted against percentage of Li_2O contained in the sample. Li_2O analyses for this graph were kindly furnished by Foote Mineral Co. By obtaining the percentage of sinks in acetylene tetrabromide and reading the corresponding Li_2O value from the graph, it was possible to obtain a reasonably accurate Li_2O analysis.

This method was used as a control on laboratory batch tests and pilot plant tests. All products were quickly and easily evaluated from a lithia standpoint without the costly and somewhat lengthy chemical analytical procedure for lithia determination. From twelve to eighteen Li_2O determinations per eight-hour shift could be made by semi-skilled operators using this method. In addition to its use as laboratory control, the method could easily be adapted in commercial plant operating control.

Conclusions

The two flotation separations described in the foregoing pages produced spodumene concentrates from Kings Mountain ores on a continuous pilot plant scale. The spodumene concentrates contained an average of 6.0% Li_2O and 0.45% Fe_2O_3 with a recovery of 70% of the available spodumene. If the iron removal step was not carried out the recovery of spodumene was approximately 75%. The process was successful on feed ground as coarse as 20 mesh. Weathered ores required light attrition scrubbing for satisfactory separation, but this was carried out in an acceptable manner by milling at high density with a high caustic addition.

The process is not recommended for use on ores containing less than 15% spodumene because recovery tends to drop off as spodumene content in the feed decreases. This is due to the fact that the gangue froth product inherently contains 3-5% spodumene and this becomes an increasingly high percentage of the total distribution as the spodumene content of the ore decreases.

There were no particularly difficult operating problems. The two most important operating points (and the ones which might easily be overlooked) were proper pretreatment of weathered ores, and strict maintenance of high pulp density in the conditioner before iron-mineral flotation.

The most difficult mineral to cope with was horneblende. Spodumene and horneblende are closely related mineralogically, and they exhibited similar reactions to the above described process. In order to satisfactorily remove horneblende, if it were encountered in appreciable amounts in the ore, it would probably be necessary to employ both flotation and magnetic separation.

Figure 2

144-813.0

NPA - Schutter
Schutter 8114

Pit
No 141
Koster 4001

ore. | D

940 445 Pet G+H N.M.

Chemical Plant + SMPA. Ce Jm Bam mill.
ore problem cap to chem. S. Bar.
Plant cap greater than ore - Coastal Plant
New Mine Minnesota
Plan in N.J. selling adjacent ore from S. Bar Maywood Chem Co.
So Va. Feeds plant Eggser Lith Chem plant - ore from Cin mtn - cap of plant 4,000,000 lb L_2O chem plant cap!
20% from Nona
Pr up to 10,000,000 lb. Oct. Rem 1955
Expanded recently

L_2O recov close to 6% L_2O
military will take up most of 10,000,000
partial mobilization
Other companies contemplating ownership
Re. Rare Earths
Also Canada Co planning

Dowa 2773

Please include
A.L. Kinkel, Rm 4234
in the listing
for custom copies
of the memos for
this application

CABLE ADDRESS: NEWLANDIN

THE NEW ENGLAND INDUSTRIES, INC.
120 WALL STREET
NEW YORK 5, N. Y.
WHITEHALL 3-1600

DMEA-2773

IN REPLY REFER TO:

November 6th, 1952

United States Department of the Interior
Defense Minerals Exploration Administration
Washington 25, D. C.

Gentlemen:

Enclosed please find application in quadruplicate of a DMEA project for the recovery of substantial quantities of columbite, tantalite, tin, mica, etc., and in order to further clarify this application, a even more detailed report is already in the hands of Mr. Mittendorf.

The application is made in the name of the New England Industries, Inc., and it will be noted that our lease states that New England Industries is the parent corporation of the Lincoln Mining Corporation, a wholly owned subsidiary. All payments with regard to this property, its up-keep, taxes, etc., have been omitted from all calculations and will be taken care of one hundred percent by our corporation without any Government assistance being requested. The lease is a 99-year lease with an option to buy.

Our original folder contains the original U.S. Geological Survey Bulletin 936J, which fully describes the property, and Plate 41 which shows the improvements on the property, fully proven ore bodies, drill holes, dykes, shafts, etc., etc.- Unfortunately we were unable to procure additional copies and therefore can only submit a copy drawing of this map with this folder.

Regarding additional improvements on the property, description of which is contained in our lease and drawn into our maps, the extent of the piece of realestate is of approximately 1000 acres. Our original folder with Mr. Mittendorf again contains photographs taken by the undersigned within the last few weeks, showing improved roads, buildings, fully timbered shafts, power stations, headframes, and list transformers, motors, hoist, incline shafts, drill holes, etc., also a great number of experimental pits which have been dug in the past.

-Over-

A great deal of additional material is contained in the original folder, referring to our application for the erection of a plant and all preliminary work has already been done, such as test work, calculation for installation, flow-sheets, etc. - At this particular point such information would only be of secondary importance in conjunction with the RFC lean and has therefore been omitted.

Very sincerely yours,

THE NEW ENGLAND INDUSTRIES, INC.

Howard S. Strouth

HSS/lew
Encls.

MF-103
(Revised April 1952)

UNITED STATES DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION

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

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
NOV 12 1952

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-2773
Metal or Mineral
Date Received 11-12-52
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: Lincoln Mining Corporation -- See Attachment

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

(*b*) State any mine name by which the property is known.

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

(*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.

(*e*) If you own the land, describe any liens or encumbrances on it

(*f*) If the land consists of unpatented claims, add to the description above, the book and page numbers for each recorded location notice.

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.

(*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.

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

5. *The exploration project.*—(*a*) State the mineral or minerals for which you wish to explore .....

(*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.

(*c*) The work will start within ..... days and be completed within ..... 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.

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 [ ] Use of equipment owned by you [ ] 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 November 6th, 1952

Lincoln Mining Corporation
(Applicant)

By Howard Steven Strouth, Executive Vice-President

120 Wall Street

New York 5, New York

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

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

1.— Lincoln Mining Corporation, Depositors' National Bank Building, Durham, North Carolina. — All correspondence to be addressed to our main office, 120 Wall Street, Room 2805, attention Mr. H. S. Strouth, Executive Vice-President.

2. - - -

3.— a) "SITUATE, lying and being in Lincolnton Township, Lincoln County, North Carolina, about two miles south of the Town of Lincolnton on both sides of U. S. Highway No. 321, and being that certain boundary of land known as the Tin Mine Property", being the identical boundary containing about 650 acres (about 240 acres in fee and the mineral rights on the remaining 410) acres, conveyed by A. L. Quickel, Trustee, to Lessor by deed dated September 4, 1937, and registered in Book 191 at Page 527 in the Lincoln County Public Registry, and being the identical boundary fully described in a deed of trust, now cancelled, dated April 18, 1932, from American Consolidated Tin Mine Corporation, to A.L. Quickel, Trustee, registered in Book 166 at Page 686 in Lincoln County, and also described in a deed from D. E. Rhyne to American Consolidated Tin Mine Corporation dated April 18, 1932, registered in Book 166 at Page 683 in Lincoln County, to all of which conveyances and descriptions specific reference is hereby made for a more particular description of the properties herein leased."

See Enclosed Lease Contract.

b) Ka-Mi-Tin Mine and American Consolidated Tin Mine.

c) 99-year lease with option to purchase.

d) Lease in quadruplicate.

4.— a) The property presently has two timbered shafts extending to the 90 ft. level with cross-cuts, an incline shaft extending 50 ft. at a 45° angle, drill holes - one extending to 1400 ft., approximately 18 exploration pits dug to various depths to 40 ft., various buildings, power lines, hoists, head assemblies, motors, pumps and other improvements, including a power installation capable of running a 250-ton mill with various transformers. The workings are fully accessible.

b.&c.)
Ore reserves, qualities and grade of ore are estimated up to two million tons with proven ore in excess of 500,000 tons, grades as per included assays, reports by Dr. Heron, report by H. S. Strouth, by Mr. St. Clair, and other references. Property fully described and mapped in Bulletin 936J.

d) Access roads as per enclosed photographs. Nearest railroad station 1 mile. Supply and residence points no problem because property is within 2 miles from Lincolnton, county seat of Lincoln County.

e) Sufficient man-power available; same applies to material, supplies, equipment, water and power, as previously stated.

5.— a) Tin, columbite, tantalite, lithium, beryllium, quartz, mica.

b) Maps as enclosed. - It is proposed that during the initial period, diamond drilling be done on the Jake dyke as per enclosed drawing and other preliminary work in accordance with attached statement.

c) Within 15 days the work can be started and a period no exceeding four months is considered necessary from the day of commencement of the work.

d) The applicant and its associate firms have successfully operated coal mines in the United States, with a production capacity of 10,000 tons of coal a day, is operating lead-zinc properties in Mexico and has operated at various times tungsten properties in Montana, manganese properties in Arkansas, uranium properties in Utah and Colorado and has managed all operations, which were conducted in miner-like manner and most of them are known to the Government. The work will be done under the supervision of Mr. William A. Hooten, mining engineer, and Dr. S. D. Heron, Jr., geologist, and other qualified engineers and geologists as may be required.

6.— Estimate of cost is enclosed.

7.— a) Yes.

b) In money.

October 10, 1952

KA-MI-TIN, NORTH CAROLINA * Estimate at Re-opening Mine for Lithium, Tin, Columbite, etc. Production.

STAGE 1. - Development Work

Road clearance and bulldozing to level and upgrade existing roads	$ 1,500.00
Diamond drilling at dyke 2, six drill holes to intercept 2 at 100 and 400 ft. levels and also intercept continuation of dyke 3 at corresponding levels. 45 degree angle at 100 ft. level - 1200 ft. at 400 ft. level - 2400 ft. at $3.00 per ft. Total 3600 ft.	10,800.00
Two crosscuts at swamp shafts 1 and 3 on dyke 3 40 ft. each, total 80 ft. crosscuts at $40.00 per ft. . .	3,200.00
Transport of drilling equipment	500.00
Retimbering and extension of shafts at dyke 3 at no. 1 shaft 40 ft. two-compartments at no. 3 shaft 20 ft. two-compartments Total 60 ft. at $140. per ft.	8,400.00
Timber	200.00
Weatherproofing of existing buildings to protect equipment and tools	300.00
Surface stripping at incline shaft on dyke 2 5000 cu. yds. at 40¢ per yd.	2,000.00
Reconditioning of existing hoist and power equipment . . .	1,000.00
Cable 1" 1000 ft. at 25¢ per ft.	250.00
Two small pumps with motors plus hose for dewatering . . . . shafts $500.00 ea.	1,000.00
3 days labor for dewatering	300.00
Handtools	100.00
Engineering	1,500.00
Assays, flowsheets, etc.	1,000.00
TOTAL	$32,050.00

NORTH CAROLINA

DURHAM COUNTY

THIS CONTRACT, AND AGREEMENT, made and entered into this the 25th day of October, 1952, by and between:

KA-MI-TIN CONCENTRATING CORPORATION, hereinafter called "LESSOR",

and

LINCOLN MINING CORPORATION, hereinafter called "LESSEE",

W I T N E S S E T H:

That for and in consideration of the mutual promises and covenants, the parties do hereby covenant, promise, agree and declare on behalf of themselves, their successors and assigns:

1. LESSOR hereby grants unto LESSEE an option for the period of six (6) months from the date hereof to lease that certain mine located and situate in Lincoln County, North Carolina, more fully described as follows, to wit:

SITUATE, lying and being in Lincolnton Township, Lincoln County, North Carolina, about two miles south of the Town of Lincolnton on both sides of U. S. Highway No. 321, and being that certain boundary of land known as the "Tin Mine Property", being the identical boundary containing about 650 acres (about 240 acres in fee and the mineral rights on the remaining 410) acres, conveyed by A. L. Quickel, Trustee, to LESSOR by deed dated September 4, 1937, and registered in Book 191 at Page 527 in the Lincoln County Public Registry, and being the identical boundary fully described in a deed of trust, now cancelled, dated April 18, 1932, from American Consolidated Tin Mine Corporation, to A. L. Quickel, Trustee, registered in Book 166 at Page 686 in Lincoln County, and also described in a deed from D. E. Rhyne to American Consolidated Tin Mine Corporation dated April 18, 1932, registered in Book 166 at Page 683 in Lincoln County, to all of which conveyances and descriptions specific reference is hereby made for a more particular description of the properties herein leased.

2. During the term of said option, and as one of the considerations therefor, LESSEE agrees to pay to LESSOR the sum of FIVE HUNDRED ($500.00) DOLLARS per month, the first monthly payment being made in advance and

simultaneously with the execution of this contract, and each subsequent payment being due and payable on the 25th day of each month ther after so long as LESSEE desires said option to continue. In the event that during said six-month option period the LESSEE should notify LESSOR that it no longer desires to continue said option, then upon payment of all monthly payments due up to the effective date of said notification, the parties shall be relieved of any and all further obligation from one to the other.

3. During said option period, LESSEE shall have the right to enter upon the aforementioned premises and to have its engineers, geologists, executives and workmen enter upon said premises for the purpose of making surveys, drillings, and taking samples, and to make whatever preparations are deemed necessary by LESSEE for the commencement of mining operations. Further, during said option period, LESSEE shall have the right to use all of the equipment presently located on the premises, all of the buildings, power, installations, machinery, timber, rights-of-way, access roads and all other improvements as more fully set forth in the attached schedule, and it is further understood and agreed by and between the parties that the monthly option payment of $500.00 shall include any and all rentals for said items. There is specifically excluded from the provisions of this paragraph three (3) Allis Chalmers motors which are individually owned by J. N. Brenizer and which are located upon the premises. LESSOR reserves the right for Mr. Brenizer to remove these motors from the premises at any time he so desires. The serial numbers of said motors are as follows: Gen Ele 30 HP, no. 1508797, Allis Ch 90 HP, no 172-18/46/1T, Allis Chalmers 50 HP, no 20B5-RS-4303-1

4. In the event LESSEE elects to exercise the option herein granted to enter into a lease for said premises along with all mineral rights thereto, it shall notify LESSOR in writing before the expiration of the said six-months period, and shall pay to LESSOR at the time of the exercise of its said option, the sum of SEVEN THOUSAND DOLLARS ($7,000.00), and upon such notification and payment the following lease between KA-MI-TIN CONCENTRATING

CORPORATION as LESSOR and LINCOLN MINING CORPORATION as LESSEE, on the aforementioned property, shall become effective upon the following terms and conditions:

A. This lease shall commence on the date of the exercise of the option above referred to and the payment of $7,000.00 by LESSEE to LESSOR, and shall continue for a period of ten (10) years from said date provided LESSEE performs and complies with all of the covenants and agreements set forth herein on its part to be performed and complied with.

B. As rent and royalty for said lease, LESSEE shall pay to LESSOR and to its successors and assigns seven (7%) percent of the gross sales of all minerals and metals mined and shipped from the aforementioned premises, provided that in the event the market prices of the products mined under this lease shall fall below the average market prices of the first year's total sales average of said products, then the 7% gross sales royalty above mentioned shall be reduced directly in proportion to such price fall; example: Average market or par prices of products mined under said lease the first year equal 100; average market or par prices of products mined under said lease any subsequent year equal 90; fall in price would equal 10% and the royalty would therefore be reduced to 6.3% for said year. It is understood that an accounting shall be made of all sales at the end of each three months during the period of the lease and that payment of said royalties and rents shall be made in the following manner:

1. On the 20th day of each calendar month, LESSEE shall pay to LESSOR an average of seventy-five (75%) percent of the royalties and rents due to LESSOR based upon the 7% of gross sales made during the preceding calendar month.

2. Thereafter, at the end of each three calendar months, an accounting and adjustment shall be made by LESSEE for obligations during the preceding three months and any balance shown to be due LESSOR by LESSEE to bring the rents and royalties paid up to 7% of gross sales shall promptly be paid by LESSEE to LESSOR.

C. LESSEE agrees that at the earliest possible date after the effective date of said lease that it will install a concentration mill on the aforesaid premises of 100 Tons or more daily capacity. It is understood and agreed that title in and to said mill shall at all times remain in LESSEE whether or not same is affixed to the realty. It is further agreed that during the term of this lease, any and all equipment and machinery that may be placed upon the premises by LESSEE shall remain the property of the LESSEE, whether affixed to the realty or not, and at the termination of the lease the LESSEE shall have the right to remove the same within a period of ninety (90) days from the termination of the lease, PROVIDED that LESSEE shall in moving said property shall do no permanent damage to the realty.

D. If all obligations of LESSEE under this lease shall have been fully complied with, the option is hereby granted unto LESSEE to renew this lease for an additional term of ten (10) years following the expiration of the first 10-year period upon the same terms and conditions as are set forth in this lease appertaining to the first 10-year period. If LESSEE exercises this option to renew, it must give written notice to LESSOR of its intention to renew not later than ninety (90) days prior to the termination of the first 10-year period. It is understood that this lease might be renewed for any number of successive 10-year periods at the option of the LESSEE.

E. LESSEE shall have the right to assign this lease or to sub-lease the property, PROVIDED LESSEE at all times remains fully liable for the performance of all conditions and obligations herein set forth on its part to be performed.

F. It is understood and agreed that the LESSEE, from and after the date of exercise of the option to lease the premises herein mentioned, shall pay all property taxes upon the real and personal property belonging to LESSOR and herein included in this lease to LESSEE. LESSEE shall carry Workmen's Compensation and other insurance in order to fully indemnify and protect LESSOR against any liability for any injuries which may be received by any persons in connection with LESSEE'S operations. It is understood that

LESSOR hereby assumes to pay all taxes accrued to the date that the option is exercised.

G. The LESSOR, through any representatives it may designate, shall have the right at reasonable intervals, but not more often than quarter-annually, to examine LESSEE'S books, records, accounts as to production, shipments and sales of ores and minerals from the leased property, and to inspect the leased property, including the underground workings, the mills and other equipment, and to draw samples of ores, concentrates and tailing from the operation. In addition, LESSEE shall arrange for duplicate copies of all return sheets from smelters, chemical plants or other concerns to which LESSEE ships products from the leased premises, direct to LESSOR.

H. LESSEE does hereby covenant with LESSOR that it will pay the rents and royalties as provided for in this lease when the same shall become due; that if it exercises its option to enter upon the lease of the premises it will thereafter proceed with mining operations in the manner necessary for good and economical mining in a workman like manner.

I. It is specifically understood and agreed that if LESSEE, after once entering upon the lease, abandons the property and discontinues operations altogether, the lease shall thereupon terminate and LESSEE shall promptly pay LESSOR all rents and royalties due to the date of termination. If, after the mining has gotten underway on the leased premises, and royalties and rental payments have become due under the terms of this lease, if thereafter LESSEE ceases or suspends operations of the mine or mines for a continuous period of ninety (90) days, excepting through strikes, acts of God, or circumstances beyond control of LESSEE, but does not exercise its right to abandon the property and cause a termination of the lease, then it is agreed that LESSEE shall pay to LESSOR a minimum rental at the rate of SIX THOUSAND ($6000.00) DOLLARS per year, payable quarter-annually and during the period when operations are suspended.

