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THE GAS HILLS URANIUM DISTRICT AND SOME PROBABLE CONTROLS FOR ORE DEPOSITION*

By

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ABSTRACT

Uranium deposits occur in the upper coarse-grained facies of the Wind River formation of Eocene age in the Gas Hills district of the southern part of the Wind River Basin. Some of the principal deposits lie below the water table in the unoxidized zone and consist of uraninite and coffinite occurring as interstitial fillings in irregular blanket-like bodies. In the near-surface deposits that lie above the water table, the common yellow uranium minerals consist of uranium phosphates, silicates, and hydrous oxides. The black unoxidized uraninite-coffinite ores show enrichment of molybdenum, arsenic, and selenium when compared to the barren sandstone. Probable geologic controls for ore deposits include: 1) permeable sediments that allowed passage of ore-bearing solutions; 2) numerous faults that acted as impermeable barriers impounding the ore-bearing solutions; 3) locally abundant pyrite, carbonaceous material, and natural gas containing hydrogen sulfide that might provide a favorable environment for precipitation of uranium.

Field and laboratory evidence indicate that the uranium deposits in the Gas Hills district are very young and related to the post-Miocene to Pleistocene regional tilting to the south associated with the collapse of the Granite Mountains fault block. This may have stopped or reversed ground water movement from a northward (basinward) direction and alkaline ground water rich in carbonate could have carried the uranium into the favorable environment that induced precipitation.

INTRODUCTION

The Gas Hills uranium district is near the geographic center of Wyoming on the east-central edge of Fremont County and the west-central edge of Natrona County. Structurally it is situated on the southern margin of the Wind River Basin and on the north side of the Granite Mountains fault block. The Beaver Rim, a southward-receding erosional scarp, makes up the southern topographic boundary of the Basin in the Gas Hills district (Blackstone, 1948).

The northwest-trending Gas Hills anticline (Dutton Basin anticline) and associated Laramide folds were deeply dissected in pre-Wind River (early Eocene) time and about 900 feet of arkosic sediments of the Wind River formation were deposited with angular discordance on rocks ranging in age from Cambrian to Paleocene. Resting with apparent conformity on the Wind River formation are about 800 feet of tuffaceous sediments of middle and late Eocene, Oligocene, and Miocene age. During a period of general regional uplift in post-Miocene time (probably late Pliocene) the Granite Mountains fault block subsided along normal faults of large displacement (Bauer, 1934, p. 687; Carey, 1954a) and the Gas Hills area was tilted gently toward the south. Field evidence in the Gas Hills district indicates that movement along these faults probably continued well into Pleistocene time. It is believed that uranium was deposited in the Wind River formation after this post-Miocene tilting.

A generalized geologic map, figure 1 (in envelope), shows the locations of the uranium mines and some of the many occurrences and prospects in the Gas Hills district. Included also are recently-mapped structural features and results of analyses of uranium in water.

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STRATIGRAPHY

Sedimentary rocks exposed in the Gas Hills area range in age from Cambrian to Miocene. Paleozoic rocks, mostly sandstones, limestones, and dolomites, average about 2,000 feet in thickness and include rocks of Cambrian, Mississippian, Pennsylvanian, and Permian ages. Mesozoic rocks, mostly shale and some sandstone, average about 10,000 feet in thickness and include rocks of Triassic, Jurassic, and Cretaceous ages. The Tertiary rocks, mostly arkosic and tuffaceous sandstone, mudstone, and shale, average about 3,000 feet in thickness and include rocks of Paleocene, Eocene, Oligocene, and Miocene ages.

For a composite stratigraphic section of the sedimentary rocks exposed in the Gas Hills area see Van Houten and Weitz (1956). For more detailed stratigraphic descriptions the reader is referred to Bogrett (1951); Downs (1948); Love (1948); Love, Johnson and others (1945); Love, Thompson and others (1945); Love, Tourtelot and others (1945, 1957); Peck and Reker (1948); Thomas (1948); Thompson, Love and Tourtelot (1949); Van Houten (1950, 1954, 1955); and Zeller, Soister and Hyden (1956).

