Reconnaissance Investigation of Uranium Occurrences in the Saratoga Area Carbon County, Wyoming

GEOLOGICAL SURVEY BULLETIN 1046-M

This report concerns work done on behalf of the U. S. Atomic Energy Commission and is published with the permission of the Commission

Reconnaissance Investigation of Uranium Occurrences in the Saratoga Area Carbon County, Wyoming

By JAMES G. STEPHENS *and* M. J. BERGIN

CONTRIBUTION TO THE GEOLOGY OF URANIUM

GEOLOGICAL SURVEY BULLETIN 1046-M

This report concerns work done on behalf of the U. S. Atomic Energy Commission and is published with the permission of the Commission

---

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1959

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The Geological Survey has cataloged this publication for the Library of Congress as follows:

Stephens, James Gilbert, 1926–

Reconnaissance investigation of uranium occurrences in the Saratoga area, Carbon County, Wyoming, by James G. Stephens and M. J. Bergin. Washington, U. S. Govt. Print. Off., 1958.

iv, 321–338 p. maps (2 fold. in pocket) diagrs., tables. 25 cm. (U. S. Geological Survey. Bulletin 1046–M. Contribution to the geology of uranium)

Bibliography: p. 338.

1. Uranium ores—Wyoming—Carbon Co. I. Bergin, Marion Joseph, 1927– joint author. II. Title (Series U. S. Geological Survey. Bulletin 1046–M. Series: U. S. Geological Survey. Contributions to the geology of uranium)

553.493

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 55 cents (paper cover)

CONTENTS

	Page
Abstract	321
Introduction	321
Geographic setting	322
Geologic setting	323
Stratigraphy	324
General	324
Age and nomenclature of the Tertiary rocks	326
Browns Park(?) formation	327
North Park(?) formation	327
Pediment deposits	328
Uranium occurrences	328
Uranium content of water	332
Localization of uranium	332
References cited	338

ILLUSTRATIONS

[Plates 39 and 41 are in pocket]

	Page
PLATE 39. Reconnaissance geologic map of the northwest quarter of the Saratoga 30-minute quadrangle, Wyoming-Colorado.	
40. *A*, Pit in the Browns Park(?) formation 3 miles west of Saratoga; *B*, Bulldozed cut on pediment surface 6 miles south of Saratoga Faces	329
41. Geologic sketch map showing distribution and uranium content of water in the Saratoga area.	
FIGURE 29. Index map of Wyoming showing the location of the Saratoga area, Carbon County	322
30. Sketch map of part of Wyoming and Colorado showing the geologic setting of the Saratoga area	323
31. Stratigraphic section in the Browns Park(?) formation showing uranium and equivalent uranium contents of rocks at locality 7	329
32. Stratigraphic section in the North Park(?) formation showing uranium and equivalent uranium contents of rocks at locality 18	330
33. Stratigraphic section showing uranium and equivalent uranium contents in pediment gravel and part of the North Park(?) formation at locality 30	331

TABLES

Page

TABLE 1. Formations exposed in the Saratoga area 325
2. Summation of analyses of water samples from the Saratoga area 332
3. Analyses of rock samples from the Saratoga area, Carbon County, Wyo 333
4. Analyses of water samples from the Saratoga area, Carbon County, Wyo 336

CONTRIBUTIONS TO THE GEOLOGY OF URANIUM

RECONNAISSANCE INVESTIGATION OF URANIUM OCCURRENCES IN THE SARATOGA AREA, CARBON COUNTY, WYOMING

By JAMES G. STEPHENS and M. J. BERGIN

ABSTRACT

Uranium occurs in the Browns Park(?) formation of Miocene(?) age, the North Park(?) formation of Pliocene(?) age, and Quaternary pediment gravels in the Saratoga area, Carbon County, Wyo. No commercial deposits have been found to date. Carnotite, $K_2(UO_2)_2(VO_4)_2 \cdot 1\text{–}3H_2O$, the only uranium mineral identified in the area, was found at two localities. It occurs in pediment deposits as a coating on individual cobbles and boulders and as disseminated specks in fine-grained material. Directly below the pediment gravel, carnotite is found as a caliche-like coating on limestone and sandstone. At 30 other localities the uranium is disseminated as a mineralogically unidentifiable form in chert, limestone, sandstone, siltstone, carbonaceous shale, or volcanic ash. The highest concentration of uranium (0.027 percent) was found in chert layers and irregular masses in silicified limestone. A concentration of 0.026 percent of uranium was found in a silicified volcanic ash bed 0.4 feet thick. A selected sample of pediment gravel containing carnotite analyzed 0.011 percent of uranium.

