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URANIUM IN THE GAS HILLS AREA, FREMONT AND NATRONA COUNTIES, WYOMING -- A PRELIMINARY REPORT

By J. D. Love

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CONTENTS

ILLUSTRATIONS

TABLES

URANIUM IN THE GAS HILLS AREA, FREMONT AND NATRONA COUNTIES, WYOMING A PRELIMINARY REPORT

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ABSTRACT

Uranium minerals have been discovered in the Wind River formation of early Eocene age, strata of middle and late Eocene age, and the Thermopolis shale of early Cretaceous age in the Gas Hills area of central Wyoming. The localities of uranium mineralization were found independently by prospectors and by geologists of the Geological Survey; geologists of the Atomic Energy Commission have examined some of the deposits.

The uranium minerals are concentrated in clayey and conglomeratic sandstone and in carbonaceous shale. A sample of sandstone from the Wind River formation contained 1.87 percent uranium and a sample of carbonaceous shale from the Wind River formation contained 0.062 percent uranium. A sample of sandstone from the sequence of middle and late Eocene age contained 0.078 percent uranium. A sample from the Thermopolis shale directly overlain by the Wind River formation contained 0.041 percent uranium.

The uranium occurs chiefly in the form of a greenish-yellow highly fluorescent mineral tentatively identified as uranospinite, $Ca(UO_2)_2(AsO_4)_2 \cdot 8\text{-}12H_2O$.

Eight localities were examined and sampled. There are not sufficient data to make even rough estimates of tonnage and grade of the occurrences. The approximate boundaries of the area of above-normal radioactivity have not been determined, although areal reconnaissance has indicated a number of localities other than those described here where additional investigation is warranted.

INTRODUCTION

The Gas Hills area is located in eastern Fremont and western Natrona Counties, central Wyo. (see fig. 1). The area was examined in reconnaissance in 1951, using a Geiger counter. Because of the geologically favorable setting, it was re-examined with a scintillation counter in September 1953. With this instrument, abnormally high background radiation was noted throughout many square miles. Localities were found with sufficient radioactivity that samples were taken for chemical analysis. Also in September 1953, Mr. Neil McNeic of Riverton, Wyo., discovered radioactive sandstone in sec. 22, T. 33 N., R. 90 W. (Loc. 7 of this report). Mr. McNeic informed geologists of the Atomic Energy Commission, who spent several days sampling and examining the deposits at localities 7 and 8 (fig. 1). Early in October, 1953, Jenkins and Hand, consulting geologists, Casper, Wyo., used airborne scintillation-detecting equipment and located several anomalies 5 miles southwest of Mr. McNeic's discovery. During October 1953, many claims were staked by private individuals and

