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ORE RESERVES AND GEOLOGY OF THE WELLBORN THORIUM PROPERTIES

BEAVERHEAD COUNTY, MONTANA

FOR

C. ANDRADE, III
Tower Petroleum Building
Dallas, Texas

BY

WARREN R. WAGNER
6526 Holiday Dr.
Boise, Idaho

Five (5) Copies: No. 1,3 & 4 to Andrade; No. 2, C.H. Kerr, Union Carbide, No. 5, file copy W.R. Wagner.

WARREN R. WAGNER
GEOLOGIST
6526 HOLIDAY DRIVE
BOISE, IDAHO
PHONE 4-1925

4/24/57

SERVING THE MINING, CHEMICAL AND CONSTRUCTION INDUSTRIES

Mr. C. Andrade, III
Tower Petroleum Building
Dallas, Texas

Dear Mr. Andrade:

As you requested, I have made an examination and evaluation of the Wellborn Thorium Properties near Armstead, Montana, and my report is attached.

As you know, the thorium market is limited. "Know How" in the processing and marketing is also scarce. From our telephone conversations, I gather that you have connections with some of the major chemical companies. I think your best bet for turning a thorium property into profit will be through cooperation with one of these.

The Last Chance-Shady Tree ore body on the Wellborn property is one of the most presistent I have ever encountered. The reserves and grade should be of interest to anyone in or contemplating entering the thorium field.

As to the europium content, that will have to await assay returns some two or three weeks from now.

Sincerely yours,
Warren R. Wagner
Warren R. Wagner.

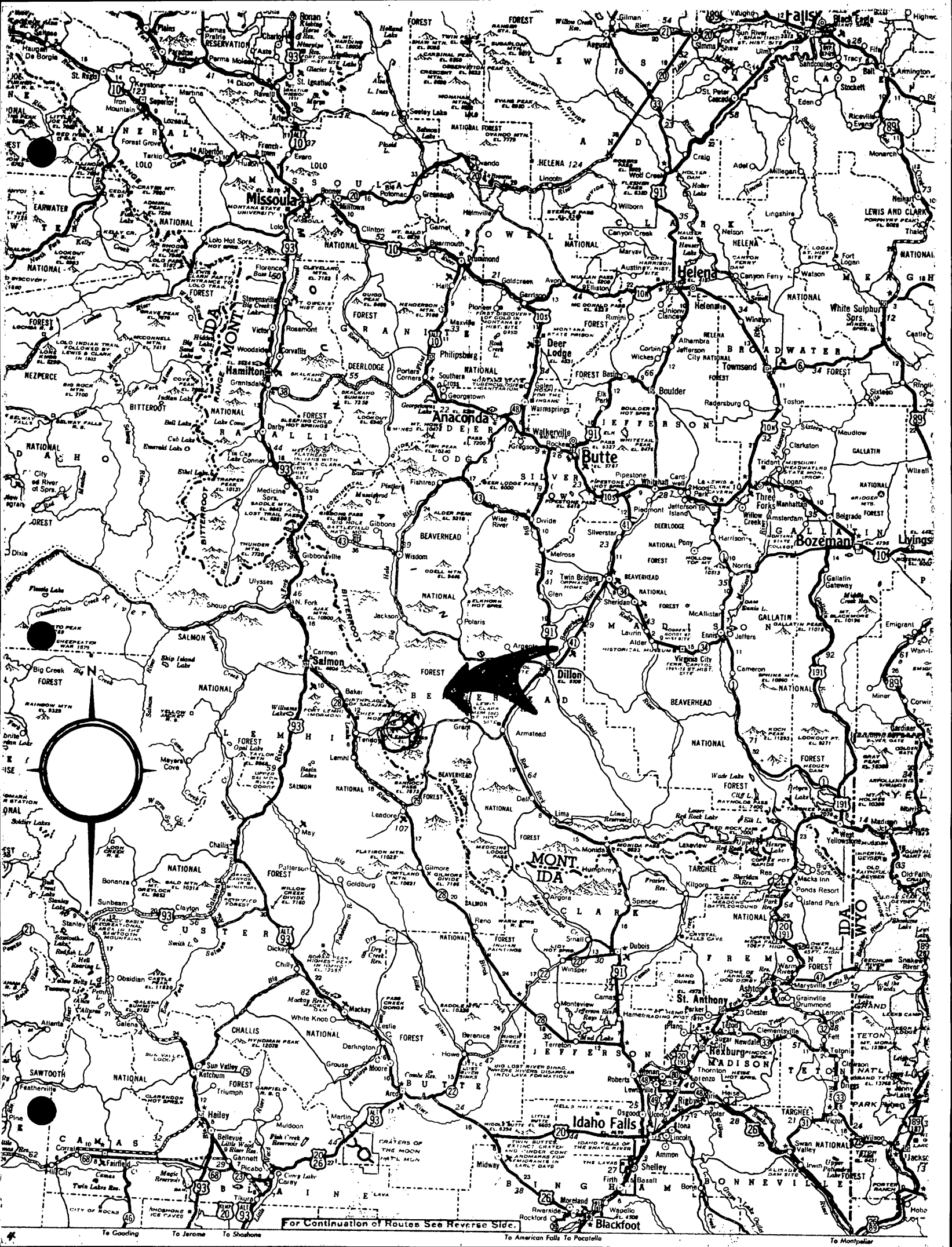
S U M M A R Y

The Wellborn Thorium Property near Armstead, Montana, have an ore reserve conservatively estimated to be 720,000 tons of 0.685 pe cent ThO_2 (thoria), within the first 300 feet of depth. The ore can be mined, concentrated (by gravity) and put on cars at Armstead, for about $20.00 per ton. At $60.00 per unit of ThO_2, the ore is worth $41.10 per ton at the mine; this price, less mining, concentration and trucking costs leaves $21.10 per ton for profit and marketing. Should the ore not be amenable to gravity concentration, then chemical treatment would be needed and the cost per ton of concentrating would rise by at least 50 percent. In this case, serious consideration should be given to the production of thorium salts and/or thorium metal at Armstead, Montana.