The carnotite occurrences are believed to have been formed by solution and redeposition of uranium by ground water.

Analyses of rock and water samples collected in the area and generalized descriptions of exposed strata are tabulated.

INTRODUCTION

The Saratoga area is in Carbon County, south-central Wyoming (fig. 29). The presence of the radioactivity anomalies shown on plate 39 was discovered by the U. S. Geological Survey in November 1953 (Henderson, 1954) as a result of an airborne survey of part of the area. The main objective of the investigation was to study and sample in detail each of the anomalous radioactive areas in order to evaluate the possible presence of commercial grade uranium deposits and to obtain information concerning the origin of the anomalous radioactivity.

Fieldwork was carried on from July 5 to August 11, 1954. Rocks exposed in anomalous radioactive areas and in many prospect pits were examined, and their radioactivity was tested with a scintillation counter. Rock samples from the localities shown on plate 39 were collected for radiometric, chemical, and mineralogic analyses (table 3). Samples of water, the locations of which are shown on plates 39 and 41, were collected for uranium analyses as a possible aid in outlining areas for more intensive prospecting (table 4). Detailed work was supplemented by reconnaissance geologic mapping in the northwest quarter of the Saratoga 30-minute quadrangle, Wyoming-Colorado, and by reconnaissance into adjoining areas to examine other radioactivity anomalies found by aerial surveys.

Mr. John de la Montagne, Dr. P. O. McGrew, and Mr. Paul Boden gave helpful suggestions and ideas regarding the geology of the area. The samples were analyzed in the Geological Survey laboratory.

GEOGRAPHIC SETTING

The Saratoga area includes about 210 square miles in the northwestward-trending Saratoga Valley which is bounded on the east by the Medicine Bow Mountains and on the southwest by the Sierra Madre (fig. 29). The northwest quarter of the Saratoga 30-minute topographic quadrangle map, Wyoming-Colorado, shows the area. Elevations range from 6,750 feet along the North Platte River to 9,050 feet on the northeast flank of the Sierra Madre giving a maximum relief of about 2,300 feet. The mean elevation is about 7,100 feet; the average relief is about 500 feet. The North Platte River and its permanent tributaries—Jack Creek, North Spring Creek, South Spring Creek, and Cow Creek—drain the area.

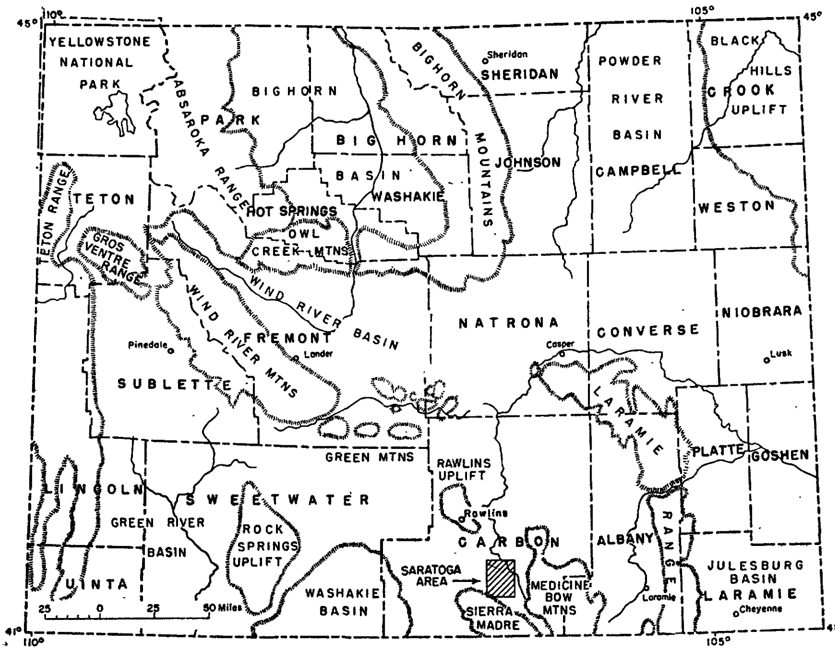


FIGURE 29.—Index map of Wyoming showing the location of the Saratoga area, Carbon County.

