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SUPPLEMENTARY REPORT ON BUNN-DENNISON URANIUM PROSPECT, NEW MEXICO

INTRODUCTION

After my examination of this property in May, 1954, Messrs. Quirk, Scharon, Ellett and myself decided that a number of further steps should be taken in an effort to evaluate it. On July 30 Mr. Ellett reported to me by telephone results of this further work, accomplished since the writing of my report of June 23, 1954; all recommended steps have been carried out except that involving correlation of results of the scintilator with those of the geiger counter.

The present report summarizes results of these steps and attempts to evaluate them.

SUMMARY AND ANALYSIS OF RECENT WORK

1. Bulldozing Lower Radioactive Horizon.- The series of cuts perpendicular to the strike of the formation originally proposed were found impracticable; instead a longitudinal cut, similar to the earlier one on the Upper horizon and 340 ft. long was made, starting, I believe, at the "hot spot" uncovered by Ellett and extending southward, in which direction the Lower horizon thickens.

The work disclosed some interesting stratigraphy: a lens of gray shale lies just below the horizon of the "hot spot", extending southward 100 ft. and with a maximum thickness of 6 ft. Below the shale lies 5 ft. of sandstone, immediately above the contact of the shale from which most of the north-south valley seems to be carved. At or near the base of the radioactive horizon occurs also a horizon of limestone, in places a series of limestone balls or boulders, but elsewhere a solid bed 1 ft. thick.

It is unfortunate that the longitudinal cut failed to expose the entire Lower radioactive horizon; but the presence of gray shale intercalated in the sandstone and presumably bleached sounds favorable, and the limestone, although thin, is a point of resemblance with the Jack Pile mine in the Grants district.

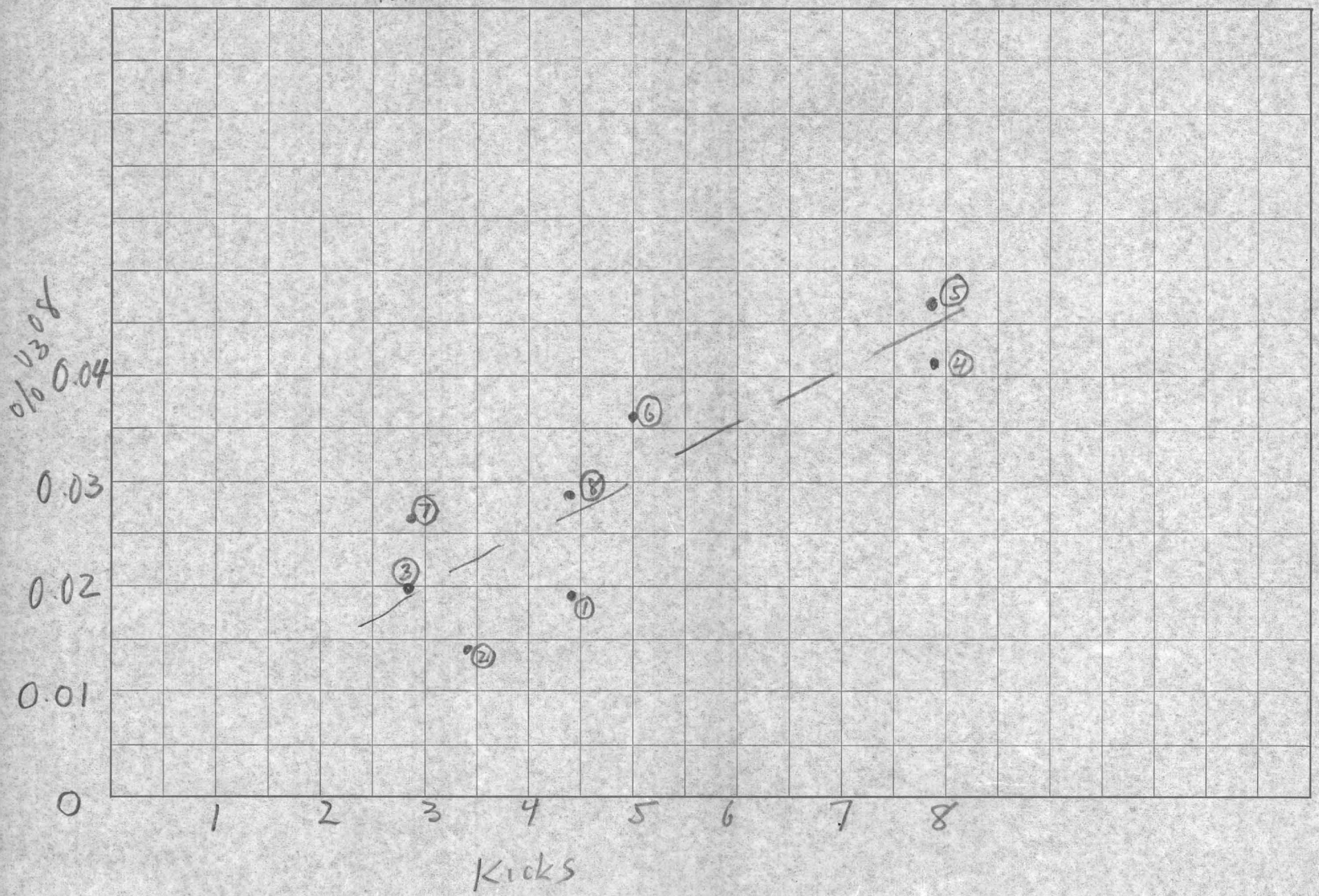
2. Comparison of U_3O_8 Content with Scintilator "Kicks".

Eight samples were cut along the longitudinal bulldozer cut along the Lower radioactive horizon.

