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AN APPRAISAL

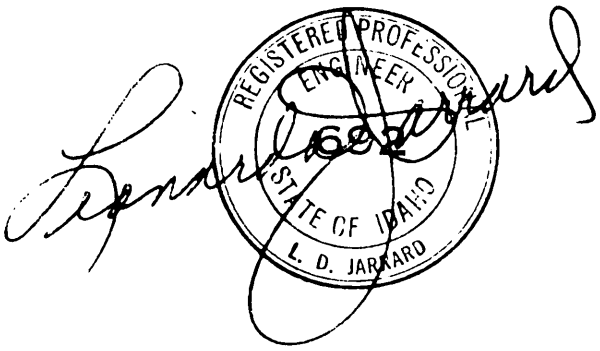
OF THE

WELLBORN THORIUM PROPERTIES

LEMHI PASS DISTRICT, MONTANA

FOR

MR. G. N. GEORGE, LAGUNA BEACH, CALIFORNIA



By.

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March 1957

INTRODUCTION

Purpose and Scope

During the early part of March, 1957, Mr. George M. George of Laguna Beach, California asked the writer to prepare an appraisal of the thorium bearing properties owned by Mr. Wellborn of Armstead, Montana. Due to recent heavy snowfall it was impossible to gain access to the property, but because of the writers familiarity with the property during his tenure with the United States Atomic Energy Commission the inability to visit the area at this time caused no difficulty in preparation of this report.

The property under consideration consists of a group of claims located along the forks of Frying Pan creek, a tributary to the Beaverhead River which drains the east slope of the Continental Divide here dividing Montana from Idaho. The property is the only one in the district that has had any appreciable amount of surface and underground exploration performed. This work was done over and during the last three years, and all such work has been mapped and closely examined by the writer. However such records were and are the property of the United States Atomic Energy Commission and as such are classified material and neither Mr. Wellborn, Mr. George nor the writer now has access to those records. Mr. George has furnished maps of the property and the details of the report have been supplied by and are strictly the opinions of the writer. However the report is accurate and reflects in detail the findings of the writer during that earlier period

Where it has been necessary to provide assays of various parts of the veins under consideration, detailed analysis of the samples are not now available, however the writer is able to furnish results that are purposely held to conservative figures. Most of the assays during the past three years have been radiometric analysis but sufficient chemical controls have been conducted to render it possible to determine that the chemical assay for the contained thoria (ThO_2) may be adequately made by multiplying the radiometric assay by a factor of 5.0. This multiplier was obtained over a period of time by comparison of radiometric assays with the chemical assays of the same samples.

Location and Accessibility

The Wellborn properties are located approximately 80 air miles south and west of Butte, Montana, about 120 miles by road, and about 35 miles west of Armstead, Montana. Butte, the principal city of the area, is a supply point for virtually every commodity that may be required in a mining operation. Specifically the claims are located in Sections 29, 32, and 33 of Township 10 South, Range 15 West, Montana Principal Meridian. All of the claims are located east of but near the Continental Divide which forms the boundary between Montana and Idaho.

From Butte, the property may be reached by driving south on U.S. Highway 91 to Armstead, Montana, a distance of approximately 88 miles. From Armstead a well maintained graveled road extends to Grant from which a well traveled dirt road continues to the thorium property.

Thorium bearing ores that will ultimately be mined from the deposits will, either in the form of raw ore or concentrates, be trucked approximately 35 miles to the railhead of the Union Pacific Railway located at Armstead, Montana.

PHYSIOGRAPHY

Topography and Drainage

Elevations in the mountains and rolling foothills of the Lemhi Pass District, the locale of the Wellborn claims, range from about 3,500 feet to nearly 8,000 feet above sea level. The topography is generally moderate and is less rugged than is the ordinary mountainous terrain of Western Montana. The hills are uniformally smooth and rock outcrops other than the veins proper are generally seen only along the creek courses. Generally speaking the north slopes are steeper and have less overburden cover than do the south slopes. Elevations on the claims range from about 6,000 to about 7,500 feet above sea level with thorium bearing ores being found over almost the entire vertical interval. There are no topographic maps of the area and the U.S. Forest Service maps of the district are too general in treatment to be of much use.