The market for thorium is limited and each operator apparently has to make his own. If chemical treatment to produce thorium salts and/or metal is necessary, then, the investment in plant facilities is considerable (probably about $1,500,000.00 for 500 tons per year capacity).

Europium has been reported on the property, but assay returns are not back to confirm this; at any rate, the europium market is less assured than the thorium market.

In conclusion, it is recommended that beneficiation tests be run on the ore before further purchase, mining, milling or marketing plans are formulated.


Missoula
Helena
Deer Lodge
Anaconda
Butte
Hamilton
Bozeman
Salmon
Dillon
Idaho Falls
Blackfoot
St. Anthony
Rexburg
MONT.
IDA
WYO
For Continuation of Routes See Reverse Side.
To Gooding
To Jerome
To Shoshone
To American Falls To Pocatello
To Montpelier

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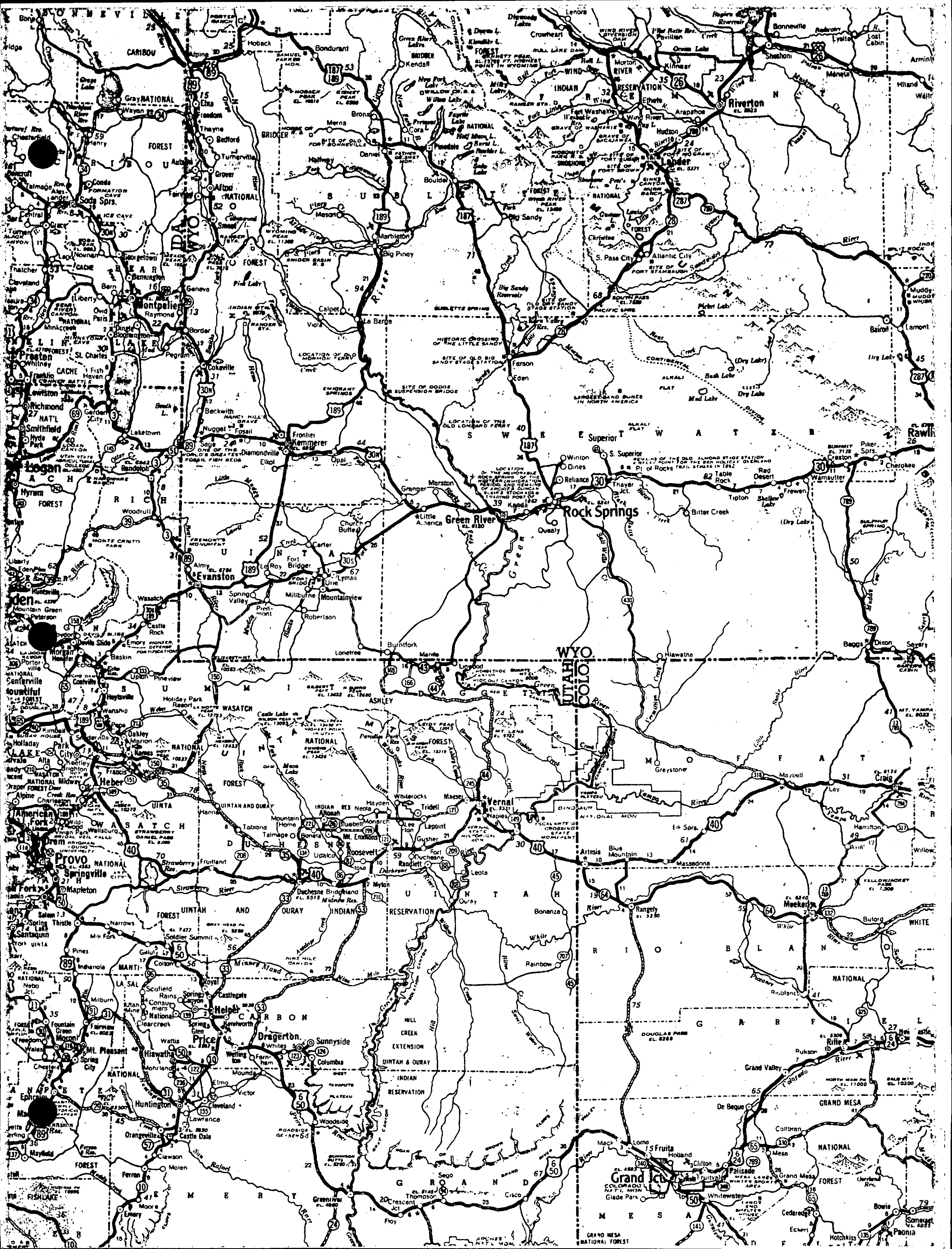
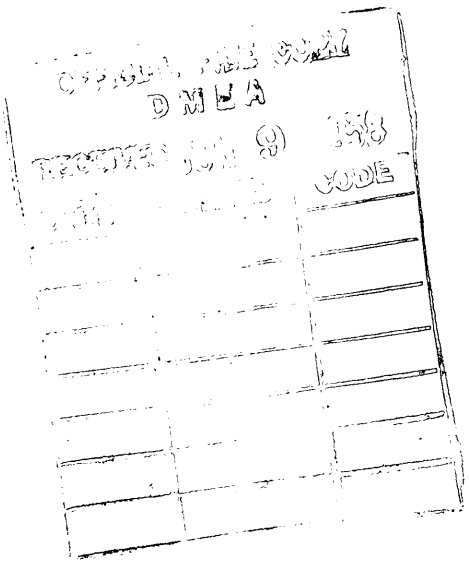