Saratoga is the only town in the area; Encampment is about 20 miles to the south; and Rawlins, the county seat of Carbon County, is 43 miles to the northwest. State Highway 230 crosses the southeast corner of the area, and State Highway 130 crosses the northeast quarter. Many improved and unimproved roads make most localities within the area accessible by automobile.

Cattle and sheep ranching are the main industries. Alfalfa and hay are grown in irrigated fields along permanent streams, and timber is cut in the mountainous regions to the east and west. Two test wells for oil and gas have been drilled in the area, but both were dry.

A sparse growth of brush and short grasses is the only vegetation at lower elevations, except along the major stream courses where cottonwood and other deciduous trees grow. The mountains are forest covered. Bedrock is comparatively well exposed throughout the area.

GEOLOGIC SETTING

The Saratoga area is in the Saratoga basin, a structural and topographic basin between the Precambrian masses of the Medicine Bow Mountains to the east and the Sierra Madre to the southwest (fig. 30).

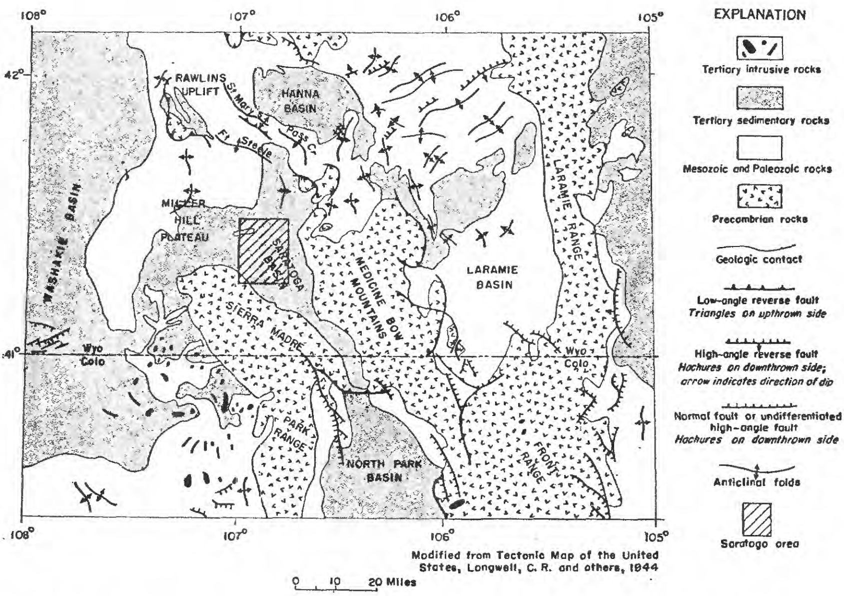


FIGURE 30.—Sketch map of part of Wyoming and Colorado showing the geologic setting of the Saratoga area, Carbon County, Wyo.

The Miller Hill plateau, an erosional remnant of tuffaceous sandstone and limestone of Tertiary age, forms a high area extending northward from the Sierra Madre west of the Saratoga area. The Fort Steele, St. Mary's, and Pass Creek anticlines and their associated faults separate the Saratoga basin to the south from the Hanna basin to the north. The Saratoga basin is separated from the North Park basin to the south by the Independence Mountain fault. Precambrian rocks have been thrust southward over rocks as young as Paleocene along this eastward-trending fault which dips northward at a low angle (Blackstone, 1953; Montagne, 1957; Walters, 1957).

Rocks of Precambrian, Paleozoic, Mesozoic, and Tertiary ages are exposed in the Saratoga basin. The Tertiary succession, which unconformably overlies Precambrian and gently folded Paleozoic and Mesozoic rocks, is composed of the Browns Park(?) formation of Miocene(?) age and the North Park(?) formation of Pliocene(?) age.