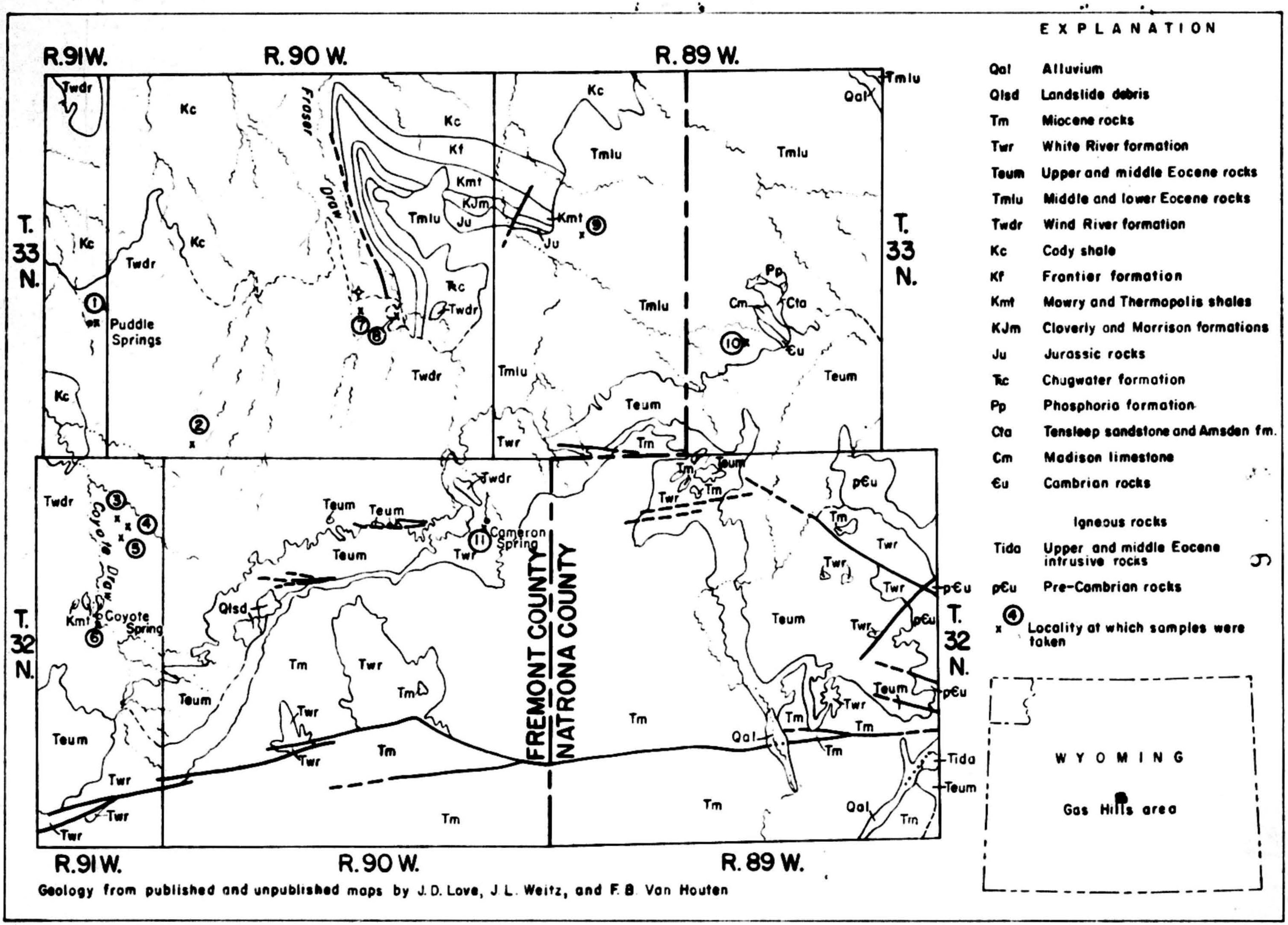

FIGURE I.-- GEOLOGIC MAP OF GAS HILLS AREA, CENTRAL WYOMING companies in the area shown in figure 1, and the area is being prospected as the weather permits.

N. M. Denson and the writer examined and sampled many of the deposits. Analyses made by the Denver Laboratory, U. S. Geological Survey are shown in table 1.

Stratigraphic and structural studies of the Wind River Basin including the Gas Hills, have been in progress by the U. S. Geological Survey since 1944. The following publications contain data on rocks in the Gas Hills area:

Love, J. D., Thompson, R. M., and others, 1945, Stratigraphic sections and thickness maps of Lower Cretaceous and non-marine Jurassic rocks of central Wyoming: U. S. Geol. Survey Oil and Gas Chart 13.

Love, J. D., Tourtelot, H. A., and others, 1945, Stratigraphic sections and thickness maps of Jurassic rocks in central Wyoming: U. S. Geol. Survey Oil and Gas Chart 14.

Love, J. D., Johnson, C. O., and others, 1945, Stratigraphic sections and thickness maps of Triassic rocks in central Wyoming: U. S. Geol. Survey Oil and Gas Chart 17.

Love, J. D., Tourtelot, H. A., and others, 1947, Stratigraphic sections of Mesozoic rocks in central Wyoming: Wyo. Geol. Survey Bull 38.

Thompson, R. M., Love, J. D., and Tourtelot, H. A., 1949, Stratigraphic sections of pre-Cody Upper Cretaceous rocks in central Wyoming: U. S. Geol. Survey Oil and Gas Chart 36.

Love, J. D., Weitz, J. L., and Hose, R. K., 1952, Geologic map of Wyoming: U. S. Geol. Survey map. The portion of this map covering the Gas Hills area is a synthesis of all available published and unpublished geologic maps.

The following unpublished studies include parts of the Gas Hills area:

Thompson, R. M., and White, V. L., 1952, Geology of the Conant Creek-Muskrat Creek area, Fremont County, Wyoming: U. S. Geol. Survey open file report.

Van Houten, F. B., Geology of the Beaver Divide area, central Wyoming: U. S. Geol. Survey Prof. Paper (in preparation). This study includes a detailed geologic map of post-lower Eocene rocks in the Gas Hills area, and the map was used in compiling the geologic map of Wyoming.

Van Houten, F. B., Volcanic-rich middle and upper Eocene sedimentary rocks northwest of Rattlesnake Hills, central Wyoming: U. S. Geol. Survey Bull. (submitted for publication).

Rachou, J. F., 1951, Tertiary stratigraphy of the Rattlesnake Hills, central Wyoming: Unpub. M. A. thesis, University of Wyoming.

Carey, B. D., Jr., Geologic map of the Rattlesnake Hills area, central Wyoming: Unpub. map. A generalized version of this map was used in compiling the geologic map of Wyoming.

Weitz, J. L., Geologic map of the Dutton Basin area, central Wyoming: U. S. Geol. Survey unpub. map (in preparation).

Topographic maps of the entire area were completed in 1953 by the Topographic Division of the U. S. Geological Survey and are available in preliminary form on a scale of 1:24,000, as the Gas Hills, Agate Butte, Black Mountain, Puddle Springs, and Coyote Springs 7.5 minute quadrangles with 20 foot contour interval.

The reconnaissance examination of the Gas Hills area was made on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

GEOGRAPHIC SETTING

The Gas Hills area lies along the southern margin of the Wind River Basin. The hills to which the name is applied are steep hogbacks of Mesozoic rocks on the north and west flanks of the Dutton Basin anticline. The Beaver Divide escarpment marks the southern boundary of the area and trends generally east. The steep north face of the Beaver Divide rises 300 to 800 feet above the Wind River Basin to the north. The lip of the escarpment is essentially the drainage divide between northward-flowing tributaries of the Wind River with high gradients and southward-flowing tributaries of the Sweetwater River with low gradients.

The Gas Hills area contains no towns and no improved roads but nearly all of it is accessible by car. Moneta is the closest post office, 25 miles to the north on U. S. Highway 20. The closest railroad station is at Lysite, on the Chicago, Burlington, and Quincy Railroad, 34 miles to the north. The area has no year-around inhabitants. Sheep and cattle ranching is the only industry. Vegetation is sparse and bedrock is comparatively well exposed.

