Bldg. 20, Denver Federal Center
Denver, Colo. 80225

April 2, 1965

Memorandum

To: George C. Selfridge, Chief
Division of Exploration Operations
Washington, D. C. 20240

From: Acting Field Officer, OME, Region III

Subject: OME-6408 (Uranium-Selenium)
Schauss and Stevens
A B Claims
Carbon County, Wyoming

Attached are the original and two copies of the Report of Examination on the subject property by T. M. Romalo, Mining Engineer, U.S. Bureau of Mines.

The Field Examiner recommends that the Applicant be awarded a two-Stage drilling contract. He also recommends that the contract provide for a 25 year royalty repayment period. I concur in both recommendations.

Seven extra copies of the claim map are included for possible use in a contract.

ORIGINAL SIGNED BY

Hugh M. Connors

Attachments

H. M. Connors (4-2-65)
cc: Allan Jones, Mgr. Oprns. Office AEC
Grand Junction, Colorado
Mineral Resources Office, Area V
OME-6408 file
Chron

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Bldg. 20, Denver Federal Center
Denver, Colo. 80225

April 1, 1965

Memorandum

To: Hugh M. Cannons, Acting Field Officer, OME, Region XII

From: T. M. Romalo, Mining Engineer, U.S. Bureau of Mines

Subject: Application OME-6405 (Uranium-Selenium)
Shanks and Stevens
A 3 Claims
Carbon County, Wyoming

The findings developed from an investigation of the subject application indicate that exploration of the A 3 claims could result in the discovery of a significant amount of uranium-bearing material. Although much of the material would be expected to occur in small, low-grade deposits, there is a fair chance that deposits of present economic interest may be discovered. Selenium may be present and should be tested for, but there is little chance that it will be found in significant amounts.

The investigations included an inspection of the proposed project area March 16, 1965, and a review of information and data furnished by the Applicant, Mr. C. L. Van Aletine of the Casper, Wyoming AEC office, and Mr. E. H. Barthmann, USGS geologist. The proposal was discussed with the Applicant, and with Mr. Barthmann, who expressed the opinion that some exploration of the claims was justified. I concur with Mr. Barthmann's finding, and recommend approval of an exploratory project that could involve the later suggested work and costs. It is further recommended that any contract awarded should provide for a 25-year royalty payment period.

The Applicant's property is in the Shirley Basin uranium district. It is underlain by the Wind River formation of Eocene age, that is composed of sediments derived from granitic rocks. The sediments occur mainly as intertonguing beds of loose or poorly cemented sand, gravel, silt and clay, and conglomerate. The Wind River formation is deposited in an eroded low area of the Cretaceous Steele shale.

In the Shirley Basin, uranium ores are known to occur only as flat-lying deposits in the lower part of the Wind River formation (described by Barnhamm and by Robert V. Bailey in attached paper). Uranium deposits now being exploited occur at depths of 100 to 500 feet below the ground surface and a few are 400 feet below the water table. The deposits are in areas where the Wind River formation is unconformably overlain by the Oligocene White River sediments. The largest deposits contain as much as several hundred thousand tons of unscidized ore assaying from about 0.60 percent to as much as 10 percent U_3O_8. Uraninite is the ore mineral, and it is associated with fine grained pyrite, marcasite, and organic material. It coats sand grains, fills openings between sand grains, and occasionally fills fractures in sand grains. The large and high-grade deposits are intimately related to large elongate tongues of greenish-yellow altered sands. Other deposits have been discovered outside the main mineralized belt where physical and geochemical conditions were favorable for uranium deposition. Deposits of this type have been discovered in the area between the main mineralized belt and the Applicant's property. Three deposits in the area, two of which are located on the attached map, have been roughly delineated by drill holes. Information obtained mainly from the AEC indicates the three deposits contain about 300,000 tons of material that varies in grade from 0.05 to 0.25 percent eU_3O_8, and averages about 0.11 eU_3O_8. Much of the lowest grade material occurs near the borders of the deposits that vary from about 100 to 300 feet wide, 300 to 600 feet long, and 5 to 15 feet thick. The long axes of the deposits trend about north-south, but whether or not buried channels localize the deposits cannot be determined from available data. Although these deposits are not presently economic, some major uranium producers reportedly consider that holding and acquiring similar deposits is justified from the long-range viewpoint.

Selenium occurs in the Shirley Basin, according to Mr. Barnhamm, and the Applicant. Mr. Barnhamm says that selenium in other than trace amounts was found only in a flat-lying veinlet about 12 feet long and a maximum 6 inches thick. The veinlet was exposed in an open pit. It was associated with high-grade uranium ore and probably contained no more than a few tons of material assaying a maximum 0.34 percent selenium. The Applicant says field tests of cuttings from widely spaced holes near the proposed project area found that selenium is present throughout an approximately 70-foot thick zone of sands resting on the Steele shale. The selenium content is unknown - no estimates nor quantitative assays were made.

Available data indicate that the top of the Steele shale on the Applicant's property should be encountered by drill holes at depths ranging from about 90 to 250 feet, and averaging about 150 feet.