Sample	Location	Width	% U_3O_8	Scintilator reading x background
1	N end	2.5'	0.019	4.4
2	25'S	3.5	0.014	3.3
3	50'S	5.5	0.020	2.8
4	75'S	3.5	0.041	7.8
5	100'S	4.5	0.047	7.8
6	125'S	5.0	0.036	5.0
7	317'S	5.0	0.026	2.8
8	338'S	4.5	0.028	4.4

NO. 31,185. CENTIMETERS BOTH WAYS. 15 BY 23 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS

Correlation of U_3O_8 Content with scintilator "Kicks"



As shown on the accompanying chart, there is an approach to a straight-line relationship between U3O8 content and scintilator counts, and the median line through the points heads toward zero.

3. Comparison of Scintilator "Kicks" with Schroekingerite Content. Scintilator readings were taken at 10 stations, 50 ft. apart, along the Upper radioactive horizon. By use of the fluorescent lamp, the percentage of schroekingerite by volume was estimated at each station. Results show no relationship whatever between the two variables, the highest scintilator readings corresponding for the most part to the lowest schroekingerite content.

Analysis of Items (2) and (3). The suggestion is strong that a source of radioactivity other than schroekingerite exists, although the evidence would have been stronger had procedure (3) been conducted on the Lower horizon. While this report was being written Mr. A.I. Rodriguez, consulting mining engineer, called upon me. He held an important position with Union Carbide on the original Manhattan Project at the time I served with them, and has kept in touch with uranium developments since. At present he is exploring by drilling a coal deposit near Farmington, N.M. The A.E.C. probes his bore holes with a scintilator. According to Rodriguez, the A.E.C. has discovered that many positive scintilator anomolies are caused by feebly-radioactive feldspars in arkosic sandstone, and that while these never make a commercial deposit, such radioactive areas often do indicate the proximity of a commercial uranium deposit. I had never heard of this supposed fact before; it should be checked at once with the A.E.C. or Geological Survey. Certainly if true this would explain the most puzzling feature of the Bunn-Dennison prospect, i.e. the failure of schroekingerite to account for scintilator anomolies.

4. Lime Content of Radioactive Sandstones. A number of samples from the Upper and Lower horizons were analysed for CaCO3, to see whether the sandstones were generally limy, which if so might account for the fixation of uranium as schroekingerite. No consistent relation exists between lime content, on the one hand, and schroekingerite content on the other.

5. Radiometric Survey of Balance of the Property. Mr. Ellett flew an extensive stretch of the Morrison outcrop, both north and south, I believe, of the segment dealt with above. The latter segment showed up well from the air, giving a scintilator anomoly of 2.8 times background. Only two other, much smaller anomolies were disclosed. This seems to prove that work has been concentrated on the most promising portion of the property.

6. One recommendation not agreed on in the conference of last May but added in my report of June 28, 1954, has not, so far as known, been acted upon: to make a radiometric survey of the Chinle formation. I still believe this should be done.

CONCLUSIONS

It must be confessed that results of this recent work are still inconclusive; on the whole, I think them moderately encouraging. Before bulldozing the Lower horizon average scintilator anomoly, largely or wholly along the Upper horizon, was as I recall about three times background. Average anomoly for the exposed stretch (340') along the Lower horizon is 4 times background.

The rough correlation between U_3O_8 content and scintilator anomoly along the Lower horizon, together with the lack of correlation between scintilator anomolies and schroekingerite content shows that the prospect is more than a schroekingerite deposit; such deposits as far as known have never made commercial mines. If as seems possible a portion of the anomolies springs from radioactive feldspars in the arkosic sandstone of the radioactive horizons, and if radioactive feldspars indicate the proximity of ore, the prospect would seem to merit further exploration. Even though the feldspar theory be found to be unsound, the mere fact that all the radioactivity exhibited cannot be accounted for by the sporadic schroekingerite seen is a point in favor of the prospect.

Additional favorable features are the presence of the prospect upon a regional uplift, bleaching and staining, and the presence of intercalated shale or mudstone, together with limestone, in the Lower horizon; and of course an average scintilator anomoly 4 times background along a stretch 340 ft. long.

Adverse features are the lack of carbonaceous "trash", of strong cross-bedding, conglomerate-filled stream channels etc.

Balancing favorable with unfavorable features, chances are probably against the prospect making a mine. The same holds for almost any prospect. The cardinal rule in exploration for mines is that possible gains must be commensurate with the stakes involved: the less favorable the prospect the higher should be the possible returns in proportion to the money spent in proving or disproving the showing. Where this correct proportion holds, the wildest wildcat may be worth exploring.

Mr. Ellett tells me that the two radioactive horizons may be explored 200-400 ft. down their dip from the outcrops by about 10 churn drill holes at a cost of about $6000. When possible financial returns from a commercial uranium deposit are considered, such an expenditure seems entirely warranted: surely 10 drill holes should prove or disprove the property.

RECOMMEDATION

I recommend that the option on the Bunn-Dennison property be excercised, i.e. that the owners be notified of your intent to drill the property, and that a drilling campaign be started. The first holes should be rather widely spaced and designed to cut the two horizons about 200 feet down the dip from their outcrops. Further drilling would depend on results from these holes.

E.W.

Edward Wisser

Berkeley, Calif.
July 31, 1954

August 1, 1954

Mr. Gloyd M. Wiles
Manager, Mining Department
National Lead Company
111 Broadway, New York 6, N.Y.

Dear Mr. Wiles:

On July 30 Messrs. Quirk and Ellett called me from Grand Junction and described in detail results of recent work on the Bunn-Dennison prospect, New Mexico. Mr. Quirk informed me that a decision whether or not to explore the property must be forthcoming by August 3rd, and asked me to be prepared to give him a yes-or-no recommendation by today. Accordingly I spend yesterday reviewing new and old data. When Mr. Quirk called me today I read him the gist of the enclosed Supplementary Report (two copies enclosed). He wrote down the essential points and therefore asked me to send you both copies.