GEOLOGIC SETTING

The Gas Hills are hogbacks of steeply dipping Mowry shale and of sandstone in the Cloverly formation on the north and west flanks of the northwestward-plunging Dutton anticline. This anticline branches off the Granite Mountains to the south and plunges into the Wind River Basin. The folding occurred near the close of Paleocene time and erosion developed the present topography on the pre-Eocene rocks. The overlying Wind River formation and the succeeding younger Tertiary strata were then deposited until the Wind River Basin was filled with nearly flat-lying Eocene, Oligocene, and Miocene rocks, at least to the level of the present crest of the Beaver Divide escarpment. Pliocene and Pleistocene uplift started the present erosion cycle, and the Beaver Divide escarpment migrated southward exhuming the Gas Hills and other areas of older rocks along the south margin of the Wind River Basin. Remnants of lower and middle Eocene rocks are present in steep valleys between the hogbacks of Mesozoic rocks. These valleys extend generally south for an unknown distance beneath the Tertiary strata that form the Beaver Divide. This relationship is mentioned because of its possible bearing on the emplacement of uranium deposits. About 10 miles southeast of the Gas Hills, in and south of the Rattlesnake Hills is a volcanic field of middle and late Eocene age, the rocks of which were intruded through pre-Cambrian, Paleozoic, and Mesozoic rocks. These vents furnished much of the volcanic debris in the middle and upper Eocene rocks in the Gas Hills area.

STRATIGRAPHY

Detailed descriptions and thicknesses of the rock units in the Gas Hills area are given in the references cited. The following is a summary description of the formations:

Alluvium: Chiefly gravel, sand, and clay derived from Tertiary rocks along the Beaver Divide escarpment and deposited along stream bottoms.

Landslide debris: Claystone and sandstone masses of Eocene and Oligocene rocks that have broken loose and moved north down the slopes of the Beaver Divide.

Miocene rocks: Gray and white soft tuffaceous sandstone with lenses of conglomerate near the base and of pumicite in the upper part. Thickness ranges from a feather edge to 100 feet.

White River formation (Oligocene): Basal 50 feet is chiefly light gray limy biotitic vitric tuff and tuffaceous mudstone. The upper 200 to 300 feet is grayish-orange to yellowish-gray sandy mudstone with some layers of gray vitric tuff and thin lenses of conglomerate. South of Coyote Spring, this sequence is, in part, soft plastic tuffaceous variegated claystone. The age of the formation in the Gas Hills area is Chadronian and the thickness ranges from a feather edge to 450 feet.

Upper and middle Eocene volcanic rocks: Chiefly light-gray to dark-gray dacite, hornblende latite, sodic trachyte, andesite, and alkalic rocks. They are intruded through pre-Cambrian, Paleozoic, and Mesozoic rocks in the Rattlesnake Hills and furnished boulders and ash that are incorporated in the upper and middle Eocene sedimentary sequence. The volcanic rocks are overlain by Oligocene and Miocene strata.

Upper and middle Eocene sedimentary rocks: Six units are recognizable along the Beaver Divide escarpment. (Van Houten, F. B., personal communication.)

6. At the top is more than 140 feet of very coarse-grained volcanic conglomerate that crops out in a massive ledge at the top of the formation, and that forms the lip of the Beaver Divide escarpment at some places.

5. This unit is composed of 130 feet of very poorly sorted dark yellowish-gray tuffaceous sandstone and volcanic conglomerate composed chiefly of andesine andesite porphyry. Uraniferous sandstone at locality 9 is believed to be a northward extension of this unit.

4. Unit 4 is 45 feet thick and consists of biotitic tuff, lapilli tuff, and cobbles of volcanic rocks.

3. This unit consists of 90 feet of tuffaceous sandstone, sandy mudstone, and conglomerate with pebbles and cobbles of sodic trachyte pumice, tuff, and lava. Giant boulders of pre-Cambrian gneiss and granite are present in lower 25 feet of the unit.

2. This unit is composed of about 100 feet of soft mudstone and arkosic sandstone with very little tuffaceous debris. The uppermost bed is a ledge-forming arkose and conglomerate containing pebbles of sodic trachyte lava.

1. At base is 25 to 30 feet of ledge-forming green to olive mudstone containing a thin bed of acidic tuff that probably records the initial volcanic outburst in the Rattlesnake Hills volcanic field.

Middle and lower Eocene rocks: For a distance of 5 miles or more north of the Beaver Divide and east of the Gas Hills, the Wind River formation is overlain by rocks of middle Eocene age. The formations look very much alike and have not as yet been mapped separately. Both sequences contain yellow soft sandstone, lenses of very ferruginous brown sandstone, and conglomerate. The chief lithologic difference is that conglomerate in the middle Eocene sequence contains abundant boulders of andesite derived from the Rattlesnake Hills, whereas the conglomerate in the Wind River formation contains no locally derived volcanic rock fragments.

Wind River formation (lower Eocene): This is an extremely variable sequence of rocks that was deposited on a rugged topography cut in folded and eroded Paleozoic and Mesozoic rocks. In the northwestern part of the area the basal strata are brightly variegated claystones and clayey sandstones. In the southeastern part of the area the basal beds are yellow to gray arkosic sandstone and granitic conglomerate. Higher in the sequence are lenticular sandstones, some of which are highly ferruginous. The sandstones contain many of the uranium deposits in this area. Thin carbonaceous shales and coals likewise contain some concentrations of uranium.