All of the claims of the Wellborn property lie on areas drained by either the North Fork or the South Fork of Frying Pan creek which flows into the Beaverhead river near Armstead and eventually into the Atlantic Ocean via the Missouri River.

Climate and Vegatation

The climate is semi-arid with an annual precipitation of about 18 inches, much of which falls as snow during the winter.

Moderate to warm summers are experienced in the area with temperatures as high as 90 degrees F. During the winter the temperature may fall as low as 30 degrees below zero. Winter weather usually lasts from about December 15 until about April 1st of the following year. Although deep snows, from 1 to 3 feet, could present an operating problem during the winter months, the present access roads are located along the comparitively open south slopes and the roads may be easily kept open during these periods.

Pine and fir trees are abundant along the north slopes and, although the quantity of sawing size and grade of timber is not large, the growth will be far more than adequate to provide all necessary mine support.

HISTORY

Thorium Deposits in the Lemhi Pass District

Radioactive minerals were first discovered in Montana in the spring of 1949 by Mr. Wayne Hinman of Clancy, Montana. The date of the first discovery of such minerals in the Lemhi Pass area is unknown to thw writer but it is probable that such discoveries were made at about the same time. It is certain that the deposits now known to contain thorium as the principal valuable mineral were first thought to be uranium bearing and that the first work was performed in search of this latter element. The Elkhorn Mining Company was probably the first company to attempt any exploration in the area when they diamond drilled the southern end of the Last Chance-Shady Tree group of claims. When it was proven that the deposits contained thorium rather than uranium the project was dropped. Although the writer recalls probing the

holes in late 1952, the information gained from such drilling was never made available, and such data as was gained was restricted by the AEC.

Although there are other known occurences of thorium bearing veins in the vicinity of the Wellborn properties, the surface exposures are usually insignificant and since no work other than surface scratching has been performed, the known area of commercial grade ore is pretty much confined to the property under consideration. In general such deposits may be said to be restricted to a small area near the crest of the Continental Divide and to the claims on the east front of the divide that have had the later to be discussed work performed on them. Only minor showings of thorium minerals are known to occur at any appreciable distance from the divide and generally these deposits contain vein monozite, primarily a rare earth mineral which may contain as much as 15 percent thorium in the monozite.

In the Lemhi Pass district of Montana, there are several properties under a diversity of ownerships that have performed small amounts of work on whatever thorium showings they may have. Ability to produce an appreciable amount of ore were they called upon to do so lies exclusively with the Wellborn property. These claims, particularly the Last Chance-Shady Tree group and those claims covering the so-called Shear Zone, have had considerable work, both surface and underground performed on them and would be able to produce substantial tonnage after only a few days of preparation. Although it would be an impossibility to attempt to predict the tonnage and average grade of thorium ores that will eventually be produced from the district, it is evident even to the most in-

experienced observor that such quantities must be measured in millions of tons. As far as the average grade is concerned, the initial production will probably contain 0.75 and 1.0 percent thoria. Though one cannot at this time say what grade will be required to constitute commercial grade ore, it seems probable that as the demand increases, the required grade of the ore may be reduced.

During the past year or 18 months more and more of the major mining and chemical concerns of the United States have evidenced interest in the potential of the Lemhi Pass area and particularly in the Wellborn claims. It is therefore possible that within the next few years a great deal of exploration, both surface and underground will be performed. Eventually, probably within a very few years, activity within the area will have reached the point where only underground active mining operations of the more productive properties will be carried on.

Since the discovery of the thorium ores of the area, the United States Government has been interested to the extent that both the Geological Survey and the Atomic Energy Commission have conducted periodic examinations and surveys of the deposits being opened. The Geological Survey has published a bulletin on the Thorium Deposits of Eastcentral Idaho and Southwestern Montana, and the Atomic Energy Commission has kept abreast of developments in the area. The AEC work has consisted of mapping of the exploration work as it was performed and the compilation of a detailed report on the Wellborn claims. That report was prepared by the present writer and consisted of an analysis of the geology and of the

probable potential of the property together with a detailed calculation of the indicated ore reserves. The report was classified material and to the writers knowledge was never made available to the public or to the owners of the property. The writer is aware that shortly after his resignation from the Commission, that Agency undertook a complete appraisal of the thorium potential of the area. The purpose in mentioning this last work is to offer the possibility that such evident interest on the governments part might be an indication that interest in thorium ores may be approaching the point that a purchasing program for these ores may soon be established.