I hope that this report makes my position clear with respect to the Bunn-Dennison prospect.

Very truly yours

Edward Wisser

August 30, 1954

National Lead Co.
111 Broadway
New York 6, N.Y.

To Edward Wisser, Dr.,

To professional services, consultation, analysis of data, preparation of supplementary report on Bunn-Dennision prospect,
July 30, 31, August 1, 1954.....$250.00

June 23, 1954

Mr.Gloyd M.Wiles
Manager, Mining Department
National Lead Co.
111 Broadway,New York 6,N.Y.

Dear Sir:

I am sending airmail today one copy of my report;a second copy follows by first class mail.

You will find the report rather comprehensive,and this distufbs me a bit,because I was not commissioned to prepare any such report. But I found it impossible to render any judgment on the Bunn-Dennison prospect without spending some time in a review of the geology of Colorado Plateau uranium deposits. It is my hope that some of the facts and possibilities brought out might aid your men in the field, who seldom find time to make the kind 66 correlation study I have ventured on.

Statement of account is enclosed.

Very truly yours

Edward Wisser

June 23, 1954

National Lead Co.
111 Broadway
New York 6, N.Y.

To Edward Wisser, Dr.,

To professional services, examination of uranium properties, 4 days @ $150	$600.00
Office research and preparing report, 7 days @ $100	700.00
Expenses (account attached)	160.44
	$1460.44

EXPENSE ACCOUNT OF EDWARD WISSER, NEW MEXICO-UTAH TRIP, MAY-June,1954

Roundtrip plane ticket, San Francisco-Albuquerque.....		$120.78
May 28	Taxi,limousine.....	3.00
June 1	Breakfast,lunch, tips.....	4.50
	Hotel,Albuquerque.....	28.66
June 20	White prints,staionary etc.....	3.50
		$160.44

600
700

NATIONAL LEAD COMPANY

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No. 27275

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REPORT ON THE

BUNN-DENNISON URANIUM PROSPECT

SANDOVAL COUNTY, NEW MEXICO

Edward Wisser

June 23, 1954

SUMMARY STATEMENT

The Bunn-Dennison prospect lies along the steep western flank of the long and relatively narrow Nacimiento Uplift. Two horizons in the Morrison formation show spotty radioactivity distributed over lengthy stretches of outcrop.The only uranium mineral recognized is schroekingerite, a far-travelling oxidation product.

While certain chemical features such as favorable iron-staining, and bleaching of shale suggest the proximity of ore, sedimentary structure and makeup is less favorable,obvious channels,cross-bedding and other scour-and-fill features characteristic of commercial ore deposits being poorly developed. Carbonaceous "trash",also typical of known ore deposits,is apparently lacking. The Nacimiento Uplift,also, does not resemble very closely uplifts with which many known deposits seem to be associated.

On the other hand, some uranium is present,the district is virgin and far removed from known deposits,and empirical criteria for ore may not wholly apply here. Some theoretical considerations suggest the possibility that ore deposits may exist.

It is recommended that if radiometric surveys of the Lower radioactive sandstome horizon,now being cleared of talus by bulldozer,should prove encouraging,both the Upper and Lower radioactive horizons should be drilled. The amount of drilling will,of course, depend on results of the first few holes.

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ILLUSTRATION

STRUCTURAL MAP SHOWING URANIUM DEPOSITS OF THE COLORADO PLATEAU REGION: In flap at end of report.

REPORT ON BUNN-DENNISON URANIUM PROSPECT, SANDOVAL COUNTY, NEW MEXICO

INTRODUCTION

The Bunn-Dennison prospect presents the puzzling feature that while radiometric surveys indicate considerable radioactivity in two horizons of the Morrison formation, visible uranium-bearing minerals are limited to schroekingerite and chemical analyses of samples cut from the radioactive horizons indicate extremely low U_3O_8 content. The writer was called in consultation in an attempt to solve this riddle, and examined the property May 29, 1954, in company with Messrs. Quirk, Scharon and Ellett of National Lead Company.

In order to obtain some basis upon which to judge the Bunn-Dennison showings, a visit to the Grants uranium field was made on the following day in company with the same gentlemen. On May 31 Messrs. Quirk, Scharon and the writer paid a short visit to the Lucky Jack mine, White Canyon, Utah, and inspected general features of the Big Indian Wash and Lisbon Valley.

Upon my return from the field trip I have felt it necessary to make a rapid office review of developments in exploration for uranium in the Colorado Plateau region since my brief participation in such work some 12 years ago. A prospect which shows no ore can be evaluated only in the light of analogous occurrences and of general principles derived from study of the mineralized region as a whole.

In the following description of the Bunn-Dennison property I have drawn freely on a report by R. D. Ellett, dated May 31, 1954, and on verbal communications from the gentlemen mentioned.

GEOLOGY

The Bunn-Dennison prospect lies on the steep western slope of the long and relatively narrow Nacimiento Uplift (see accompanying Structural Map). Rock formations on and near the property dip about 45° west; the dip flattens rapidly in the large plain west of the property and probably steepens to the east, toward the crest of the uplift.

The sedimentary strata on and west of the property form a typical hogback, the relatively gentle western slope of which is formed on the resistant Dakota sandstone. The eastern slope is a steep erosional scarp, forming the west wall of a north-south valley carved in soft rocks, probably those of the Lower Morrison and Summerville formations. A spine of relatively resistant Todilto gypsum crops out in the valley floor. To the east the hogback structure resumes on a larger scale, exposing successively the Wingate, Chinle and Yeso formations and culminating at the crest of the Nacimiento Range, where the Nacimiento or New Mexico fault brings the Precambrian core of the uplift, on the east, against the Permian Yeso formation on the west. The fault is probably of the reverse type, dipping steeply east.