Wind River formation

The Wind River formation was deposited on an irregular mature erosion surface which formed the northern slope of the ancestral Granite Mountains. Sediments were deposited first in the low central part of the Wind River Basin north of the Gas Hills. As deposition continued, progressively younger sediments overlapped southward onto the topographically and structurally higher parts of the Basin margin.

The pre-Wind River erosion surface in the Gas Hills district had a relief of more than 1,300 feet. The Wind River sediments covered all of the older rocks except a few very high ridges in the southeastern and perhaps the southwestern part of the district.

The formation is composed of a lower fine-grained facies and an upper coarse-grained facies. Sediments of the lower fine-grained facies were derived mainly from Mesozoic rocks, whereas about 90 percent of the upper coarse-grained facies was derived from Precambrian granite of the ancestral Granite Mountains to the south.

Lower fine-grained facies

The lower fine-grained facies is about 125 feet in thickness and is predominantly light gray to grayish-green siltstone, fine-grained sandstone, and claystone with a few discontinuous reddish-orange to reddish-brown bands. Red-banded sediments are more common in the Wind River formation in other parts of the Wind River Basin (Bauer, 1934; Tourtelot, 1946, 1948, and 1953; Van Houten, 1948). The lower fine-grained facies is absent in the eastern part of the Gas Hills area (T. 33 N., R. 89 W.) but is fairly persistent from the Lucky Mc mines (T. 33 N., R. 90 W.) to the vicinity of Muskrat Creek (T. 33 N., R. 91 W.).

Upper coarse-grained facies

The upper coarse-grained facies of the Wind River formation is the host rock for the uranium deposits in the Gas Hills district. It is about 800 feet thick and is composed largely of poorly sorted coarse-grained arkosic sandstone and granite pebble- to boulder-conglomerate. Minor amounts of mudstone, siltstone, and carbonaceous shale are also present. The upper 100 feet of the unit is finer grained and grades into the tuffaceous mudstones typical of the middle and upper Eocene rocks.

The upper coarse-grained facies rests directly on the pre-Wind River rocks in the eastern part of the Gas Hills district. It seems to represent a series of coalescing alluvial fans containing many channel fillings. Cut-and-fill structure and cross-bedding are common features observed in the open-pit mine faces. The thickest continuous section found to date is 700 feet in the graben just south of the P-C mine in T. 33 N., R. 89 W. (fig. 1).

STRUCTURE

The pre-Wind River rocks dip northward about 10 to 15 degrees along the north flank of the Granite Mountains fault block. This gentle dip is modified by northwest-plunging folds, the more prominent of which are the Gas Hills anticline (Dutton Basin anticline) and the Rattlesnake anticline. The Wind River formation and younger rocks dip gently 2 or 3 degrees to the south.

East-trending normal faults are common in the map area. Along the Beaver Rim large normal faults, part of the North Granite Mountains fault zone, are downthrown to the south (Carey, 1954a, p. 32; Van Houten and Weitz, 1956). In the vicinity of Coyote Springs (T. 32 N., R. 91 W.) most of the east-trending faults are, in contrast, downthrown to the north, making the area between Coyote Springs and the Beaver Rim a low broad horst.

Displacements on the normal faults generally range from less than 5 feet to 300 feet. Just south of Puddle Springs (T. 33 N., R. 91 W.) the upper coarse-grained facies of the Wind River formation is downthrown on the north against Cody shale. The displacement is estimated from drilling data to be greater than 200 feet. In the eastern part of the

Gas Hills area horst and graben structures occur in the West Canyon Creek area in the vicinity of the P-C mine. The maximum displacement along the faults bounding the largest graben is about 300 feet as evidenced by remnants of middle and upper Eocene rocks exposed within the structure.