GEOLOGY

Regional Geology

Leesbi Pass and the surrounding area is located along the southeast edge of the Idaho batholith, an intrusive mass of granitic rocks of probable late Cretaceous age, rocks emplaced about 75 million years ago. To the east of the area there is a large expanse of Tertiary pyroclastics and sediments somewhat younger than the Idaho batholith. The thorium deposits are contained in rocks of late Precambrian time, rocks that are probably in excess of 750 millions of years in age. These Precambrian rocks form part of the southern extremity of a vast area of such material known collectively as the Belt formation. Throughout the entire expanse of the Belt rocks there exist areas, large and small, which have intruded the older rocks or have covered them as sediments or as volcanic outbursts. The entire series has been tilted and warped in varying degrees so that at this time it is rare to see them in the position in which they were originally deposited. Uplifting, tilting and warping

and faulting of the rocks has generally been slow and of insufficient degree to fracture them extensively and the Belt rocks as a whole form a region in which mineral deposits are not abundant. Rather wherever fracturing has caused later emplacement of ore deposits, such deposits seem to appear more concentrated than if the minerals available for formation of ore deposits were free to settle in a variety or multitude of locations. Most, if not all, of the mineral deposits occuring in the veins and vein systems of the area were probably localised as a result of fracturing caused by the intrusion of the Idaho batholith and such deposits were undoubtedly formed during the rising of the molten magma and for a time after the cooling and solidification of that mass. Thus the veins themselves, though contained within a rock formation as much as 750 to 1000 lillions of years in age, are probably not more than 70 or 75 million years old.

Local Geology

Although much of the Lemhi Pass district is covered with varying thicknesses of overburden, there are enough rock outcrops and road cut exposures present to establish the presence of the Belt Precambrian rocks as the dominent ones of the area. Fresh exposures of the rock are generally grey to light buff in color and the texture varies from a soft quartzite to very hard argillite. The rocks are usually fine grained and non-porphyritic and in general the bedding planes stand at steep angles while shearing and crushing of the rock is not uncommon. Here and there one may observe Tertiary volcanic agglomerates and rhyolite dikes. The general attitude of the agglomerates is difficult to determine although it appears that they dip generally to the east and that

they may have had their origin to the west. In reality they propably are a part of the Challis Volcanics so common to the west and southwest. Slightly east of the Wellborn property there is an exposure of conglomeratic rock that may represent the base of the Cambrian formation. These rocks are only slightly younger than the Precambrian rocks of the area. If these are the base of the Cambrian, and stratigraphically they are in correct position, it becomes apparent that the ore deposits of the district are in rocks forming the uppermost portion of the Belt formation.

Drainage features of the district indicate that the major geological structures adopt a general northwest to northeast alignment and that these structures cross the general bedding directions of the Precambrian metamorphosed sediments. It is interesting to note that as a pattern the dominent veins likewise assume the ternd of the indicated major structures. This would indicate that the veins have an excellent chance of continuity both in length and in depth and also that the mineralized structures have a better chance to acquire an appreciable width than they would have were they transverse to the major structural features.

Thorium Vein Deposits

In the area in general copper veins and thorium-bearing quartz-hematite veins occur as fracture fillings in the Ravalli (?) member of the Belt series of Precambrian rocks. Thorite, hydrothorite (?), monosite and allanite occur in the thorium -bearing veins but only thorite and hydrotherite (?) have been found in significant amounts. In the quartz-hematite veins the thorite occurs as disseminated crystals associated with the quartz, hematite, hydrous iron oxides and barite. The gangue minerals are mainly quartz, py-

rite and hematite .