BONNEVILLE
CARIBOU
Alpine
Hoback
Bondurant
SAMUEL PARKER MON.
Kendall
BRIDGER
FOREST
Lenore
Crowheart
WIND RIVER DIVERSION DAM
BULL LAKE DAM
GANNETT PEAK EL. 13785 FT. HIGHEST POINT IN WYOMING
Pavillion
Ocean Lake
Bonneville
Lysite
Lost Cabin
Shoshoni
Armint
Morton
Kinnear
RIVER
INDIAN
RESERVATION
Riverton
Hiland
Waltr
Gray NATIONAL
Wayan
Etna
Freedom
Thayne
Bedford
Turnerville
Auburn
Grover
Afton
NATIONAL
Smoot
FOREST
Chesterfield
Henry
Bancroft
Talmage
Alexander
Soda Sprs.
Conda
FORMATION CAVE
ICE CAVE
Central
Grace
Turner
BLACK CANYON
HOBACK PEAK
KISMET PEAK
Merna
Bronx
Cora
Fremont L.
NATIONAL
Half Moon L.
Pinedale
Daniel
Halfway
SITE OF OLD FORT BONNEVILLE
Boulder
Mason
Marbleton
Big Piney
WYOMING PEAK EL. 11363
SNIDER BASIN
Fort Washakie
Ethete
Wind River
Arapahoe
Hudson
GRAVE OF WASHAKIE
GRAVE OF SACAJAWEA
SITE OF FORT AUGUR
SITE OF FORT McGRAW
SITE OF FORT BROWN
Lander
EL. 5371
SHOSHONE
SINKS CANYON
WIND RIVER PEAK EL. 13499
Big Sandy
Atlantic City
S. Pass City
SITE OF FORT STAMBAUGH
SOUTH PASS EL. 7550
PACIFIC SPRS
Big Sandy Reservoir
SITE OF OLD DRY SANDY STAGE STATION
Farson
Eden
LARGEST SAND DUNES IN NORTH AMERICA
CONTINENTAL DIVIDE
ALKALI FLAT
Bush Lake
Mud Lake
Dry Lake
Muddy
Bairoil
Lamont
SPLIT ROCK
Rawlins
IDA
WYO
Georgetown
Nounan
Lago
Thatcher
Cleveland
CACHE
Bennington
Bern
Montpelier
Raymond
Geneva
Liberty
Ovid
Paris
Border
Dingle
Bloomington
Minkcreek
MINNETONKA CAVE
St. Charles
Fish Haven
BEAR
LAKE
Preston
Whitney
Franklin
Lewiston
Richmond
Smithfield
Hyde Park
Logan
LOGAN CANYON
UTAH STATE AGRICULTURAL COLLEGE
Garden City
Laketown
Pegram
Cokeville
Beckwith
NANCY HILL'S GRAVE
Nugget
Fossil
Sage
ONE OF THE WORLD'S GREATEST FOSSIL FISH BEDS
Diamondville
Frontier
Kemmerer
Elkol
Opal
Randolph
HARDWARE RANCH
Hyrum
FOREST
RICH
Woodruff
MONTE CRISTO PARK
FREMONT'S MONUMENT
La Barge
Calpet
Viola
LOCATION OF OLD MORMON FERRY
SITE OF DODGE SUSPENSION BRIDGE
EMIGRANT SPRINGS
HISTORIC CROSSING OF THE LITTLE SANDY
SITE OF OLD BIG SANDY STAGE STATION
LOCATION OF THE OLD LOMBARD FERRY
SWEETWATER
Superior
S. Superior
Winton
Dines
Reliance
Pt of Rocks
REMAINS OF THE OLD ALMOND STAGE STATION
Thayer Jct.
Table Rock
Red Desert
Tipton
Wamsutter
Creston
Piker Sprs.
Cherokee
Frewen
Bitter Creek
Granger
Marston
Little America
Green River
Kanda
Rock Springs
Quealy
Church Buttes
Carter
UINTA
Almy
Evanston
Le Roy
Fort Bridger
Lyman
Urie
Spring Valley
Millburne
Mountainview
Piedmont
Robertson
Wasatch
Castle Rock
Devils Slide
Emory
Baskin
Lonetree
Burntfork
Manila
Linwood
Hiawatha
WYO.
UTAH
COLO.
Baggs
Dixon
Savery
Ogden
Huntsville
Eden
Mountain Green
Peterson
Morgan
Henefer
Echo
Coalville
Porterville
Centerville
Bountiful
Hoytsville
Wanship
Upton
Pineview
SUMMIT
Holiday Park Resort
WASATCH
Kimball
Holladay
Park City
Alta
Brighton
Keetley
Oakley
Marion
Kamas
Francis
Woodland
Heber
Midway
Charleston
Alpine
American Fork
Orem
Provo
Springville
Mapleton
Spanish Fork
Salem
Santaquin
Thistle
Narrows
Mill Fork
Soldier Summit
Colton
Gilluly
Pines
Indianola
Milburn
Fairview
Mt. Pleasant
Spring City
Moroni
Fountain Green
Wales
Chester
Ephraim
Manti
Mayfield
FISHLAKE
DAGGETT
ASHLEY
UINTA
NATIONAL
FOREST
Greystone
MOFFAT
Maybell
Lay
Craig
Hamilton
Vernal
Naples
Maeser
Whiterocks
Tridell
Lapoint
Gusher
Hayden
Neola
Altonah
Bluebell
Monarch
Mt. Emmons
Roosevelt
Upalco
Ioka
Myton
Fort Duchesne
Randlett
Leota
Ouray
Tabiona
Hanna
Mountain Home
Talmage
Boneta
Duchesne
Bridgeland
Fruitland
Strawberry Res.
UINTAH AND OURAY INDIAN RESERVATION
DINOSAUR NATIONAL MON
Artesia
Blue Mountain
Massadona
Elk Sprs.
Rangely
Bonanza
Rainbow
RIO BLANCO
Meeker
Buford
WHITE
Rio Blanco
GARFIELD
DOUGLAS PASS EL. 8268
Rifle
Silt
Rulison
Grand Valley
De Beque
GRAND MESA
Collbran
Mesa
Palisade
Clifton
Fruitvale
Grand Jct
COLORADO NAT'L MON
Glade Park
Whitewater
Loma
Fruita
Mack
Holland
Cedaredge
Eckert
Hotchkiss
Bowie
Somerset
Paonia
GRAND MESA NATIONAL FOREST
MANTI-LA SAL
Scofield
Clear Creek
Helper
Castlegate
Royal
Kenilworth
Spring Glen
Price
Wattis
Hiawatha
Mohrland
Wellington
Farnham
Dragerton
Sunnyside
Columbia
CARBON
HILL CREEK EXTENSION
UINTAH & OURAY INDIAN RESERVATION
Huntington
Cleveland
Elmo
Victor
Lawrence
Castle Dale
Orangeville
Clawson
Molen
Ferron
Moore
Emery
EMERY
Woodside
Greenriver
Sego
Thompson
Crescent Jct
Floy
Cisco
GRAND
ARCHES NAT'L MON