Many of the faults with displacements of only a few feet are readily identified on aerial photographs as lineations, and some faults with as little as 10 feet of throw can be traced more than a mile. Both major and minor fault trends in this area have been delineated very successfully by the U. S. Geological Survey through use of the seismic refraction method (Black, 1956).

Two periods of normal faulting are recognized in the Gas Hills district: 1) faulting of early Eocene age contemporaneous with the deposition of the Wind River formation; and 2) faulting of post-Miocene age in which movement appears to have continued to Pleistocene time. The earlier faults generally trend in a northeasterly direction, and the more recent faults trend more westerly to northwesterly. A mile south of Iron Spring (T. 33 N., R. 89 W.) there is evidence that faulting displaces a Pleistocene(?) pediment surface composed of cobbles and boulders derived from middle and upper Eocene rocks. A short distance northwest of the Redwood mine a fault scarp that is only slightly modified by erosion is exposed. The apparent faulting of a pediment and the slight erosion of a fault scarp indicate that movement along faults associated with the collapse of the Granite Mountains fault block to the south continued into Pleistocene and possibly into Recent time.

URANIUM DEPOSITS AND MINERALOGY

All of the economically important uranium deposits occur in the upper coarse-grained facies of the Wind River formation. The uranium minerals generally occur as interstitial fillings in irregular blanket-like bodies. The main ore minerals in the unoxidized zone are uraninite and coffinite. Uranium phosphates, silicates, and hydrous oxides are the main minerals in the oxidized zone. More than 200 occurrences of uranium are known in the Gas Hills area (Grutt, 1957, p. 4), and over 20 distinct uranium mineral species have been identified (Coleman, 1956; Gruner and others, 1956, p. 8-13).

Many of the ore bodies are large and open pit mining operations are being used. Uranium minerals have been found by drilling in the Wind River formation at depths as much as 600 feet.

Figure 2 is a photograph of the open-pit operation at the Lucky Mc main pit (T. 33 N., R. 90 W.). The contact of the oxidized and unoxidized zone is near the water table; the main ore occurs just below the water table. The oxidized zone at the point shown in the photograph contains only scattered uranium minerals. The tops of the other important ore bodies in the district are also near the top of or below the present ground-water table.

R. G. Coleman's study of the mineralogy and geochemistry of the deposits (Coleman, 1956) shows that the uranium was deposited in two distinct environments: 1) uraninite-coffinite-iron sulfides formed