J. In consideration of the sum of ONE DOLLAR ($1.00) in hand paid to LESSOR by LESSEE, the receipt of which is hereby acknowledged, and in further consideration of the covenants and mutual agreements herein contained, LESSOR does hereby grant unto LESSEE, its successors and assigns, an option to purchase the aforementioned property at any time during the term of the option period, and the term of the lease, or any renewal or extension thereof, for the purchase price as follows: If the LESSEE shall exercise the option given herein within two years from the date of said lease, purchase price shall be THREE HUNDRED THOUSAND ($300,000.00) DOLLARS; if the LESSEE SHALL exercise the option given herein within the first ten (10) years from the date of said lease, purchase price shall be FOUR HUNDRED FIFTY THOUSAND ($450,000.00) DOLLARS; if the LESSEE shall exercise the option given herein within subsequent years from the date of said lease, purchase price shall be SIX HUNDRED THOUSAND ($600,000.00) DOLLARS. All royalties and rental payments made during the terms of the lease, as well as payments made during the option period, shall be credited and applied to the purchase price. Upon the notification by LESSEE of its desire to exercise this option to purchase, LESSOR contracts to tender to LESSEE a warranty deed which will convey the said property without encumbrances to LESSEE or its successors and assigns. Taxes and any other apportionable charges shall be apportioned as of the date of conveyance.

K. If LESSEE shall for any reason default in the payment of any rent or royalty payment due LESSOR as provided for in this lease, or if LESSEE shall default in the performance of any other duty or obligation herein required to be performed by it, and if any of such defaults continue for a period of 90 days after written notice by registered mail of said default is given LESSEE by LESSOR, the lease and option to lease shall, at the option of LESSOR, be terminated; and LESSOR shall thereupon have the right, without any further notice, and with or without legal process, to enter upon the leased premises and dispossess the LESSEE therefrom, and these rights shall not be exclusive but the LESSOR specifically reserves any and all legal rights and remedies now or hereafter authorized and granted

by the State of North Carolina to LESSORS to cancel and terminate leases upon default and to recover possession of leased property.

L. Written notice of any matter requiring notice shall be given LESSEE by LESSOR by depositing such notice in the United States mail, Registered, and addressed to LESSEE, General Delivery, Lincolnton, N. C., and any written notice to LESSOR by LESSEE shall be given by depositing same in the United States mail, Registered, and addressed to LESSEE, at 120 Wall Street, New York, N. Y., and proof of the depositing of such written notice in such manner shall be deemed conclusive upon all concerned.

M. The within agreement shall be binding upon the parties hereto, and their successors and assigns.

N. In the event that any dispute should arise out of the within agreement, same shall be submitted to arbitration to be held in Washington, District of Columbia, in accordance with the rules of the American Arbitration Association then pertaining, and the decision of such arbitration may be entered as a final judgment in any court of record having jurisdiction.

IN TESTIMONY WHEREOF, said LESSOR has caused this contract to be signed in its corporate name by its President and attested by its Secretary and its corporate seal to be hereunto affixed the day and year first above written; and said LESSEE has caused this contract to be signed in its corporate name by its President and attested by its Secretary and its corporate seal to be hereunto affixed the day and year first above written.

KA-MI-TIN CONCENTRATING CORPORATION

ATTEST:

By _____
President

Joseph R. Jarvis
Secretary

LINCOLN MINING CORPORATION

ATTEST:

By _____
President

_____
Secretary

NORTH CAROLINA

Lincoln COUNTY

I, Martha P. Bailey, a Notary Public in and for the County of Lincoln, and State of North Carolina, do hereby certify that Joseph R. Davis, Secretary of KA-MI-TIN CONCENTRATING CORPORATION, personally appeared before me this day and acknowledged that he is Secretary of KA-MI-TIN CONCENTRATING CORPORATION, a Corporation, and that by authority duly given and as the act of the Corporation, the foregoing instrument was signed in its name by its President J. M. Brenizer, sealed with its corporate seal and attested by himself as its Secretary.

WITNESS my hand and Notarial Seal this the 25th day of ~~November,~~ October 1952.

Martha P. Bailey
NOTARY PUBLIC

My Com. expires:
Sept. 12 1953

NORTH CAROLINA

_____ COUNTY

I, _____, a Notary Public in and for the County of _____, and State of North Carolina, do hereby certify that _____, Secretary of LINCOLN MINING CORPORATION, personally appeared before me this day and acknowledged that he is Secretary of LINCOLN MINING CORPORATION, a Corporation, and that by authority duly given and as the act of the Corporation, the foregoing instrument was signed in its name by its President _____, sealed with its corporate seal and attested by himself as its Secretary.

WITNESS my hand and Notarial Seal this the ____ day of November, 1952.

_____
Notary Public

My Com. Expires:

_____

ABSTRACT ON APPLICATION FOR EXPLORATION DEVELOPMENT AND PRODUCTION LOAN AT LINCOLNTON, NORTH CAROLINA, PROPERTY OF THE LINCOLN MINING CORPORATION ALSO CALLED THE KA-MI-TIN PROPERTY.

SUMMARY:

For a considerable period of time certain minerals in short supply have been on the strategic list for Government stockpiling, and this abstract, containing an application for Government loan, will attempt to prove that with such loan and on a proven property, the stockpiling program will be assured of a quantity of estimated -

60,000 tons Mica	estimated value $60.00/ton	$ 3,600,000.—
200,000 lbs.)Columbite lbs.)Tantalite	4.00/lb.	800,000.—
5,000 tons Tin	2400.00 24.00/ton	12,000,000.—
180,000 tons Lithium	50.00/ton	9,000,000.—
50,000 tons Quartz	15.00/ton	750,000.—
	TOTAL estimated value	$26,150,000.—

plus other minerals of importance and incidental to the production.

Repayment to the Government should therefore not present any problems. The property in question is an improved property, well-known and previously inspected, mapped and commented upon by Government geologists and engineers, as well as engineers of good reputation, working for private companies.

LEGAL STATUS:

The property known as the Ka-Mi-Tin mine, is under 10-year renewable lease to the LINCOLN MINING CORPORATION , an associate of the NEW ENGLAND INDUSTRIES, INC. which have demonstrated through past mining operations in the United States and abroad, that their organization and mining engineers are well-qualified to schedule, plan and to successfully conduct an operation such as outlined. — Attachment No. 1 - Lease contract between owners of the Ka-Mi-Tin property and the Lincoln Mining Corp.

GEOLOGY:

This property is well-known and described in literature, such as the report of Mr. St. Clair — attachment No. 3; Mr. T. J. Kessler — attachment No. 4 and

in back folder, called "U.S. Geological Bulletin 936 J", which shows the different deposits on the property; reports of the American Consolidated Tin Mines Corporation, which used to have a tin smelter on the property, shipping a tin-columbite-tantalite concentrate to England and Germany, - see attachment No. 5: the Ka-Mi-Tin Corporation which last operated the property in 1936; reports of Government geologist, Mr. Hess, as well as 21 other references listed in attachment No. 6, (and others in back folder).

We believe that these attachments, as well as a complete report by Dr. S. D. Heron, Jr., Vice-Chairman of Duke University, geologist, who visited the property twice during the last month, and whose report forms attachment No. 2, fully documents the type of mineralization and the extent of the ore bodies beyond any reasonable doubt. We also wish to refer to a publication called, "Resources for Freedom", a report to the President, published in June 1952, which stresses the importance of the minerals which we wish to mine, including lithium, their particular application to the defense effort, and the obvious shortage of these strategic minerals existing in the United States at the present time. Excerpts - attachment No. 7 enclosed.

DEVELOPMENT OF PROPERTY:

As evident from attachments submitted, this is a developed property, which has been previously in operation, with roads, housing, shafts, hoists, underground development, diamond drill holes and other improvements in place, including power installations and transformers for a substantial plant and mining operation. Attachment No. 8, report of recent visit of the undersigned to the location with geologist, Dr. Heron. (Pictures, maps).

EXCERPTS FROM REPORTS ON PROPERTY:

T. L. Kessler, U. S. Geological Survey

... the pegmatite bodies are straight, tabular and nearly uniform in thickness .... Speaking of the Ka-Mi-Tin Concentrating Company, Mr. Kessler states, the remaining tin bodies of ore, 1 ft. or more thick, have an average grade of possibly 1.5% tin, an average thickness of 3 ft. and an average length of 100 ft., are assumed giving a calculated reserve of 12,500 tons of ore .... an average of 0.375 ton of tin per ft. of depth on each deposit. The eight deposits of mineable width which have been mined to or below the water level may contain ore of equal or even higher tin

and quartz.... channel samples taken on the hanging wall side, give assays running from .657 to .921% metallic content, as determined by fire assay. He quotes many series of samples showing such assays and higher, taken by Dr. Banks, Dr. Pryson, Dr. Nelson, and others. He took 6.714 lbs. of samples and states that a composite sample showed .65% metallic content. Mica will be found scattered throughout the pegmatite.... the mica is high grade and should command a good price, especially when ground... The quartz will be found intimately mixed through the pegmatite, but chiefly in the Greisen area. In 1935 nearly a 100,000 tons of material were moved, 1200 ft. of drifting was done... on the incline dyke.... Aside from proving another commercial body of.... mica, tin values run from 1/4 of 1% to 2%.... (The main interest of the Ka-Mi-Tin Corporation was of course solely in the tin.)

. . .

Dr. Heron in his report of July 30th, again shows on camparison level, the Kings Mountain Lithium Corporation property in operation producing from an ore with an average of 21% spodumene, showing the columbite, tantalite, quartz and mica values as set forth by us at the beginning of this exposé. However, in our particular case, the amount of tin oxide accrueing would be much greater as set forth in Mr. St. Clair's report.

Dr. Heron in his final conclusive report of October 11th, gives figures far in excess of those claimed by us, due to our effort to make our estimates as conservative as possible. He states the average quartz percentage of 35%, whereas we have merely figured 5% in our application. He states a tonnage on the property of 2 million tons, whereas we have given a figure of one million tons as an estimate, and stated as our first objective that we would endeavor to block out 537,000 tons. Otherwise the report confirms our plan of action and the findings of every eminent geologist and mining engineer, who have inspected the property.

ORE:

The ore has been sufficiently described in many of the publications and assays of past operations, which are attachment No. 9, as well as assays taken recently on the property. It has been clearly established which average values exist in the tin-spodumene belt and even though our assays show considerable higher values than the averages for the entire belt, we have taken as a basis for our calculations, the basic figures given by the Bureau of Mines, showing 18% spodumene, containing 7 - 8% Li_2O, 1/2 of 1% tin in form of cassiterite, 6% mica, 1/100 of 1% combined columbite and tantalite, 6% quartz, plus a substantial percentage of feldspar, kaolin, etc., and some beryllium which was found on our last investigation trip.

The strong mineralization, starting below the weathered zone of 100 feet and extending to a depth beyond the 500 ft. level, in strong dykes, shown by enclosed drawing, attachment No. 10, demonstrates clearly a quantity of ore far in excess of a million tons of mineable ore, but for the sake of our initial phase of operation and

content .... The tin spodumene belt contains an enormous amount of spodumene .... it may contain from 10 to 50% spodumene .... Possible by-product minerals include, cassiterite, columbite, tantalite, beryl, fine grained muscovite, feldspar and possibly ambligonite.....

F. L. Hess, "Economic Geology"

States that hand-cobbed ore mined southwest of Kings Mountain contains more than 50% spodumene. He estimates that the pegmatite bodies of the entire belt may contain an average of 15% spodumene. He estimates 3.7 million tons of possible ore.

Edwards & Barbour

The map of the Ka-Mi-Tin property, made by Edwards & Barbour, Plate 41, Bulletin 936-J, shows 21 tin showings and can be increased to about 50 tin showings according to our work. It contains some two dozen spodumene pegmatite bodies of which the longest, as drawn, is 525 ft. in length with an average 40 ft. width. This body is taken as a basis for our calculation. Actually this ore body is almost 300 ft. longer and the one running parallel and starting from the Swamp shafts, is almost twice that length.

Mr. V. J. Hampton, Manager of the Patino Mine and his assistant

.. estimated the total in four dykes as representing 1.5 million tons of ore to the 500 ft. level.

Banks, McDaniel & Sales

The Banks, McDaniel & Sales report on concentration methods for North Carolina spodumene ores is self-explanatory as to the percentages of the various mineral values contained and ample proof of recovery.

W. R. Huspetch, Cief Engineer - Foote Minerals Plant, Kings Mountain.

Article by W. R. Hudspeth in Mining and Engineering, August 1952, again proves composition of ore and process of recovery.

H. D. Heron, Jr., Professor of Geology, Vice-Chairman, Duke University.

Professor Heron, Jr. in his report of September 9th, speaks of this property as the most promising in the region. According to his findings, sampling the shafts, yielded spodumene alone with a rather high percentage of cassiterite. He mentions the presence of quartz, mica, columbite and tantalite.... I personally believe this prospect is better than any one single part in the belt, with the exception of Foote's holdings near the town of Kings Mountain..... The possible reserve here might well approach those of Foote's, but let me emphasize again that there is only one way of telling, that is by a diamond drilling program.... The other by-products could be columbite, tantalite.... I believe that spodumene will be found in almost each and everyone in the pegmatite dykes located on the entire property.

Mr. St. Clair, Geologist & Consulting Engineer & Formerly with the War Minerals Administration, Washington, D.C.

In his 1937 report states, tin exists in the form of cassiterite with metallic tin content of 60 - 70%, as shown in numerous analyses. The cassiterite occurs as fine disseminations throughout the pegmatite..... He proves the presence and percentage of mica, columbite, spodumene, which he states makes up 20% of the volume,

to show clearly the presence of sufficient ore, we have merely assumed a 400 ft. block of ore on dyke No. 2, extending over 525 ft. with 40 ft. in width and showing with a specific weight of 2.72, an ore body of 537,000 tons, which breaks down to the following quantities of minerals which can be recovered:

96,600 tons	Spodumene	18.0 %
2,685 tons	Tin	0.5
32,220 tons	Mica	6.0
107,400 lbs.	Columbium and Tantalum	1/5 lb per ton
26,850 tons	Quartz, etc. -	5.0 %

Dr. Heron's exposé clearly demonstrates that while proving the 537,000 tons in dyke 2, we intercept by diamond drills dyke 3 at the same time thereby establishing possibly twice the tonnage, not counting the swamp dyke extension and other ore bodies. His estimate of the entire property 2,000,000 tons.

COST:

As per attachment No. 11, the first phase of development and diamond drilling to increase the true tonnage estimate, prove the assays and open up the mine sufficiently for a mining operation, is shown at $32,050.- during the initial phase as per attachment No. 12, while the cost of erecting a 250-ton mill and starting operations at 250 tons daily production, is shown with a cost of $686,600.- as per attachment No. 13. - It is our understanding that in view of the strategic importance of the minerals which will be produced, the Government will grant us a loan amounting to 90% of the moneys to be invested and we will submit clear and sufficient proof that we are capable of contributing our share of such moneys and accounting for all amounts spent, until such time when repayment will be made out of production to the Government.

PROCESSING:

Please find in attachment No. 14, a description of the machinery which we expect to use to set up a concentration plant, which equipment roughly corresponds to similar equipment being presently used on the Kings Mountain operation of Foote Minerals and also proven for mica separation on the property of the Kings Mountain Mica Corporation. Also find in attachment No. 15, a complete flow-sheet, worked out

for the separation of the ores, as prepared for these specific ores by Mr. Banks and others for the Tennessee Valley Authority, Foote Minerals Corporation, and other Government agencies interested in such separation.

Finally we can procure the services of Mr. Ralph Adarr, an ore dressing expert, who built the addition to the Solway and Foote plants, processing these ores.

CONCLUSION:

We again wish to emphasise the proven merit of these properties and deposits, the proof of our qualifications, the complete details which have been worked out to assure proper results and our firm belief that such operations will increase the Government stockpile on mica, columbite, tantalite, tin and lithium to a considerable extent.

Further documentations will be gladly submitted and we respectfully request early action on this request.

Howard Steven Strouth

H.S/lew

REPORT ON THE KA-MI-TIN CONCENTRATING CORPORATION SPODUMENE PROSPECT NEAR LINCOLNTON, LINCOLN COUNTY, NORTH CAROLINA.

By

S. Duncan Heron, Jr. October 11, 1952.

The Ka-Mi-Tin Concentrating Corporation spodumene prospect is located at the extreme northern end of the tin-spodumene belt of the Carolinas. Mr. Howard S. Strouth of the Standard Ore and Alloys Corporation requested the writer to examine this property and other parts of the belt. Field work was done during parts of August, September and October. The Ka-Mi-Tin property was examined on September 6 and 7 and again on October 6 and 7.

LOCATION, SIZE AND PHYSICAL PROPERTIES

The tin-spodumene belt extends from Grover, North Carolina, in a northeast direction for 25 miles to Lincolnton, North Carolina. The Ka-Mi-Tin property forms the northern portion of the belt and is located two miles southeast of the Lincolnton town limit.

The land is about 2½ miles long, approximately ¼ mile wide at the greatest width, and trends in a northeast direction. The property contains about 650 acres, of which 250 acres are owned in fee and the balance in deeded mineral rights. U. S. Highway 321 cuts the property so that most of the land owned in fee is in the northeast portion. This report concerns this section of about 200 acres, because it has the better mineral occurrences. (See accompanying map).

The nearest railway station is 4 miles away in Lincolnton. A metal surfaced road serves the southern portion of the area under discussion and there are several unimproved roads on the property.

The area has gently rolling topography of moderate relief. There is no suitable timber on this property. There are some small pine trees, a few deciduous trees, and undergrowth of honeysuckle vines, kudzu, etc. The annual rainfall is about 47 inches.

GENERAL GEOLOGY

Country rock - The major rocks of this area, like those in the rest of the tin-spodumene belt, are mostly mica schist, hornblende gneiss and mixtures of the two. In general they are well weathered to an average depth of about 100 feet. The mica schists are more thoroughly weathered.

Pegmatites - Throughout the tin-spodumene belt are numerous massive pegmatite dikes that apparently filled fissures aligned with the general northeast trend of the foliation and schistosity of the country rock; however, some of the pegmatites filled joints or fissures formed at right angles to the general structure and, therefore, strike northwest. A few pegmatites are irregular in outline.

Most of the pegmatites of the belt show little, if any, weathering, but the pegmatites of the Ka-Mi-Tin property are almost completely weathered to a depth of between 70 and 100 feet. Some of these pegmatites are very irregular in form while others, like the Inclined Dike and the Jake Dike (named for the Inclined Shaft and the Jake Drift), are tabular.