ORE RESERVES AND GEOLOGY OF THE WELLBORN THORIUM PROPERTIES
BEAVERHEAD COUNTY, MONTANA

I N T R O D U C T I O N

Purpose and Scope: At the request of Mr. C. Andrade, III, Tower Petroleum Building, Dallas, Texas, the writer spent April 16, and 17, 1957, on the Wellborn Thorium Property for the purpose of examining and evaluating the deposits.

As deep snow (3-4') covered the surface, little could be seen of the surface and regional ge logy. Snow had been removed from access roads, adit portals and a few open cuts.

Mine records and maps were examined carefully. The report of Mr. Leonard D. Jarrard, Minerals Consultant, Butte, Montana, was an especially valuable aid. Mr. Jarrard enjoys a wide reputation as a sound engineer and much of the Atomic Energy Commission's work at the Wellborn property was done under his direction previous to his leaving the commission.

Location and Accessibility: The property is located just east of the continental divide and the Idaho-Montana border in west central Beaverhead County, Montana (secs. 29, 32 and 33, T.10S., R.15W.). The claims lie 35 miles by road east of Armstead, Montana and 80 airline miles southwest of Butte, Montana (see highway map, next page)

The property may be reached from Butte via U.S. Highway 91, south to Armstead, hence 35 miles over county and mine roads in a general westward direction to the mine. An Union Pacific railroad branch line connects Armstead with Butte, Montana, and Salt Lake City, Utah.

A main line electric power transmission installation passes within 2-3 miles of the property.

Property and Development: The Wellborn thorium properties consist of 33 unpatented lode mining claims. The claims appear to be in good order with assessment work completed for the 1956-57 period. Proof of labor should be filed in Dillon, Montana, county seat of Beaverhead County, if it has not been.

A small camp, made up of several bunk houses, a cook house and dinning hall, and an office building is located along the South Fork of Frying Pan Creek, the main drainage of the area, about one and one half miles from the mine workings.

Exploration work on the claims is extensive. The outcrops have been thoroughly trenched; a 52' shaft has been sunk near the southeast end of the Last Chance-Shady Tree vein; a cross-cut has been driven to intersect the ore at approximately 300 feet vertically below the highest outcrop point. The cross-cut is located near the northwest end of the vein (see map in envelope below). A second cross-cut, planned to intersect the ore structure 180 feet below the first cross-cut has been started and is in about 110 feet of the necessary 1,100 feet.

G E O L O G Y

General Statement: Because of snow conditions very little surface geology could be done during this visit. The writer is familiar with the regional geology of the area.

The property lies within a group of pre-Cambrian rocks that are in contact with the Idaho batholith, a vast igneous intrusive of late Cretaceous age that lies to the west.