The steep east flank of the western hogback forms a dip-in slope upon which the members of the Morrison formation are exposed as in a longitudinal section, although talus, especially toward the foot of the slope, considerably obscures the picture.

The base of the Dakota sandstone caps this slope. Below the Dakota are some 200 feet of green and red shale with intercalated sandstone lenses, correlated by Ellett with the Brushy Basin member of the Morrison, and underlain by white to tan sandstone, varying in thickness from

10 to 90 feet. This unit is tentatively correlated with the Westwater Canyon unit of the Morrison. It is here called the Upper radioactive horizon.

Below this unit are 50 to 130 feet of green shale which may correspond to the Recapture Creek member of the Morrison. Underlying the shale is a brownish sandstone unit 20-90 feet thick which may be Lower Morrison in age, or may correspond to the Bluff formation of the San Rafael group which underlies the Morrison. It is here called the Lower radioactive horizon. Underlying this horizon is green shale, at the toe of the dip-in slope. East of the toe valley wash separates the shale from the spine of Todilto gypsum mentioned.

The Upper radioactive sandstone unit is thickest at the north end of the stretch of outcrop examined, thinning and splitting toward the south. The Lower radioactive sandstone member does just the reverse, being thinnest below the thickest portion of the Upper horizon, and thickening toward the south, where the Upper horizon thins and splits.

Where bulldozing has exposed the Upper horizon in its thicker, northern segment, what appears to be schroekingerite occurs along joint planes, and in places disseminated through the sandstone, which here is fine- and equigranular and somewhat arkosic, exhibiting feldspar grains. A white, earthy material coats quartz and feldspar grains.

Gypsum is also common along joints. Irregular seams of red iron oxide occur, together with "worls" or "rolls" of the same. In places the sandstone is peppered with limonite spots suggesting former disseminated pyrite. According to Ellett, iron oxide and gypsum show relatively higher radioactivity than the surrounding sandstone.

Cross-bedding is not prominent in the Upper horizon sandstone; "trash", consisting of carbonized wood, clay galls and pellets etc.,

and associated with many uranium deposits of the Plateau region,is notably absent,at least in the Upper radioactive horizon.

The Lower radioactive horizon was seen at only one place where a square foot or so had been exposed with a pick. Here the sandstone was highly ferruginous and is said to show relatively high radioactivity.

It is my recollection that shale and clay beds underlying the radioactive sandstone units and ordinarilly red or green in color,are bleached gray where radiactivity in the nearby sandstone is relatively high;also that where general rock stains change,going north,from tan or brown to red,radioactivity drops radically.

RADIOACTIVITY

Geologic and radiometric cross-sections were made at 200-foot intervals along the strike of the formations;radioactivity was investigated with the scintillation counter.

Results show that the two sandstone horizons are not everywhere radioactive and that where they are intensity seems concentrated near their bases. With both horizons radioactivity is at a maximum where the sandstone unit thickens;in the case of the Upper horizon,toward the north,with the Lower horizon,toward the south.

As I understand it,while stretches along the two horizons showing anomolies are long (aggregating perhaps 2420 feet according to Ellett) the anomolies are not large over the greater part of such stretches, perhaps on the order of three times normal background. Within the anomolous stretches however,isolated sharp peaks occur.

SIGNIFICANCE OF SCHROEKINGERITE

Since most uranium deposits are notable for the diversity of uranium minerals present, the fact that schroekingerite alone has been identified at the Bunn-Dennison prospect must be significant.

According to Stugard, Wyant and Gude[1] the complex carbonate-sulphate

1. F.Stugard Jr., D.G.Wyant, A.J.Gude 3rd: Secondary uranium deposits in the U.S., in Selected Papers on Uranium Deposits, U.S.Geol.Surv.Circ. 220, 1952, p.19-25.

schroekingerite is the farthest-travelling, most extreme oxidation product of the weathering and solution of other uranium minerals. Solutions forming it are capable of travelling several hundred feet, at least, from its source.

At Sanastee, New Mexico, a uranium district on the extreme northeast flank of the Defiance Uplift (see Structural Map) Droullard and Jones[2]

2. R.F.Droullard, E.E.Jones: Investigation of uranium deposits near Sanastee, N.M., A.E.C. RMO-909, 1951.

state that schroekingerite is found above, within and below the ore deposits, which consist of carnotite-type minerals, and that the schroekingerite may represent a redeposited form of the uranium originally emplaced as carnotite.

While solutions forming schroekingerite are the most mobile of all connected with weathering and solution of uranium deposits, the mineral itself is the most stable under conditions of weathering. Thus at Marysvale (Reference 1) where pitchblende occurs in hydrothermal veins, schroekingerite is the sole uranium mineral in many outcrops and spreads several hundred feet into the wall rock, being succeeded at depth by uranophane, autunite and torbernite and, near the water table, by pitchblende.

Thus at the Bunn-Dennison prospect, while the schroekingerite may represent merely extreme oxidation and dissipation of a few scattered,

very small carnotite or pitchblende deposits, there is a more encouraging possibility, namely, that it represents the end-product of extreme leaching of an ore deposit which formerly cropped out in the present exposures. Since schroekingerite solutions have the ability to climb as well as travel laterally or downward, it may even be possible that the former top of any ore body present may lie somewhat below the present surface. (It seems to me unlikely that the Bunn-Dennison schroekingerite represents downward leaching from a former ore body now eroded).