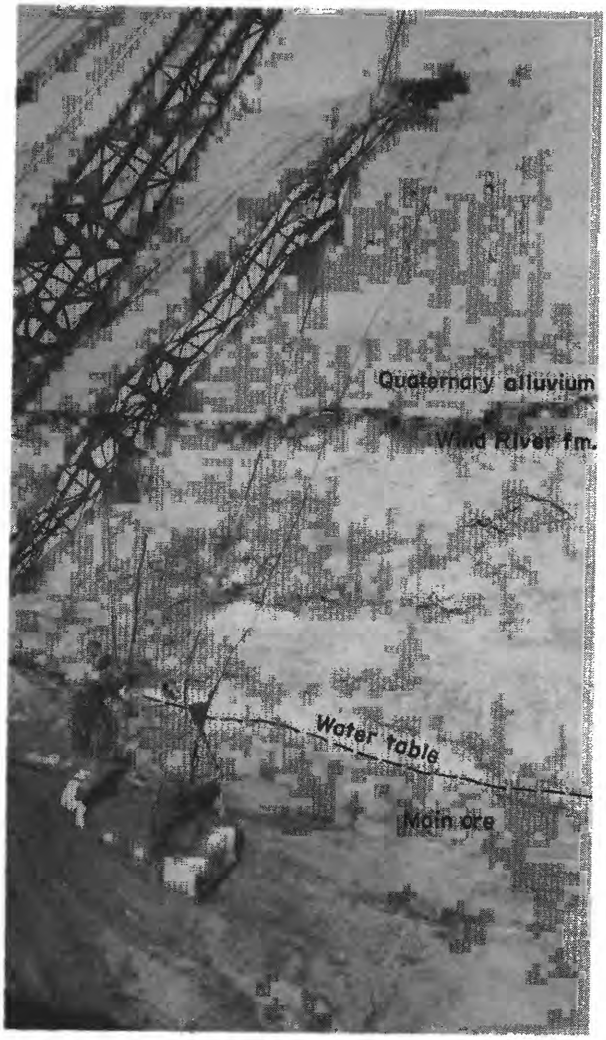

Figure 2.--Southeast face of the Lucky Mc mine pit showing relationship of oxidized zone (above water table) to unoxidized zone containing main ore.

under reducing conditions; and 2) uranium deposited in and near phosphate zones under partial reducing conditions. These studies also indicate that the black unoxidized uraninite-coffinite ores show enrichment of molybdenum, arsenic, and selenium when compared to the barren sandstone. Further, this work shows that downward leaching of uranium associated with recent fluctuation of the ground-water table produced some enrichment at the interface between the oxidized and unoxidized ore and at mudstone-sandstone contacts.

Radiochemical studies made by J. N. Rosholt, Jr., of the U. S. Geological Survey on samples submitted by the U. S. Atomic Energy Commission give a possible age of 11,000 years for the mineralization in a lignitic coal at the Lucky Mc mine. Unoxidized ore from the Vitro mine showed a possible age of 170,000 years (Pleistocene?).

CONTROLS FOR ORE DEPOSITION

Post-Miocene to Pleistocene normal faulting related to the collapse of the Granite Mountains fault block is, in part, controlling the present ground-water movement in the Gas Hills district. The movement of ground water is in turn believed to have controlled the deposition of uranium. Impermeable fault gouge or impermeable barriers formed by mudstones in fault contact with coarse-grained sandstone can be observed to control the position of ground-water tables in the vicinity of the P-C and Ranrex mines (T. 33 N., R. 89 W.). Drilling information indicates that the depth to the ground-water table in the graben south of the P-C mine is over 160 feet from the surface in places. The P-C mine is located in a horst-like structure north of the graben where the top of a perched water table about 60 feet below the surface coincides with the top of the ore deposit. This perched water table is confined to the horst by the fault gouge and fault contact with mudstone to the south.

At the Ranrex mine two faults of early Eocene age, contemporaneous with the deposition of the Wind River formation, trend in a northeasterly direction. The ore is restricted to a coarse-grained sandstone in a small horst-like structure between these faults. A perched water table is supported by a mudstone which underlies the ore-bearing sandstone and is confined on the north by a fault contact with mudstone, and on the south by a clayey fault gouge. Two other uranium deposits have been found between or near the projections of these faults to the northeast. Detailed drilling information will be needed to determine the extent of these faults and their positions relative to the ore deposits.

A belt of mineralization apparently extends over 2 miles southward from Lucky Mc and Vitro mines. Depth to the ore zone increases to the south with southward dip of the Wind River formation. Incomplete drill data suggest that most of the mineralization occurs in two persistent zones (Grutt, 1957, personal communication). Depth to ore varies from 60 to over 300 feet. This belt of mineralization may be related to a pre-Wind River valley which trends southeast from the Lucky Mc-Vitro mine area. (See Zeller and Soister, 1955, figure 30.) This ancient valley is a major geologic feature in the area and sandstone of the valley fill may have served as a channelway for ore-bearing solutions. Trending in the same direction and overlying this valley fill is a younger channel 1.5 miles wide in which the White River formation was deposited directly on the upper coarse-grained facies of the Wind River formation (Van Houten and Weitz, 1956). The thick impermeable mudstone beds of the middle and upper Eocene sequence have been completely removed by erosion.