The mineralization is associated with structural deformation of the pre-Cambrian, Beltian rocks, that occurred during Laramide times.

Rocks: The host rocks of the ore bodies are metamorphosed sandstones or quartzites. The original sandstone was probably somewhat argillaceous and the resutling metamorphic rock is a dense, brittle, fine-grained, dunn-colored rock.

Structure: The mineralization is associated with northwest-southeast trending fracture and shear zones. The pre-Cambrian quartzite beds are complexly folded and contorted. In general, the beds strike approximately east-west in the vicinity of the Last Chance-Shady Tree ore body, and the fracture zone controlling the ore deposition strikes N. 65-75° W. and dips 45-60° southwest. Other ore bearing structures on the property appear to parallel the Last Chance-Shady Tree structure.

ORE DEPOSITS

Mineralogy: The quartz-hematite-thorium veins are typical of fracture zone fillings. Quartz with considerable iron stain and some specular hematite makes up the greater part of the vein filling material. Thorium minerals occur occassionally as isolated grains in the quartz, but normally they fill the minute fracture systems that make up the structure.

Ore Minerals

Thorite $ThSiO_4$, thorium silicate
Hydrothorite, hydrous thorium silicate
Monazite, rare earth thorium phosphate
Allanite, complex silicate with Th and Y.

Gangue Minerals

Quartz
Hematite
Pyrite
Barite

Thorite appears to be the chief ore mineral. Monazite and allanite are rare and hydrothorite appears to be intimately associated with the iron oxides.

Europium has been reported from this property; a composite sample from the Last Chance-Shady Tree ore body has been sent out for analysis. Assay returns on these samples will not be back for another 2-3 weeks.

Ore Bodies: According to Jarrard's report, there are two more-or-less parallel ore structures on the property, known as the Last Chance-Shady Tree and the Shear Zone ore bodies. The writer's studies were limited to the former because of snow conditions.

The Last Chance-Shady Tree ore body is a strong, apparently continuously mineralized fracture zone that strikes N. 65-75° W. and dips 45-60° SW (See map in envelope, next page).

Exploration work has opened the vein for 2,000 feet along the strike and over a vertical range of 300 feet. The vein varies in thickness from 14 feet to over 30 feet and averages about 22 feet.

Thorium mineralization within the walls is entirely across the structure. There is a higher grade band along the footwall and also near the hanging wall of the structure.

Tenor (grade) of Ore: Using only the samples the writer cut underground, the ore averages 0.685 percent ThO_2 (thoria) (see sample and geology maps, below). The assay values are radiometric, checked against a thorium standard.

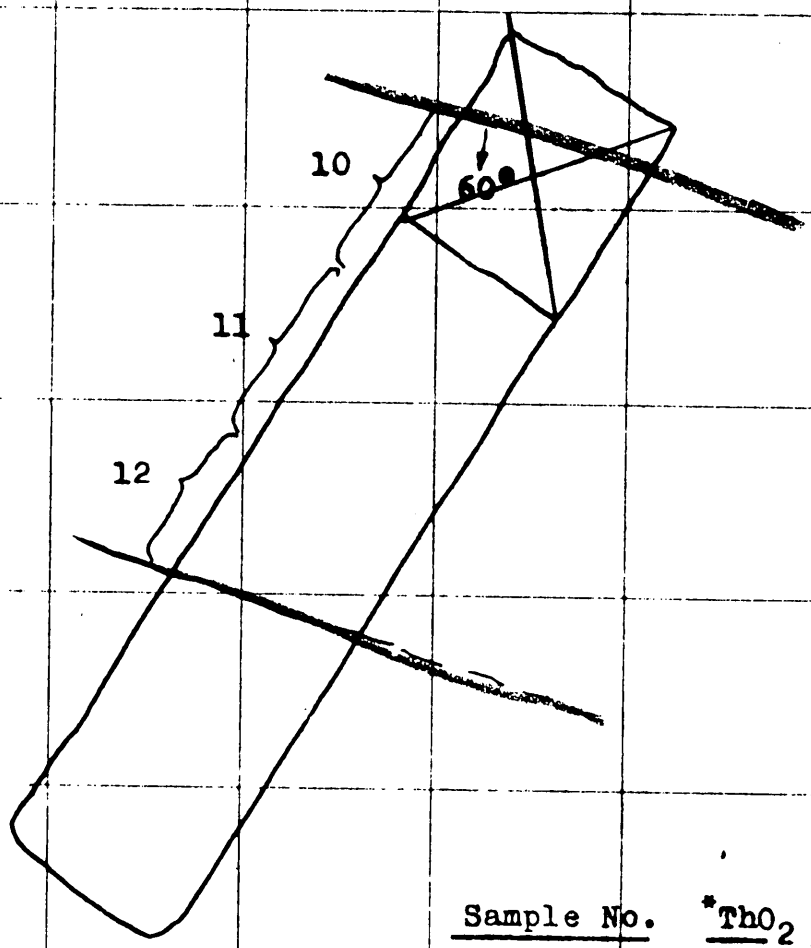
Jarrard's report gives a somewhat higher average and is probably more nearly the true grade of the deposit as he had hundreds of chemical and radiometric assay returns from which to make his average.