The thorite-beraing veins are usually reddish brown in color whether they are represented by weathered outcrops or by freshly opened cuts or underground penetrations. The veins are usually more resistent to weathering than is the wall rock and in many instances form bold outcrops. In addition to the previously mentioned minerals specular hematite is a common associate. Most of the radioactivity is due to the thorium contained in the thorite (thorium silicate) and very little can be attributed to uranium. Minor amounts of thorium may be contained in the mixture of iron oxides, in which case it would probably be hydrothorite, an alteration product of the thorite. At no place have secondary minerals of thorium been recognized and the mineralization at depth will undoubtedly be very similar to that observed at the surface or near surface exposures. The one exception to this probability is that at depth at least a part of the iron now seen as oxides will be present in the sulphide form. Trites and Tooker (1953, page 36) have found that samples from the quartz-hematite veins contain as much as 1.25 per cent equivilent, 0.008 uranium, and 6.6 percent thoria (thorium oxide). The rare earth minerals yttrium, cerium, samarium, neodymium, gadolinium and lanthanum were found by spectrographic analysis of both the heavy and the light mineral fractions of the samples. The above mentioned reference, page six, states that of four thorite-bearing samples from the district which were analyzid in the Surveys Washington D.C. laboratory, the thorite rich fractions indicated the major constituents to be thorium, barium, phosphorus, and silicon. The minor constituents were iron, barium and manganese and the trace parts were lead, copper, and magnesium. It further states

that the analyzed four samples of thorite contained no detectable rare earth elements or uranium, thereby distinguishing it from thorite from most other parts of the world.

EXPLORATION

Sine the discovery of the thorium-bearing veins on the Wellborn property, radiometric and geological studies of the deposits have been conducted by geologists of the United States Geological Survey and the United States Atomic Energy Commission and considerable exploration has been conducted by the operator and owner. Such exploration has consisted of initial transit survey of the claims coupled with surface radiometric surveys of the several claims under Mr. Wellbor's ownership. Following the radiometric work, extensive bulldozing was conducted on the Last Chance-Shady Tree group in order to deliniate the abnormal surface radioactivity earlie detected. Bulldozing tended to develop the main deposits into two distinct zones, one of which is now known to be a continuous hydrothermal filled vein in excess of 1,900 feet in length. Both ends of this vein are open for additional exploration so that the total length may be far in excess of this dimension. Conservatively the known length could be projected a distance at least equal to one-third the known length and the strngth of the vein at both extremities indicates that the expected additional length may be greater than the arbitrary figure of one-third. Although other mineralized structures, particularly the so-called Shear Zone, are known on the Wellborn properties, the above described Last Chance-Shady Tree vein is the best known and explored and probably will be the best and most productive vein in the

entire district. Additional surface bulldozing has been accomplished on some of the other veins and the Shear Zone structure has been partially outlined by such work. Subsurface or underground exploration has been centered ainly on the Last Chance-Shady Tree vein. Near what was thought to be the southeast end of the obviously mineralized zone an inclined shaft was sunk to a depth of 50 feet along the footwall or underside of the vein. From the bottom of the shaft, a horizontal crosscut was southwest through approximately 14 feet of vein filling of ore grade. The thickness of the vein at the bottom of the shaft belied surface showings so that it was then evident that the shaft could have been sunk at a point farther southwest along the projected strike of the vein and thus could have indicated that much more strike length for the structure. Surface showings northwest from the point of the shaft entry were sufficient to indicate that the vein was strong enough and probably of sufficient grade to make additional exploration work at these points unwarrented at that time. At a point approximately 1,900 feet northwest of the shaft, the surface overburden was too thick to permit unquestioned projection of the vein to this point. Consequently a crosscut was planned and subsequently driven to intersect the calculated downward extension of the vein at a point nearly 250 feet below the surface. The vein was intersected in the crosscut at a distance of slightly over 700 feet from the portal and almost exactly at the point where it was calculated to be. At the point of intersection the crosscut was swung to the right in order to penetrate at right angles. Thirty two feet of vein was crossed before encountering the hanging wall or upper side of the vein. Although portions of the vein at this

point were og higher grade than were other parts, the average tenor from footwall to hanging wall falls only a short way below 1.0 percent contained ThO_2 (thoria). The sum of the work accomplished on the Last Chance-Shady Tree vein indicates that the structure strikes generally to the northwest and dipsfrom 40 to 45 degrees to the southwest. Actually the vein describes a gentle arc concave to the southwest rather than being a near plane structure. In order to further explore the limits of the vein and at the request of the writer, who was then connected with the Atomic Energy Commission, an additional crosscut was planned to intersect the vein at a point 180 feet vertically below the above described penetration. Such work would have required approximately 1,100 feet of additional underground tunnel work. The crosscut was started and was driven approximately 100 feet before work was stopped.