It is important to note that pegmatite dikes are characterized by changing form and mineral content at different depths.

Minerals - A variety of minerals have been found in the pegmatites of the tin-spodumene belt, but feldspar and quartz make up the bulk of the mass. In most of the pegmatites, mica and spodumene occur in association with minerals like cassiterite, columbite-tantalite, beryl, etc.

The only unweathered pegmatite on the Ka-Mi-Tin property is found on two very small dumps adjacent to Swamp Shafts 1 and 3. The following minerals have been identified by the writer and are listed in order of abundance, according to earlier reports.[1]

Feldspar) Albite)	40%
Quartz	35%
Spodumene	18%
Mica	6%
Cassiterite	0.25%
Columbite-) tantalite)	0.01%
Beryl	?

The percentages listed have not been determined by accurate sampling or assaying and should serve only as a guide.

Spodumene occurs as lath-shaped crystals that are usually fractured and veined with quartz and feldspar. It is not distributed evenly throughout the dikes, nor are the crystals of uniform size. The largest observed crystal was about 18 inches long. The average length appears to be around one or two inches.

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[1]Stuart St. Clair and J. N. Brenizer

Cassiterite is not directly associated with the spodumene but usually occurs as small, irregular grains embedded in masses of muscovite mica and quartz called greisen. The greisen occur as small pockets within the pegmatite. Also cassiterite and columbite-tantalite are found throughout the spodumene pegmatite as very small grains of less than 1 mm in diameter.

ESTIMATED TONNAGE

It is possible to calculate a rough estimate of the tonnage of spodumene-bearing pegmatite within the northern part of the Ka-Mi-Tin property. The following tonnage is based on a pegmatite specific gravity of 2.72 and on the assumptions that the pegmatites have no splits or inclusions of country rock or change in shape to a depth of 500 feet. Since the pegmatites are weathered to an approximate depth of 100 feet, these calculations will apply to the area between the 100 and 500 foot level.

Inclined Dike	430,000 tons
Jake Dike	445,000 tons
Fourteen dikes located near the Condon Shaft	1,170,000 tons
Total	2,045,000 tons

DESCRIPTION OF PREVIOUS WORKINGS

Over the past fifty years the weathered pegmatite has been worked unsuccessfully by a number of companies for the mineral cassiterite. The present owners have sunk two shafts, made several open cuts and worked some in the Condon Shaft. (See map). The most successful work from the standpoint of spodumene was in Swamp Shafts 1 and 3, both of which are now filled with water.

Swamp Shaft 1 is a one-compartment hole about 70 feet deep. Good cassiterite grains occur within the greisen reportedly found in a drift off the 30' level. Some spodumene was also found on the dump. No assays are available from this shaft.

Swamp Shaft 3 is a two-compartment shaft about 90 feet deep. The unweathered pegmatite was reported at about 60 feet. Excellent specimens of spodumene pegmatites can be found on the dump next to this shaft.

Two diamond drill holes have been drilled on the property but no record other than hearsay is available. It has been reported that four dikes averaging 10 feet thick each were encountered in a 1300 foot, 45° inclined hole located near the Bungalow shaft and drilled in a general eastward direction.

No records, assays, or written report are available for any of the previous workings.

EQUIPMENT ON HAND

A power line with two single-phase, 75 KVA transformers serves the Swamp Area and several small wooden buildings are located here. At least three of these buildings are in usable condition. Three electric motors of 50, 30, and 20 horsepower appear to be in working condition. One pneumatic hoist of undetermined capacity could be placed in operation without much expense.

MINING COST

Mr. H. Jardin of Waxhaw, North Carolina, for ten years superintendent of the Teck Hughes Mine in Canada, was kind enough to supply the following figures for a 100 ton and 250 ton mine:[2]

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[2] A breakdown of these figures is in the hands of Mr. Strouth.

100 ton

Equipment Total	$46,825.00
Building and Structures	35,150.00
Workmen Compensation, Insurance, Social Security, etc.	8,197.50
Total	$90,172.50

250 ton

Equipment Total	$70,475.00
Building and Structures	63,650.00
Workmen Compensation, Insurance, Social Security, etc.	13,137.50
	$148,137.50

Mine development costs as estimated by Mr. Jardin are $140 per foot for two-compartment vertical shafts, $200 for three-compartment shafts, and $30.00 per foot for drifts and crosscuts 5 X 7 feet.

No estimates are available for milling and concentration costs.

RECOMMENDATIONS

Before any large amounts of money are invested in a mine and concentration plant, it will be necessary to block out at least 300,000 tons of ore. Since all of the pegmatites are completely weathered at the surface, sampling can only be accomplished by diamond drilling. In order to prove the desired tonnage, at least one of the larger dikes must be adequately drilled.

Both the Jake Dike and the Inclined Dike offer theoritical tonnage that would justify proof by drilling. It would seem wiser to drill the Inclined Dike because of the possibility of discovering the reported pegmatites adjacent to this dike (said to be encountered in the 1300' drill hole).

Six holes drilled from three positions would be the most economical way of exploring this dike. These drill holes should be located on the

east side of the dike and drilled so that the first hole will intersect the dike at the 125 foot level and the second hole at the 500 foot level. The first hole should continue on past the dike for a horizontal distance of at least 400 feet. This will provide for exploration of the pegmatites reported from the old diamond drill hole.

It should be emphasized that careful drilling and interpretation of cores will be invaluable to the development of this prospect. Care should be taken during drilling so that adequate cores and sludge may be collected for assays.

Swamp Shaft No. 3 should be pumped out and cleaned so that the pegmatites may be examined and sampled. A small drift would serve to determine the width of the dike and to guide in drilling so as to determine its exact size.

CONCLUSION

The Ka-Mi-Tin Concentrating Corporation property has all the possibilities of developing into a successful spodumene-producing mine. Cassiterite, and to some extent columbite-tantalite, should be very important by-products. A carefully planned drilling program should prove the necessary tonnage and the tenor of the ore.

Respectfully submitted,

S. Duncan Heron, Jr.

S. Duncan Heron, Jr.

Durham, North Carolina

October 11, 1952.

REPORT ON THE KA-MI-TIN CONCENTRATING CORPORATION

SPODUMENE PROSPECT.

Location and Size:

The KA-MI-Tin Concentrating Corporation's property is located about two miles southeast of Lincolnton, North Carolina; U. S. Highway No. 321 cuts the property, slightly north of the middle section. The Southern Railroad crosses the extreme lower end of the property adjacent to the South Fork River. There are approximately 650 acres of which 250 is owned in fee, and the balance in deeded mineral rights. The land is about two-and-a-half miles long, approximately one half mile at the greatest width and trends in a northeast direction. For convenience in this report, we shall divide the property in two parts. The boundary between the northern portion and the southern portion will be represented by U. S. Highway No. 321.

General Comments on the Pegmatites:

The pegmatites of the KA-MI-Tin Concentrating Corporation differ from the pegmatites of the balance of the North Carolina Spodumene belt in that they are more completely weathered. There is no visible hard rock at the surface, and none is reached until a depth of approximately 60 to 90 feet. The upper weathered zone consists of completely kaolinized feldspar and spodumene, along with quartz and minor mines of mica, tin and other accessory minerals such as columbite-tantalite. This is in contrast to the unweathered pegmatites as exemplified in Foote's holdings near Kings Mountain.

At no place on the property of the KA-MI-Tin Concentrating Corporation was spodumene observed on the surface outcrops. However, it was found upon the dumps of the old workings.

North End of the Prospect:

Enclosed with this report is a map made by the U. S. Geological Survey that represents most of the area north of the U. S. Highway No. 321. Most of this property is owned in fee by the KA-MI-Tin Concentrating Corporation.

Condon Shaft Area: In and around the Condon Shaft area several open cuts (10 to 20 ft deep) and old water-filled shafts. The pegmatite exposed here are very difficult to follow along the original surface. They can be followed, however, in the old cuts and they outcrop originally as illustrated on the accompanying map. No spodumene was observed because of the thoroughly weathered nature of the rocks.

Swamp Area: The swamp area is that portion of the map located in and around Swamp Shaft No. 1, 2, and 3. As indicated on the USGS map no recognizable pegmatite is exposed on the surface. As reported in Mr. Stuart St. Clair's report, a rich tin strike was made at a depth of 30 ft. in Swamp Shaft No. 1.

Between the 30 and 70 ft. level of this shaft the hard pegmatite had been encountered and this pegmatite bears spodumene. I have collected several specimens off the dump near Shaft No. 1 that contains spodumene along with a rather high percentage of cassiterite (tin oxide).

Off the dum of Swamp No. 2, more spodumen-cassiterite pegmatite was collected.

Swamp Shaft No. 3 is a two-compartment shaft 14 ft X 6 ft. Spodumene pegmatite samples were collected from the dump near the shaft. One sample weighs approximately 150 lbs. and appears to contain a relatively high percentage of spodumene. It is available for analysis. Another 50 lb. block collected from this dump may run as high as 40% spodumene. These samples were reported to have been removed between the 60 and 80 ft. level. The shaft is down to 90 feet; the hard unweathered pegmatite was encountered below 60 feet.

The Jake Area: The Jake Dike is exposed in an open cut approximately 350 ft long. Here again the pegmatite is completely weathered so that naturally no spodumene would be recognized.

The South End of the Prospect:

Near the lower end of the property approximately 1000 feet from the South Fork River were found two very old hydraulic cuts. One runs approximately north-south and the other tends in a northeast direction. No pegmatite was observed in the former, but one weathered pegmatite was seen in the northwest wall of the latter. It, too, was completely kaolinized and there was no recognizable spodumene.

Other shafts in this southern portion did not go down to sufficient depth to reveal the unweathered pegmatite.

Ownership and History:

The history of this particular portion of the spodumene tin belt of the Carolinas is rather sad. The properties and mineral rights were acquired as early as 1900. There was originally some 6000 acres under lease and was eventually cut down to the present size - mostly under the actions of a Mr. Rhyne. It was in those days a tin prospect. A considerable amount of money was spent by various companies in trying to develop a working tin mine. At least two tin concentrate mills have been erected in the northern portion of the property. It is my opinion that a lot of the money was wasted and pocketed by speculators. Mr. J. N. Brenizer of New York City, between 1930 and 1935 lent to the old American Tin Concentrate Company approximately $75,000.00. When the company went broke he foreclosed, took over the property and formed the KAMMI-Tin Concentrating Corporation. He issued stock to the stockholders of the old company at the rate of one share for every two shares. He and his wife owned 55% of the new corporation. Most of the other owners live in New York City. Mr. Brenizer

tried to develop the property as a tin-producing mine. Because of either poor tin, or most probably because of lack of capital, the venture failed. With the advent of spodumene in the district, he had been interested in seeing that the property was developed as a spodumene producer.

Mr. Brenizer is eighty years old and he has a bad heart. He is a very likeable old gentleman, and I believe that he is completely honest. He has told me that his sole interest is to see the property in operation, and that he is willing to sell the property outright, or else to lease it. He has been approached by the Lithium Corporation of America, but he knows the history of that corporation and he does not believe that they have the money or the gumption to actually go into production. In plain words, he doesn't like the company, their methods of operation, or their president. He said that he would give the Standard Ore & Alloys Corporation twice a better deal than he would the Lithium Corporation of America. He is a fine gentleman whom I believe is primarily interested in seeing his property developed and working.

Conclusions and Recommendations:

I personally believe that this prospect is better than any one single area within the belt, with the exception of Foote's holdings near the town of Kings Mountain. The big difference between the two is that you can see what you have at Kings Mountain, because the pegmatites are unweathered and you can't see what you have at Lincolnton because of the weathered nature of the pegmatites. The possible reserves here might well approach those of Foote, but let me emphasize that there is only one way of telling, and that is by a rather extensive diamond drilling program.

All of the removal of spodumene ore will have to be done underground. This will, of course, raise the cost of mining, but I believe that it will be offset by the rather high percentage of the recovery of cassiterite. Then too a very selective type of mining would be possible. The very conservative Hess, principal mineralogist of the Bureau of Mines, told Mr. Brenizer that he believed the whole property would average one quarter of one percent cassiterite. At today's prices this should be over $5.00 a ton, and would certainly pay most of the cost of mining.

The other by-products would be columbite-tantalite — and possibly feldspar. The weathered pegmatites also contain a very high grade of kaolin.

It would be quite possible to start mining the spodumene ore almost immediately. Swamp Shaft No. 3, could be drained and cleaned with a minimum of expense. There is one pneumatic hoist near the shaft, a few electric motors and enough power and water on the land to operate at least a 100-ton concentrate plant.

I would recommend an extensive drilling program before any large-scale concentrate plant is erected. Mr. Stuart St. Clair on page 29 of his report mentions a thirteen hundred drill hole that cuts four pegmatites, each 10 to 20 feet thick. The red pencilled lines on the enclosed map were copied from Mr. Brenizer's map. These red pencilled lines represent pegmatites, and they were put on by Mr. Stuart St. Clair. I believe that the pegmatite extending from Shaft No. 1 through Shafts Nos. 2 and 3 to the first open cut northeast of Swamp

Shaft No. 5 is accurately portrayed. It is possible that this may represent several pegmatites pinched and swelling along the strike. But it seems reasonable to conclude the existence of the pegmatite at least to the open cut. The thickness of this pegmatite is unknown. I could see no evidence of the pegmatite extending on approximately 1000 ft to the northeast, but then it is quite possible to be standing on top of these dikes and never know it. I believe that spodumene will be found in almost each and every one of the pegmatite dikes located on the entire property. The only reason you can't find it now is because of the extensive weathering. The northern portion of the property is by far the best, but drilling on the lower end may reveal more pegmatites. It seems advisable to obtain all of the property because of the railroad and the large quantity of water that could be obtained from South Fork River.

According to Mr. Brenizer, the percentage of spodumene as determined by one analysis is 18.

S. D. Heron Jr.

S. D. Heron, Jr.

GEOLOGY [illegible]

on

[illegible] SHIP

[illegible]

By

Stuart St. Clair

Consulting Geologist

New York, N.Y.

June 1, 1937

TABLE OF CONTENTS

	Page
Letter of Transmittal	
General Geology	1
The Pegmatite	4
Economic Geology	10
Ore Minerals	10
Tin	11
Kaolin	11
Mica	12
Feldspar	12
Silica	12
Columbite	13
Spodumene	13
Accessory minerals	13
Ore Occurrence	14
Developments	20
Lincolnston Area	20
List of Publications	30

General Surface Map Northern Part Lincolnston Property
Development Map Metcalf Property

These geological notes are principally on the north end of the Tin Belt, North Carolina, as the writer has made a more careful study of this section. Also, the southern end, from Kings Mountain south into South Carolina, has been reported on in the U. S. Geological Survey Folio 222 and Bulletin 260 D.

GENERAL GEOLOGY

The general area lies in the Piedmont Province, an eastward-sloping plateau extending from the Blue Ridge Mountains on the west to the Coastal Plain on the east.

The general topography is a gently sloping surface eastward, dissected by the rivers and streams that flow over the surface.

The rocks are both igneous and sedimentary, most of which have been metamorphosed to varying degrees and now appearing as schists and gneisses. This is especially true in the Pre-Cambrian rocks whereas in some of the later intrusives unaltered facies are common.

The oldest rocks of the area are the Carolina gneiss and schist which primarily were sedimentary, igneous and volcanic rocks but which were highly metamorphosed in Pre-Cambrian time.

The rocks that now make up the Roan gneiss and schist were intruded into the Carolina formation. The Roan rocks are determined chiefly by the amount of associated hornblende. They are metamorphosed along with the Carolina and in places they are

hard to separate. Both of these formations are deeply weathered and make up a large part of the country rock of the area.

Included in the Pre-Cambrian complex is a series of basic rocks intrusive into the Carolina and Roan formations and also occurring as isolated bodies in the Bessemer granite.

The Bessemer granite is a light-colored, schistose granite which is intrusive into the rocks of the Carolina and Roan formations. It has an extensive outcropping in Gaston County and to the south. It occupies chiefly a belt running northeast through Bessemer City, Gaston County. Some pegmatite is associated with the Bessemer granite.

A series of schists, generally dark in color, probably Algonkian in age, and narrow outcrops of Cambrian rocks made up chiefly of dark schists, conglomerates, quartzites, all of which are highly altered, outcrop in bands which extend in a general north-northeast direction. These rocks are often faulted and folded into the older rocks and, therefore, form a most complex series of outcrops. All the outstanding topographic features in the area are the result of differential weathering and erosion of these various rocks.

At a much later time, presumably late Carboniferous, there was intruded into the older rocks granites of light color made up largely of quartz, feldspars and muscovite mica in varying quantities. A large batholithic intrusion of this granite is found in the Cherryville area to the southwest of

Mineralization.

The younger granites are considered of economic importance as the pegmatite which is found in dikes and which carries tin is probably an early end product of the differentiation of the granite magma, and the quartz and mica which occur in veins and in replacements are probably the final product in the cooling of the granite batholith. The pegmatite will be discussed in detail later.

Younger than any of the intrusives and cutting all other rock formations is a series of diabase dikes which run in a general northwest direction. The dikes vary in width from a few inches to 200 feet and extend for long distances, relatively. They evidently occupy tension cracks that probably resulted from vertical uplift of the area. The dikes are of Triassic age or younger. What economic effect they may have exercised is not known.

The general structure of the region was produced by compressive stresses acting from the southeast, thereby producing folds, faults and schistosity which trend in a general north-northeast direction. Most mineralization should follow this general trend although some may occur nearly perpendicular to it as there would be secondary stress relief in a general northwest direction. Such topographic features as Kings Mountain range, Crowders Mountain and Pasour Mountain have the north-northeast structural trend.

[illegible] dikes in the Pre-Kambrian rocks are usually [illegible], [illegible] variable. Local [illegible] artificial and sym- [illegible] [illegible] most of the variations. There is some [illegible] [illegible] fault fault, the [illegible] of some [illegible] [illegible] [illegible] thousand feet.

[illegible] general structural features should be spoken of [illegible] economic significance. For [illegible] Creek [illegible] Township, Nassau County, the general trend of [illegible], which is north-northeast, including the Tin Belt, [illegible] to the east a mile or more. The writer has [illegible] this change of [illegible] in the field and is not prepared [illegible] whether this phenomenon is due to a bend in the [illegible] or to a fault. Probably both conditions exist.

The Pegmatite

The country rock at the north end of the Tin Belt, and, more particularly on the property of Ka-Mi-Tin Concentrating Corporation, is gneiss and schist. Near the surface the schist is soft, but below the weathered zone and near the contacts with pegmatite dikes the schist is highly indurated. The schist has been cut by a paralleling series of pegmatite dikes which are much younger in age and which have undergone no intense metamorphism such as has the earlier enclosing rock.

The pegmatite dikes are in places massive and in other places more in the nature of veins. Such are probably

apophyses which extend into the country rock from the main dikes.