In the western part of the Gas Hills area almost all the known oxidized uranium deposits occur in or stratigraphically near a granite cobble and boulder conglomerate, 5 to 30 feet thick. (See Zeller and Soister, 1955, p. 165.)

The following ore controls are believed to be important in the Gas Hills district:

1. Permeable coarse sandstones and conglomerates of the Wind River formation filling ancient valleys cut in the older impermeable rocks may have served as channels for ore solutions, as at present they control ground-water flow. These coarse rocks also fill channels within the Wind River formation, well above any influence from buried topography.

2. The presence of lower Eocene and post-Miocene to Pleistocene faults which, as they now act as impermeable barriers and control present-day ground-water movement, could formerly have acted as barriers to movement of the ore-bearing solutions.

3. Facies changes within the upper part of the Wind River formation, where impermeable lenses of mudstone in sandstone could act as barriers to the flow of ore-bearing solutions. (See Zeller, Soister, and Hyden, 1954, p. 124; and Grutt, 1957, p. 4 and fig. 2-B, p. 7).

4. The abundance of pyrite in sandstones and mudstones, the association of carbonaceous material, and the hydrogen sulfide associated with present natural gas seeps (Grutt, 1957) separately or in combination could provide a favorable reducing environment for precipitation of uranium.

ORIGIN OF THE DEPOSITS

The origin of the ore deposits in the Gas Hills district is unknown, and further study is necessary before any conclusions can be drawn. Three possible sources are listed.

1. The uranium was leached from the thick sequence of tuffaceous beds directly overlying the Wind River formation (Love, 1954, p. 9). The White River channel south of the Lucky Mc and Vitro mines would give ground water, carrying uranium leached from the tuffaceous rocks, easy access to the underlying sandstone host rocks of the Wind River formation.

2. Uranium may have been leached by ground water from the Precambrian granite detritus making up 90 percent of the upper coarse-grained facies of the Wind River formation. There is much evidence that extensive leaching has taken place in the Wind River sediments (Coleman, 1957, personal communication).

3. The uranium may be the result of hydrothermal solutions coming from the Rattlesnake Hills volcanic field. No evidence has been found to indicate such a source.

WATER SAMPLING AS A GUIDE TO PROSPECTING

The results of more than 100 uranium analyses of water are plotted on the generalized geologic map, figure 1. The results of these analyses show that ground water in the Gas Hills district is carrying above-normal amounts of uranium. Most ground water contains less than 2 parts per billion uranium (Denson, Zeller, and Stephens, 1956).

With the exception of Muskrat Creek, which drains a large part of the area and has an abnormally high uranium content, the water samples show a greater uranium concentration in the vicinity of uranium deposits or directly downstream from deposits. The writer believes that many of the known uranium deposits could have been discovered by using only the uranium content of all available waters as a prospecting tool (Denson, Zeller, and Stephens, 1956). Water sampling may be especially useful in areas where thick Quaternary alluvium or excessive barren overburden masks radioactivity and makes Geiger and scintillation counters ineffective.

Ground water at the location of two open-pit uranium mines contained 5,400 to 5,760 parts per billion uranium. This abnormal content, along with the abnormally high uranium analyses of other waters sampled throughout the district, suggests that uranium is still actively migrating in ground-water solution.

SUMMARY

In conclusion, field and laboratory evidence indicates that at least some of the uranium deposits in the Gas Hills district are very young and are related to post-Miocene to Pleistocene regional tilting to the south associated with the collapse of the Granite Mountains fault block. This may have had the effect of stopping or reversing the ground-water movement from a northward (basinward) direction (Rich, 1956). The introduction of uranium into the district appears to have been by alkaline ground water rich in carbonate (Coleman, 1957, personal communication). Where these waters came in contact with favorable reducing environments in stratigraphic and structural traps, the uranium was precipitated. The evidence of recent secondary enrichment (Coleman, 1956) and the excessive uranium content of present-day ground water suggest that migration and deposition of uranium is still going on.

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