Following completion of the 700 foot crosscut, drifting southwest was carried on from the crosscut for a distance of 50 feet along the footwall. At this point the vein was then crossed to the naging wall. The writer measured true thickness of the vein at this point and distance from footwall to hanging wall at right angles to the dip was 31 feet. A higher than average grade zone of ore was sampled along both the footwall and the hanging wall. Following this crosscut the drift was extended an additional 50 feet. The writer did not visit the work after this final drifting though the contractor verbally stated that there was apparently no change in grade or thickness of the ore body.

During and following the above described exploration of the Last Chance-Shady Tree vein, a drift was run approximately 100

feet in length was driven along a portion of the Shear Zone orebody. This structure lies approximately 1,200 feet northeast of the Last Chance-Shady Tree vein and the drift was driven at a point almost due east of the initial shaft work on the other vein. This drifting indicated that the mineralized portions of the Shear Zone are inferior to and less continuous than the first explored vein. Ore occurs in and along the length of the drift but the true thicknesses are less and the ore is in the form of discontinuous lenticular pods distributed along the vein. Individual pods are of good average grade, but the width ranges from about four feet to as little as eight inches and is such as to make subsequent mining operations difficult. Additional work along this vein was then discontinued and the decision made to expend all near future exploration work on the Last Chance-Shady Tree vein. Accordingly, work was then concentrated on finishing the initial exploration of the last mentioned vein at depth and the following season work was started on the 1,100 foot crosscut previously mentioned. The work thus far completed on both the Last Chance-Shady Tree vein and on the Shear Zone structure has enjoyed remarkable success in that they have served to outline the fact that an enormous tonnage of ore grade material exists on the property, particularly on the Last Chance-Shady Tree vein but also, though on a lesser scale, on the Shear Zone. If it had been possible to continue the last started crosscut which was designed to intersect the main structure at an additional 180 feet of depth (230 feet along the dip of the vein), it would undoubtedly have nearly doubled the calculated ore reserves. The lack of capitol can be the only reason why the 1,100 foot cross-

cut was not completed. Certainly there could have been no other reason for attempting to further outline the excellent orebody thus far developed.

ORE RESERVES

The calculation of indicated ore reserves, particularly on the Last Chance-Shady Tree orebody was undertaken while the writer was still in the employ of the AEC. The work was not difficult due to the spendid amount of surface exposures of ore opened along the strike length of the vein and due also to the underground exploration that had been conducted. Even though such exposures were evident, the calculations were purposely held at conservative figures, this because of the purpose of the report. If no concrete figures were known for any portion of the vein, then no reserves were calculated for that, or those, portions. However in some cases it would have been entirely logical to project the adjoining ore blocks into, if not through, the unknown areas. Likewise if some blocks had only portions of the width or length of the vein exposed, the reserve figures assigned those blocks included only the portions of the vein that could actually be seen and no consideration was given the unseen or unsampled portions of the vein but which could probably have been proven present had the exploration work been adequately extended. In addition to the Last Chance and Shady Tree orebodies, there exists several veins that show excellent widths and grades on surface outcrops but on which no exploration work of any kind has been carried on. The potential of these veins was not and is not included in the present ore reserve estimates. Grades of the indicated ore blocks are the

result of many samples taken, both at the surface and underground, and assayed both radiometrically and chemically, principally the former. Where radiometric assays governed it was possible to convert these to calculated ThO_2 by applying the factor of 5.0, derived from comparison of a multitude of radiometric assays with the corresponding chemical assay of that same sample. In addition it was possible to set up a relation between contained thoria of assayed samples and indicated thoria content as derived from profiles across the exposed vein widths. These profiles were made after traversing with radioactivity recording instruments, usually of the scintillation type. In some cases these relations between assayed samples and measured profiles were used to calculate ore grades where either insufficient samples had been taken or cuts had not been extended entirely through the overburden cover.