Cody shale (Upper Cretaceous): This formation consists of gray soft shale that is sandy in the upper part. The Cody shale is more than 3,000 feet thick and underlies extensive areas of the Wind River formation north and west of the Gas Hills. Because of its impermeability, it doubtless was of major significance in determining the course of ground waters in the overlying Wind River formation.

Frontier formation (Upper Cretaceous): Chiefly gray soft lenticular sandstone interbedded with gray to black soft shale. White tuff and bentonite beds mark base of formation, which here is about 580 feet thick.

Mowry and Thermopolis shales (Lower Cretaceous): The Mowry shale consists of dark-gray hard siliceous shale containing abundant fish scales. It weathers silvery gray and crops out in ridges forming the outer portion of the Gas Hills. The shale is about 470 feet thick. Below it is the Thermopolis shale with the Muddy sandstone member at the top. The Muddy sandstone member is 32 feet thick and consists of gray fine-grained sandstone and siltstone interbedded with black shale. It is underlain by 150 feet of soft black fissile shale. This shale contains one of the uranium deposits in this area.

Cloverly and Morrison formations (Lower Cretaceous and Upper Jurassic): These formations aggregate 280 feet in thickness of which the top 80 feet is chiefly ferruginous sandstone and conglomerate which forms the highest inner ridges of the Gas Hills. The middle and lower part of the sequence is interbedded variegated claystone and sandstone.

Jurassic rocks: This sequence includes the Sundance formation, which consists of 240 feet of interbedded gray sandstone and green shale, underlain by gray and white Nugget sandstone 170 feet thick.

Chugwater formation (Triassic): Only the upper part of this formation is exposed. The Popo Agie member at the top is 300 feet thick and consists of red shale, red sandstone and siltstone, and thin sparse limestone pellet conglomerates. It is underlain by the Alcova limestone member, a gray thin-bedded hard limestone 5 feet thick. The underlying Red Peak member is a red sandstone, siltstone, and shale sequence about 700 feet thick.

Phosphoria formation (Permian): This formation consists of about 325 feet of interbedded cherty dolomite and red shale with thin anhydrite beds.

Tensleep and Amsden formations (Pennsylvanian): The white hard fine-grained Tensleep sandstone, about 200 feet thick, is underlain by the Amsden formation, consisting of about 200 feet of red and green shale, cherty dolomite and a basal ferruginous sandstone about 60 feet thick.

Madison limestone (Mississippian): This formation consists of about 300 feet of blue-gray massive to thick-bedded cherty limestone with some dolomite near the base.

Cambrian rocks: Chiefly arkosic red and brown sandstone in the lower half, and green and gray sandy and silty shale, and sparse thin limestones in the upper half. Thickness is about 800 feet.

Pre-Cambrian rocks: Chiefly red and brown granite, granite gneiss, and black schist cut by quartz pegmatite dikes.

URANIUM OCCURRENCES

In the Gas Hills area, uranium occurs in the Thermopolis shale of early Cretaceous age, in the Wind River formation, and in middle Eocene rocks. One conspicuous feature of the area is that the background of radioactivity is high and in the vicinity of the richer occurrences there does not seem to be a sharp line between uraniferous rock and barren rock.

Description of localities

Locality 2

Locality 2 (C SW 1/4 sec. 32, T. 33 N., R. 90 W.) contains carbonaceous shale that is stratigraphically above the uraniferous sandstone beds at Localities 3, 4, and 5. The section above and below the carbonaceous shale is as follows, from top to bottom:

Unit No.	Thickness (feet)	Lithologic Character
6	20	Sandstone, pale green, arkosic, coarse-grained, finely conglomeratic in upper 10 feet; 1 3-foot granite boulder present but average size is less than 2 inches; no volcanic rock fragments observed; most fragments are of gray granite.

5	0.5	Shale, dark brown, carbonaceous, contains 0.031 percent equivalent uranium and 0.021 percent uranium; contains flattened plant and tree fragments; forms top of ledge.
4	1.5	Shale, black, coaly, interbedded with thin coal partings.
3	2.2	Shale, brown and gray, carbonaceous, platy; contains leaf impressions.
2	5	Claystone, pale green, plastic, soft.
1	15	Sandstone, pale brownish green, soft, coarse-grained, interbedded with arkose and fine-grained conglomerate with small black chert and granite pebbles.

In the general vicinity of this locality there are many spots of higher radioactivity, chiefly in sandstone, both above and below the carbonaceous shale. Because of these, Jenkins and Hand have staked claims in a solid block for a distance of about 9,000 feet, extending southward from a point a quarter of a mile north of Locality 2. These claims have not been examined in detail. Although the carbonaceous shale is of no commerical interest, it is believed that carbonaceous shales with abnormally high uranium content can be useful guides in locating areas of possible uranium deposits.

Locality 3

Locality 3 (SW 1/4 SE 1/4 SW 1/4 sec. 1, T. 32 N., R. 91 W.) not only contains a significant concentration of uranium but it also is at a place where overlying and underlying rocks of the Wind River formation can be observed (fig. 1). Localities 3, 4, and 5 are stratigraphically lower than Locality 2. The rocks at Locality 3 dip about 1° SW. The following stratigraphic section was measured on the west-facing slope just west of the uraniferous deposit. Unit 1 is at the base of the section.