In order to decide which of the two alternatives mentioned is the more likely to be the true one, it is necessary to determine whether any physical features suggest that an ore body was formerly present in exposures on the Bunn-Dennison prospect.

EMPIRICAL ORE GUIDES

Experience has led to formulation of a number of physical ore guides for the uranium deposits of the Plateau region. Such empirical guides apply well in the districts in which they were derived, but become less certain, the farther away the area in which their application is attempted. The nearest known uranium deposit in the Morrison formation lies about 60 miles from the Bunn-dennison prospect.

The following guides for ore in the Morrison formation are compiled from a number of sources. They apply largely to the Uravan area, where major ore deposits are confined to the basal Salt Wash member of the Morrison. The Salt Wash is lacking in New Mexico; in the Grants district ore deposits are found in the upper Westwater and the Brushy Basin members. Criteria derived from deposits in the Salt Wash should therefore be applied elsewhere with caution.

1. Ore-bearing sandstone lenses are lenticular,and the ore occurs in the thickest part of the lenses,optimum thickness being 30 to 50 feet. With ore deposits near the base of the Shinarump,and probably with those near the base of the Chinle,the lenticular structure is furnished by channels scoured from the underlying formation, and filled similar channels exist,and control ore,in the Salt Wash,but they do not lie at the base;they are scoured structures in sand and filled with sand,and may be determined only by an interruption in the bedding and sometimes by thin,gray mudstone partings at the bottom and on the sides of a channel[3]. Such channels,or the thickest portions of lenses,seem

3. W.I.Finch: Geologic aspects of the resource appraisal of uranium deposits in pre-Morrison formations of the Colorado Plateau, U.S. Geol.Surv. TEI-328-A, 1953.

to have provided maximum permeability and porosity for ground water and/or hydrothermal solutions.

2. The normal color of the Salt Wash is reddish or pinkish. Sandstone enclosing ore deposits is pale to light yellow brown,speckled with limonite stain,the favorable staining extending several hundred feet beyond ore deposits.

3. Ore-bearing sandstone is interbedded with mudstone,and contains thin lenses of mudstone and mudstone-pebble conglomerate. The normally red mudstone,both within the ore sandstone and just beneath it,is altered to gray.

4. Ore horizons are commonly signified by the presence of relatively abundant carbonized plant remains,the "trash" of the miners. A number of deposits,however,have been found unassociated with "trash".

The Geological Survey in evaluating prospects assigns each of these main ore guides a relative weight of 25%,the critical percentage

being 55. It is interesting to compare commercial deposits in the Grants area with the showings on the Bunn-Dennison prospect, although data for neither area are complete enough to make the comparison worth much. The following table attempts to rate these areas on the basis of their exhibition of the four ore guides.

Ore Guide	Grants Area	Bunn*Dennison Prospect
1	20%	10%
2	20%	20%
3	20%	12%
4	25%	--
	85%	42%

It may be noted, first, that criteria for the Salt Wash seem to apply to the Westwater member of the Morrison as well, as demonstrated at Grants.

With regard to Bunn-Dennison ratings, these are based entirely on the Upper horizon, since the Lower horizon is very poorly exposed.

Ore Guide 1.- While the best radiometric anomolies in both horizons occur where the units are thickest, the latter are not markedly lenticular, tapering very gradually from their thickest portions, which are themselves elongated. Finch (Ref.3) states that it is not so much the absolute thickness as the rate of change of thickness i.e. the "fatness" of the lens that favors ore. Further, at the Bunn-Dennison prospect the Upper horizon shows little scour-and-fill structure, cross-bedding etc. that mark favorable sandstone units elsewhere. The rating of 10% may be generous.

Ore Guide 2.- This criterion of staining seems to be met, especially, in all probability, by the Lower horizon.

Ore Guide 3.- While no mudstone, clay gall horizons etc. were noted within the sandstone of the Upper Horizon, the underlying shale is bleached as required by this criterion.

4. No carbonaceous "trash" was noted. However, dark mottled or speckled rock was observed which might possibly represent weathered hydrocarbon.

GENERAL CONSIDERATIONS

One or two general considerations may apply in an attempt to evaluate this prospect.

Stratigraphic Position of Radioactive Horizons.- Ellett has tentatively identified the Upper horizon with the Westwater Canyon member of the Morrison, a productive horizon in the Grants district; if correct, this is a point in favor of the prospect. The Lower horizon has been provisionally assigned to the Bluff division of the San Rafael group underlying the Morrison. So far as I know, the Bluff is not known to carry ore, but, given the right physical characteristics, I see no reason why it could not be an ore-bearer.

Thickness of the Morrison.- The Morrison formation at the prospect is probably little over 200 feet thick, possibly 300 feet. It seems to be considerably thicker in the Grants area; certainly the individual sandstone units are much thicker than at the prospect. A study of Morrison stratigraphy in relation to carnotite deposits[4] brings out

4. L.C.Craig et al.: Preliminary report on the stratigraphy of the Morrison and related formations of the Colorado Plateau region, U.S. Geol.Surv. TEI-180,1951.Isopah Map,Fig.12;ore deposit map,Fig.13.

the fact that few important ore deposits have been found where the formation is less than 600 feet thick, and none where it is less than 400 feet thick. It may be that where the whole formation is thin individual sandstone units are too thin to carry ore.

Incidentally, placing the Bunn-Dennison prospect on the isopachous map of Ref.4 shows that the Morrison should be over 600 feet there. The measured thickness was 600 feet at a point 20 miles south of the prospect

and 500 feet, 40 miles to the northeast, where the formation should be thinner than at the prospect. This suggests that the Lower horizon may belong in the Morrison,or,which seems more likely, that the Nacimiento uplift area was a structural high during deposition of the Morrison and probably earlier.