Normal faults cut the Tertiary rocks at several places. In sec. 19, T. 16 N., R. 84 W., a displacement of about 10 feet on a pediment surface and the damming of small streams indicate that minor movements have taken place in relatively recent time.

STRATIGRAPHY

GENERAL

Because fieldwork was directed primarily toward the investigation of uranium occurrences in the area, rocks other than those related to the uranium occurrences are not discussed. The general characteristics and thicknesses of rocks exposed in the Saratoga area, given in table 1, are summarized from descriptions by Ashley (1948), McGrew (1951, 1953), Weitz and Love (1952), Love (1953), and Vine and Prichard (written communication, 1956). Unusually high radioactivity in rocks older than Tertiary was not detected by the airborne survey or by a hand scintillation counter.

TABLE 1.—*Formations exposed in the Saratoga area*

System	Series	Formation	Approximate thickness (feet)	Description
Quaternary	Recent	Alluvium	------	Alluvium consisting of clay, silt, sand, and gravel; found along major streams.
	?	Pediment deposits	1-15	Unconsolidated pediment deposits consisting of poorly sorted silt, sand, gravel, cobbles, and boulders; found on relatively flat upland surfaces.
		—Unconformity—		
Tertiary	?	Conglomerate of post-North Park(?) age	100±	Poorly cemented conglomerate composed of rounded rock fragments up to 2 ft. across in matrix of poorly sorted sandstone; exposed only along Jack Creek. Mapped with North Park(?) formation.
	Pliocene(?)	North Park(?) formation	1000±	Sequence of fine-grained sandstone; white- to yellowish-gray tuff; light-gray cherty limestone, bentonitic claystone and marlstone; and volcanic ash.
	Miocene(?)	Browns Park(?) formation	850±	Basal conglomerate and overlying sequence of gray to white fine-grained sandstone with thin beds of cherty limestone, marlstone, claystone, and green to gray volcanic ash. Basal conglomerate may be absent but is 100 ft. thick locally.
		—Unconformity—		
Cretaceous	Upper	Steele shale	2500±	Sequence of gray soft shale with numerous thin fine-grained sandstone beds in upper part; contains marine fossils.
		Niobrara formation	1200±	Sequence of smoky-gray limy shale and light-gray argillaceous chalky limestone; contains marine fossils.
		Frontier formation	650±	Gray thin-bedded sandstone interbedded with gray to black silty and sandy shale; contains marine fossils.
	Lower	Mowry shale	350±	Black hard siliceous shale, which weathers to distinctive silver gray. Contains a few thin bentonite beds and fish scale impressions.
		Thermopolis shale	100±	Dark-gray to black soft shale in the lower part and interbedded black shale and gray ferruginous sandstone (Muddy sandstone member) in upper part; mapped with Mowry shale.
		Cloverly formation	150±	Clean light-gray sparkling sandstone with beds and lenses of chert pebble conglomerate in lower part and dark-gray to black shale partings near top; some shale partings are carbonaceous.
Jurassic	Upper	Morrison formation	250±	Greenish-gray and variegated shale, claystone and siltstone with thin beds of gray, green, and pink nodular limestone and silty sandstone.
	Lower	Jurassic rocks undivided	225±	Dull pink to light-gray noncalcareous sandstone (Nugget sandstone of Lower Jurassic age) at base and an overlying sequence of gray fine-grained calcareous nonglauconitic sandstone and greenish-gray glauconitic shale and sandstone; limited exposures in the Saratoga area.
Precambrian		Precambrian rocks undivided	?	Granite, granite gneiss, and schist.

466354—59——2

AGE AND NOMENCLATURE OF THE TERTIARY ROCKS

In a description of the Tertiary strata in central Carbon County, Wyo., Veatch (1907) included about 4,500 feet of white ashy beds, cherty bands, and basal conglomerate in the North Park formation unconformably overlying about 1,200 feet of dark shales and shaly sandstone of the Fort Union formation. He designated the age of the formations as Tertiary.