The data also indicate that oxidation may extend to depths close to 100 feet. In the more highly oxidized portions of the Shirley Basin, leaching has removed much of the radioactive material. Areas in which this condition is found by geological logging could be tested by more widely spaced holes or might be eliminated. The logging also could indicate that abnormal radioactivity in thin zones above the favorable horizon is due to the presence of monazite. Exploration for these zones that generally assay less than 0.03 eU_3O_8 probably could not be justified. Favorable zones would, of course, include those in which the normally grayish sands have been chemically altered to a greenish-yellow. The Applicant suggests that the Graybeal Anticline may have some favorable ore deposition influence on the A B claims. Because the anticline is of pre-Wind River age, the assumed favorable structural conditions would not be expected.

Suggested Work and Costs

It is suggested that, initially, sufficient exploratory work be done under Stage I to determine if further exploration of the property would be warranted. If favorable findings are developed by Stage I work, additional exploratory work could be started with the Government's written consent, and if justified by favorable findings, could be continued until completion of the work provided under Stage II.

The exploration would include the rotary drilling of about 4-3/4-inch diameter holes that would be bottomed as near as practicable to the Wind River-Steele contact. No holes would be drilled closer than 200 feet from property's boundary lines. Each hole would be surveyed, and logged with Century-type Gamma ray and electrical resistivity curves, and log interpretations would be made for uranium content, lithographic units, and depths to water table. The Applicant's Babbel probing is not considered sufficiently reliable or inclusive, and the AEC reported that they could not be expected to probe more than 4 or 5 of the proposed holes. Cuttings from 5-foot hole intervals would be logged to include lithographic units, and the estimated degree of oxidation and chemical alteration. The cuttings also would be tested for selenium by an acceptable method such as that described in the attachment to this report. The extent of such testing would be determined from the results obtained in testing all piles of cuttings from the first few holes drilled. A maximum of 18 samples containing indicated significant amounts of selenium would be chemically assayed. The selenium content of any additional samples found to contain interesting amounts of selenium by the field tests would be estimated visually. The Government would be furnished copies of the Gamma ray and resistivity curves and logs, copies of the

geological logs with either the estimated or assayed selenium content, and maps showing the locations and collar elevations of all holes. Samples of cuttings containing interesting amounts of selenium also would be made available to the Government.

Stage I drilling - Stage I drilling could be confined to the approximately eastern one-half of proposed project area. Initial drilling could be done as follows:

1. Drill holes at 100-foot intervals along fences 1 and 2, as proposed by the Applicant, or, drill holes at 200-foot intervals along fences 1, 2, 3, and 4 (see attached map).

2. Drill off-set holes in any areas found favorable by the fence holes and by the holes previously drilled by Earl Myers. Favorable areas would be those adjoining holes that penetrated either not less than 3 feet of 0.05 eU_3O_8 material at a potential ore horizon, or zones of chemically altered sands. The zone of chemically altered sands would not have to be radioactive. Holes to off-set those drilled by Myers could be drilled only with prior Government approval. To obtain this approval, the Operator would be required to furnish a map showing the locations of all the Myers holes, and evidence that the above described favorable conditions prevail in the area of proposed off-set holes. No off-set hole should be less than 100 feet from any other hole except in areas underlain by chemically altered sands. In these areas prior approval would be required for a closer spacing than 50 feet.

3. In the areas not explored by the initial drill holes and off-set holes, drilling could consist of a grid of holes on 400 to 600-foot centers, and off-set holes in any favorable area encountered.

Stage II drilling - Stage II drilling, if warranted, could consist of that described in item 3 of Stage I.

The amount of drilling required probably would not exceed 30,000 feet for each stage. Transfer of drilling footage and attendant costs from either stage could be allowed.

The drilling program should be as flexible as possible.

Suggested Allowable Costs

Drilling cost - The Applicant would perform the drilling operations (letter to Connors, 3/24/65), rather than have it done by a drilling contractor. Information pertaining to this proposal was given in the application, and additional information was furnished verbally during the field investigation. The Applicant would acquire necessary

equipment (truck-mounted rig and water truck) and accessories, and hire a drill operator and helper. Potential use of the outfit is for the proposed uranium project, for a probable small amount of drilling to about 200-foot depths in an oil field, and for any other supplementary jobs that may be found.

Although Shauss and Stevens say they will do the drilling, they probably would not sign a contract to do the drilling at a fixed cost much lower than $1.00 per foot, the lowest of three bids by drilling contractors. Preparation of any contract should therefore be withheld pending word that the contemplated fixed cost would be acceptable.

Century logging - The Century Geophysical Corporation's bid of 10 cents per foot logged plus $2.00 per hole logged is considered acceptable as an actual cost. The corporation does high-quality work and is the only logging contractor in the area.