This local thinning of the Morrison might be tentatively considered a point against the prospect.

Relation of Colorado Plateau Uranium Deposits to Structure.- The Structural Map suggests but does not prove a relation between uranium deposits and uplifts. For one thing, ore-bearing formations are exposed on domical and anticlinal structures,tend to be buried in basins and synclines. Nevertheless, many linear miles of Morrison outcrops in neutral areas(neither domes or basins) are,as the map shows,apparently barren. Miles of similar outcrops on swells are barren also,but it does seem a fact that where the Morrison carries ore deposits,the latter are far more likely to lie on an uplift than in a neutral area.The relatively minor ore deposits on the east flank of the Henry Mountains lie on the east rim of a sharp basin.

On the other hand,the newly-found deposits in the belt of Chinle between Cameron and Holbrook, in northeast Arizona, show little or no relation to structure. The Jack Pile mine,also,seems to lie in a neutral area between the Lucero uplift and the San Juan Basin.

The most convincing evidence to me of structural control of some obscure kind is furnished by the "Mineral Belt" in the Uravan productive area. (Shown stippled on the map). Within this belt,which contains nearly all major ore deposits of the area, individual deposits are elongated east-west,transverse to the belt,and so are fossil logs and ore"rolls",both of which indicate the direction of the Morrison stream

channels[5].

5/R.P.Fischer, L.S.Hilpert:Geology of Uravan Mineral Belt, U.S.Geol.Surv.Bull.988-A,1952.

At its northern end the Uravan Mineral Belt trends subparallel to the structural grain of the complex Uncompahgre Uplift,which includes the Salt Valley Anticline, Lisbon Valley Anticline,Paradox Graben etc. Over most of of its course however the Mineral Belt lies nearly normal to the uplift and to the many normal faults along its crest.

The Uravan Mineral Belt is reminiscent of the Colorado Porphyry Belt between Boulder and Leadville,and probably extending southwest of Leadville (see map). This belt,which carries silver-lead-zinc ores at its southwest end, gold-tungsten-uranium ores toward its northeast end, is no continuous fault or fissure,but is made up of a series of en echelon northeast fractures and a more important series of northwest fractures,developed only within the narrow northeast belt. Clearly some hidden earth flaw at depth is involved.

The "favorable areas" of Finch (Ref.3) for ore deposits in pre-Morrison formations also suggest structural control (areas are colored red on the map). The northern area at its west end crosses the San Rafael Swell perpendicular to the major axis of that structure and includes the Temple Mountain mine. Extension of this belt east to the Cane Creek anticline is speculative;but a favorable belt certainly includes that anticline and the Lisbon Valley anticline southeast of it.

Finch's central favorable belt trends nearly normal to the major axis of the Monument Uplift,while his southern belt shows a radial relation to the plunging south end of the uplift.

Bucher[6] makes a fairly convincing case for ore localization on the

6. W.H.Bucher:Fracture studies in the Zuni and Lucero uplifts, New Mexico, A.E.C. RME-3042:Annual report for June 15,1952 to April 1, 1953, Part I.

Zuni and Lucero Uplifts by joint systems genetically connected with those uplifts and suggests that uranium was introduced by hydrothermal solutions ascending hidden major fractures in the basement and utilizing joints in the domed sedimentary cover for rapid advance in the sediments

In the case of the Lucero Uplift,part of the basement major fracture may be represented by the major fault bordering that uplift on the east, resembling somewhat the Nacimiento fault. Faults are the normal expression of vertical deformation in the crystalline basement,while the same deformation is expressed by domes,anticlines,relatively minor faults and joints in the sedimentary cover. In the Plateau region, any dome or anticline may overlie a major basement fracture or fault;where the dome or anticline is assymetric,it is extremely probable that the steep side,if straight,is the cover expression of a basement fault.

While not well shown on the accompanying map,the southeast flank of the San Rafael Swell is steep and straight and probably overlies a basement fault striking northeast. The Temple Mountain mine which lies close to this flank is one of the few deposits showing obvious fracture control.

Again,the string of mines and prospects,including the Mi Vida mine, along the southwest rim of the Lisbon Valley and paralleling the Lisbon Valley fault suggests that the fault zone might have been a major channel for hydrothermal solutions,if the origin of these ores is hydrothermal.

Obviously,these and other apparent relations to structure are fallacious and coincidental if the uranium ores are purely syngenetic.

Genesis of Colorado Plateau Uranium Ores.- There are at present two extreme, opposing theories and one intermediate theory embracing the two.

1. The Syngenetic Theory. This is held by Fischer, Bain, Gruner and most earlier workers and postulates that the uranium deposits were forme by groundwater solutions migrating through ore-bearing beds, probably soon after deposition of the sediments, and collecting and concentrating uranium, vanadium and their accessory elements.

2. The Epigenetic or Hydrothermal Theory. This is supported by Benson,

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7. W.E.Benson et al.: Preliminary report on the White Canyon Area San Juan Co., Utah, U.S.Geol.Surv.Circ.217, 1952.

Bucher (Ref.6) and a number of others and holds that the deposits were formed by hydrothermal solutions ascending from depth, probably along major flaws in the basement.

3. The Compromise Theory. One phase of this was advanced by Waters and Granger[8], who believe the uranium, vanadium and other metallic elements were locked up in glassy, explosive volcanic material associated with the normal, non-volcanic components of the Shinarump and Salt Wash beds, and that these elements were released by devitrification and entered, to a greater or less extent, the connate water in these formations. Such water could not, however, circulate owing to lack of hydrostatic head produced by uplift plus the presence of impermeable rocks above and below the ore-bearing horizons.