The pegmatite was injected into the schists at depth, as, due to the high degree of crystallization, the cooling was slow. The inclusion of bodies of schist in the pegmatite would indicate that the pegmatite, although probably filling some fault planes or fissures, also stoped its way through and into the schist. We would, therefore, expect irregular masses as well as dike-like bodies of pegmatite between regular inclosing walls.

The primary pegmatite is composed chiefly of quartz, feldspar and mica, the feldspar in many places predominating. A few minor minerals such as spodumene, tourmaline and others may occur in the pegmatite. Cassiterite is found sparingly disseminated throughout the pegmatite, but where in commercial quantities it is found in lenses and pockets throughout the pegmatite mass and along the foot-wall and hanging-wall. The occurrence of the cassiterite and its gangue minerals would indicate that deposition had taken place largely through replacement.

The order of events in the deposition of the pegmatites and the tin ore may be briefly summarized as follows:-

1. Intrusion of a granite magma in the form of a batholith in the west part of the area at or about the time that earth stresses were accumulating and which later caused the great Appalachian revolution.

2. Cooling at depth of this magma and the separation therefrom of aqueo-igneous solutions rich in mineralizers.

3. The expulsion of this highly-mineralized solution into the country rock of schist and gneiss along and filling fault planes and fissures which had been caused by earth movements.

4. Slow crystallization of the pegmatite solutions at depth allowing growth of large crystals of feldspar, quartz and mica. It may be found at depth that primarily the pegmatite is composed chiefly of feldspars.

5. With the cooling of the pegmatite, the formation of shrinkage cracks chiefly at and near the contacts with the walls, around inclusions of country rock that had floated off into the pegmatite, and within the main mass of the dike.

6. Injection into these shrinkage cracks of even a later phase of differentiation of the granitic magma, aqueous solutions rich in silica, fluorine, tin and other minerals and mineralizers. These solutions would replace the feldspars first with quartz and mica and cassiterite as well as crystallize out as primary minerals. The cassiterite would thus be found in greisen, quartz and mica chiefly, the characteristic gangue of tin.

7. The final step in the cooling and crystallization of the granite magma is the giving off of fumaroles, or vapors, rich in mineralizers which would find their way throughout the pegmatite mass wherever porous and replace the feldspars and deposit by crystallization quartz, micas, cassiterite,

and probably such minerals as tourmaline, fluorite, axinite, topaz, and metals, should they be present in the original magma or be absorbed from the enclosing country rock.

5. The final step is the action of supergene agents so that the pegmatite is exposed at the surface through erosion and to alter through weathering those minerals susceptible to change such as the feldspars. Thus we have exposed at the surface now kaolin, as the result of weathering of the feldspars; and quartz and mica, the reisen, with which is associated the cassiterite. Below the zone of weathering there should be the primary rocks, pegmatite which should be made up of feldspars, micas and quartz, with the greisen veins, pockets and lenses, formed as outlined above, in which will be found the cassiterite in minable quantities.

The main pegmatite dikes vary in width from a few inches to as much as 200 feet. The 200-foot thickness is found at Hanneur Hill, western Gaston County, and probably represents a joining of several of the dikes into one main dike.

As exposed at the present surface, the dikes represent the filling of faults and fissures many of which may join at depth to form a main dike of pegmatite.

The dikes are not continuous in length, but as they die out others continue at a short offset distance, thus indicating the filling of fissures. However, the dikes must extend to depth as the pegmatite injection came from below and the rock cooled at depth, as indicated by the degree

or crystallization.

In the northern end of the belt, the main dikes are from 2 to 65 feet in width, with several smaller dikes or stringers that outcrop at the surface and which probably join the main dikes at shallow depth. These stringers or apophyses are usually rich in cassiterite.

There is no question as to the depth to which the pegmatite extends. If the granite batholith underlay the pegmatite at shallow depth, there would not be the perfect parallelism between the pegmatite dikes and the faults and folds of the older sedimentary belt adjoining. The batholith evidently lies to the west and the intense pressure due to thrust and folding during the Appalachian revolution kept the eastern side of the magma fluid longer than the other parts and thus allowed a greater degree of differentiation and provided the necessary channels through which the aqueo-igneous solutions were squeezed. The pegmatite should extend at least to the depth at which mining of this character would be economical.

In the Metcalf and adjoining section, five miles southwest of the Lincolnton area, the pegmatite is more in the nature of veins of quartz and mica in diorite country rock, the latter being of the Moan series. The veins at the surface are narrow, that is up to three feet, and only slightly weathered, and carry cassiterite.

Economic Factors. From the facts above given, it may be well to present at this point the factors which should largely influence the economic value of the pegmatites. Primarily, the area into which the pegmatite is injected should be broken up by faults and fissures so that there should be large and continuous bodies of pegmatite. There should also be irregular walls and there should be numerous embayments and kidney-shaped areas where there may be a segregation of the cassiterite upon crystallization from the original pegmatite or into which the later injections may find their way. Numerous fissures in the country rock will lead to the formation of apophyses running out from the main pegmatite dike, and these should contain some of the richest cassiterite deposits.

The more cooling surfaces to which the solutions are exposed, the more rapid the crystallization with the resulting shrinkage cracks which act as channels for later aqueous solutions and fumaroles to move and replace the feldspars and deposit their mineral content.

In prospecting the area, where one finds where there has been excessive earth stressing in association with the pegmatite, it is a fair assumption that rich pockets or veins of cassiterite may be found. Also where there are a number of paralleling dikes of pegmatite with numerous apophyses or stringers outcropping parallel to the main dikes, one may conclude that earth movements have been severe and there should be some rich cassiterite deposits in the area.

ECONOMIC GEOLOGY

The "Tin Belt" extends from Lincolnton, North Carolina to Gaffney, South Carolina, a distance of some 3[illegible] miles. Many other minerals are found in belts parallel-ing the above and include gold, iron, barite, manganese, lead, mica, monosite, garnet, graphite, corundum, emerald, beryl, pyrite, clay, limestone, furnace rock, and building stone. In this report, only the tin and its by-product minerals will be discussed.

Ore Minerals

The ore minerals on the property of Ka-Mi-Tin Concentration Corporation are cassiterite, the oxide of tin, theoretically 78.6% metallic tin but usually around 65- 0% due to associated metals and impurities; kaolin, the weathered product of the feldspars; mica, a primary constituent of the pegmatite but enriched in the greisen to commercial proportions; feldspar, when unweathered, primary constituent of the pegmatite; silica, primary constituent of the pegmatite and one of the replacement minerals of the feldspar in greisen veins and lenses; spodumene, a mineral that is found in quantities in the east series of dikes and valuable as a source of lithium; columbite, a mineral found in appreciable quantities in certain sections of the tin-bearing parts of the dikes.

The tin and columbite are recoverable through concentration, the kaolin by washing, the mica by crushing and water separation, the feldspar will be recovered, as a market is developed, by hand picking when mining is in the primary pegmatite, the silica or quartz will be the waste material from the mill and will be intimately mixed with the crushed feldspar rock. Unless the quartz can be mechanically separated from the feldspar, probably the only use for the material will be for road surfacing. The spodumene can be separated on the tables or by decrepitation.

Tin. Cassiterite, the dioxide of tin, SnO_2, is dark brown to black in color, has a specific gravity of 6-7, i.e., seven times as heavy as water, equal volume, and has a metallic tin content in these deposits of 60-70%, as shown by numerous analyses. The cassiterite occurs as fine disseminations throughout the pegmatite and as well-formed crystals of varying size in greisen veins and replacements.

Kaolin. This is a secondary product resulting from the weathering of the feldspars. Primarily, it should be pure and generally white with a composition chiefly of silica and alumina. Small amounts of soda and potash may be present as well as calcium and magnesium. A little iron impurity would probably come from inclosing beds and the color of the kaolin affected to a degree dependent upon the amount of iron oxide washed into it. A large part of the iron can be removed in the processing of the kaolin.

Chemical and refractory tests of the kaolin show it to be very high grade. The uses will be governed by the degree of preness and the color when processed and ready for market. Reference is made to the report of E. J. Bryson for the kaolin tests.

Mica. The mica is a mechanical separation and is a by-product. It is chiefly muscovite or margarite mica and has a brilliant lustre. When ground and screened it should bring a good price and there should be a ready market for mica of this grade.

Feldspar. The mining of feldspar will come when the primary pegmatite is reached below the zone of weathering. In selective mining for the cassiterite, it will be necessary to mine some feldspar also. Where it can be separated by hand-picking, it can be saved in chunks and ground separately and prepared for market. There should be some rich bodies of feldspar in the pegmatite dikes, and, when a market is developed, selective mining of feldspar can be carried on to a degree to meet requirements. As a rule, the cassiterite does not occur in quantity associated with the feldspar but more in greisen lenses and veins, the minerals of which have largely replaced the feldspars.

Silica. If it were practical to separate the quartz and feldspar after crushing at the mill, the quartz could be used in glass manufacture. However, the specific

gravities of quartz and feldspar are so nearly the same, about 2.6, that their separation does not appear possible and economical. Any separation must be made by hand-sorting before crushing. The tailings, therefore, from the mill run can be used only for road building and probably for concrete mixtures.

Columbite. There is a growing demand for this mineral as it has a valuable use in the metallurgy of Steel. Separation from the cassiterite can be effected.

Spodumene. The eastern series of dikes at the north end of the Tin Belt carry up to 20% of spodumene in the pegmatite mass. The U. S. Bureau of Mines has been carrying on experiments in the beneficiation of spodumene and find a method of separation from the associated feldspar by by decrepitation. Further work is being done at this time and the experimental results will soon be available. The lithium salts are finding increasing uses.

Accessory minerals. No ilmenite, magnetite, wolframite, arsenopyrite or other metallics have been found associated with the cassiterite on this property except as traces. Some ilmenite and magnetite are found in placer deposits with the cassiterite but their source must be outside the tin-bearing pegmatites.

Such fumarole minerals as tourmaline, apatite, beryl, garnet, topaz, fluorite, axinite, lithiophylite, etcetera that might be found in the greisen veins or in the

[illegible], or as the contents of the enclosing schists, [illegible] separate from the cassiterite in the [illegible] operation.

Ore Occurrence

All the ores on the property of the Ka-Mi-Ti [illegible] Corporation occurs in and associated with the pegmatite. The pegmatite has been traced [illegible] pits, shafts [illegible] trenches from the north end of the property southward for 2½ miles to near South Fork River. There are at least four parallelling dikes at the north end and several paralleling stringers or apophyses. The present surface outcropping aggregates a width of about 120 feet of pegmatite, and the upper part of each dike has been weathered to kaolin, in some places to a depth of 50 to 70 feet.

The strike of the dikes is N. 20 to 25E. and the general dip is to the northwest. In the major dikes the dip is 70-80 degrees; in the stringers or apophyses the dip may be from 45 degrees up indicating that they probably join the larger dikes at varying and minor depths.

The hanging and foot walls of the dikes and apophyses are not regular. There are numerous bays in which kidney-shaped bodies of pegmatite have formed. Should there have been much cassiterite disseminated in the pegmatite magma and being an original constituent of the magma, we should expect to find segregations of cassiterite, both by magmatic and mechanical separation, in the embayments and pockets which branch off from the dikes and the apophyses.

My opportunities for study of the deposits under ground have been too limited to determine if there are such types of segregation which are free and distinct from the greisen replacement ore bodies, but I should expect to find some. In such case, there should be more feldspar associated with the cassiterite than in the greisen vein and replacement deposits.

In many places where thin quartz veins string through the pegmatite, above and below the quartz there are rich areas of cassiterite associated with quartz and mica chiefly. This would indicate an aqueo-igneous solution injected along a fissure or fracture in the already partly solidified pegmatite mass, the deposits being replacements of the feldspar by quartz, mica and cassiterite. What I term "Tin Reefs" are greisen rock rich in cassiterite which occurs in the hard, primary pegmatite and which is a fissure filling and replacement. Such a reef is typically shown in Swamp Shaft number one on the Ka-Mi-Tin property.

The richest greisen should be near the hanging and foot walls, the former being the more favorable for rich areas of cassiterite. Another favorable place is around inclusions and horses of country rock found within the pegmatite. These are caused by stoping action of the pegmatite, the country rock or schist being broken off and floated out into the solidifying magma.

From what has been said, the apophyses extending into the schists should be very favorable places for circulation of the aqueo-igneous and aqueous solutions as well as the fumaroles, and for replacement of the feldspar by greisen minerals and cassiterite, as well as primary deposition of them.

No evidence of typical vein filling such as banded or ribbon structure was noted. Without doubt there has been vein filling but the walls were at the same time attacked by the solutions and the feldspar replaced by greisen minerals for varying distances back from the fissures, thus giving the appearance of replacement deposits entirely, except where there is a quartz stringer more or less in the center.

Within the pegmatite where shrinkage cracks had developed at the time of crystallization and solidification, greisen minerals and cassiterite are found. Thus when the primary rocks are reached at the base of and below the weathered zone, a selective mining system will be called for.

Where there is a change in the regional direction of the pegmatite dikes, we may look for such fracturing and fissuring as to form favorable areas for the deposition of cassiterite. At the south end of the Ka-Mi-Tin property near South Fork River, the strike of the pegmatite is N. 45-60 W. Approximately at this point, the pegmatite series has been offset to the west. The pegmatite has not been traced over

this offset distance but in the southerly trend again numerous pits have been opened and several mines developed to a point beyond Kings Mountain town.

Examination of the turn in the dike at the southern end of the property, disclosed a much shattered area and very irregular bodies of pegmatite. Channel samples taken on the hanging-wall side gave assays running from 0.867% to 0.921% metallic tin, as determined by fire assay. The association is typical greisen and quartz stringers. The contacts are extremely irregular.

Nineteen samples were taken from the northern part of the property by Dr. John H. Banks and two composite samples milled and assayed. No. 1 gave a return of 1.36% metallic tin; No. 2 gave 0.53% tin, or an average of nearly 1.00% tin from all samples. The reports of Dr. Banks and L. S. James are available for verification and for a full description of the method of procedure.

Dr. L. J. Bryson, State Geologist of North Carolina, took a series of samples in which cassiterite ran from 0.21% to 6.80%, an average he considered of a out 1.00% tin. Report on file for verification.

Dr. Wilbur Nelson took seven samples at random from the 50 and 70 foot levels of the old Condon shaft. Four ran from 0.30% to 0.85%; three, trace only of tin.

The values of cassiterite in the pegmatite are extremely variable. Some assays show only a trace, others

show up to 50% in some rich shoots. The average for the full thickness of the pegmatite is problematic. In mining the weathered zone, probably all the dike material will be removed. The cost of both mining and milling will be so small that an average of considerably less than 1.00% cassiterite or 0.65% metallic tin will be profitable as the kaolin and mica will also be saved. It would appear safe to say that the average recovery should be at least 0.25% tin for all material mined to the base of the weathered zone. If we take 100 feet for the aggregate thickness of the several dikes, an average depth of 75 feet for the weathered zone, 15 cu. ft. per ton, for a length of 3000 feet along the strike, there would be 1,500,000 tons of minable material.

Below the weathered zone in the primary pegmatite, selective mining can raise the percentage of cassiterite to whatever degree is economically required.

Assays were made on an average of many samples of the surface material or residuum. To a depth of three feet, the average of 70 pits, 8714 lbs. samples, the recovery was 5.6 lbs. of metallic tin per ton, or 0.18%. From a series of pits varying in depth from 8 to 21 feet, and averaging 14½ feet, a composite sample gave 0.58% metallic tin. Map and report of this work are on file.

The kaolin deposit will be found only in the weathered zone of the pegmatites as they are formed by the complete break-down of the feldspars. The high-grade rite-free kaolin comes from the weathering of pure masses of the feldspar. Where found in such pockets, the kaolin should be mined separately. The depth to which the kaolin deposits will extend will not greatly exceed 75 feet.

The upper part of the weathered pegmatite will be iron stained in varying degrees but much of the discoloration should wash out in the milling operation.

The kaolin is all high-grade and runs nearly theoretically pure. The white has little or no iron impurity. Analyses by Dr. Bryson on ten samples show an average kaolin recovery of 46.90%. H. G. Jones found 31.7% by weight to be clay, all of which can be saved.

The amount of mica in the weathered zone of pegmatite was estimated from one to five percent of the material by Dr. Bryson. In two tests made by H. G. Jones, the mica recovery was 6.22% and 7.40% respectively.

The mica will be found scattered through the pegmatite and concentrated in the greisen areas with the cassiterite. When the primary rocks are reached, probably the only mica that can be profitably mined will be that associated with the greisen. The mica is high-grade and should command a good price, especially when ground.

Feldspar can be mined and saved only when operations reach the primary pegmatite below the zone of weathering. There should be bodies of pure feldspar which can be mined and hand-picked, if necessary. The only milling operation should be to crush to commercial sizes. The high-grade feldspar should extend to great depth.

The quartz will be found intimately mixed through the pegmatite but chiefly in the greisen areas. If a method of separation is worked out, the quartz may be used for purposes more valuable than just road material.

Developments

The developments on the Lincolnton property, prior to the fall of 1935 when the Ka-Mi-Tin Concentrating Corporation began operations, are ancient history. Suffice to say that the ten or more shafts and the several thousand feet of underground work were confined almost exclusively to the weathered or soft zone which extends to a maximum depth of about 80 feet. Large bodies of kaolin containing commercial quantities of muscovite mica were proved and good tin values in many places were found. A mill was built, ore milled, and concentrates shipped. Very little work was carried into the hard, primary pegmatite.

From a tin standpoint, there was proved for the Condon area a tin reef six to twelve feet wide for a horizontal length of 149 feet. This was on a 70-foot level. On the Jake dike, promising tin enrichments were found but never carried to depth in the hard rock. The same can be said for the Incline dike and for the Carpenter dike. These are all on the north end of the property.

One mile to the south the Henry shaft was sunk and good tin ore taken from the 65-foot level. Many test pits were sunk over the entire length of the property, a distance of $2\frac{1}{3}$ miles. At the southern end there was some hydraulic work and open-cutting. Assay values are given in the preceding pages, the highest being 0.921 metallic tin.

On the strength of all the early work and following a report on the area by St. Clair, Ka-Mi-Tin began steam shovel operation late in 1935. Cross-cuts and pits were dug and nearly 100,000 tons of material moved. Supplementing this about 1200 feet of drifting was done in the pegmatite dikes in the weathered zone at depths of 20 to 40 feet below the surface, this work being done in 1936.

To conserve space a resume of the 1936 developments as printed in January 1937 is here inserted.

Three long cross-cuts of the mineralized area were made by steam shovel which gave an excellent picture of the form and character of the pegmatite dikes. Three large pits were dragged, each to a depth of about 40 feet. From the cuts and pits drifts were run into and through the pegmatite dikes to determine contacts and enrichments. All this work was done in the soft, weathered zone, the depth of which extends to about 60 feet where hard-pan is encountered.