Incidental cost - This could include a fixed cost per foot of Century-logged holes for supervision, labor, office accounting, preparation of reports, and use of a pick-up truck. Mr. Stevens expects to supervise the project. He can be expected to properly do the office accounting, selenium testing, and report writing, and with a helper can be expected to do necessary surveying and lithographic logging. He will require the part-time services of a consulting engineer for checking the lithographic logs, interpreting the lithographic and Century logs, and planning additional drilling sites. Allowable incidental costs would be:

Supervisor $600.00/mo. (22 working days)	cost/day	$27.30
Helper $400.00/mo. (22 working days)	"	18.20
Truck (round trip from Casper) 110 mi. @ 10 cents	"	11.00
Estimated total daily cost		$56.50

On contract 2174 (Gas Hills Uranium Co.) an approximate total 1,000 feet of drilling to an average depth of about 270 feet was completed by two rigs in a 10-hour shift. The drilling was done under conditions that are considered comparable to those expected in drilling the proposed holes to an average depth of about 150 feet. Any increase in the rate of drilling the shallower holes would probably be offset by the additional moving-time loss. On this basis, the fixed incidental cost of the proposed drilling would be $56.50/1,000 ft, or $0.057 per foot of hole. The fixed incidental cost under contract 2174 was $0.02 per foot, and amounted to a total $225.16 for 11,258 feet of drilling. The Government's share of the total cost at 50 percent was $112.58. This amount probably came close to covering 50 percent of the helper's wages for 12 to 13 days, but certainly left little or nothing for the supervisor's service and use of the pick-up truck.

Other costs - Other costs would be actual costs for a consulting geologist, sample sacks, test tubes and chemicals for selenium tests, and selenium assays.

Consulting geologist, 3 days each stage at $130.00/day	$780.00
Paper sample sacks, test tubes & chemicals, $75/stage	150.00
Selenium assays, 10 @ $15.00/each	150.00

TMR

T. M. Romals

Attachments

cc: G. C. Selfridge (2)
AEC
File 6408
DFC
Chron

APPLIED GEOLOGY IN THE SHIRLEY BASIN URANIUM DISTRICT, WYOMING

The author of this paper says a modified version (with photographs) of the paper will soon appear in Contributions To Geology, a publication by the Univ. of Wyoming Geology Department.

DMP

by Robert V. Bailey
Utah Construction & Mining Co.
142 East 3rd South
Salt Lake City, Utah

Presented at the
Ninth Annual Minerals Symposium
American Institute of Mining, Metallurgical and Petroleum Engineers
Uranium Section
Moab, Utah
May 23, 1964

ABSTRACT

At Utah Construction & Mining Co.'s Shirley Basin underground mine in the central part of southeast Wyoming, uranium ore has been mined from poorly consolidated sand units in the Eocene Wind River formation. Loose ground and abundant water created difficult mining conditions. A geologic mapping program of the mine, accompanied by detailed drill hole logging and geologic cross section construction, has revealed habits and relationships of the mineralization and associated alteration. Mineralization and ore were found to lie along the periphery of tongues of altered ground. The greenish to rusty altered ground was usually recognizable in hand specimen and represented 'leached' ground through which mineralizing solutions had passed. The major tongue of alteration was found to be as much as 70 feet thick, hundreds of feet across, and several miles long. The best ore occurs on rolls, or geochemical fronts, at the terminal edges of altered ground, and additional ore was found to occur in subsidiary rolls on the upper and lower surfaces of the altered ground. This concept of ore occurrence has been successfully applied to exploration and development drilling, to ore projections ahead of mine workings, and to reserve estimates.

INTRODUCTION

Most of you are aware that geochemical fronts have been recognized in the Shirley Basin Uranium District. The purpose of this paper is to describe the occurrence of these fronts in some detail and to point out how the identification of altered ground and the determination of roll location can aid drilling, mine planning, and reserve estimation.

From a historical viewpoint it now seems important to note that uranium mineralization rolls at Shirley Basin were first recognized from drilling and broadly related to some of the ore by Utah Construction & Mining Co. geologists in 1959. The concept was successfully used in development drilling in 1960, and in 1961 was put to extensive practical use in ore projections for underground planning and to aid in more efficient exploration and development drilling.

Shirley Basin is located in southeast Wyoming between the Laramie Range on the northeast and the Shirley Range on the southwest. The Shirley Basin Uranium District lies in the northeast

part of the basin and most of the important uranium deposits occur along a southeast-northwest trend. This trend is caused by the localization of uranium in northwest-trending transmissive sands in the Wind River formation paralleling a Cretaceous ridge which is buried in the area where ore has been found. Tertiary sediments in the basin are the White River and Wind River formations which lie unconformably on Cretaceous and older rocks. Tertiary sediments dip less than 2 degrees northeast throughout most of Shirley Basin and Cretaceous sediments underlying the uranium district dip about 5 degrees southwest. Wind River sands in and near the mineralized zones are remarkably continuous and uniform laterally for fluviatile deposits and this condition has contributed to the development of very continuous mineralization features in the Shirley Basin uranium deposits.

Acknowledgments

The writer would like to acknowledge the important contributions to the understanding of Shirley Basin uranium deposits made by Utah Construction & Mining Co. geologists, especially R. E. Melin and P. N. Shockey, and by U.S. Geol. Survey geologist E. N. Harshman. The writer would like to express appreciation to Utah Construction & Mining Co. for permission to present this paper and to Chief Geologist H. G. Peacock, who kindly reviewed the manuscript.