8. A.C.Waters, H.C.Granger: Volcanic debris in uraniferous sandstones etc. U.S. Geol Surv. Circ. 224, 1953

In the early Tertiary (Laramide) pronounced deformation was accompanied by intrusion and hydrothermal activity. The resulting tectonic changes in elevation supplied a hydrostatic head to activate groundwater circulation, which was further stimulated by opening of joints and faults through previously impervious formations, and by the entry of hot magmatic waters, which contained, perhaps, additional uranium, vanadium etc.

The rejuvenated and reinforced groundwater, actively circulating, would at first collect the uranium and vanadium in the connate water and in the sediments, and transport it; but mixing of the cool connate water with the hot magmatic water would lower the temperature of the combination and induce precipitation; the connate water itself was strongly reducing in nature. Solutions passing through permiable channels such as fossil channels, thicker parts of lenses etc., and encountering carbonaceous "trash" would quickly drop their load.

It may be noted that both Theory 2 and Theory 3 involve structural control.

The most potent argument against Theory 1, the syngenetic theory, is the age of the uranium deposits. According to Stieff[9] the uranium

9. L.R.Stieff et al.: Preliminary determination of the age of some uranium ores of the Colorado Plateau by the lead-uranium method, U.S. Geol.Surv. TEI-330, 1953. Also, Stieff at al.: Isotope geology of the Colc TEI-330, 1953.

deposits in the Shinarump and those in the Salt Wash member of the Morrison are of the same age, 65,000,000 years or less. The approximate age of the Morrison is 127,000,000 years while that of the Shinarump is 152,000,000 years.

An age of 65,000,000 years corresponds closely to that of the Laramide deformation (close of Cretaceous-beginning of Tertiary). Most of the domical structures of the Plateau date from this period, although the Uinta and San Juan basins formed mainly somewhat later.

This writer is attracted to the general concept of Theory 3. Use of the theory as a working hypothesis in exploration seems worth a trial. Such use would involve (1) delimitation of areas wherein syngenetic deposition of uranium in the various known ore-bearing horizons is indicated or seems probable. (2) Within these areas, search for any plausible structural control which might further contract the area to

be explored. Step (1) would involve study of sedimentary structures, channels, lenses, cross-bedding etc., and of the makeup of sediments, the proportion of sandstone, interbedded clay seams and clay conglomerates,"trash" etc.,following the methods of Fischer,Bain and others. The structures of Step (2) would include not only joints,faults etc., but minor anticlines and synclines and "rolls" (Grants area) together with the spatial relation of the area to major structures. It is my impression that ore favors,not the steeper but the flatter portions of major domes and anticlines.

CONCLUSIONS

Results of bulldozing the Lower Bunn-Dennison horizon and those of the further geophysical exploration planned,which are not at hand, may render the following conclusions invalid.

From the standpoint of empirical ore guides,the Bunn-Dennison prospect rates only half as highly as do the commercial uranium deposits in the Grants area. Radiometric anomolies so far disclosed are far from startling,but are clearly of interest.

The Nacimiento Uplift is long and relatively narrow and is of a different shape from those known to be productive. With the latter type the beds are flexed convex upward while at the prospect they show in section their concave sides upward,more in the manner of fault drag on the Nacimiento fault than in the manner of normal doming. According to Bucher (Ref.6) no ore has as yet been found along the steep,faulted side of the Lucero uplift.

On the other hand, uranium exists on the property.The district is virgin and ore controls valid elsewhere may not wholly apply here. If there is anything to either the Hydrothermal or the Compromise theory,the Nacimiento fault may well have been a channel for solutions involved in ore formation;nor does the Syngenetic theory necessarily

preclude the presence of ore here.

I am unable to reject this property on the basis of present data, and offer a qualified recommendation in its favor as brought out below.

RECOMMENDATIONS

The following specific operations were decided on by Messrs. Quirk, Scharon, Ellett and myself in Albuquerque last May 31:

1. Bulldozer cuts across the Lower horizon.

2. Correlating results of the scintillator with those of the Geiger counter, and results of both with those of the fluorescent lamp.

3. Extension of all this instrumental work to the south end of the property.

4. Bulldozer cuts in the southern area if results of (3) warrant it.

5. Chemical analyses of sandstone from the two horizons, for CaO and possibly for trace elements.

To these I add:

6. Radiometric survey of Chinle formation in case the property extends that far east, or is open there; perhaps in any case.

If exposure of the Lower horizon should reveal ore or near-ore, immediate development is indicated. If results are discouraging, I should feel inclined to drop the property. If consistent radioactivity comparable to that shown by the tiny bit of Lower sandstone exposed at the time of my visit is revealed, I recommend

7. Drilling both Upper and Lower horizons. While drilling should be opposite (west of) major anomolies in the outcrops, should be inclined to risk the drill holes some distance west, where the dips of

the strata decreases appreciably. If the Compromise theory (3) holds, reactivated groundwater may have utilized the two sandstone units, between impermiable shale, as artesian aquifers; if so the water flowed downward to the west. If ore-bearing, these solutions would tend to drop their load where the water-bearers flattened. The same applies to recent solution of any ore bodies formerly present in the steeper-dipping segments.