The work was made very hazardous and difficult by the continual unexpected encountering of old workings from which large volumes of water and muck would break in upon the new workings.

Without further detailing the work done in the old areas, we may briefly summarize the results. In the Condon area, the management has established the fact that a rich tin-bearing reef rock is near or at the hanging wall of the west pegmatite dike, and the top of the reef is at a depth of about 50 feet from the surface. Later, this will be mined by a shaft to be sunk west of all the old workings and to a depth of at least 150 feet so as to get underneath all the old water and muck-filled drifts. Diamond drilling will first outline the shape and extent of the tin reef.

The work in the Condon area has also established the fact that the company has a large deposit of high-grade Kaolin and Mica which when milling and treating facilities are available should prove a source of income. Other tin enrichments at the several contacts, hanging-and foot-walls of the dikes, will be followed down and should develop into valuable ore bodies at depth.

On the Jake dike, a high-grade deposit of Kaolin and Mica and several enrichments of tin have been proved, none of which have been carried to a depth of more than 20 feet all in the soft weathered zone.

On the Incline dike, a good part of the old workings were cleaned out and extended. All work was in the soft, weathered rock; at no place to a depth of more than 30 feet. Aside from proving another commercial body of Kaolin and Mica, tin values run from ¼ of one percent to two percent, the richer bodies being at the foot-wall contact of the main dike. No work was done in the old Carpenter area.

Work in the Swamp section, which lies about 1,000 feet south of the Incline area, was started early in September 1936. In a cross-cut from Swamp Shaft Number 1 at a depth of only 30 feet from the surface a rich tin

strike was made, assays running up to several percent tin over a reef width of four to six feet. A drift was run north a distance of 85 feet paralleling the reef but in the soft, weathered rock and above the harder reef rock. An incline or slope the full width of the reef has been run for a distance of 33 feet and attaining a depth of 40 feet in the reef. Milling ore is being hoisted to the surface and stored.

Swamp Shaft Number 2 was sunk to a depth of 45 feet, cross-cut made to connect with the north en ry from Shaft Number 1, and is now being used for ventilation and drainage of the workings in Number 1. Later it will be deepened and used for both mining and hoisting.

Swamp Number 3 is a two-compartment shaft with pipe and ladder-way and is 14 feet x 6 feet. The present depth is 65 feet and sinking is continuing. Progress has been slow due to the rock being very hard and highly silicified. Earth mechanics and water have also retarded the expected progress. All these are being overcome and the Shaft will be carried to depth. A level will be established within the next 15 to 30 feet where drifting will be done to reach the foot-wall and the hanging-wall. From this level only one compartment of the Shaft will be carried deeper and the sinking will be more rapid.

Very encouraging values for such highly silicified

rock, both in tin and columbite, have been followed down in Number 3 Shaft. It is anticipated that the hanging-wall or foot-wall contact, where the rock should not be so hard, should have tin-bearing rock similar in character to what was found at the hanging wall in Number 1 which is only 300 feet to the south. The formations appear similar.

Practically all work is being concentrated in the Swamp area at this time. There are 27 men on the pay-roll and day and night shifts are [redacted] Shaft Number 3.

The steam shovel is being used as a hoist and stacker for Number 3 Shaft. Hand winches are used on the others. A compressor plant was installed in November and furnishes power for four air drills and one pump. Two gasoline engines and pumps are in Shaft Number 3. A generator plant furnishes Electric current for surface and underground work. There are eight buildings in the Swamp Shaft enclosure including the office and two bunk houses. An ore bin 30 feet by 80 feet is being constructed.

A recent development has added color to the picture. A mile to the south at the Henry Shaft, a recent work has opened a tin reef similar to the strike in Swamp Number 1. Sufficient depth has not yet been reached to determine the full width of the reef.

The work in the Henry is on the 30-foot level. Years ago limited mining was done on a 60-foot level where good ore

values were reported. To mine at this depth now would require the installation of a new unit, including pump, compressor and air drills as well as a hoist. The Company is fully occupied in its development at the Swamp Shafts and nothing more than exploratory work is planned for the Henry area for the moment. Probably by Spring when the weather conditions are more favorable, plans will be made to open up this new area.

In conclusion, the year 1936 has seen the Company develop into a smoothly functioning organization and a well-trained and experienced personnel. Local labor conditions have caused delays in the past but this is being overcome by importing miners from other districts. In Canada the saying is "five years to develop a mine." We hope that the year 1937 will see developed a tin-producing mining and milling company, and later an installation to handle the Mica and Kaolin, and the Feldspar and spodumene (source of lithium).

In all, the year 1936 has seen satisfactory progress and results in the development of this new project. The work is under the supervision of L.H. Hepp, resident superintendent and the consulting geological advice of Stuart St. Clair of New York."

Since this report, the number three shaft has been carried down to 80 feet and number one shaft has reached 70 feet. A cross-cut from shaft number one on the 30-foot level struck a rich tin reef. A cross-cut is now being driven on the 65-foot level to reach the same reef. Assay results on careful sampling of the Swamp number one reef give the following results: Cut number one, width 8 feet, roof channel 3.24% metallic tin, floor channel 2.74% tin. Cut number two, 16 feet north, width 5 feet, roof channel 4.92% metallic tin, floor channel, 5.66% tin. Assays by John H. Banks Laboratories, New York City.

Of some interest, - in sinking Swamp shaft number one and driving 65-foot level cross-cut, considerable iron sulphide was encountered in the gneiss. Assay by Banks gives gold per ton 0.05 oz.; silver per ton 0.12 oz.; copper 0.03%.

After the above report was made, further drifting from the Henry shaft on a 30-foot level struck 5 feet of weathered greisen which panned 3% cassiterite; second sample 1.25% cassiterite. Hard greisen reef, 2 feet in width, uncovered, estimated 2.5% cassiterite.

Early diamond drill holes should be mentioned. Unfortunately, no record is now available except from word of mouth of people who worked on the drill. One hole 450

feet in depth, angle 45° in the Condon area, passed through 10 feet of dike, good tin values. This would be about 60 feet horizontal thickness. This checks with known widths of this dike.

A drill hole west of the Incline area and north 1000 feet from Swamp shafts went to a depth of 1300 feet on a 45° angle. Four dikes were cut ranging from 10 to 20 feet in thickness, tin assays averaging 1.5 to 2.0%. This length of drill hole would give 920 feet on a horizontal and vertical projection. The findings check with known dikes. A few cores picked up around the collars of the holes are of hard gneiss and schist, the country rock.

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Dr. H. J. Bryson, State Geologist of North Carolina.
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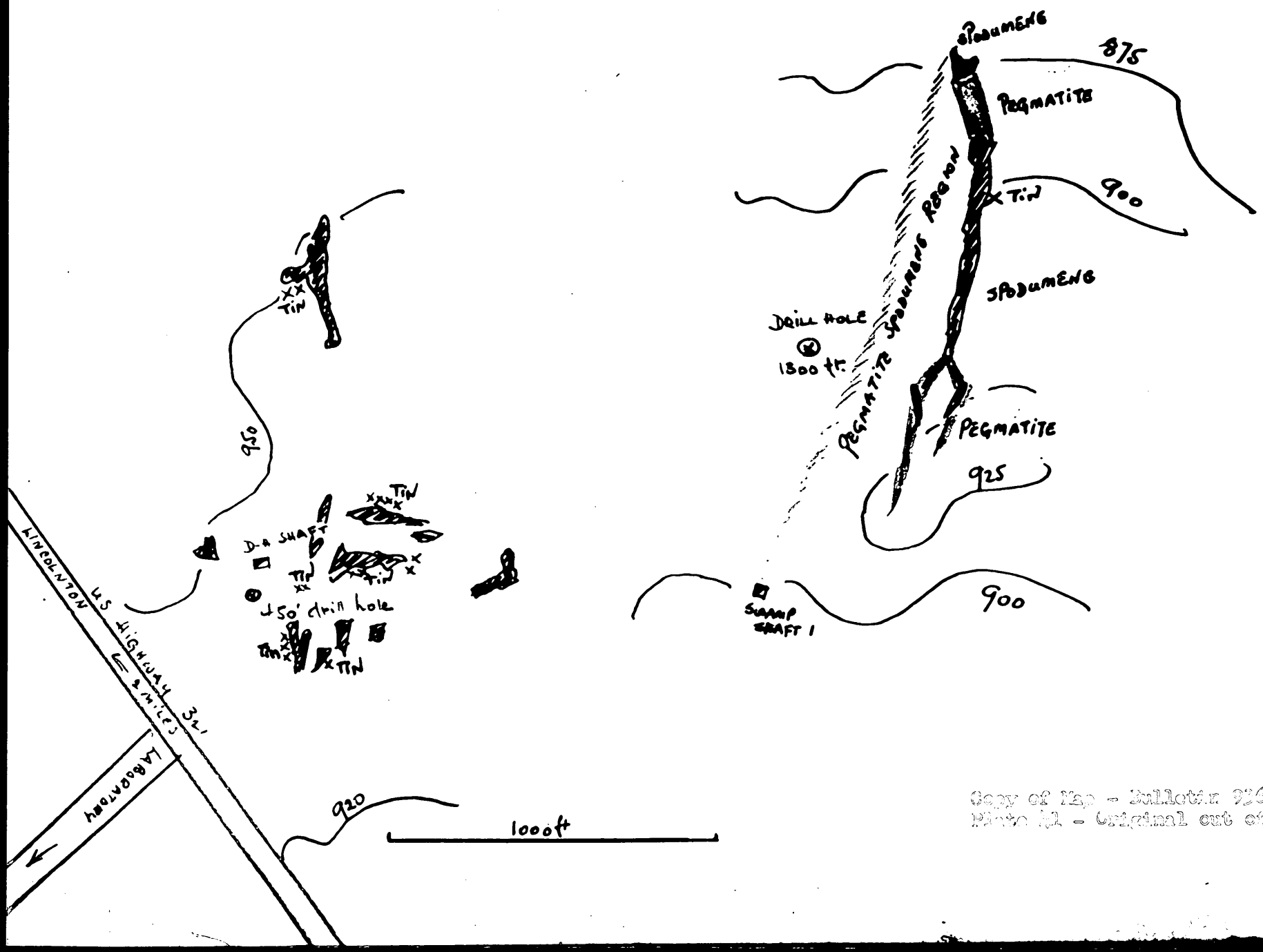
Stuart St. Clair, New York City, Consulting Geologist.
V. J. Hampton, Patino Mines, Bolivia. Mining Engineer.
Mr. Bennett, before the Tin Investigation Committee, Foreign Relations Comm. Samuel McReynolds Chairman. Washington.

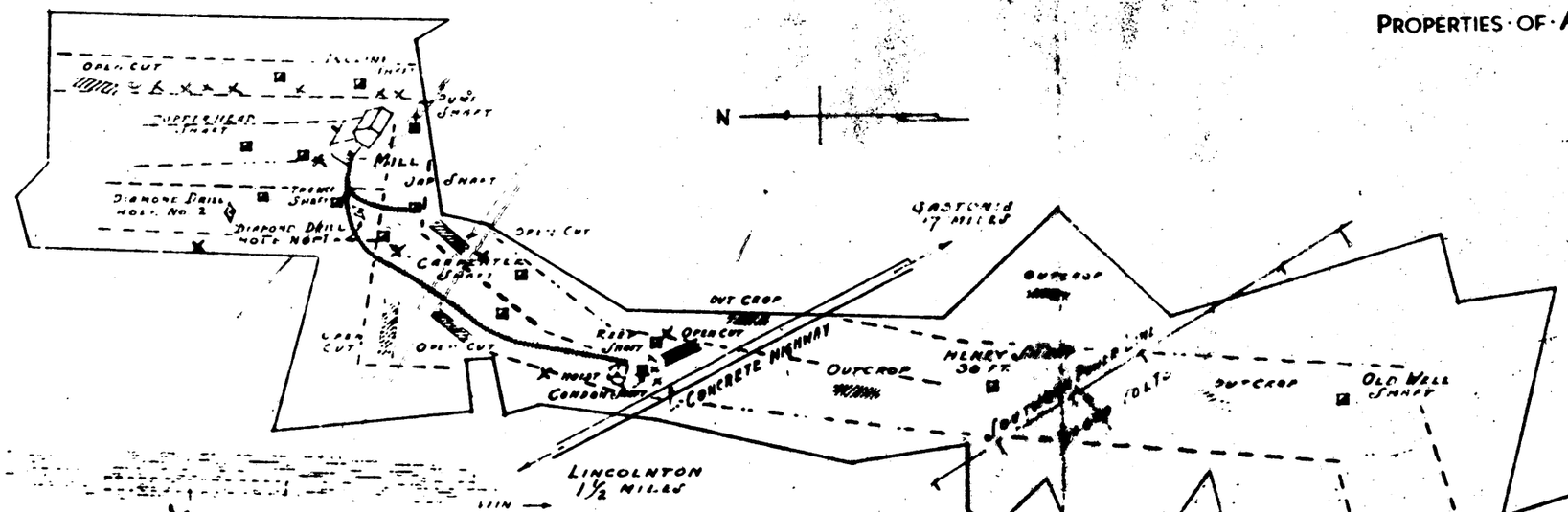
650 acres
over 250 acres
other deeded mineral rights

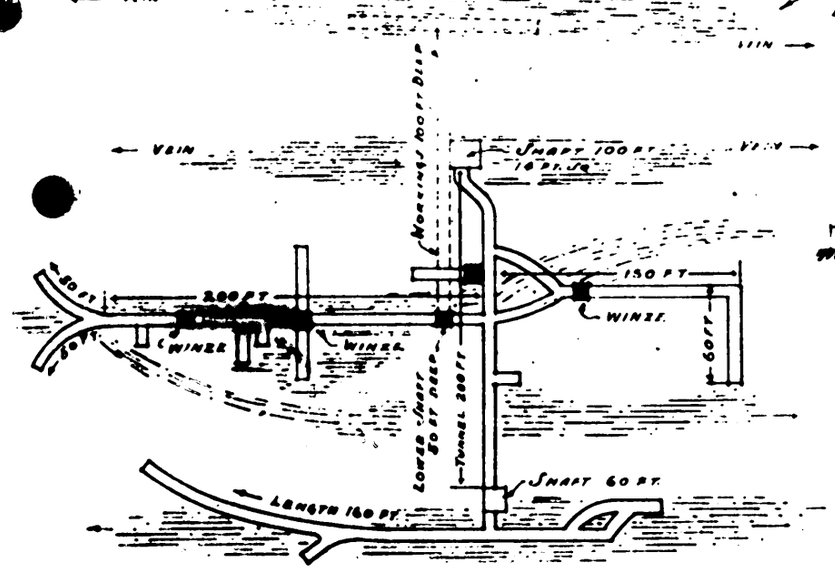


Copy of Map - Bulletin 926J
Plate 32 - Original out of print

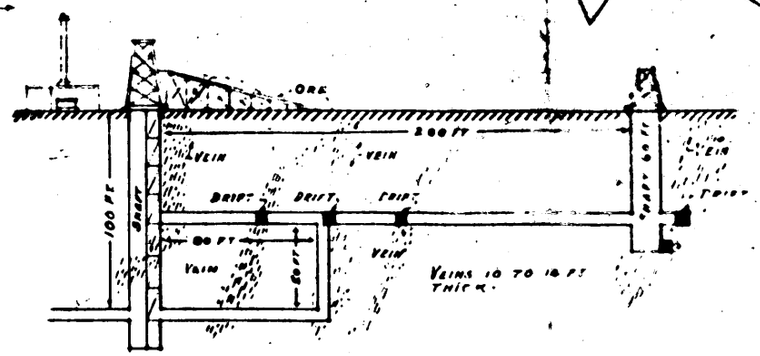
PROPERTIES · OF · AMERICAN · CONSOLIDATED · TIN · MINES · CORP ·

=== ORE ZONES.
DIAMOND DRILL HOLES.
SHAFTS
OUTCROP OF VEINS
OPEN CUT WORKINGS ON VEINS
TRENCHES ON VEINS
COMPANY'S RAIL TRAMWAY
LOCATIONS APPROXIMATE.
AREA - 600 ACRES - 2½ MILES BY ½ MI
X SAMPLE ASSAYS





DETAIL PLAN OF WORKINGS ESTABLISHED FIFTY FEET BELOW THE SURFACE, SHOWING THE FIVE LARGE VEINS. THE DOTTED LINES INDICATE WORKINGS 100 FEET BELOW THE SURFACE.



SECTIONAL VIEW OF THE CONDON SHAFT WORKINGS, SHOWING SHAFTS 50, 60 AND 100 FEET DEEP, ALSO THE LEVELS ESTABLISHED 50 AND 100 FT. BELOW THE SURFACE.

ENGINEERS
INSPECTIONS and TESTS

CHEMISTS
INDUSTRIAL and ANALYTICAL

The Bruce Williams Laboratories

ESTABLISHED 1898
Main Office 618-622 Joplin Street Telephone 55
JOPLIN, MISSOURI

[illegible] Cornell Street
Miami, Oklahoma
Telephone 210

St. Louis, Missouri
306 Valley Drive
Telephone Imperial 3226

October 16, 1952

[illegible] Alloys Corporation
[illegible] Street
New York 5, New York

Attn: [illegible] Strouth

628355 Sample [illegible]

Tin	Sn	0.77%	Cassiterite	SnO_2	0.98%
Beryllium	Be	0.12%	The Metal Beryllium	[illegible]	0.12%
Lithium	Li	0.26%	Spodumene	$LiAl(SiO_3)_2$	6.97%
Columbium Tantalum	Cb) Ta)		Combined as the oxides	Cb_2O_5) Ta_2O_5)	0.145%

It was necessary to grind the entire sample in order to have a representative pulp. Mica or Feldspar, or any other rock, should be determined on a separate sample.

Very truly yours,

Bruce Williams

Bruce Williams

WHITEHALL 3-1600

SIMPSON COAL & CHEMICAL CORPORATION
120 WALL STREET
NEW YORK 5, N. Y.