HISTORY OF DEVELOPMENT

Competitive uranium exploration got underway in the Shirley Basin area of Wyoming in 1957 and resulted in the discovery of valuable high grade uranium deposits. Two mines are currently in operation in Shirley Basin: one an open pit operated by Petrotomics Company and the other an underground mine operated by Utah Construction & Mining Co. Both Petrotomics and Utah mines are extracting uranium ore from what is apparently the same sand unit within the Wind River formation, but because of formational dip the ore at the Utah mine is considerably deeper than that at the Petrotomics operation.

Initial grid drilling by Utah Construction & Mining Co. which encountered ore in Shirley Basin led the geologists to suspect that the ore occurred mostly in pods, sheets, and possibly irregular channels as had frequently been described in deposits in the Colorado Plateau. Reserve estimates were made by conventional block or modified block methods.

The shaft for underground mining was sunk in 1959 and a major haulage drift was driven from the shaft to permit mining of ore at depths of 290 to 330 feet below the surface. It was found that the Wind River formation, as well as the overlying White River formation, was composed of unconsolidated and uncemented sand, gravel, and clay, and in addition was an excellent aquifer completely saturated with water to within 100 feet of the surface. At times more

than 5,000 gpm were pumped from the mine and from water wells mostly located near the shaft. Such abundant water in unconsolidated sand obviously can result in some difficult operating problems.

MINING METHODS

Because of the character of the sediments, drifting had to be done with extensive timbering, lagging, and overhead spiling. The tracked haulage drifts which measured 7x9 feet were driven near defined ore areas and development "scrams" (small drifts) were then driven into the ore. Squareset stoping was utilized and the broken ore was pulled to cars in the drift by slusher buckets driven by pneumatic winches. The squaresets for the most part did not exceed a size of 5x5x5 feet. In drifting and stoping only a small amount of explosives were used. Indeed, sometimes only with great difficulty was serious back caving and face caving at the heading prevented. Most of the sand, both in ore and waste, could be easily dug with pneumatic spaders. Long hole drilling for dewatering ahead of drifting was employed and this was found to help a great deal in lowering water from high up in the face and back.

GEOLOGIC MAPPING

With the commencement of drift-driving a geologic mapping program was initiated. Since mapping in an underground uranium mine in Tertiary sediments of this type was practically unknown to the industry, modifications of existing mapping techniques had to be developed. In the initial geologic mapping a great amount of detail was noted. Mine maps and cross sections were made at a scale 1"= 5' and cross sections were made at intervals of roughly 20 feet. Multiple level mapping was carried out at a vertical spacing of about 5 feet which amounted to 5 plan maps for the first stope because there were 5 floors. Mining engineers' maps showed each squareset mined and this made it quite convenient for the geologist to simply plot in each series of sets the geology which he observed in the walls, back, or floors.

After several entries had been made into the first orebody and after stoping had exposed several hundred feet of mine wall, it became apparent that some of the barren ground immediately adjacent to high grade ore had a rather strong rusty to green color. This color, or staining, which had also been noted in drill cuttings, was later found to be an extremely significant and valuable guide to the occurrence of mineralization and of ore. Several avenues of detailed geological research were followed, and this work after a time converged to point out how and why the rusty stain (later called alteration) could be used as an indicator of mineralization and possibly ore. These avenues were: careful field logging of drill cuttings with strong emphasis on resistance logs for sand and clay picks; improvement of detailed interpretation of gamma logs; construction of detailed geologic cross sections from resistance records, lithologic logs, and gamma records; and detailed

observations and mapping in the mine itself. The geologic cross sections from drill hole data, constructed at a scale 1" = 20', were found to be particularly helpful in learning something about the large-scale mineralization habits and contributed other clues to the nature of the ore occurrence. After underground mapping had been carried on for several months it was found that for mine mapping and cross section purposes a scale 1" = 20' was quite adequate and mapping at a scale of 1" = 5' was discontinued.

RECOGNITION OF MINERAL RELATIONSHIPS

The mine mapping, drill hole logging, and geologic cross sections all indicated that practically all of the uranium mineralization, and certainly all of the significant uranium mineralization, was directly related to what was called the "contact" between altered and unaltered ground. Altered ground represented leached, barren, usually discolored ground through which the mineralizing solutions had passed, and unaltered ground represented normal ground which had been unaffected by the mineralizing solutions. The mineralization occurred along the contact with the best ore usually immediately adjacent to altered ground and with decreasing grades away from the contact. The change from rusty-colored, barren, altered ground to black uraninite-rich ore was very often sharp enough to be covered with a silver dollar (if, nowadays, you could find a silver dollar). The overall shape of the mineralized feature in cross section and in plan within a particular sand unit appeared to be that of a tongue with altered ground within the tongue and persistent uranium mineralization along the sides, top, and bottom of the tongue (see Fig. 1). The major tongue of alteration appeared to be as much as 70 feet thick, hundreds of feet across, and several miles long, and occurred mostly in a trend paralleling the strike of buried Cretaceous sediments, particularly the resistant Wall Creek sandstone member of the Frontier formation. The best ore appeared to be concentrated along the leading edges of the tongue, but ore also occurred on the lateral edges. As additional stopes were opened in the mine, mineralization and ore were consistently found at the contact between altered and unaltered ground. Almost no ore and practically no mineralization was found anywhere else.