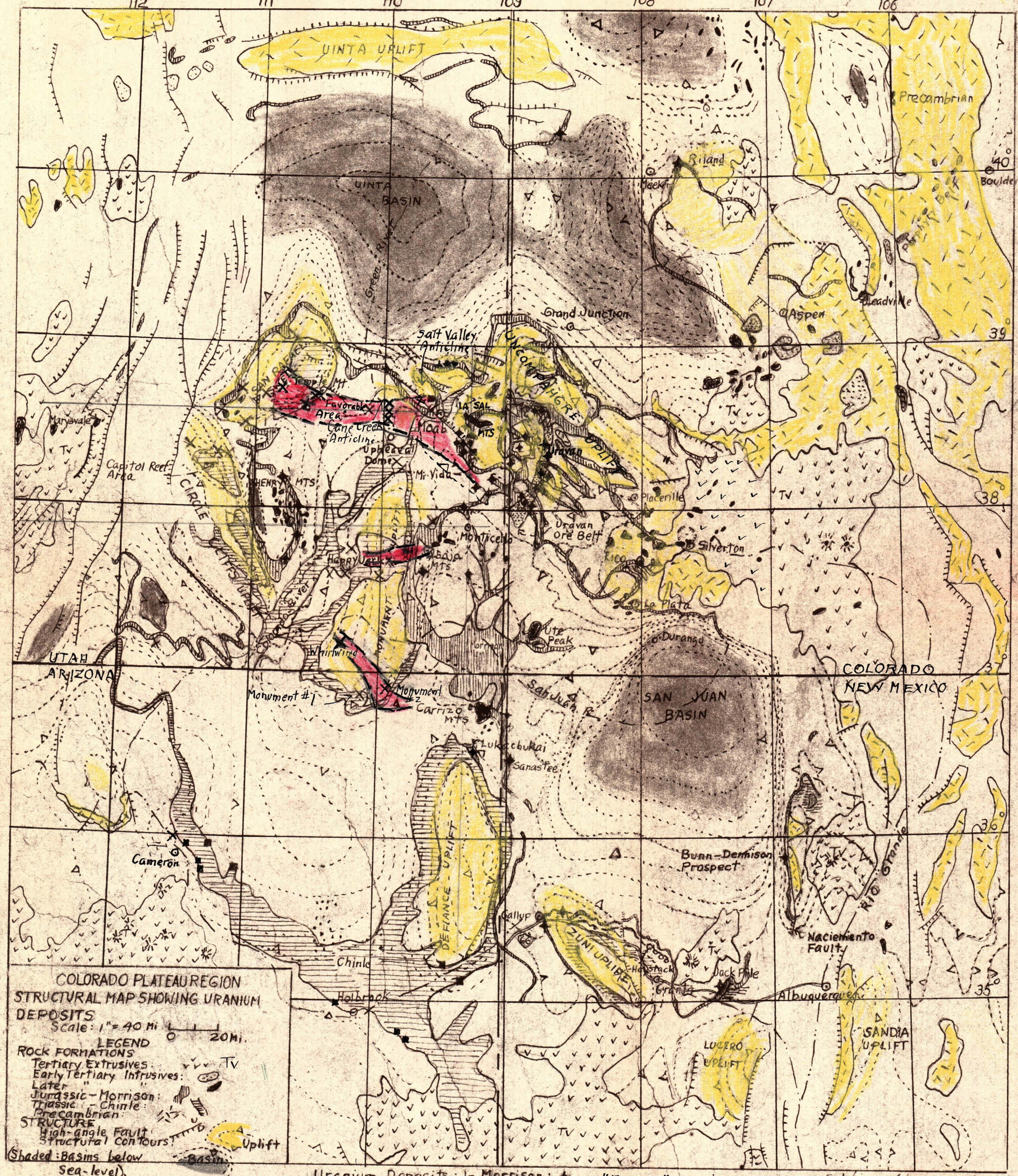
The western limit of such drilling may be determined by the western limit of the property.

Probably the first several holes should be by core-drill, to check the stratigraphy and furnish solid samples of the mineralization, if any.

E.W.

Berkeley, Calif.
June 23, 1954

Edward Wisser
Consulting Geologist


E.W.
112°
111°
110°
109°
108°
107°
106°
40°
39°
38°
37°
36°
35°
UINTA UPLIFT
UINTA BASIN
Green River
Precambrian
Riland
Meeker
Boulder
Leadville
Aspen
Grand Junction
Salt Valley Anticline
UNCOMPAHGRE UPLIFT
Temple Mt.
Favorable Area
Cane Creek Anticline
Moab
LA SAL MTS
Uravan
Upheaval Dome
Mi Vida
Maryvale
Capitol Reef Area
CIRCLE CLIFFS UPLIFT
HENRY MTS
Placerville
Uravan Ore Belt
Monticello
Silverton
Happy Jack
Abajo Mts
Rico
La Plata
Durango
Ute Peak
Whirlwind
MONUMENT UPLIFT
UTAH
ARIZONA
COLORADO
NEW MEXICO
Monument #1
Monument #2
Carrizo Mts
San Juan R.
SAN JUAN BASIN
Lukachukai
Sanastee
Cameron
DEFIANCE UPLIFT
Bunn-Dennison Prospect
RIO Grande
Gallup
ZUNI UPLIFT
Haystack
Jack Pile
Grants
Naciemento Fault
Chinle
Holbrook
Albuquerque
LUCERO UPLIFT
SANDIA UPLIFT
COLORADO PLATEAU REGION
STRUCTURAL MAP SHOWING URANIUM DEPOSITS
Scale: 1" = 40 Mi
0 20 Mi.
LEGEND
ROCK FORMATIONS
Tertiary Extrusives: Tv
Early Tertiary Intrusives:
Later "
Jurassic - Morrison:
Triassic - Chinle:
Precambrian:
STRUCTURE
High-angle Fault:
Structural Contours:
Uplift
Basin
(Shaded: Basins below Sea-level).
Uranium Deposits: In Morrison:
" Todilto:
" Chinle:
" Shinarump:
"Favorable" Areas in Pre-Morrison Formations:
(Finch, 1953)
E. Wisser 6/54
Uravan Ore Belt:
(Fischer & Hilpert, 1952)