October 27, 1952

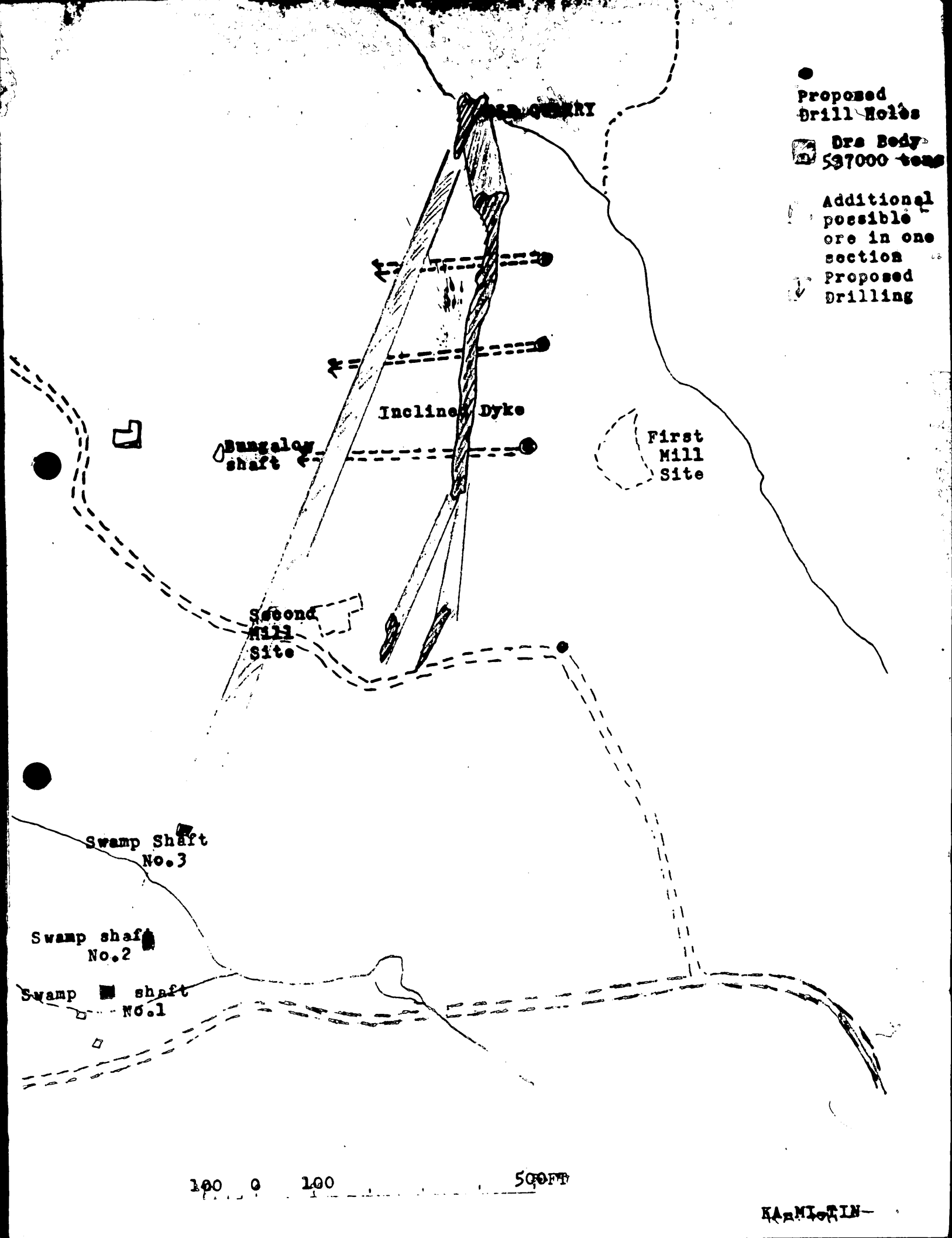
ANALYSIS

Pegmatite Ore - Composite Sample K U T

	% Present
Spodumene (Lithia content 7% Li_2O)	18
Quartz	35
Mica	6
Tin (In form of Cassiderite)	.5
Columbium-Tantalum Comb.	.015
Beryllium	Trace
Iron	2.0
Feldspar	30.5
Alumina	6
Moisture	Balance
	100 %

SIMPSON COAL & CHEMICAL CORPORATION

D. Shenkin, Chemist


Proposed Drill Holes
Ore Body 537000 tons
Additional possible ore in one section
Proposed Drilling
Inclined Dyke
Bungalow shaft
First Mill Site
Second Mill Site
Swamp Shaft No.3
Swamp shaft No.2
Swamp shaft No.1
100 0 100 500FT

Received by A. I. M. E. 9/7/53
Please [illegible] of the manuscript by returning it to the institute with your comment and recommendations at your earliest convenience.

NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING

OF THE

UNIVERSITY OF NORTH CAROLINA

MINERALS RESEARCH LABORATORY
Asheville, North Carolina

March, 1952

A METHOD FOR CONCENTRATION

OF

NORTH CAROLINA SPODUMENE ORES

By

Mason E. Banks, William T. McDaniel and Philip H. Sales

Report prepared in cooperation with the North Carolina Department of Conservation and Development and the Tennessee Valley Authority

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A B S T R A C T

Studies of a froth flotation process for concentration of spodumene from ores obtained in the vicinity of Kings Mountain, North Carolina were made on both batch and pilot plant scales. A process was developed for the production of concentrates which assayed 6.0% Li_2O and 0.45% Fe_2O_3 with 70-75% recovery of spodumene. The process requires two flotation separations, i.e., (1) a procedure whereby mica, feldspar, and quartz are simultaneously removed as a froth product with a cationic collector, and (2) the subsequent removal of iron-bearing minerals as a froth product while spodumene is depressed as a tailing. The process is the reverse of the usual procedure of collecting spodumene as a froth product with anionic collectors.

The investigation was undertaken by North Carolina State College Minerals Research Laboratory of Asheville, North Carolina at the request of Foote Mineral Company of Philadelphia, Pennsylvania. Parts of the process are now being used on a commercial scale at the Foote Mineral Company plant near Kings Mountain, North Carolina

Introduction

During the 1944-45 period of World War II, Selwy Process Company operated a flotation plant with a daily capacity of 300 tons of ore for the production of spodumene concentrate near Kings Mountain, North Carolina. The operation was shut down upon cessation of wartime demand for lithium chemicals and, until recently, there has been no production from the Carolinas.

In April, 1950 an investigation of the problem of spodumene flotation from North Carolina ores was begun at N. C. State College Minerals Research Laboratory at Asheville, N. C. This laboratory, operating under the combined auspices of N. C. State College, N. C. Department of Conservation and Development, and Tennessee Valley Authority undertook the spodumene project at the request of Foote Mineral Company of Philadelphia, Pennsylvania. The work, involving a period of fifteen months of intensive batch and pilot plant investigation, was completed in June, 1951, and resulted in development of a process for concentration of spodumene by flotation which has been heretofore unrecorded in the literature. A similar approach has been used before on iron, ilmenite, and other minerals, but the literature shows no record of its having been applied to spodumene. Parts of the process are now being used on a commercial scale at the Foote Mineral Company plant near Kings Mountain, N. C., which has been in production since July, 1951. It is the purpose of this paper to describe some of the results of the investigation.

Acknowledgements

The authors would like to acknowledge with sincere appreciation the assistance of the following people and organizations in connection with this investigation: Dr. J. L. Stuckey, State Geologist of North Carolina and his assistant, Sam D. Broadhurst; Charles E. Hunter, former TVA Geologist, for field sampling and geological assistance; Carolina Mineral Company; United Feldspar and Mineral Company; Research and Development Division, Foote Mineral Company for furnishing checks on analytical control samples, and for part of the pilot plant equipment; W. H. Powell, R. B. Terrell, and W. R. Hudspeth for assistance in carrying out laboratory tests.

The Ore Bodies

According to statements judged to be conservative the tin-spodumene belt of the Carolinas contains an estimated 4,300,000 tons of pegmatite ore averaging 15% spodumene. This amounts to "a reserve of at least 650,000 tons of spodumene (more than 20,000 tons of metallic lithium) to a depth of 100 feet." (1)

Spodumene-bearing pegmatites occur in a narrow belt 24.5 miles long and 1.8 miles wide extending southwestward from Lincolnton to Grover, N. C. There are hundreds of pegmatites in the belt most of which are less than 10 feet wide, however, there are sufficient larger bodies to permit the establishment of the reserves figure of 4,300,000 tons of ore. This figure includes only bodies having an average thickness of 35 feet and length of 550 feet. The largest pegmatite in the area has a maximum thickness of 395 feet and maximum length of 3250 feet. (1)

These larger pegmatites are composed principally of albite and microcline feldspars (albite predominating), quartz, spodumene, and muscovite. There are many accessory minerals, but the important ones are cassiterite and beryl, and possibly columbite-tantalite. Approximate composition of ores from the belt which were used in this investigation is as follows:

Table I

Ore	Supplied by	Spodumene	Feldspar	Quartz	Mica	Others
Lab. No. 808	Laboratory Staff	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lab. No. 837-A	Foote Mineral Co.	35	33	26	[illegible]	2
Lab. No. 971	Consolidated Feldspar Corp.	29	41	27	[illegible]	4
Lab. No. 943	Foote Mineral Co.	32	35	23	4	7
Lab. No. 969	Foote Mineral Co.	32	42	25	4	6
Lab. No. 985	Foote Mineral Co.	13	36	22	4	5

Note: 1. "Others includes hornblende gneiss and sericite schist particles from wall rock and inclusions, as well as beryl, cassiterite, and numbers of accessory pegmatite minerals present in trace quantities.

2. The Foote samples contained 0.03-0.05% Sn, or approximately 1.0 pound Sn per ton of ore. These came from the old Selvey quarry about 1 mile SW of Kings Mountain.

Table I shows that quartz and muscovite content remain fairly constant in all the ores, while feldspar content increases when spodumene content decreases, and vice versa. This is interesting because feldspar is potentially an important by-product.

The Spodumene

According to Boyd,(3) the following analysis is typical of the Carolina spodumene:

SiO_2	Al_2O_3	Li_2O	Fe_2O_3	CaO	MnO	MgO	Na_2O	Ignition Loss
63.84	28.61	7.26	0.19	0.04	Trace	Nil	Nil	0.16

Spectrographic analysis shows the presence of minor amounts of Fe_2O_3, MnO, TiO_2, SnO_2, Ga_2O_3, Na_2O and MgO in the spodumene. One sample contained Nb_2O. Petrographic and X-ray studies indicated that these impurities are probably isomorphous replacements in the crystal structure of the spodumene.(9)

The molecular dispersion of the iron within the spodumene crystal has been substantiated by acid-leaching and magnetic separation tests in which the Fe_2O_3 content of spodumene crystals remained from 0.15-0.40% after magnetic separation and acid leaching.(2)

The iron content of the spodumene crystals is usually reflected in the color of the crystals, the colorless to white variety containing from 0.08-0.20% Fe_2O_3, the buff or cream variety containing 0.20-0.40% Fe_2O_3 and the yellow or greenish-yellow variety containing up to 0.65% Fe_2O_3, etc. The darker the color the higher the iron content of the spodumene.

The amount of iron dispersed in the spodumene crystals is a significant factor since it effects the use to which the concentrates may be put. For use in ceramics the spodumene concentrate should contain less than 0.5% Fe_2O_3, but for use in extraction of lithia for chemical purposes the presence of iron presents no special problem. None of the samples handled from the Carolina belt contained spodumene with low enough isomorphous iron content to yield a product with less than 0.2% Fe_2O_3. The average iron content of spodumene concentrates prepared from these ores was 0.40-0.50%.

The Carolina spodumene is somewhat variable in Li_2O content, but apparently averages approximately 7.0% or slightly in excess of this figure, although, the textbook gives 8.03% theoretical Li_2O. Some variation is caused by weathering for it has been established that Li_2O is lost by leaching when the rock undergoes weathering, just as the Na_2O and K_2O are lost in kaolinization of feldspar.

Since the close of World War II there have been numerous developments which have tended to increase the use of lithium by industry. Notable among these has been the development of an industrial lubricant based on lithium stearate. The lubricant is fluid at low temperatures, stable at high temperature, and insoluble in water. A new bleaching agent, lithium hypochlorite, has also been developed recently.[11] Other well-known uses are listed below:

1. Lithium oxide in ceramics reduces firing time, lowers melting temperatures, lowers thermal expansion, raises refractive index, and improves chemical resistivity.
2. Lithium carbonate and lithium stronitium nitrate are used in pyrotechnics for their brilliant red color.[10]
3. Lithium chlorides and fluorides are used as fluxes for welding aluminum and magnesium.[10]
4. The affinity of lithium for nitrogen is the basis for a process used in purifying helium.[10]
5. Lithium chlorides and bromides are used in air conditioning for their powers to absorb organic amines, ammonia, and smoke.[11]
6. Lithium hydride has been used as a source of hydrogen to inflate life rafts and balloons used by the Air Forces and Navy.[11]
7. Lithium metal and lithium hydride are useful in the atomic energy program in connection with the production of the isotopes of hydrogen.[7]

Review of Concentration Methods

The literature reveals the following methods which have been used for production of spodumene concentrates: 1. The spodumene of the Black Hills of South Dakota was present in such large crystals that it was easily concentrated by selective mining and hand sorting. 2. The Bureau of Mines developed a method by which alpha spodumene was decrepitated at a temperature between 1000°C and 1100°C, changing its form to beta spodumene, a soft pulverulent material, which could be recovered from the harder gangue minerals by differential grinding following the decrepitation.[6] 3. Froth flotation of spodumene using anionic collectors (fatty acids) in an alkaline circuit was worked out by the Bureau of Mines, and enlarged upon by Norman and Gieseke.[2] This method was utilized by Solvay Process Company at Kings Mountain, N. C. during its wartime operation. 4. Froth flotation with sulfonated oils in an acid circuit was also shown to be feasible, as well as a method of producing a feldspar-spodumene mixture by using cationic collectors in an HF circuit.[2] 5. A mill at Keystone, South Dakota operated by Lithium Corp. of America has been utilizing the heavy media method, treating 15 tons of minus 1½-in. ore per hour, and producing a concentrate of 4 to 5% Li_2O.[7]

All of the methods above have their advantages and disadvantages. The method described on the following pages is presented merely as a different approach and is acknowledged also to have both advantages and disadvantages.

The Flotation Process

The final process developed for spodumene concentration of North Carolina ores revolves around two primary flotation separations, i.e., 1. a process whereby mica, feldspar and quartz are simultaneously removed as a froth product while spodumene and iron-bearing minerals are depressed as a tailing; and, 2. the subsequent removal of iron-bearing minerals as a froth product while spodumene is depressed as a tailing. The removal of silicate gangue minerals in Step 1 is accomplished in an alkaline circuit, using a long-chain amine as collector, and a colloidal depressant, such as starch or dextrine as selective depressant for the spodumene and iron-minerals. The iron minerals are removed in an acid circuit, using sodium resinate as collector and hydrofluoric acid as controller for prevention of spodumene flotation. Suitable frothers are used in both floats.

The gangue froth product containing mica, feldspar, and quartz may be split into its component parts for recovery of a feldspar by-product. Since approximately one-third of the feed is generally recoverable as a feldspar concentrate, it was felt that efforts to recover it should be made. The general procedure for feldspar recovery would be to dewater the gangue froth product, and then treat it in the conventional manner for feldspar ores which consists of removal of mica with sulfuric acid and amine, washing by classification, then flotation of other iron-bearing silicates with sulfonated oil or fatty acid collectors, and finally flotation of feldspar from quartz with the conventional hydrofluoric acid-amine process.

The final process which breaks the ore into its component parts is described generally as follows:

1. Grinding. The ore as received was ground in a batch rod mill at 25 percent solids to pass a 28 mesh screen. The plus 28 mesh fraction, consisting almost entirely of mica, was removed. The minus 28 mesh fraction, was deslimed by decanting over a 325 mesh screen. Approximately 0.5 pound caustic per ton of feed was used in the mill to keep the pulp dispersed for desliming. The oversize product consisted of about 1.0 percent weight of the feed, while slime loss amounted to 12-18 percent weight of the feed. Separations were obtained with feed as coarse as 20 mesh, and the general range of 20-28 mesh was satisfactory. The feed should be sized by screening or classification, with oversize returning to the mill in practice. The rod mill is preferred to the ball mill, because it produces a coarser, more granular, feed with much closer size distribution. It is believed that ball milling would produce excessive slimes and a long particle size range, both of which have been shown to be undesirable in this process.

2. Rougher Gangue Flotation. The deslimed minus 28 mesh plus 325 mesh pulp was placed in a Denver 2000 gram laboratory flotation machine and brought to 20-25 percent solids. The following reagents* were added: 1.0 lb/T Lime, 0.5 lb/T dextrine, 0.4-0.7 lb/T Armac T, and 0.4 lb/T B-23. The pulp was conditioned for one minute, then floated for four minutes, with the quartz, feldspar, and mica being simultaneously removed as a froth product. The spodumene and iron-bearing minerals were selectively depressed and removed as a tailing. Most of the froth was removed in two minutes. The float is heavy and fast if sufficient frother is used. The rougher is more selective if little or no frother is used, but requires more collector (Armac T) and an excessive float time. Lime

*Calculated in pounds per ton of dry mill feed.

and dextrine are more selective and cheaper than caustic and dextrine, although either may be used. If dextrine is not available, causticized-starch may be used, although dextrine is preferable. An excess of starch or dextrine does not break down the separation, but merely causes an increase in collector required. Approximately 0.5 lb/T dextrine or causticized-starch is generally sufficient to depress the spodumene. An excess of caustic or lime can cause complete break-down of the separation as the amine collector is unstable when the pH is above 11.5.

3. Cleaner Gangue Flotation. The rougher gangue froth was next placed in the cell at 15-20 percent solids with 0.5 lb/T Lime, 0.5 lb/T Dextrine, and 0.2 lb/T B-23. It was conditioned 15 seconds, then floated four minutes. This is practically a repetition of the rougher, for the purpose of dropping out fine spodumene particles which were mechanically entrained in the heavy rougher froth. It requires no additional collector. If sufficient frother is used, the cleaner tailing or middling is a high-grade spodumene concentrate and may be combined with the rougher tailing.

4. Iron Mineral Flotation. The combined rougher tailing and cleaner tailing, consisting of a high-grade spodumene concentrate with substantially all of the iron-bearing minerals present, was then washed by decantation, thickened to 65-75 percent solids, and conditioned for ten minutes with 0.35 lb/T NF (100 percent), 2.0 lb/T sodium resinate, 0.1 lb/T B-24. The pulp was transferred to the cell and floated four minutes at 25 percent solids, with iron-bearing minerals being removed as a froth product, and relatively iron-free (except for molecularly contained iron) spodumene discharged as a tailing. The tailing is the finished spodumene concentrate, which may be thickened, filtered, and dried in conventional manner. The sodium resinate collector was chosen over sulfonated oils as iron-mineral collector because it tends to concentrate the spodumene by floating mica and feldspar impurities along with the iron minerals, whereas the sulfonated oils tend to float pure spodumene along with the iron minerals. It is most important to maintain pulp density in the conditioner as high as possible before flotation of iron minerals.

5. Mica Flotation. The cleaner gangue froth was next conditioned for three minutes with 1.0 lb/T H_2SO_4, 0.1 lb/T B-23, and 0.05 lb/T Armac T at 35 percent solids. Mica was then removed as a froth product.