Unit No.	Thickness (feet)	Lithologic Character
9	47	Sandstone, pale green, clayey, in lower 5 feet, grading up to ledge forming coarse-grained gray sandstone, and then to granite boulder conglomerate. The top of the unit is the top of the knob just west of the uranium locality. The uranium is concentrated in a pale green and brown clayey sandstone about 7 feet above the base of the unit. A trench sample of 1 foot of beds contains 0.13 percent equivalent uranium and 0.050 percent uranium.
8	1	Sandstone, dark brown, hard, forming ledge, lenticular; appears at slightly different levels in outcrops to northeast and southwest; locally gives readings of 1.5 mr/hr.
7	18	Sandstone, pale green, interbedded with conglomerate of granite fragments, very soft; sandstone is very coarse grained but has a greenish clay matrix in part; roundstones are chiefly of gray granite as much as 6 inches in diameter but averaging 1 to 2 inches.
6	10	Sandstone and conglomerate, greenish brown; matrix is so soft it is almost unlithified; rock fragments are chiefly gray granite; gives readings of 0.2 to 0.25 mr/hr.
5	6	Conglomerate and sandstone, gray to brown, forming ledges; middle part is a mass of boulders as much as 2 feet in diameter jumbled together; almost all are of coarse-grained gray granite but some are of black chert from Paleozoic rocks;

		sandstone is coarse-grained and lenticular; gives readings of 0.1 to 0.15 mr/hr.
4	66	Sandstone, pale greenish brown, soft, with clay matrix, interbedded with brownish-green plastic claystone in which are many sand grains, in lower half of unit; upper half is largely very coarse grained greenish-brown soft arkosic sandstone.
3	0-12	Sandstone, gray, hard, lenticular; forms ledges that appear intermittently in outcrops to south at this same position; very coarse-grained and pebbly; most pebbles are of granite as much as 1 inch in diameter but commonly less than 1/10 inch; gives reading of 0.06 mr/hr.
2	22	Sandstone, greenish gray, coarse-grained; with clay matrix; less clayey toward top; gives readings of 0.06 to 0.07 mr/hr.
1	17	Claystone, brownish green, soft, plastic, very sandy; grades up to coarse-grained arkosic sandstone with a clay matrix; in upper 5 feet and particularly at top are abundant groups of aragonite crystals as much as 2 feet in diameter; gives reading of 0.05 mr/hr.
	187-199	Total thickness of measured part of Wind River formation.

The underlying rocks are not exposed but the base of the section is believed to be not more than 50 to 75 feet above the contact with the Cody shale.

The area for 50 feet surrounding the spot sampled for analysis (fig. 2) is markedly radioactive. To the northwest, the radioactivity appears to extend through 7 feet of rocks, but at the spot sampled, because of lack of time, a trench only 1 foot deep was dug. This trench sample contained 0.13 percent equivalent uranium and 0.050 percent uranium (table 1). The uranium mineral is bright greenish-yellow, clayey, superficially resembles

Figure 2. --View looking southeast toward Beaver Divide. Arrow at left indicates Locality 3 where sandstone 7 feet above base of unit 9 in the measured section of the Wind River formation contains 0.05 percent uranium. Arrow at right marks Locality 4 where sandstone in the Wind River formation contains 1.87 percent uranium. Jeep station wagon is mounted with 2 scintillation-type recorders.

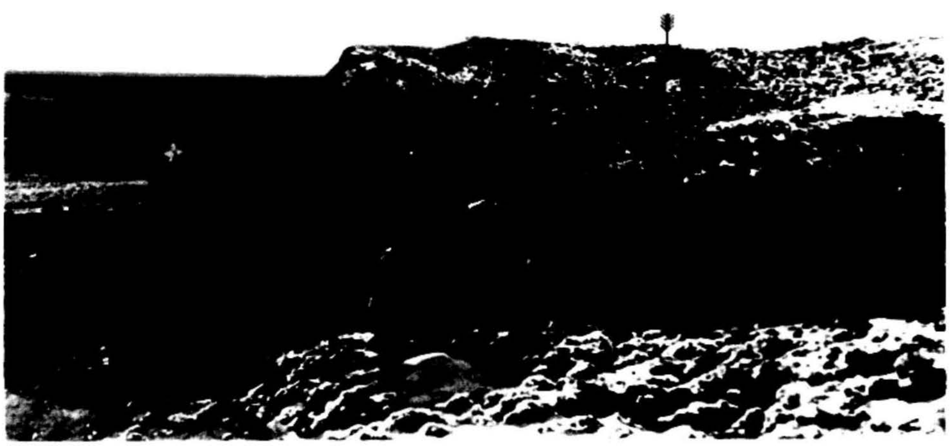

Figure 3. --View looking north into Wind River Basin from Locality 7. Section in foreground is in the Wind River formation and flats in left background are cut in Cody shale. Arrow marks zone of uraniferous sandstone.