GEOCHEMICAL CONSIDERATIONS

The configuration of the mineralized features within the sand units at Shirley Basin suggests that the mineralizing solutions moved from the southeast toward the northwest even though present ground water movement is in the opposite direction: from northwest to southeast. The mineralogical evidence suggests that the mineralizing solutions were composed of slightly oxygenated ground water which was cool and weakly alkaline (present ground water pH is about 7.8), but local slightly acid conditions may have prevailed as a result of the oxidation of pyrite. The solutions contained dilute quantities of uranium which probably had been leached from

Probable Direction of

Mineralizing Solution Movement (pH?)

DECREASING GRADE

Sharp Contact

ALTERED GROUND - Ground through which mineralizing solutions have passed.

1. Clay: Mostly nontronite (high iron montmorillonite)
2. Pyrite: removed
3. Limonite: abundant
4. Coalified Wood: decomposed or destroyed
5. Uraninite: removed
6. Calcite: removed
7. Hematite: removed
8. Usual Color: rusty to greenish

MINERALIZED GROUND - Chemical interface where mineralizing solutions were arrested.

1. Clay: montmorillonite
2. Pyrite: abundant, also marcasite
3. Limonite: absent
4. Coalified Wood: quite abundant, nuclei for uraninite deposition
5. Uraninite: present
6. Calcite: quite abundant, mostly in distinct concretions
7. Hematite: often present, usually with calcite
8. Usual Color: black to dark gray
9. H_2S gas noted in fresh cores and locally in mine

Gradational Contact

UNALTERED GROUND - Unaffected by mineralizing solutions.

1. Clay: montmorillonite
2. Pyrite: locally
3. Limonite: absent
4. Coalified Wood: quite abundant, has fresh appearance
5. Uraninite: absent
6. Calcite: scarce
7. Hematite: absent
8. Usual Color: light gray

DECREASING GRADE

Present (Pre-mine) Direction of

Ground Water Movement (pH 7.8)

Figure 1. Major observed mineral features in Shirley Basin Uranium Deposits, Hypothetical Cross Section.

granitic sands in the Basin. The uranium was probably transported in the form of uranyl dicarbonate and tricarbonate complexes as described by Gruner (2) and by Hostetler and Garrels (3). Mineral precipitation took place along the edges of the tongues of altered ground, and these edges were in effect chemical interfaces between invading oxygenated solutions and an invaded reduced environment. Precipitation resulted mostly from reduction by hydrogen sulfide, with some local precipitation on and around carbonaceous material. The hydrogen sulfide was perhaps generated by anaerobic bacteria as described by Jensen (4) and by Cheney (1). The geochemical fronts traveled in the same direction as ground water movement and, through the process of multiple migration-accretion as described by Gruner (2), uranium concentration at the fronts was raised to a very high percentage. The tongues advanced into the sand segments having the best transmissivity and so long as the oxygenated solutions were fed into the system the tongues advanced with mineral precipitation taking place at the interface between the two environments. When the oxygenated solution flow in that direction was stopped, perhaps because of change of direction of ground water movement or because of lack of supply, the tongues and uranium deposits along their edges were arrested where we now see them.

TESTS OF THE FRONT THEORY

The first important usage test for the geochemical front theory was to determine if the alignment of several grid drill holes which had encountered high grade ore in the uppermost sand could be attributed to a tongue edge. An attempt to utilize this procedure was surprisingly successful. Not only did the high grade holes fall into place along the leading edge of the tongue in the uppermost sand, but the occurrence of additional ore was accurately predicted along the edge of the tongue in an area where no ore had been encountered by grid drilling.

Additional raises were now planned to permit extraction of ore which had been discovered by drill holes which penetrated the uppermost sand. These raises were planned in an area not yet opened by any other mining, but in an area where the roll (a term used to denote the actual turnover point of the front) location had been predicted and plotted on maps by the geologists (see Fig. 2). Here was the first real underground test of the tongue theory and whether it could be successfully used in the prediction of uranium ore location for underground mining purposes. The first raise driven passed through about 12 feet of clay and, after encountering a great deal of perched water, penetrated the uppermost sand where moderate grade uranium mineralization was found. As anticipated, no alteration was found at the raise. The geologists had shown a major roll about 50 feet south of the raise with no alteration between the raise and the roll. A cross cut driven south from the raise proved the prediction to be accurate within 10 feet. The roll, the altered ground, and the ore were all found to have a relationship as had been predicted (see Figs. 3 and 4).