6. Feldspar Flotation. The quartz-feldspar tailing from the mica float was washed by decantation, then conditioned six minutes at 50 percent solids with 1.5 lb/T NF (100 percent). It was then placed in the cell, diluted to 25 percent solids, and 0.05-0.20 lb/T Armac T and 0.3 lb/T B-23 were added before flotation. Feldspar was removed as a froth product and quartz was discharged as a tailing.

Using the process as outlined, results on batch testing several ores are shown in Table II. Figure I is a flowsheet of the process.

Table II
Batch Test Results

Lab. No. 808 Head Sample: 38% spodumene, 0.24% Fe_2O_3 in spodumene crystals.

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	Fe_2O_3	Al_2O_3	SiO_2	(1) Li_2O	(2) Li_2O
Spodumene Conc.	29.4	91	26.8	70.8	0.26			6.55	
Iron Froth Product	3.2	62	2.0	5.3				4.85	
Mica Froth Product	4.2	4	0.2	0.5				0.45	
Feldspar Froth Product	21.0	14	2.9	7.7	0.07		67.0	1.25	
Quartz Tailing	29.8	8	2.4	6.3	0.04		93.3	0.75	
Slime & Oversize	12.5	29*	3.6*	9.5*					
Total	100.1		37.9	100.1					

Lab. No. 837-A Head Sample: 36% spodumene, 0.43% Fe_2O_3 in spodumene crystals.

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	Fe_2O_3	Al_2O_3	SiO_2	(1) Li_2O	(2) Li_2O
Spodumene Conc.	33.8	89	30.1	83.6	0.44			6.50	6.44
Iron Froth Product	1.9	50	1.0	2.8	8.29			4.05	4.50
Mica Froth Product	1.5	3	0.1	0.3				0.35	0.52
Feldspar Froth Product	27.5	8	2.2	6.1	0.09	19.9	68.4	0.70	0.68
Quartz Tailing	20.9	1	0.2	0.6	0.02		98.0	0.10	0.11
Slime & Oversize	14.4	18*	2.4*	6.7*					
Total	100.0		36.0	100.1					

Lab. No. 943 Head Sample: 19% spodumene, ____% Fe_2O_3 in spodumene crystals.

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	Fe_2O_3	Al_2O_3	SiO_2	(1) Li_2O	(2) Li_2O
Spodumene Conc.	14.3	82	11.7	63	0.86			6.35	6.40
Iron Froth Product	2.6	55	1.4	7				4.35	4.00
Mica Froth Product	6.0	5	0.3	2				0.50	1.19
Feldspar Froth Product	37.9	7	2.6	14	0.26	20.6	66.0	0.70	1.40
Quartz Tailing	20.1	1	0.2	1	0.14		94.1	0.10	0.36
Slime & Oversize	19.1	13*	2.4*	13*					
Total	100.0		18.6	100					

Lab. No. 971 Head Sample: 23% spodumene, 0.47% Fe_2O_3 in spodumene crystals.

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	Fe_2O_3	Al_2O_3	SiO_2	(1) Li_2O	(2) Li_2O
Spodumene Conc.	22.8	84	19.2	83.5	0.56			6.25	
Iron Froth Product	1.0	94	0.9	3.9				6.70	
Mica Froth Product	4.4	1	0.0	0.0				0.10	
Feldspar Froth Product	36.6	4	1.5	6.5	0.12	20.4	68.1	0.40	
Quartz Tailing	20.8	1	0.2	0.9	0.05		96.5	0.10	
Slime & Oversize	14.3	8*	1.2*	5.2					
Total	99.9		23.0	100.0					

(1) By using curve showing Li_2O vs. percent sinks in acetylene tetrabromide.
(2) By actual chemical analysis.

*Calculated using head sample analysis.
Distribution of spodumene based on percentage of sinks in acetylene tetrabromide.
Li_2O analyses by Foote Mineral Company.

PROPOSED SPODUMENE FLOTATION PLANT FLOWSHEET

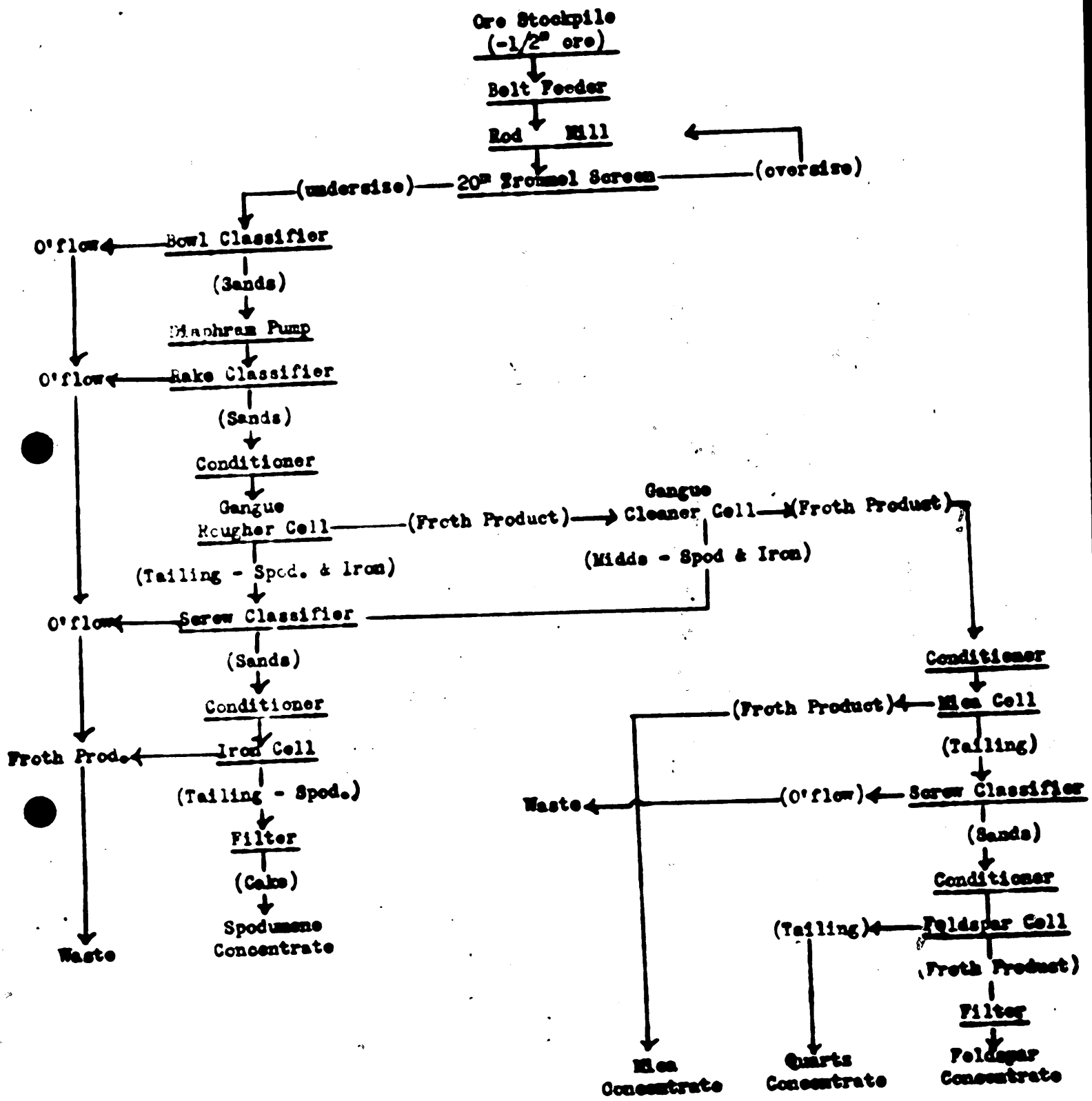


Figure 1

Pretreatment of Weathered Ores

It was found necessary to employ light attrition scrubbing on ore types which were weathered appreciably. Unless alteration products were removed from the mineral particle surfaces, selectivity was rather poor. This condition had been noted previously in application of anionic flotation to these same ores.(2) The main effect of weathering on this cationic float was to inhibit flotation of stained particles of quartz and increase amine consumption. This substantially lowered the grade of concentrates obtained. It was found that conditioning at 65-70 percent solids for 5-10 minutes with 4-5 lb/T of caustic followed by a decantation wash was effective in removing the alteration products on particle surfaces. When the spodumene-gangue separation was performed on weathered ores which had been scrubbed in this manner, selectivity was usually as good as that obtained on fresh, unweathered ore samples.

An alternate method was also found to be effective. This alternate method was to change the grinding pulp density from the normal low percent solids to high percent solids, using 4-5 lbs/T of caustic in the mill, thereby getting a scrubbing action in the mill. This procedure resulted in improved flotation selectivity, but changed the nature of the mill discharge from a rather coarse, uniformly-sized feed, to a finer feed with a much greater range of size.

Of these two methods of handling weathered ores, the one utilizing dilute grinding conditions and a separate scrubbing step has been shown to be the best procedure, although the alternative use of the mill as a scrubbing device may be used if it becomes expedient to do so.

The following three batch test results indicate the beneficial effect of scrubbing on a weathered ore. In each case shown, treatment of the samples was identical except for grinding and scrubbing conditions as indicated. Feed was Lab. No. 969.

Table III

Test 1 - Dilute (25% solids) grind. No scrubbing.

Results:	% Wt.	% Spod.	Units Spod.	Distribution of Spodumene
Spodumene Conc.	20.0	71.0	14.3	65
Gangue Froth	69.3	8.0	5.3	24
Slime Loss	10.7			11
Total	100.0			100

Test 2 - Dilute (25% solids) grind. Scrubbed 6 min. at 75% solids with 5.0 lbs/T NaOH. Washed.

Results:	% Wt.	% Spod.	Units Spod.	Distribution of Spodumene
Spodumene Conc.	16.1	90.7	14.6	66
Gangue Froth	72.9	5.4	3.9	18
Slime Loss	11.0			16
Total	100.0			100

Test 3 - Thick (60% solids) grind with 4.0 lbs/T NaOH in grind.

Results:	% Wt.	% Spod.	Units Spod.	Distribution of Spodumene
Spodumene Conc.	20.2	86.3	17.3	79
Gangue Froth	66.3	5.0	3.3	15
Slime Loss	13.5			6
Total	100.0			100

Pilot Plant Tests

Since the method outlined in the preceding pages represented a rather novel approach to spodumene flotation, it was decided to make pilot plant tests so that the spodumene-gangue and spodumene-iron separations could be studied under continuous operating conditions. Part of the necessary equipment was furnished the laboratory by Foote Mineral Company.

The flowsheet followed was the same as that shown in Fig. 2, except that the gangue froth product was collected as a bulk froth product with no attempt made to separate the mica, feldspar, and quartz. Grinding conditions were set-up to utilize the mill as a scrubbing device, i. e., high density grinding with caustic. Feed rate for most of the tests was 300 lbs/hr of minus 1/2 inch ore and a total of 15 tons of ore were used in these tests. Operating time on the test runs varied from two to eight hours. Two ore samples were studied in this manner. Lab. No. 969 containing 22% spodumene, and Lab. No. 985 containing 12.5% spodumene. Seven complete tests were made on each ore. Variables studied in these fourteen continuous pilot plant tests included amount of caustic used in the mill, pH studies in rougher and cleaner gangue floats, conditioning time and cell retention time in the gangue float section, comparison of pine oil, B-23, and cresylic acid as frothers, determination of optimum dextrine and amine amounts required, studies comparing sulfonated oils with soap as iron mineral collector, conditioning time and cell retention time in the iron float section. A short study was also made of the problem of concentration of the small amount of cassiterite which occurs in the spodumene ores. The cassiterite problem is not considered within the scope of this paper, but is mentioned to indicate that the presence of the mineral in interesting quantities was recognized and a method was evolved to recover it.

Table IV shows the results obtained in pilot plant tests number 2 and number 14.

Table IV

Pilot Plant Test 2

Operating Conditions

Feed: -1/2 inch Lab. No. 969, 22% spodumene, 0.89% Fe_2O_3, fed at 300 lbs/hr. Mill discharge minus 28 mesh.

Equipment	Reagent	Quantity Reagents - lbs/T	pH	Percent Solids
Rod Mill	NaOH	4.34		65
Rougher Cell	NaOH	0.27	10.9	20
	Dextrine	1.15		
	Amine	0.90		
	Pine Oil	1.13		
Cleaner Cell	Dextrine	1.10	10.0	15
	Pine Oil	0.69		
Fe Conditioner	Sodium Resinate	3.20	5.0	65
	HF	0.24		
	Pine Oil	0.76		
Fe Cell			5.4	20

Metallurgical Results

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	% Fe_2O_3	(1) % Li_2O	(2) % Li_2O
Heads	100.0	22.0	22.0	100.0	0.89	1.90	1.30
Oversize	0.1	75.0	0.1	0.5	[illegible]	5.80	5.80
Bowl O'flow	3.8	3.0	0.1	0.5	1.02	0.35	0.74
Rake O'flow	3.2	3.0	0.1	0.5	0.68	0.35	0.87
Gangue Froth	72.0	7.0	5.0	23.0	0.23	0.70	0.64
Iron Froth	1.5	59.0	0.9	4.1	7.08	4.40	3.50
Spodumene Conc.	19.1	81.0	15.5	71.4	0.47	6.10	6.00
Total	99.7		21.7	100.0			

Pilot Plant Test 14

Operating Conditions

Feed: -1/2 inch Lab. No. 985, 12.5% spodumene, 0.35% Fe_2O_3, fed at 325 lbs/hr. Mill discharge minus 28 mesh.

Equipment	Reagent	Quantity-lbs/T	pH	Percent Solids
Rod Mill	NaOH	4.80		65
Rougher Conditioner	NaOH	0.17	11.1	50
	Dextrine	0.98		
	Amine	0.68		
	Pine Oil	0.90		
Rougher Cell	NaOH	0.26	11.0	20
Cleaner Cell	Dextrine	0.98	10.5	15
	Pine Oil	0.46		
Iron Conditioner	Sodium Resinate	2.16		
	HF	0.70		65
	Cresylic Acid	0.52		

Metallurgical Results

Product	% Wt.	Spodumene %	Spodumene Units	Spodumene Dist.	% Fe_2O_3	(1) % Li_2O	(2) % Li_2O
Heads	100.0	12.7	12.7	100.0	0.35	1.15	1.15
Oversize	0.1	80.0	0.1	0.7		6.05	6.00
Bowl O'flow	7.7	5.0	0.4	2.8	1.64	0.50	0.87
Rake O'flow	2.3	6.0	0.1	0.7	0.96	0.60	0.81
Screw O'flow	0.4	12.0			1.00	1.10	1.80
Gangue Froth	77.0	4.7	3.6	26.0	0.19	0.50	0.42
Iron Froth	0.6	53.3	0.3	2.2	11.00	4.30	3.96
Spodumene Conc.	11.8	80.0	9.3	67.5	0.65	6.05	6.44
	99.9		13.8	99.9			

(1) By using curve showing % Li_2O vs percent sinks in acetylene tetrabromide.

(2) By actual chemical analysis.

Distribution based on percentage of sinks in acetylene tetrabromide.
Chemical analyses by Foote Mineral Company.

Heavy Liquid Control Method

The use of acetylene tetrabromide as a laboratory control aid is worthy of mention here in view of its extensive use in this investigation. The liquid has a specific gravity of 2.96. The only major constituent of the spodumene ores having a specific gravity higher than 2.96 was spodumene itself. It was found that minus 20 mesh ore samples when placed in acetylene tetrabromide, resulted in a sinks product averaging 98 percent spodumene, the remaining 2 percent consisting of traces of cassiterite, hornblende, tourmaline, apatite, pyrite, and numerous others. Therefore, for all practical control purposes, the percentage of sinks in acetylene tetrabromide was the actual percentage of spodumene in the product.

A method was evolved in which the test samples were weighed, placed in acetylene tetrabromide contained in centrifuge tubes, and centrifuged for 10 minutes. Centrifuging brought about excellent separation of gangue minerals as floats and spodumene as sinks. Floats and sinks were then easily separated by a simple pouring technique, filtered, washed with benzene to remove excess tetrabromide, dried and weighed.

A graph (Figure 2) was then drawn in which percentage of sinks in a given sample was plotted against percentage of Li_2O contained in the sample. Li_2O analyses for this graph were kindly furnished by Foote Mineral Co. By obtaining the percentage of sinks in acetylene tetrabromide and reading the corresponding Li_2O value from the graph, it was possible to obtain a reasonably accurate Li_2O analysis.

This method was used as a control on laboratory batch tests and pilot plant tests. All products were quickly and easily evaluated from a lithia standpoint without the costly and somewhat lengthy chemical analytical procedure for lithia determination. From twelve to eighteen Li_2O determinations per eight-hour shift could be made by semi-skilled operators using this method. In addition to its use as laboratory control, the method could easily be adapted in commercial plant operating control.

Conclusions

The two flotation separations described in the foregoing pages produced spodumene concentrates from Kings Mountain ores on a continuous pilot plant scale. The spodumene concentrates contained an average of 6.0% Li_2O and 0.45% Fe_2O_3 with a recovery of 70% of the available spodumene. If the iron removal step was not carried out the recovery of spodumene was approximately 75%. The process was successful on feed ground as coarse as 20 mesh. Weathered ores required light attrition scrubbing for satisfactory separation, but this was carried out in an acceptable manner by milling at high density with a high caustic addition.

The process is not recommended for use on ores containing less than 15% spodumene because recovery tends to drop off as spodumene content in the feed decreases. This is due to the fact that the gangue froth product inherently contains 3-5% spodumene and this becomes an increasingly high percentage of the total distribution as the spodumene content of the ore decreases.

There were no particularly difficult operating problems. The two most important operating points (and the ones which might easily be overlooked) were proper pretreatment of weathered ores, and strict maintenance of high pulp density in the conditioner before iron-mineral flotation.

The most difficult mineral to cope with was hornblende. Spodumene and hornblende are closely related mineralogically, and they exhibited similar reactions to the above described process. In order to satisfactorily remove hornblende, if it were encountered in appreciable amounts in the ore, it would probably be necessary to employ both flotation and magnetic separation.