Table 1.--Analyses of samples from Gas Hills area 1/

Laboratory Sample No.	Locality	Equiv. U. (percent)	Uranium (percent)	V_2O_5 (percent)	Location (see fig. 1), Lithology, and Formation
58068	10	0.015	0.018		C SE1/4 NE1/4 sec. 27, T. 33 N., R. 89 W., Carbonaceous shale in Wind River formation.
99211	10	.078	.062	0.12	30 feet southwest of sample 58068, channel 1 ft carb. shale in Wind River formation.
58067	10	.003	.003		SE1/4 SE1/4 NE1/4 sec. 27, T. 33 N., R. 89 W. Tuff in middle and upper Eocene rocks above Wind River formation.
99212	9	.06	.078	0.08	NW1/4 NE1/4 SW1/4 sec. 17, T. 33 N., R. 89 W. Ferruginous sandstone in middle Eocene sequence.
99201	3	.13	.050	.06	SW1/4 SE1/4 SW1/4 sec. 1, T. 32 N., R. 91 W. Channel sample of 1 ft of sandstone in Wind River formation.
99204	4	1.2	1.87	.06	NE1/4 NE1/4 NW1/4 sec. 12, T. 32 N., R. 91 W. Channel sample of 1 ft of sandstone in Wind River formation.
99205	5	0.58	0.25	.06	SE1/4 NE1/4 NW1/4 sec. 12, T. 32 N., R. 91 W. Channel sample of 1 ft of conglomeratic sandstone in Wind River formation.

1/ Samples analysed in Denver Laboratory, U. S. Geological Survey
Analysts: Furman, Dufour, Meadows, Mountjoy, and Wilson.

Table 1.--Analyses of samples from Gas Hills area--Continued

Laboratory Sample No.	Locality	Equiv. U. (percent)	Uranium (percent)	V_2O_5 (percent)	Location (see fig. 1), Lithology, and Formation
99202	2	0.031	0.021	0.06	C SW1/4 sec. 32, T. 33 N., R. 90 W. Channel sample of 6 in. of carbonaceous shale in Wind River formation.
99206	7	.21	.24	.06	NE1/4 SE1/4 sec. 22, T. 33 N., R. 90 W. Channel sample of 1 ft of sandstone in Wind River formation.
99207	7 AEC sample loc. EWS-6	.047	.014	.05	36 ft SW of 99206. Channel sample of 1 ft of sandstone in Wind River formation.
99209	7 AEC sample loc. EWS-2	.19	.24	.06	126 ft SW of 99207. Channel sample of 1 ft of sandstone in Wind River formation.
99208	7 AEC sample loc. EWS-1	.08	.096	.06	81 ft SW of 99209. Channel sample of 1 ft of sandstone in Wind River formation.
99210	8 AEC sample loc. EWS-8	.039	.041	.05	NE1/4 SE1/4 SW1/4 sec. 23, T. 33 N., R. 90 W. Channel sample of 1 ft of black Thermopolis shale.

schroeckingerite and has an almost identical brilliant greenish-yellow fluorescence. It has been tentatively identified by L. B. Riley (personal communication) as the rare mineral uranospinite, a calcium uranyl arsenate. The mineral is disseminated through the sandstone and in places is concentrated in small green pods. The sandstone is so soft that the deposit could easily be explored with a bulldozer or power shovel. No estimate of tonnage or grade can be made.

Locality 4

Locality 4 (NE 1/4 NE 1/4 NW 1/4 sec. 12, T. 32 N., R. 91 W.) is the most radioactive spot known in the area at the present time. A scintillation counter reads 8 mr/hr and a trench sample of the uppermost 1 foot of sandstone contains 1.2 percent equivalent uranium and 1.87 percent uranium. The uranium is concentrated in a very light-gray slightly clayey sandstone at about the same horizon as that at Locality 3 (fig. 1), or perhaps slightly lower. The thickness of the sandstone and of the uranium impregnation cannot be determined without trenching, but 50 feet to the southwest on the point of the hills, the sandstone crops out in a ledge 5 feet thick and is moderately radioactive. The bright greenish-yellow fluorescent mineral uranospinite (?) is disseminated throughout the coarse-grained sandstone. The area is very radioactive for 20 feet on each side of the spot that was sampled and moderately radioactive for another 50 feet beyond that. No estimates of tonnage and grade can be made without physical exploration.

Locality 5

Locality 5 (SE 1/4 NE 1/4 NW 1/4 sec. 12, T. 32 N., R. 91 W.) contains abundant uranospinite (?) thoroughly disseminated throughout the host rock. A trench sample of 1 foot of rock contains 0.58 percent equivalent uranium and 0.25 percent uranium. The deposit is in a very soft ferruginous conglomeratic sandstone about 50 feet stratigraphically below the uraniferous sandstone at Locality 4. The sandstone is brown, coarse grained, and contains rounded pebbles of granite as much as 2 inches in diameter. A scintillation counter reads 8 mr/hr at the point sampled, and indicates a high level of radioactivity for 20 feet in all directions. About 400 feet to the southeast another occurrence of high radioactivity was located but lack of time prevented a detailed examination. Until physical exploration is done there is no way of determining tonnage, grade, and extent of the deposit.

Locality 7

Locality 7 (fig. 2) (NE 1/4 SE 1/4 sec. 22, T. 33 N., R. 90 W.) is the discovery claim of Neil McNeic, and it has already been examined and sampled by representatives of the Atomic Energy Commission. The uranium is in the Wind River formation which here overlies the Cody shale and which strikes east and dips 3° S. Exposures of the Wind River formation begin about 50 feet above the Cody shale. A very generalized section is as follows, from top to bottom: (fig. 2)

Unit No.	Estimated thickness (feet)	Lithologic Character
7	10	Sandstone, gray, medium-grained to coarse-grained, cross-bedded, with hard and soft layers; forms intermittent ledges; contains numerous very ferruginous uraniferous concretionary masses that cut across bedding and resemble the uranium-bearing concretions in the Pumpkin Buttes area. Some uranospinite (?) is visible. A channel sample of 1 foot of sandstone contained 0.21 percent equivalent uranium and 0.24 percent uranium.
6	0.5	Shale, brown, carbonaceous.
5	10	Sandstone and claystone, greenish-brown, soft, interbedded.
4	1	Shale, dark brown, carbonaceous.
3	20	Sandstone and claystone, greenish-brown, soft.
2	1	Shale, brown, carbonaceous.
1	25	Sandstone and claystone, greenish-brown, soft.