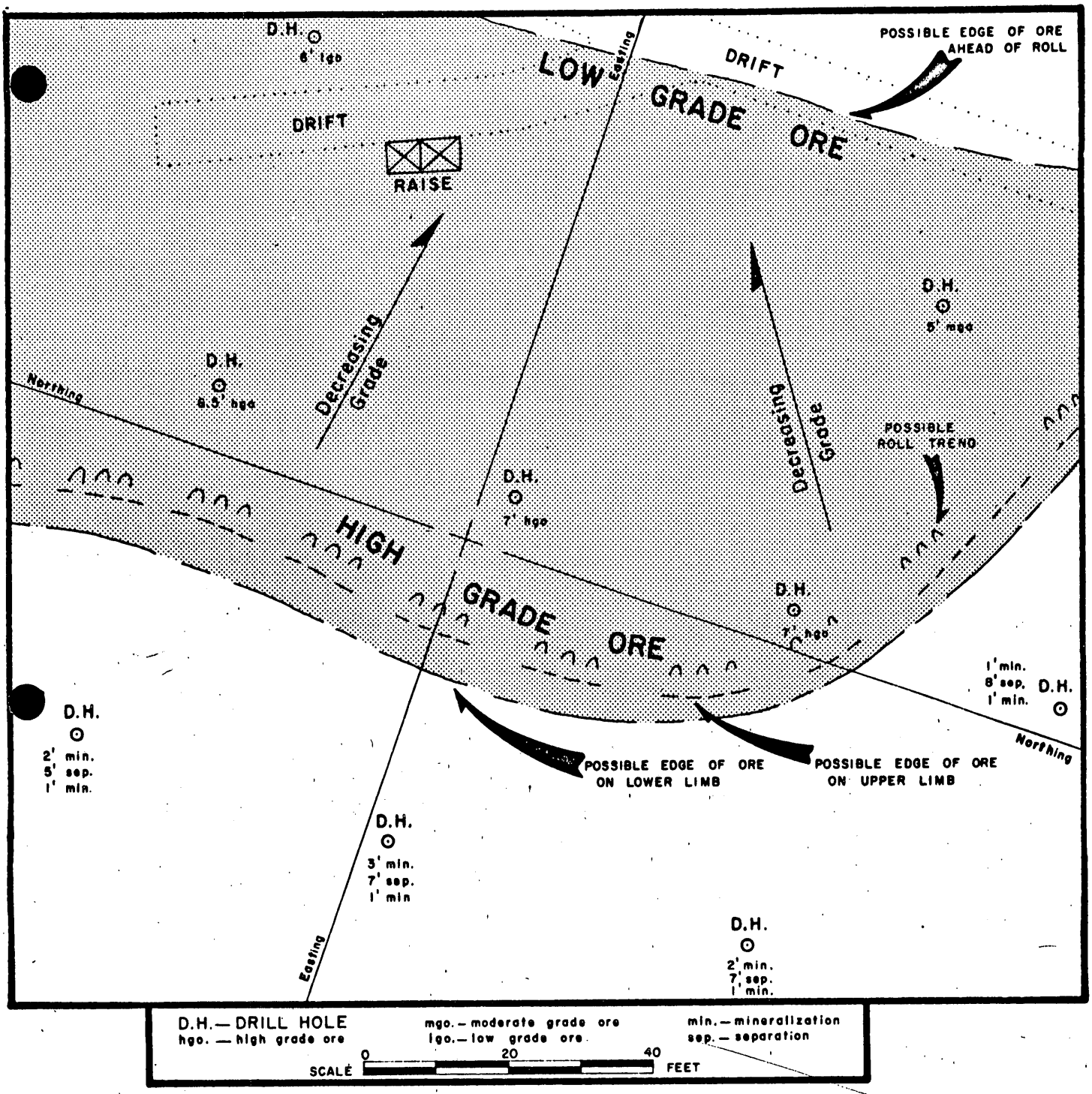


Figure 2. Pre-mining geological map of upper sand in one raise area. From grid drilling on 50 and 100 foot centers a possible roll trend and associated high grade ore was predicted. The location of the edge of ore ahead of the roll and on the upper and lower limbs on the concave side of the roll was also predicted. South of the roll two mineralized zones are separated by altered ground.

D.H. — DRILL HOLE
hgo. — high grade ore
mgo. — moderate grade ore
lgo. — low grade ore
min. — mineralization
sep. — separation
SCALE 0 20 40 FEET

Figure 3. Same area as shown in Figure 2 but after stoping was almost completed. Roll and edges of ore were very nearly where predicted. Prediction on right side was off slightly due to hole wander and nonrecognition of alteration.