ORE RESERVES

Since the writer could examine only the Last Chance-Shady Tree ore body, reserves are shown for that structure only. However, Jarrard's report gives the size and grade of other ore bodies.

SHAFT

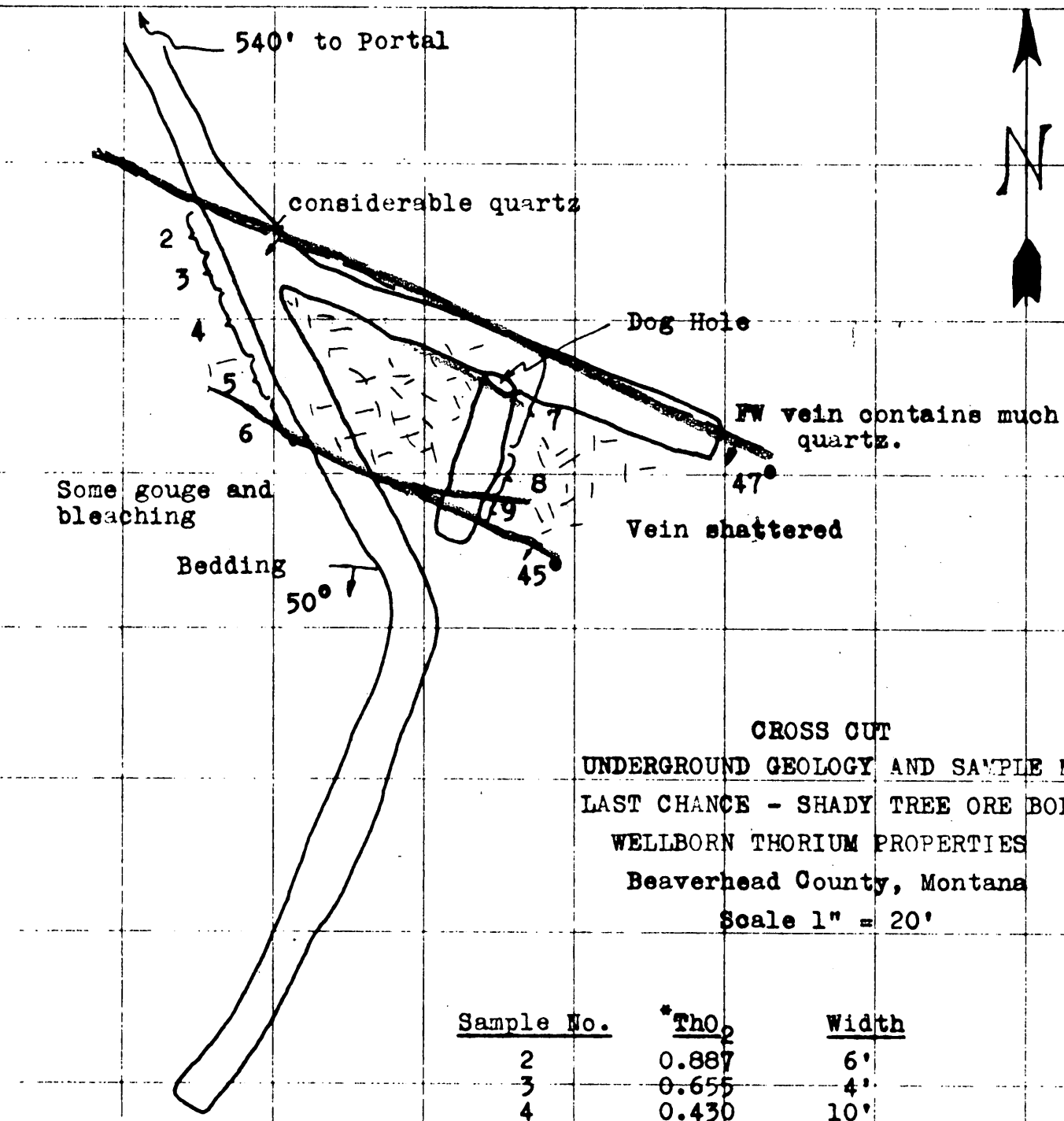
UNDERGROUND GEOLOGY AND SAMPLE MAP
LAST CHANCE - SHADY TREE ORE BODY
WELLBORN THORIUM PROPERTIES
Beaverhead County, Montana
Scale 1" = 5'



Sample No.	*ThO_2	Width
10	0.652	5'
11	0.621	5'
12	0.628	4'
10-12	0.621	14'

Fault
Quartz
Mineralization

wagner and oberbillig 4/16/57



CROSS CUT
UNDERGROUND GEOLOGY AND SAMPLE MAP
LAST CHANCE - SHADY TREE ORE BODY
WELLBORN THORIUM PROPERTIES
Beaverhead County, Montana
Scale 1" = 20'

Sample No.	*ThO_2	Width
2	0.887	6'
3	0.655	4'
4	0.430	10'
5	0.468	6'
6	0.556	8'
7	1.316	13'
8	0.409	5'
9	0.441	3
*radiometric		
2-6	0.574	34'
7-9	0.975	21'
2-9	0.727	22' (True vein width.

Fault
Quartz
Minerallization
Fracture pattern

wagner and oberbillig 4/16/57.

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The writer thinks highly of Jarrard's work and was able to check part of it from available records. An open road cut on the Shear Zone ore body gave an extremely high radioactive anomaly. From the geology of the Last Chance-Shady Tree ore body and the information in Jarrard's report, the figures below are considered to be a minimum.