The uraniferous sandstone crops out extensively along the top of a broad upland area. A 1-foot channel sample of this sandstone from AEC pit EWS-6, approximately 36 feet southwest of the measured section, contained 0.047 percent equivalent uranium and 0.014 percent uranium. About 125 feet farther southwest, a 1-foot channel sample of sandstone at the same horizon in AEC pit EWS-2, contained 0.19 percent equivalent uranium and 0.24 percent uranium. Another 1-foot channel sample of sandstone taken from the same horizon 81 feet farther southwest, at AEC pit EWS-1 contained 0.08 percent equivalent uranium and 0.096 percent uranium. This zone of ferruginous radioactive sandstone crops out for a distance of 450 feet farther southwest but was not sampled because the amount of radioactivity seems to decrease. High radioactivity was detected at a number of additional places southeast and east of Locality 7 on the same ridge and at approximately the same sandstone horizon. Physical exploration will be necessary to determine whether these localities are all parts of one continuous mass of uraniferous sandstone.

Locality 8

Locality 8 (NE 1/4 SE 1/4 SW 1/4 sec. 23, T. 33 N., R. 90 W.) is in the black Thermopolis shale of early Cretaceous age. A channel sample of the shale taken at AEC pit EWS 8 contained 0.039 percent equivalent uranium and 0.041 percent uranium. The shale dips west about 25° and is overlain by essentially horizontal ferruginous conglomeratic sandstone in the Wind River formation. The radioactive zone is approximately 30 feet below the Muddy sandstone member. Neither the Muddy sandstone member nor the basal sandstone of the Wind River formation are conspicuously radioactive. The radioactive zone in the Thermopolis shale extends for more than 50 feet north-south, and has a stratigraphic thickness of about 10 feet, but the radioactivity gradually diminishes in both directions from the pit where the sample was taken. A dusty yellowish stain is present along some fractures but it has not been identified as a uranium mineral.

The sandstones of the Wind River formation were deposited in a steep narrow valley cut along strike in the soft Thermopolis shale and flanked on the west by a resistant ridge of Mowry shale and on the east by resistant sandstone in the Cloverly formation. It is believed that the uranium was carried by ground water along porous sandstones in the Wind River formation, that it could not escape laterally because of the confines of the pre-Wind River valley, and that it was deposited in carbonaceous shales in the impervious underlying Thermopolis shale. Sandstones in the Cloverly formation on the east side of this pre-Wind River valley are slightly radioactive.

Locality 9

Locality 9 (NW 1/4 NE 1/4 SW 1/4 sec. 17, T. 33 N., R. 89 W.) is the only uranium occurrence found so far in middle Eocene rocks. It is in the middle of an area of abnormally high background radioactivity. The rocks are very ferruginous coarse-grained conglomeratic sandstones near the base of the middle and upper Eocene sequence. A 2-foot channel sample contained 0.06 percent equivalent uranium and 0.078 percent uranium. These rocks crop out as dark-brown discontinuous ledges for half a mile. Neither the sandstones nor the adjacent rocks have been explored adequately for uranium deposits. A generalized section of the rocks here is as follows, from top to bottom:

Unit No.	Estimated thickness (feet)	Lithologic Character
5	30	Conglomerate, gray; composed largely of boulders of mouse-gray andesite derived from volcanic rocks of middle Eocene age in the Rattlesnake Hills; conglomerate interbedded with a minor amount of chalky white crystal tuff.
4	50	Sandstone, yellowish white, coarse-grained, slightly tuffaceous, soft, interbedded with conglomerate in which roundstones are of both pre-Cambrian granite and Eocene volcanic rocks from the Rattlesnake Hills.
3	30	Volcanic conglomerate, mouse gray, composed largely of boulders of gray andesite porphyry derived from Eocene vents in the Rattlesnake Hills; some boulders 3 feet in diameter.
2	30	Sandstone, pale yellow, very coarse-grained, arkosic, soft, with white tuff fragments.
1	50	Sandstone and conglomerate, gray to dark brown, with very ferruginous lenses in middle; some lenses 15 feet thick and 100 feet long; a channel sample of 2 feet of sandstone from one lens contained 0.06 percent equivalent uranium and 0.078 percent uranium; conglomerate intertongued with the sandstone contains rounded fragments of pre-Cambrian granite and Eocene andesite porphyry from the Rattlesnake Hills; some andesite boulders are 3 feet in diameter.

This part of the Gas Hills area has received no attention yet from prospectors, but appears to be of sufficient promise to warrant an airborne radioactivity survey, and additional investigation on the ground.

Locality 10

Locality 10 (C SE 1/4 NE 1/4 sec. 27, T. 33 N., R. 89 W.) is in a carbonaceous shale near the top of the Wind River formation. A channel sample of 1 foot of shale contained 0.078 percent equivalent uranium and 0.062 percent uranium. This carbonaceous shale bed contains fossil leaves and overlies coarse-grained greenish-yellow arkosic sandstone. The top of the bed grades upward through 6 inches of slightly carbonaceous shale to a greenish gray plastic claystone. Leaves identified by R. W. Brown of the U. S. Geological Survey from this carbonaceous shale are: Ulmus sp., Leguminosites sp., Aralia sp., Quercus castaneopsis, and Zizyphus cinnamomoides. The carbonaceous shale is exposed in an area only about 75 feet long and 25 feet wide but its uranium content and its location in an unexplored area suggest that an airborne radioactivity survey and additional ground investigations are warranted.