Ashley (1948) states that the Tertiary strata in the Saratoga Basin have been mapped as the North Park(?) formation by several geologists. The name was queried because of the uncertain correlation between the Tertiary sequence in the Saratoga basin and the North Park formation as redefined by Beekly (1915) at North Park, Colo. On the basis of lithologic characteristics, Ashley divided his North Park(?) formation into two parts. The lower part, predominantly gray, consists of a basal conglomerate overlain by persistent beds of sandstone, limestone, chert, clay, and volcanic ash. The upper part, characteristically buff, consists of lenticular beds of conglomerate, sandstone, limestone, clay, and volcanic ash. According to Ashley, vertebrate fossils collected in the vicinity of Saratoga establish the age of the lower part of the North Park(?) formation as used by him as early Miocene and the upper part as early Pliocene. He suggested tentatively that in the Saratoga basin the Miocene–Pliocene boundary be drawn at the color change from gray to buff.

McGrew (1951) also recognized the two lithologic units present in the vicinity of Saratoga and referred to the lower unit as the Browns Park formation of middle Miocene age and the upper unit as the North Park formation of early Pliocene age. Subsequently, a larger vertebrate fauna was obtained from the area by Montagne (1954). Study of this fauna led McGrew (1953) to consider the North Park formation of the Saratoga area as Barstovian in age or uppermost Miocene in age in accordance with the classification of these rocks by the Committee on Nomenclature and Correlation of the North American Continental Tertiary. The writers follow the usage of the Geological Survey in referring to the Browns Park formation as Miocene(?) in age and to the North Park formation as Pliocene(?) in age.

The Tertiary formations shown on plate 39 of this report are queried because of the uncertainty of the age relations and the correlation of the rocks in the Saratoga Valley with those at the type localities at Browns Park and North Park, Colo. Contacts have been modified from those shown in previous work (Love and others, 1952; Weitz and Love, 1952) on the basis of lithologic characteristics observed during a general reconnaissance in the area, but no supporting fossil evidence was found.

BROWNS PARK(?) FORMATION

Rocks in which Miocene fossil vertebrates have been found crop out east of the North Platte River 5 miles north of Saratoga. The sequence consists of gray sandstone and siltstone with thin beds of gray cherty limestone and very light-gray clay, marlstone, and volcanic ash. The rocks are massive, usually poorly bedded, and weather drab to dull gray. The strata have a general dip of from 5° to 15° to the east. The cherty limestone beds usually form dip slopes of small cuestas that can be traced for several miles southwest of Saratoga where they are truncated and covered by pediment gravels. The base of the Browns Park(?) formation is not exposed in the area investigated, but several miles north of Saratoga along the North Platte River a basal conglomerate as much as 100 feet thick unconformably overlies the Mesaverde formation of Late Cretaceous age.

NORTH PARK(?) FORMATION

Rocks thought to represent the North Park(?) formation crop out east of the North Platte River north of Saratoga. The rocks consist of pale-yellowish-brown sandstone and siltstone, light-gray cherty limestone, and white chalky marlstone and volcanic ash. They usually have fairly well-developed bedding and on weathering appear thin layered. The weathered colors are chalky white, light gray, and pale yellowish brown. The strata in general dip about 2° to the east.

No continuous horizon on which to draw the base of the North Park(?) formation was observed. The color change as noted by Ashley (1948) and McGrew (1951) along the North Platte River several miles north of Saratoga could not be traced to the south. Ashley (1948) states that at many localities the base of the upper part of his North Park(?) formation is marked by a calcareous conglomerate, and J. D. Vine and G. E. Prichard (written communication, 1956) have mapped such a conglomerate at the base of the North Park(?) formation in the Miller Hill area west of Saratoga. In most areas the contact between the Browns Park(?) and North Park(?) formations appears to be conformable and gradational, but locally the difference in attitude of the rocks indicates a probable unconformable relation. The nature of the contact was not studied in detail.