Using a Strike length of 2,000 feet, a mining width of 18' feet and a down dip distance of 300 feet, the reserves for the Last Chance-Shady Tree ore body would be as follows:

$$\frac{2{,}000' \times 18' \times 300'}{15 \text{ cu.ft./ton}} = 720{,}000 \text{ tons}$$

At a grade of 0.685 percent thoria or 13.7 pounds per ton, these reserves would contain 9,864,000 pounds of thoria. Or at a value of $41.10 per ton, the inground value would be:

$41.10 X 720,000 tons = $29,592,000.00

The $41.10 value is calculated from recently quoted monazite ore prices based on $60.00 for the contained thoria per unit (1 unit = 20 pounds per ton).

The above inground value does not show mining and milling losses, and, at this time it would be hard to calculate these, as nothing is known concerning the beneficiation of thorite ores from this property.

The probability of increasing the reserves with drilling or cross-cutting at depth is excellent.

B E N E F I C I A T I O N

To the writer's knowledge, no beneficiation tests have been run on the ores. As the present thorium ore market demands a 10 percent thoria content, tests should be conducted to determine the amenability of the ores to gravity concentration.

Panning of the ore from the high grade footwall band in the northwest end of the Last Chance-Shady Tree ore body shows some concentration of values. Like other thorite ores of the writer's experience, it is suspected that at least part of the ore will respond to gravity concentration.

The Colorado School of Mines Research Foundation has had considerable experience in concentrating thorite ores and the writer suggests that samples be sent to:

Mr. Ed Crabtree, Director
Colorado School of Mines Research Foundation
Golden, Colorado.

The Foundation's past experience with such ores will allow them to determine the amenability of these ore in a relatively short time. If gravity concentration methods are not feasable, then the more expensive chemical methods of up-grading will be required. Should chemical methods be necessary; then, serious consideration should be given to placing a complete chemical plant at Armstead, Montana, for utilizing the ores from the Wellborn properties.

M I N I N G A N D M I L L I N G

Because of the shattered character and rather flat attitude of the vein some mining problems will be involved. Considerable timber will be necessary, but an abundant supply is on the claims.

Mining costs should not exceed $12.00 per ton. If the ore is delivered to the rail head at Armstead, trucking would be about $3.00 per ton; or, in other words, with careful operation, ore can be delivered to the car at the railhead for $15.00 per ton.

If it is necessary to concentrate the ore to produce a marketable ore, the necessary gravity or flotation plant will cost about $3,000.00 per ton of capacity; or, about $300,000.00 for the construction of a 100 ton plant.

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Milling costs of concentrating the thorium ore should not exceed $5.00 per ton. By putting the plant at the mine and trucking only concentrates to the rail head, the cost would be about $17.00 per ton for mining and milling plus the cost of trucking concentrates to the railroad.

With the price of thorium ores at $60.00 per unit of ThO_2 (1 unit = 20 pounds or 1% of 2,000 pounds), ore at the Wellborn property would be worth $60.00 X 0.685 = $41.10 per ton. Using a combined mining, milling and trucking cost of $20.00 per ton (this may be high), there would be $21.10 per ton for marketing and profit. The $60.00 per unit of ThO_2 price is F.O.B. the plant of the purchaser (probably about $50 to $60 per ton to the eastern seaboard).

In order to make a market for the thorium from this property, it may be necessary to produce thorium salts or the metal. This would require a chemical plant that would cost about $1,500,000.00 for a 500 ton capacity per year.

Detailed information on the cost of producing thorium salts is not available, but would run somewhere around $2.00 to $3.00 per pound.

M A R K E T

Thorium uses in the United States have steadily increased over the past few years, but a ready market for domestic thorium ores is difficult to find. Lindsay Chemical, Chicago, Ill., will apparently buy thorium ores containing 10 percent or more thoria.

High-temperature thorium bearing magnesium alloys are in demand, and a potential market exists in the nuclear energy field. This usage is not clear, but predictions are that thorium will be used as a fertile reactor material because of its ability to yield fissionable U-233 in breeding type reactors.

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A recent forecast on thorium by an AEC official indicates that full scale thorium usage in reactors will develop in the next 2, 5 or ten years. Apparently the completion and operation of Consolidated Edison's reactor will furnish much needed technology on thorium in the reactor field.

The price of thorium compounds as quoted on page 101, ENGINEERING AND MINING JOURNAL, Vol. 158, No. 2, Feb. 1957, follows:

Compound	% ThO_2	Price/lb. 100lb.lots.
Carbonate	80-85	$7.25-8.80*
Chloride	50	7.00
Fluoride	80	6.50
Nitrate	46	3.00
Oxide	97-99	8.25-9.35

*variable on rare earth content

Also according to the same source, Consolidated Edison Company purchased from the AEC in 1956, 27,500 pounds of thorium metal for $537,000.00 (about $19.53 per pound).

The outlook for thorium is good in high-temperature magnesium alloys, but much information is needed on thorium's role in nuclear energy.

C O N C L U S I O N S

The strength and persistence of the Last Chance-Shady Tree ore body is sufficient to indicate that the reserves calculated for the property are conservative.

The fact that the thorium market is limited points to the necessity of ore beneficitation tests in order to evaluate properly and to plan the future operation of the property.