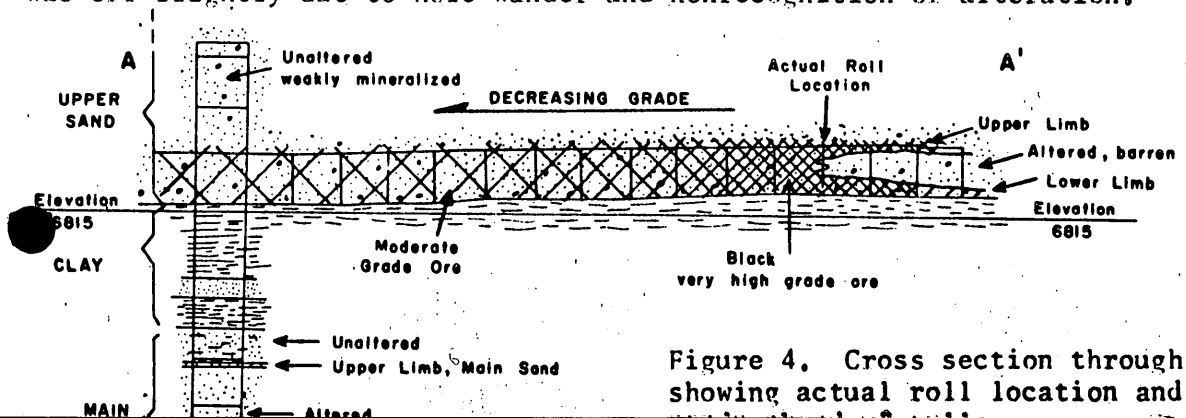


Figure 4. Cross section through raise showing actual roll location and decreasing

ORE PREDICTIONS

With concrete data from detailed studies at hand the geologists could now attempt to predict, with reasonable accuracy, where the altered-unaltered contact might be found and where ore associated with the rolls could be anticipated. Some of the earlier data from drilling and mapping could be re-evaluated and the results incorporated in new predictions of mineralization, roll, and ore occurrences. In addition, it now appeared that this approach would have an extremely important bearing on future drilling proposals, and particularly on drill hole spacing. All previous drilling had been carried out on a grid basis, but if the ore occurred along definable rolls associated principally with the edge of alteration, it was possible that with accurate roll location prediction, drilling could be done on close-spaced fences perpendicular to the roll trend to yield details of ore thickness, width, and grade. In the areas where the geologist felt more control was desirable, fence drilling was recommended. Fence drill hole spacing of 25 to as close as 10 feet was employed.

Mapping and cross section work now indicated that the elevation of the apex of a roll could be a very valuable guide in differentiating between rolls and in efforts to determine roll location and trend. The rolls had a very strong tendency to maintain a constant elevation and experience showed that a roll at elevation 6780 could be expected to maintain essentially the same elevation and was not to be confused with one at 6740 a few hundred feet away. It was found that some specific rolls on the tongue edges were remarkably continuous. One particular roll was followed by mine workings for more than 3,000 feet and another was followed for more than 2,000 feet.

CONCEPT UTILIZATION AND RESULTANT SAVINGS

In one area near the shaft re-evaluation of the uppermost sand mineralization in the light of the tongue theory suggested the possible occurrence of ore in an area within a previously-drilled grid where no ore had yet been encountered. The geologists recommended that a limited drilling program, consisting of a fence drilled at right angles to the projected roll trend, be initiated in that area with drill hole spacing on then unheard-of 10 foot centers to determine the location of the roll and to determine if ore was present along the roll in the uppermost sand. A 100 foot grid previously drilled in the area had encountered no ore. Six of the seven holes drilled in the fence encountered ore grade mineralization.

With strong supporting evidence from drilling results and from roll and ore trend prediction ahead of mine workings, the tongue theory was extensively used to aid mine planning, to point out possible areas for undiscovered ore, and to eliminate areas where no ore could be expected. Reserve estimation methods were changed

from block and modified block methods to a method which utilized the location of the geochemical fronts and which divided ore into segments on the upper limb, lower limb, and ahead of the fronts.

In addition to savings on drilling, the good geologic control provided mine management with expense-saving information on ore location, elevations, and trends to facilitate mine planning. Understanding the mineralization habits also practically eliminated longhole drilling underground.

The recognition of alteration and geochemical fronts and the significance of each has proven a valuable and important uranium mineralization guide at Shirley Basin. Perhaps the mineralization features observed there will provide clues to help solve the mysteries of ore emplacement in other districts.

REFERENCES CITED

(1). Cheney, E. S., 1964, Stable isotopic geology of the Gas Hills uranium district, Wyoming: Ph.D. dissertation, Yale University, p. 126-128.

(2). Gruner, J. W., 1956, Concentration of uranium in sediments by multiple migration-accretion: Econ. Geol., v. 51, p. 495-520.

(3). Hostetler, P. B., and Garrels, R. M., 1962, Transportation and precipitation of uranium and vanadium at low temperatures, with special reference to sandstone-type uranium deposits: Econ. Geol., v. 57, p. 137-167.

(4). Jensen, M. L., 1958, Sulfur isotopes and the origin of sandstone-type uranium deposits: Econ. Geol., v. 53, p. 598-616.

Field Test of Selenium

Equipment:

Pyrex test tube - 25mm x 200mm
Pyrex test tube - 15mm - 75mm
2 Stoddard test-tube clamps
Mortar and pestle
Propane torch or facsimile
20ml iron or nickel crucible
crucible tongs
4 x 5 steel plate

Chemicals:

Pyrosulphate
Cream of Tartar
Sodium peroxide

Method:

probably not needed for drill-hole cuttings

A sample is pulverized in mortar and pestle to a semi-fine powder.