ORIGIN OF URANIUM IN THE GAS HILLS AREA

Insufficient data are available on the occurrences of uranium minerals now known in the Gas Hills area to warrant more than mention of the possibilities for the origin of the deposits. It is apparent that the minerals were deposited in their present sites by water moving through the rocks and bringing uranium and other ions into environments favorable for their combination and precipitation. The source of the uranium ions and the origin of the water that carried them can only be guessed at the present time.

The uranium deposits may be the result of hydrothermal solutions coming from the volcanic rocks in and south of the Rattlesnake Hills. These volcanic rocks are dacites, andesites, and alkalic rocks (F. B. Van Houten and B. D. Carey, Jr., personal communications) of middle and late Eocene age. There is no known evidence of hydrothermal activity in the Gas Hills area other than, possibly, the uranium deposits themselves. However, there is no evidence that would indicate such activity was unlikely.

The uranium deposits may be the result of ground-water solution and transportation of uranium disseminated in the White River formation or younger Tertiary rocks, also of volcanic origin, but not derived from the Rattlesnake Hills. These post-Eocene rocks once extended over the Gas Hills area and filled the Wind River Basin. Denson, Bachman, and Zeller (1951) have reported uraniferous lignites of Paleocene age overlain by the White River formation in South Dakota. J. R. Gill (personal communication) has found carnotite in the White River formation in the Slim Buttes area, S. Dak., and G. W. Moore and H. A. Tourtelot have found uranocircite and tyuyamunite in rocks of the White River formation in the Big Badlands of South Dakota. In the Powder River Basin, Wyoming, the Wasatch formation in which the uranium deposits of the Pumpkin Buttes area are found (Love, 1952) was overlain by the White River formation, which itself is uraniferous. Miocene (?) rocks in the Miller Hill area, southern Wyoming, contain as much as 0.15 percent uranium (Love, 1953); and Pliocene (?) rocks in the Split Rock area in Sweetwater County, Wyo., contain abnormal amounts of uranium (Love, 1952). In most of these areas, the possibility of hydrothermal activity that would form uranium deposits seems slight. The White River formation in the Gas Hills area is contributing above-normal amounts of uranium to ground water today (table 2) and the White River formation may have supplied the uranium to the underlying rocks in the Gas Hills area. The uranium in the water in the Wind River formation may come from the White River formation or from secondary uranium minerals in the Wind River formation. However, the uranium in both these formations may have a common source.

Characteristics of the presently known deposits that need further investigation and that will assist in determining the origin and history of the deposits include (1) the only mineral tentatively identified so far, uranospinite, and (2) the curious relationships between the level of radioactivity expressed as percent equivalent uranium and the amount of uranium chemically determined. Uranospinite, $Ca(UO_2)_2(AsO_4)_2 \cdot 8\text{-}12H_2O$, is a rare mineral; it has not yet been reported from the Colorado Plateau (Weeks and Thompson, 1953).

The level of radioactivity of the samples, expressed as percent equivalent uranium, is out of balance with the uranium content of the samples; in some samples the radioactivity is in excess of the uranium content and in others the radioactivity is deficient. In sample 99207

Table 2. --Analyses of water from Gas Hills area

Laboratory Sample No.	Locality	Uranium (parts per million)	Location (see fig. 1), Formation, and Other Data
1/	11	0.010	Cameron Spring, NE cor. sec. 11, T. 32 N., R. 90 W. Cold water spring about 160 feet above base of White River formation. Other constituents, in parts per million 2/: SiO_2 48, Fe 0.01, Ca 7.0, Mg. 0.1, Na 78, K 7, CO_3 0, HCO_3 212, SO_4 19, Cl 4, F 0.1, NO_3 1.3, PO_4 --, solids dissolved 279, hardness $CaCO_3$ 13, specific conductance 367, pH 7.9.
99199 3/	1	.012	SE SW SE sec. 24, T. 33 N., R. 91 W. Pump well from Wind River formation on north side of road, just east of Puddle Springs.
99200 3/	1	.035	SE SW SE sec. 24, T. 33 N., R. 91 W. Flowing well on south side of road just east of Puddle Springs. Well flows a 1-in. pipe full of clear water from Wind River formation.
99203 3/	6	.090	NE SE NE sec. 14, T. 32 N., R. 91 W., Coyote Spring, flowing 1-in. pipe of clear cold water from arkosic sandstone in Wind River formation just above contact with Mowry shale.

1/ Analysis by Oak Ridge National Laboratory.
2/ Quality of Water Laboratory, Geological Survey.
3/ Denver Laboratory, Geological Survey.

(table 1), the radioactivity of 0.047 percent equivalent uranium is 4 times the uranium content of 0.014 percent, and in sample 99205, the equivalent uranium content of 0.58 percent is twice the uranium content of 0.25 percent. In some other samples, however, the uranium content is greater than the radioactivity expressed in percent equivalent uranium. For example, sample 99204 contains 1.87 percent uranium but only 1.2 percent equivalent uranium. No explanation is offered now for these relationships between uranium content and radioactivity, but when more data are available, they should lead to a better understanding of the origin and history of the deposits.

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