In the vicinity of Jack Creek (western half of T. 17 N., R. 85 W.) a poorly cemented conglomerate composed of rounded rock fragments as much as 2 feet in diameter, but averaging less than 1 foot, in a matrix of poorly sorted sandstone overlies the truncated edges of tilted Mesozoic rocks. The conglomerate is as much as 100 feet thick. At one exposure about 5 feet of well-cemented conglomerate composed of fragments of quartz, chert, and igneous rock is exposed between the Mesozoic rocks and the poorly cemented conglomerate above. The entire thickness of the lower conglomerate is not exposed because of talus cover at the base of the upper conglomerate. According to N. M. Denson (oral communication, 1954) the lower conglomerate is similar to that mapped by J. D. Vine and G. E. Prichard (written communication, 1956) as the base of the North Park(?) formation in the Miller Hill area. The thick, poorly cemented conglomerate overlying the well-cemented conglomerate is probably post-North Park(?) in age and may be equivalent to the gravel of post-North Park(?) age described by Vine and Prichard in the southeastern part of the Miller Hill area. An inferred boundary between the Browns Park(?) and the North Park(?) formations has been sketched in this area to indicate the possible presence of both formations.

PEDIMENT DEPOSITS

Much prospecting has been carried on in the pediment gravels west of State Highway 130 from 4 to 7 miles south of Saratoga. Carnotite has been found in the gravel and underlying rocks. The pediment deposits consist of a very poorly sorted mixture of silt, sand, pebbles, cobbles, and boulders. The rock fragments are usually less than 1 foot in diameter and are well rounded. Fragments of many rock types including sandstone, limestone, chert, granite, schist, and basic igneous rocks are present, and pods of gypsum are common. The deposits are unconsolidated and massive.

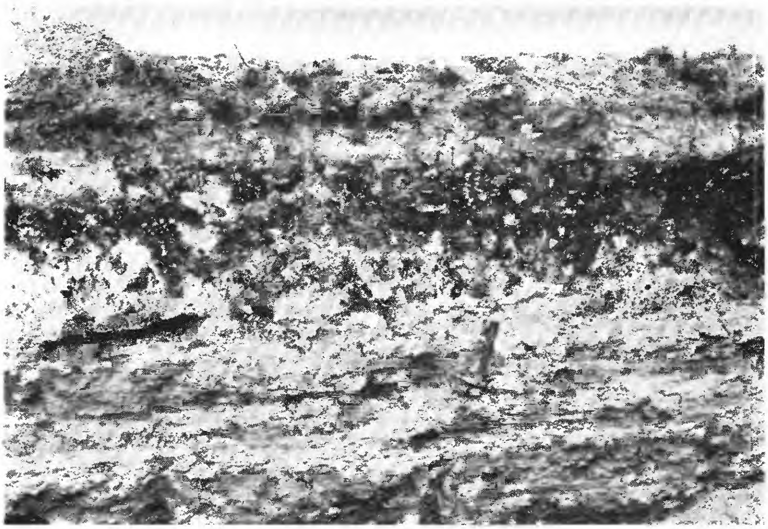
URANIUM OCCURRENCES

In the Saratoga area, uranium in small quantities occurs in both the Browns Park(?) formation and the North Park(?) formation and in the overlying Quaternary pediment gravels. No commercial deposits have been found to date. Carnotite, $K_2(UO_2)_2(VO_4)_2 \cdot 1\text{–}3H_2O$, the only uranium mineral identified was found at localities 22 and 30 (plate 39), where it occurs as a calichelike deposit coating sandstone and limestone in the North Park(?) formation directly beneath pediment gravel, as disseminated specks in the overlying pediment gravel, and as a coating on pebbles and boulders in the pediment gravel. At the other localities the uranium is disseminated in chert, limestone, sandstone, siltstone, or volcanic ash, but no uranium minerals were seen. Table 3 shows the equivalent uranium and uranium contents of the rocks collected in the area.

Most of the uranium in the Browns Park(?) formation occurs in layers and irregular masses of chert in thin hard dense medium-light-gray limestone beds that contain only minor amounts of uranium. Figure 31 and plate 40*A* show a typical example of this type of occurrence. The limestone beds range from 1 to 5 feet in thickness and usually form dip slopes on small cuestas. Because of the hard and resistant character of the limestone beds, few prospect pits have been dug; only a few samples of fresh rock could be obtained. The amount

A, PIT IN THE BROWNS PARK(?) FORMATION 3 MILES WEST OF SARATOGA

The pit is at locality 7 (sec. 20, T. 17 N., R. 84 W.). A radioactive cherty limestone bed (limestone appears light and chert dark) overlies siltstone (lower light area). Base of cherty limestone is near center of hammer handle. See figure 31 for description and analyses.