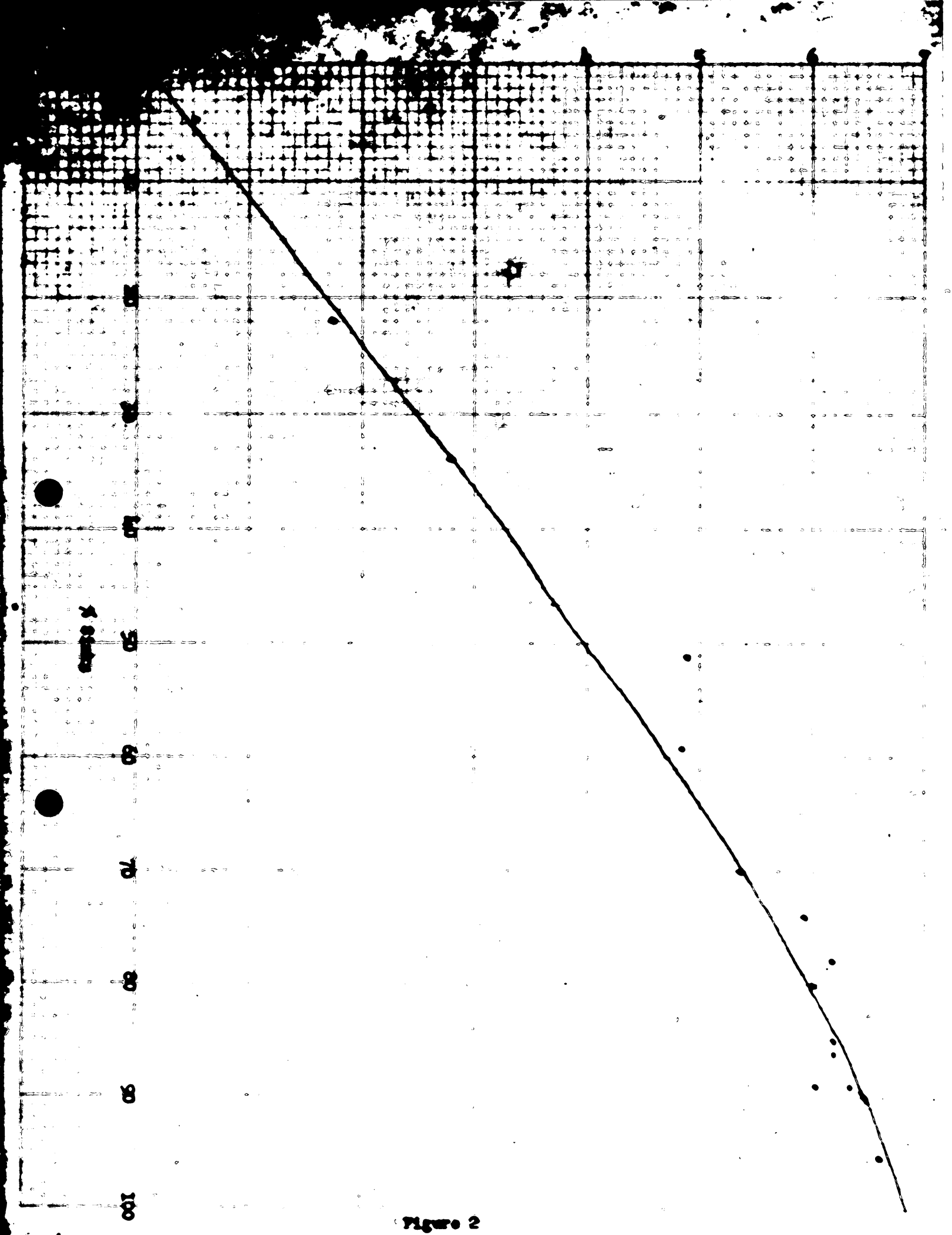
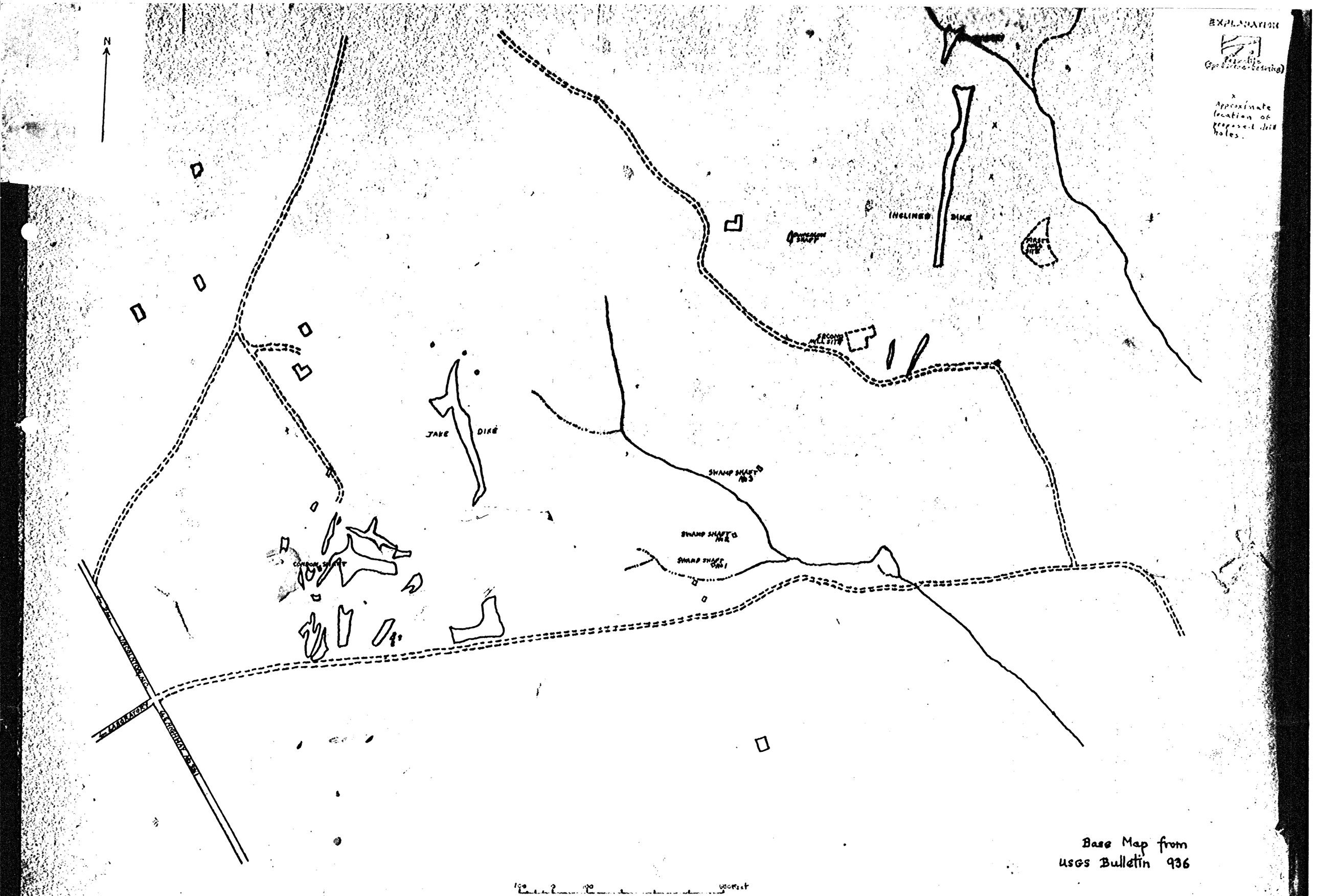
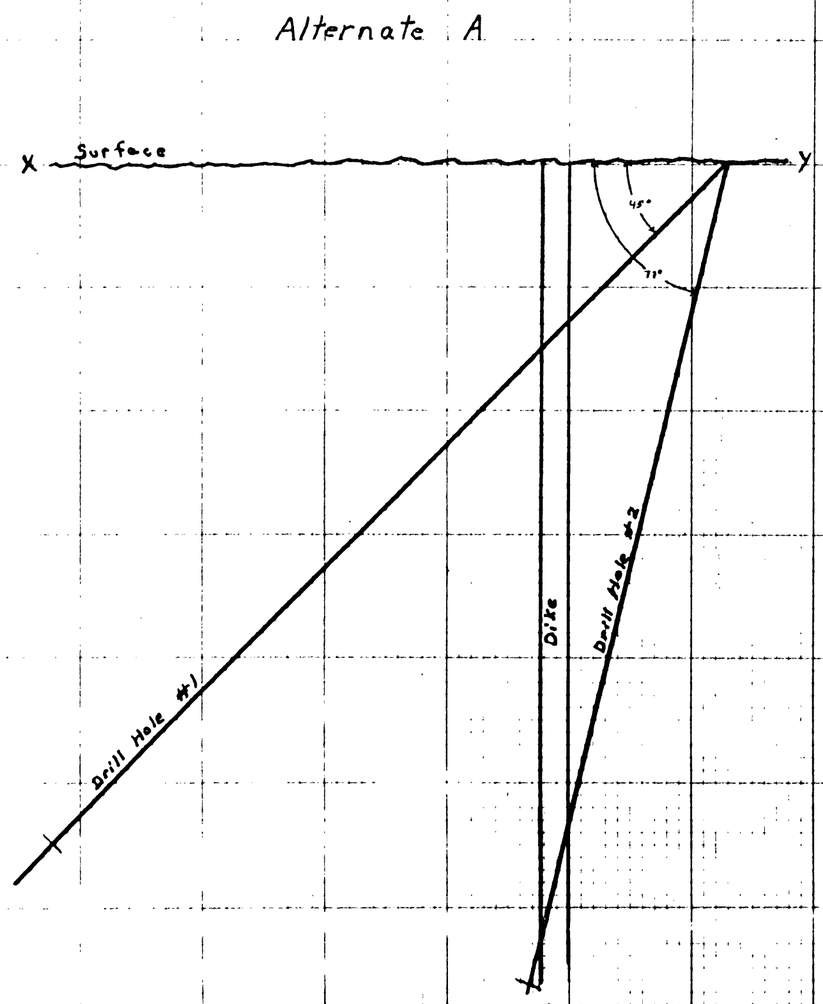


Figure 2



PEGMATITE BODIES EXPOSED ON PROPERTY OF THE KA-MI-TIN CONCENTRATING CO.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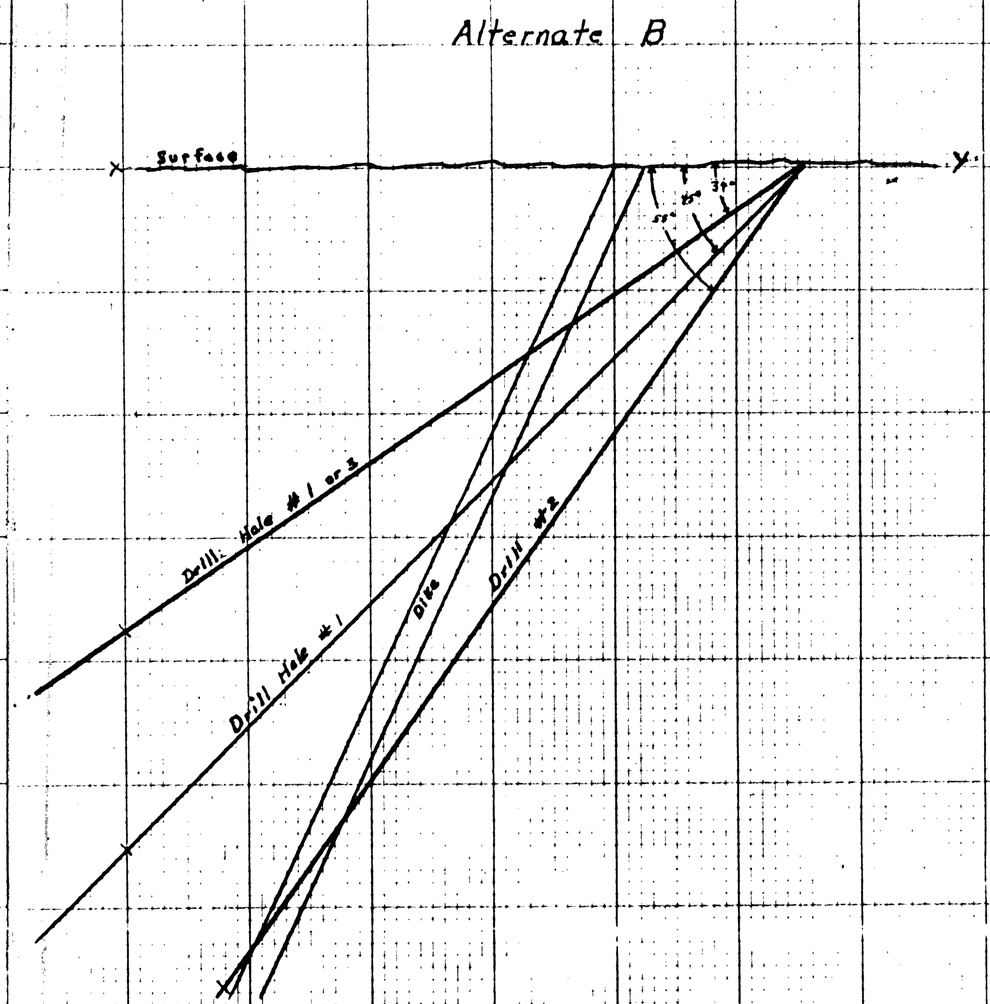
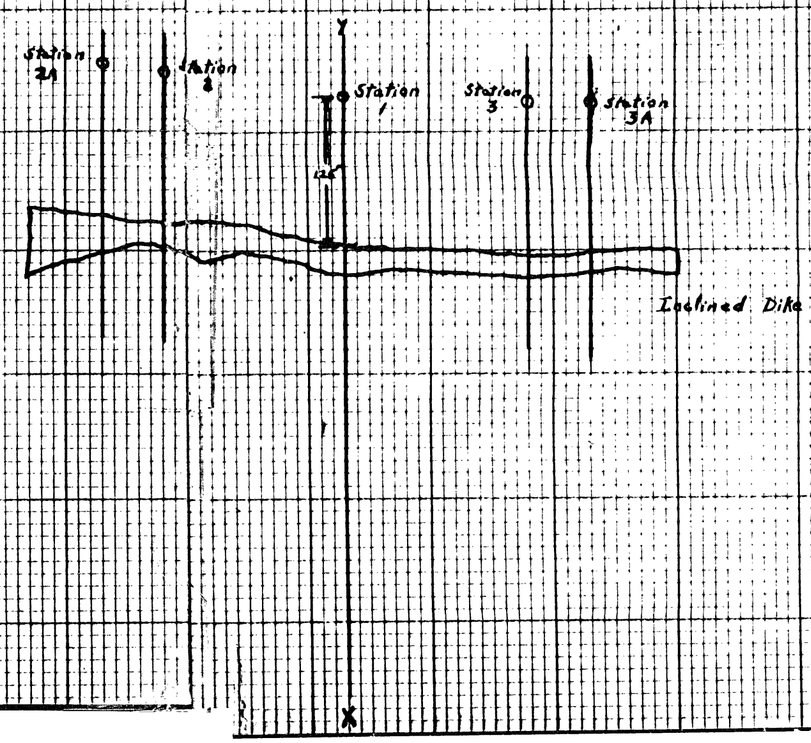
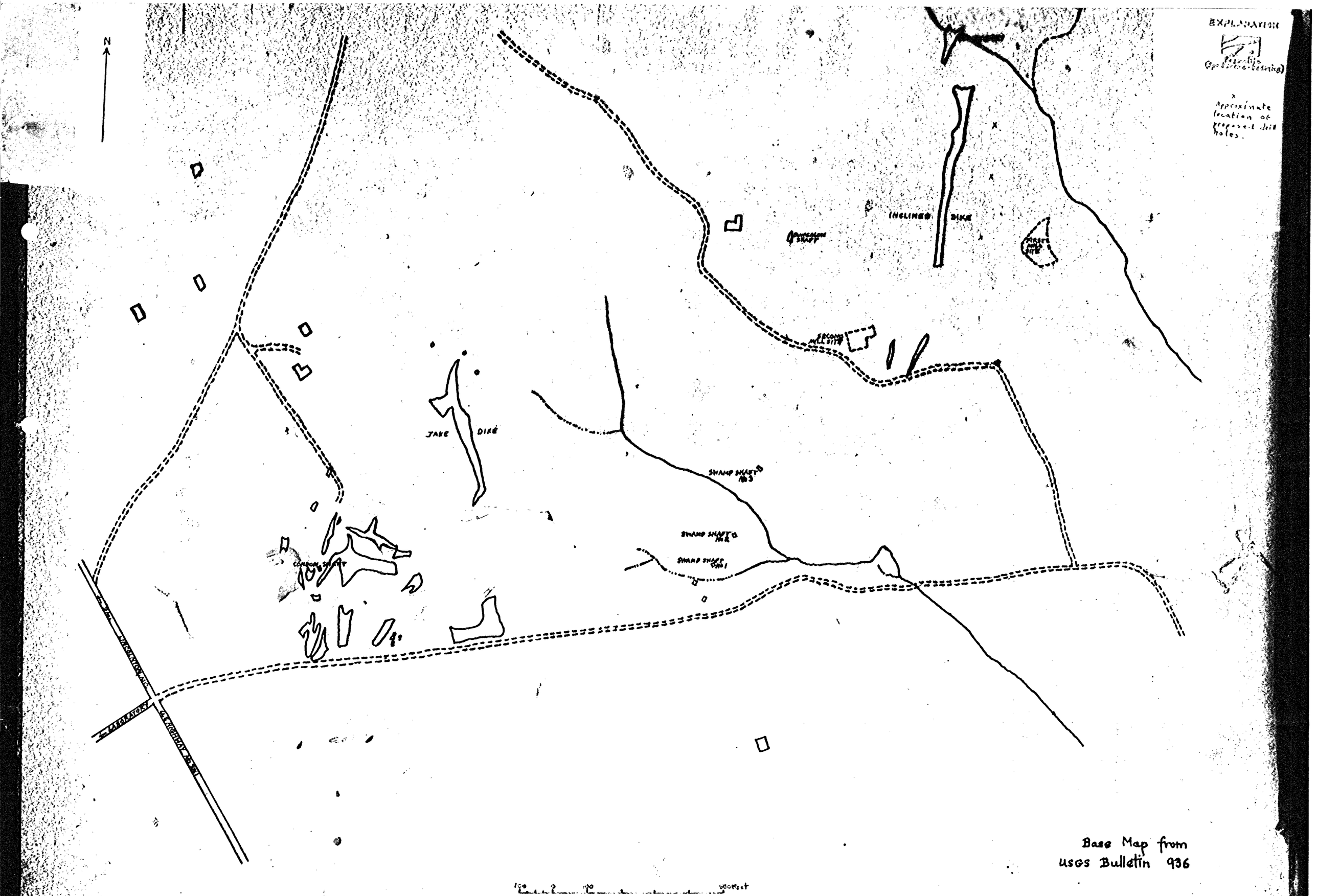
Dike
Drill Hole #2
Cross section


Alternate B
X
Surface
Y
Drill Hole #1 or 3
Drill Hole #1
Dike
Drill #2
Cross section


Station 2A
Station 2
Station 1
Station 3
Station 3A
Y
X
Inclined Dike
Map View
Scale 1 inch = 100 feet
S.O. Mason Oct 11-22



PEGMATITE BODIES EXPOSED ON PROPERTY OF THE KA-MI-TIN CONCENTRATING CO.