Europium has been reported on the property, but assay returns are not back to confirm this; at any rate, the europium market is much less assured than the thorium market.

QUALIFICATIONS

Education:

Berea College, Berea, Ky., B.S. Geology, 1936.
Idaho School of Mines, Moscow, Idaho, M.S. Geology, 1937.
The Johns Hopkins Univ., Ph. D. Geology, 1947.

Experience:

United States Geological Survey, 2½ years.
Anaconda Copper Mining Company, Butte, Mont., 2 years.
University of Idaho, teaching, 1942-1945
Idaho Bureau of Mines and Geology, geologist 1942-1947.
Colorado School of Mines, teaching, 1947-1953.
Colorado School of Mines Research Foundation, Research geologist, 1948-1953.
Geological Consultant, Market Research Industrial Chemicals Mallinckrodt Chemical Works, 1953 to present.
Independent Consulting Geologist. 1953 to present. Serving the Mining, Chemical and Construction Industries.
Consulting Geologist, Arrowhead Urnaium, 1951-1953, and to Arrowhead successor Trace Elements Corporation, 1953'till November 1956.
Companies served are some of the major chemical companies, leading mining companies and several large contractors.

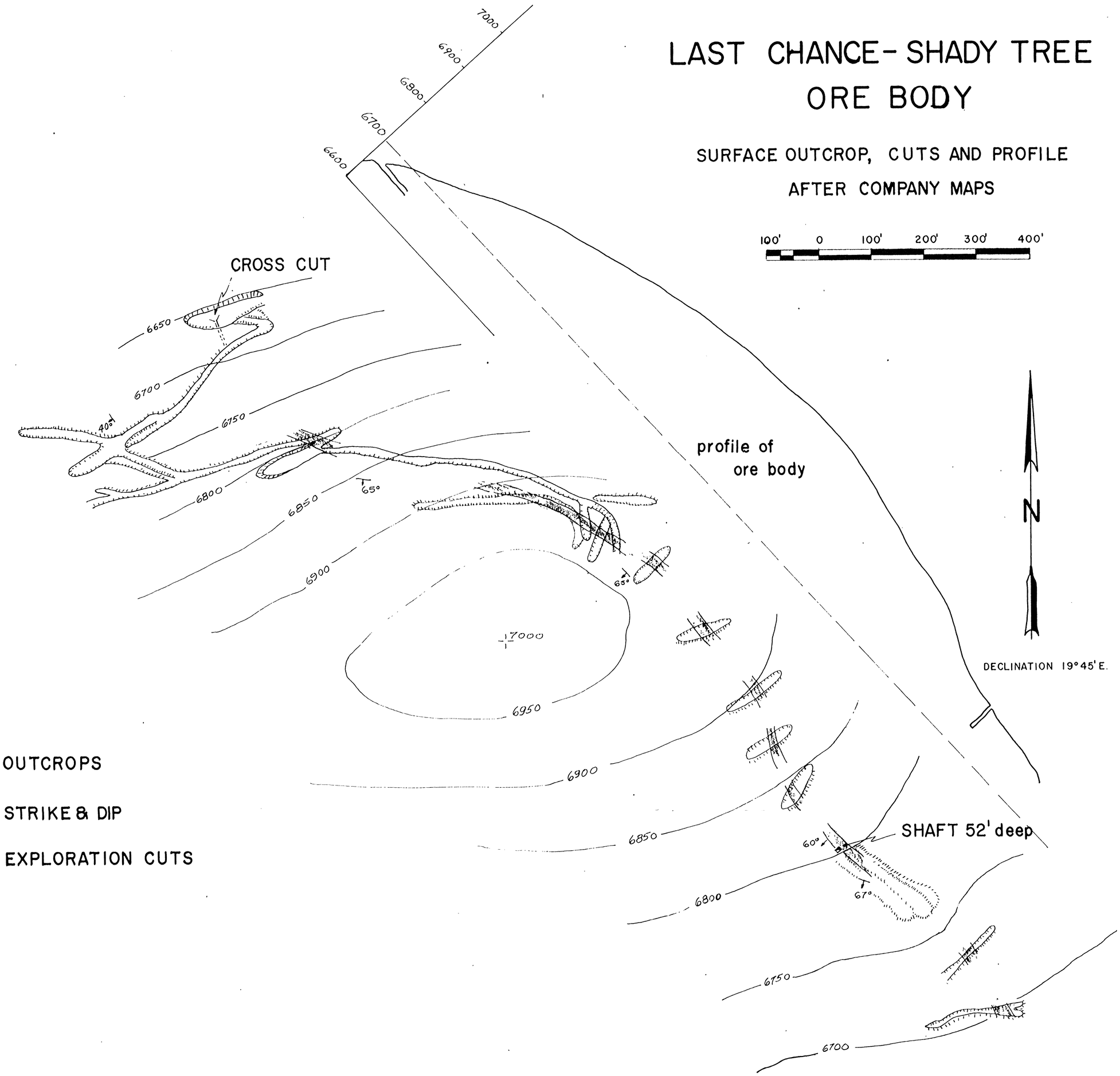
Registered Professional Geological Engineer, State of Nevada, No. 1029.

Warren R. Wagner

Warren R. Wagner

LAST CHANCE-SHADY TREE ORE BODY

SURFACE OUTCROP, CUTS AND PROFILE
AFTER COMPANY MAPS



W.R.W. 4/20/57