B, BULLDOZED CUT ON PEDIMENT SURFACE 6 MILES SOUTH OF SARATOGA

Carnotite coatings occur on both the pediment gravel and their limestone lenses in the underlying sandstone of the North Park(?) formation. The cut is at locality 30 (sec. 13, T. 16 N., R. 84 W.). Base of the pediment gravel is just above the hammer handle. Hammer is resting on one of the limestone lenses. See figure 33 for description and analyses.

of radioactivity of the limestone beds appears to be directly proportional to the amount of chert present; and, since the amount of chert varies considerably along the outcrop, the radioactivity of the beds is erratic. The limestone contains both dusky-yellow-brown and medium-light-gray chert, usually in the same bed. In general, the darker chert has the most uranium. An exception to this generalization is a medium-light-gray chert at locality 14 which contains the most uranium found in the Browns Park(?) formation in this area (0.027 percent). Other rock types in the Browns Park(?) formation have only minor amounts of uranium. Sandstone contains as much as 0.002 percent of uranium; siltstone, as much as 0.003 percent of uranium; and calcite, as vein filling in sandstone, as much as 0.005 percent of uranium.

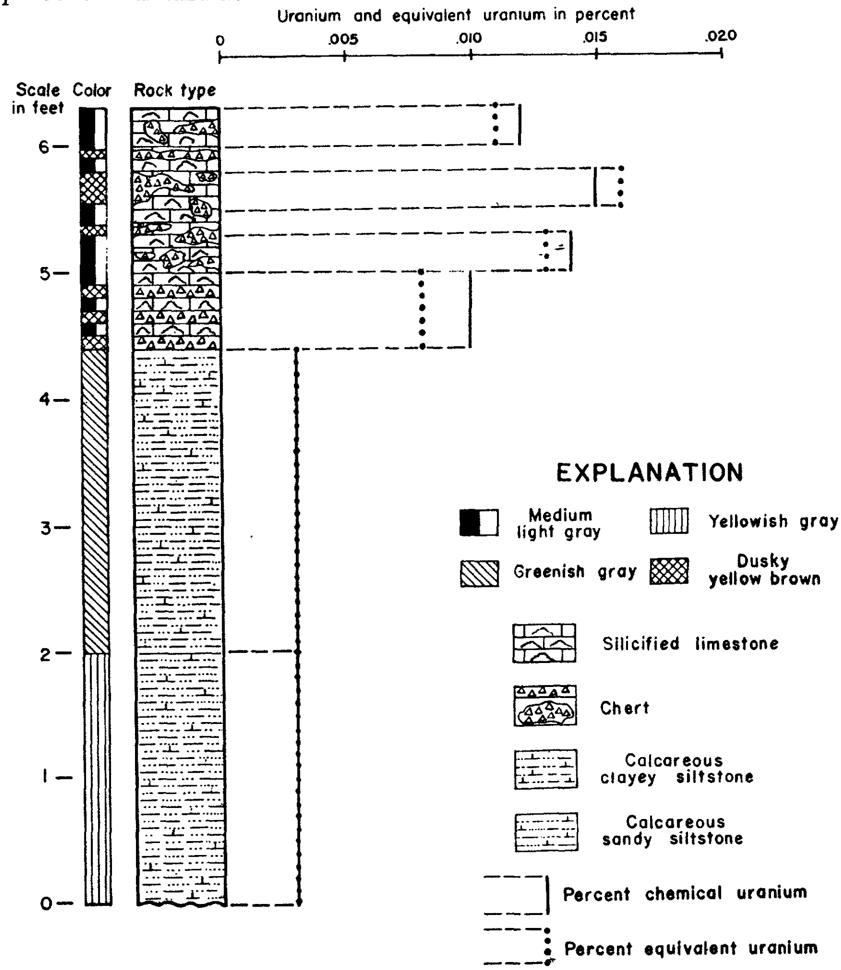


FIGURE 31.—Stratigraphic section in the Browns Park(?) formation showing uranium and equivalent uranium contents of rocks at locality 7.