4 parts of pyrosulphate are mixed with 1 part of sample and a very small amount of cream of tartar added. The mixture is then put into the large pyrex tube (25mm x 200mm) and roughly mixed by rotating the tube held at an angle.

The small pyrex tube (15mm x 75mm) is filled with cold water and inserted into the larger one with one of the Stoddard clamps used to prevent it from entering fully into the larger tube.

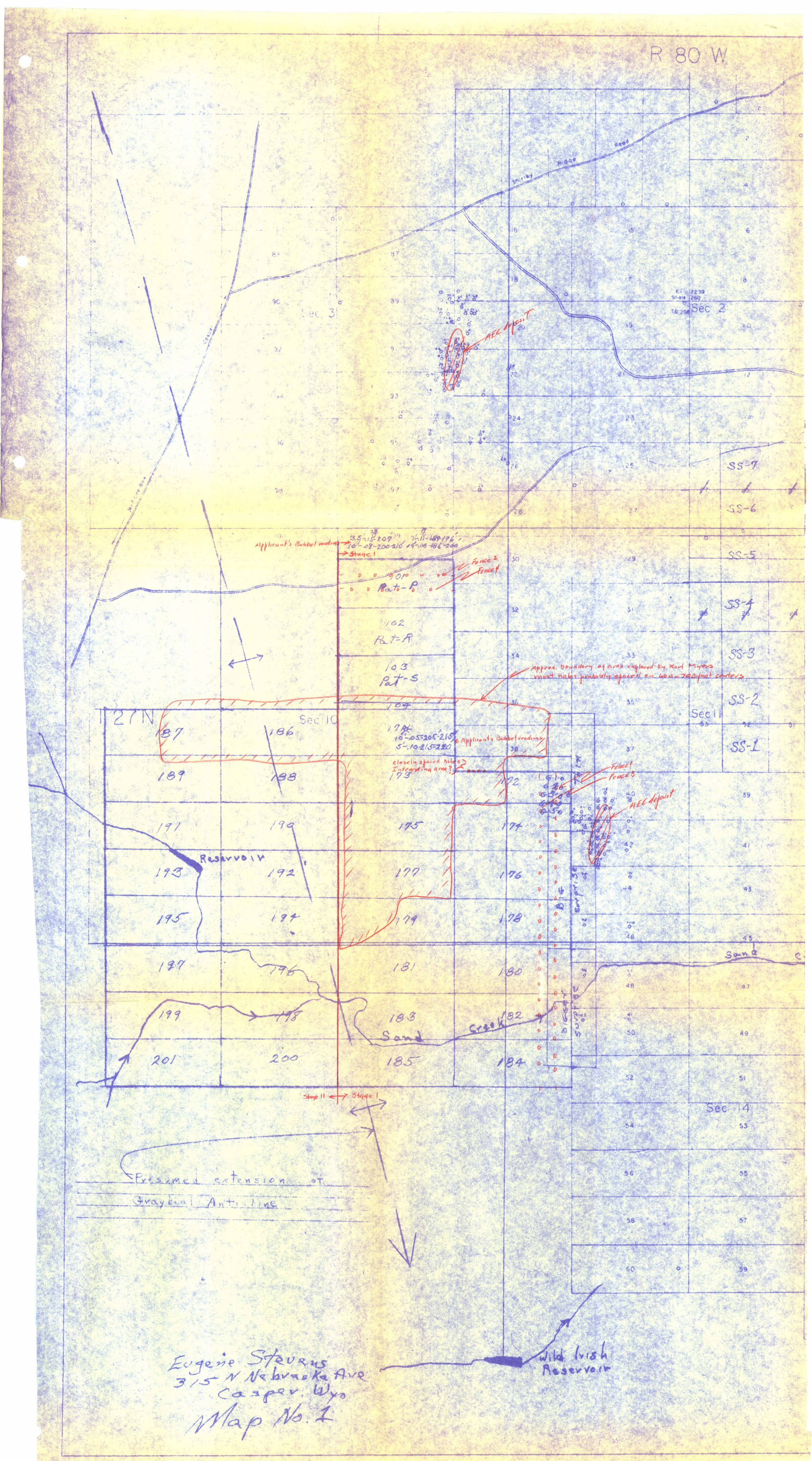
The mixture in the larger pyrex tube is slowly heated with the propane torch until the pyrosulphate melts. The melt is then brought to a boil for a few seconds.

If selenium is present in the sample, a red mirror will appear on the cool surface of the small pyrex tube just below the white coating of SO_3.

← not expected

If (considerable sulphides are) present, the yellow sulphur coating will mask the red mirror of selenium, and the method followed is:

The sample is powdered and 4 parts of sodium peroxide are mixed with 1 part of sample in the iron crucible. This is brought to a melt for a few seconds, after which the melt is poured onto the steel plate and allowed to cool. The button is broken into four parts. One quarter of the button is then tested as in the first part of the method.



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Map No. 1