In the original calculations, a cutoff grade of 0.60% thoria was used, it being arbitrarily assumed after preliminary calculations that material containing less than 0.60 % thoria could not be mined at a profit. As a result the figures obtained reflected only those portions of the orebodies that contain material in excess of 0.60% thoria. At that time a conservative figure of approximately $1.50 per pound for the contained thoria was usde and since calculated mining costs, including amortization of the property would approximate $18.00 per ton of ore mined, 0.60 % or 12 pounds of contained thoria was assumed was assumed to be the lowest grade material that could be profitably mined. The latest published figures indicate that the market price for thorium salts may be nearer $7.00 per pound for contained thoria. Assuming that this figure may be reduced by as much as 50 percent because of the cost

of producing these salts, it is reasonable to anticipate a return of at least $3.50 per pound for the thoria contained in these ores, particularly since thorite is oneof the easiest of the thorium minerals to reduce metalurgically. With the above figures in mind it is probable that the cutoff between non-commercial grade ores and those that could be mined at a profit may be nearer 0.25 % thoria than it was originally set at 0.60 % thoria.

The following table presents the ore reserve figures derived when using a cutoff figure of 0.60% thoria and the revised portion shows the corresponding calculated tonnages arrived at when the cutoff point is lowered to 0.25 % thoria.

Cutoff grade equals 0.60 % thoria

Mining Width	Mining Grade	Ore Reserves
	Last Chance-Shady Tree Orebody	
13.5 feet	0.97 % ThO_2	600,000 tons
	Shear Zone Orebody	
3.0 feet	1.01 % ThO_2	145,000 tons
Total and average	0.99 % ThO_2	745,000 tons

Cutoff Grade equals 0.25 % thoria

	Last Chance Shady Tree Orebody	
15.0 feet	0.75 % ThO_2	1,100,000 tons
	Shear Zone Orebody	
3.5 feet	0.80 % ThO_2	200,000 tons
Total and Average	0.79 % ThO_2	1,300,000 tons

The increase in tonnage over that evidenced by being able to mine a greater width of vein material is brought about by the fact that ore blocks that were not mineable when using a cutoff of 0.60 percent thoria may now be brought into production when using a cutoff grade of 0.25 percent thoria (ThO_2).

Although it would of course depend on what was encountered if and when the longer and lower crosscut, which is now in 100 feet, is completed, the strength and latitude of the vein in the upper levels is sufficient to indicate that the present ore reserves of the Last Chance Shady Tree orebody may be increased from 50 to 70 percent when that crosscut and attendent drifting are completed. Thus assuming that the crosscut and drifting are to be finished I would estimate that the reserves of that orebody may be incresed to 1,500,000 or possibly to 1,750,000 tons of ore having a grade commensurate with that in the upper levels. The thought that at least some of the contained iron oxides at the present horizon may be replaced by sulphides at a greater depth may tend to lower the grade of the material there encountered. This lower-of grade would be proportional only to the difference in specific gravity between the iron oxides and the iron sulphides. The decrese in grade would probably not amount to more than 0.01 or 0.02 % ThO_2 in the ore at greater depth.

CONCERNING THE FUTURE OF THORIUM METAL

The following is taken in a large part from the latest Survey and Market Outlook issue of The Engineering and Mining Journal.

During 1956 an ever increasing amount of thorium was required for high-temperature alloys and AEC investigations of the potential of thorium metal as a nuclear power fuel were intensified. The AEC announced that reactor grade thorium metal was available for purchace from its stocks. In June of 1956 , Davison Chemical Company and its affiliate , Rare Earths Inc., opened a new $2 million processing plant at Curtis Bay, Maryland to jein join others as a producer. Westinghouse Electric Corp. lamp division prepared a small amount of thorium metal from refined salts for use in electrical equipment and a number of firms were reportedly engaged in research concerning methods of producing high purity thorium metal. Significant growth continued in the use of thorium in magnesium alloys for aircraft and guided missles, because of its light weight, strength at elevated temperatures and good forming properties. The alloy, weighing only ¼ as much as steel, expresses good strength and elastic modulus characteristics to temperatures around 600 degrees F., good creep resistense, can be heat treated and welded and is available from its fabricators cast and wrought forms. A special thorium-magnesium alloy is to be used in the earth satellite, Project Vanguard, Consolidated and Edison, in 1956, purchased 27,500 pounds of AEC thorium for $537,000.00 to be used in conducting critical experiments in a full sized reactor core prior to installation of their reactor at the Indian Point, N. Y. site.

Outlook is good for thorium in high temperature alloys of mag-

nesium . Most of the applications for this alloy are presently in defence products but with increased publicity concerning its versatility there is opportunity for more widespread use, particularly so as the anticipated speed of future aircraft approach and pass the speed of sound. In this speed range, now called the "Thermal Thicket", a planes skin temperature at Mach 2 (twice the speed of sound) can reach 275 degrees F., and at Mach 3 it may leap to 650 degrees F.

Export of the thorium nitrate salt for foreign production of gas mantles will probably continue to increase.

Market quotations for thorium salts range from a low of $3.00 per pound for the nitrate of gas mantle grade (46% ThO_2) to an average of about $7.00 per pound for material containing from 80 to 90 percent thoria (ThO_2). A high of from $8.25 to $9.35 is asked for the oxide containing from 97 to 99 percent thoria. The price asked for thorium metal is probably in the range of from $18.00 to $20.00 per pound.

CONCLUSIONS

Conclusions reached after more than three years of observation of the Wellborn thorium bearing properties may be simply stated to the effect that:

1. There is now thought to be a minimum of from 750,000 to 1,000,000 tons of thorium bearing ores on the property that may in the writers opinion be mined at a profit. Most of this probable tonnage is located on the orebody known as the Last Chance-Shady Tree vein.

2. The grade of the above amount of thorium ores calculated

to be present on the considered property will fall in the range of from 0.75 percent thoria to 1.0 percent thoria.

3. It is believed that the strength and persistence of the Last Chance- Shady Tree vein is sufficient to render it probable that the completion of the lower and last started crosscut directed toward that vein will intersect the structure at approximately 1,100 feet and that the additional ore thus found will increase the known and probable reserves from 50 to 70 percent.

4. The Wellborn properties in the Lemhi Pass district of Montana are, so far as is known by the writer, the only such properties that could in a short period of preparation, produce substantial amounts of ores above mentioned.

RECOMMENDATIONS

It is recommended that should additional exploration and development be undertaken at the Wellborn thorium properties, first consideration be given to the completion of the lower and last started crosscut. The adit has presently been advanced a total of approximately 100 feet and the remaining amount of tunneling, about 1,000 feet, should be completed in less than six months time. Since there is an abundance of ore now outlined for beginning mining operations, the driving of this crosscut could however be made to coincide with mining operations of the upper levels.

No additional recommendations for explorations and development of these claims are possible since exploration thus far completed has shown that sufficient ore of good grade is present and there the matter rests.

REPORT ON LEONARD D. JARRARD, MINERALS CONSULTANT

Education

B. Sc. Degree in Mining Engineering, 1938, Montana School of Mines, Butte, Montana

M. Sc. Degree in Mining Engineering, 1939, Scholarship from Montana State Bureau of Mines and Geology, Montana School of Mines, Butte, Montana.

Professional Affiliation

Registered Professional Engineer by Examination, State of Idaho, 1949.

Member, Northwest Mining Association, Colorado Mining Assoc.

Experience

1935 - 1942

Seven years experience as laborer, assayer, geologist, engineer (mining and research), shift boss and superintendent, Anaconda Copper Mining Company and Victoria Mines Inc.

1942 -1946

Officer in the United States Marine Corps, Combat Engr.

1946 - 1952

Six years as District Geologist, Region I, Boise, Idaho U. S. Bureau of Reclamation.

1949

Registered Professional Engineer (Mining) State of Idaho, Number 692, by examination.

1952 - 1956

Chief, Butte Sub-Office, U. S. Atomic Energy Commission in charge of Raw Materials explorations in Montana,

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1956 - Present

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Modern Mines Development Company
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Atomic Minerals Corporation
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Mr. Buford Miles, Mine Operator
Helena, Montana

Bunker Hill and Sullivan Mining Company
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References

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