In the North Park(?) formation, uranium occurs in small quantities in several rock types in addition to chert and limestone as described above. At locality 10 a blocky pale-yellow-brown limestone 0.2 feet thick contains 0.017 percent of uranium, and a carbonaceous shale 0.1 foot thick overlying the limestone contains 0.006 percent of uranium. A light-gray fine-grained limy sandstone 1 foot thick at locality 16 contains 0.017 percent of uranium. At locality 18 a light-gray soft volcanic ash 1.7 feet thick contains from 0.019 to 0.026 percent of uranium (fig. 32). A light-gray clayey siltstone at the same locality

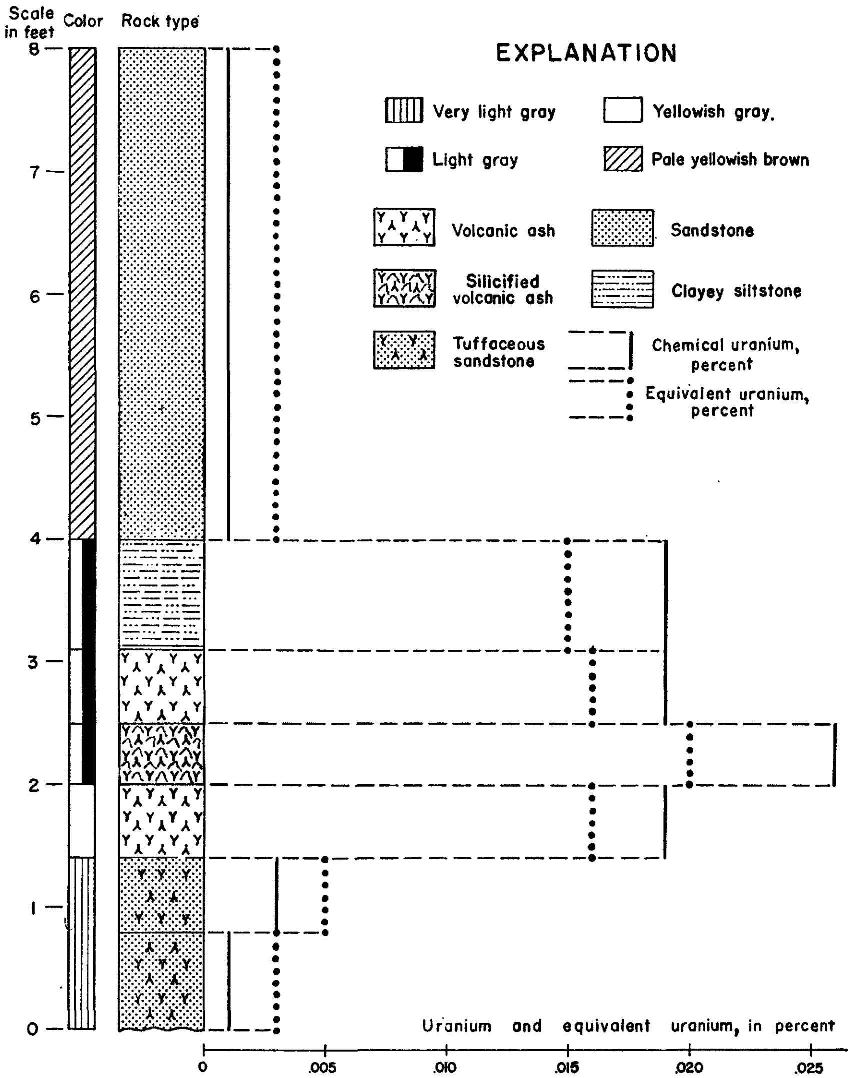


FIGURE 32.—Stratigraphic section in the North Park(?) formation showing uranium and equivalent uranium contents of rocks at locality 18.

contains 0.019 percent of uranium. At locality 30 a sandstone 4.5 feet thick with many carnotite-coated lenses of light-gray limestone up to 2 inches in thickness, contains as much as 0.004 percent of uranium (fig. 33 and pl. 40*B*).

The highest uranium content in pediment gravel in the area was found at locality 30 (fig. 33 and pl. 40*B*). Carnotite is visible as

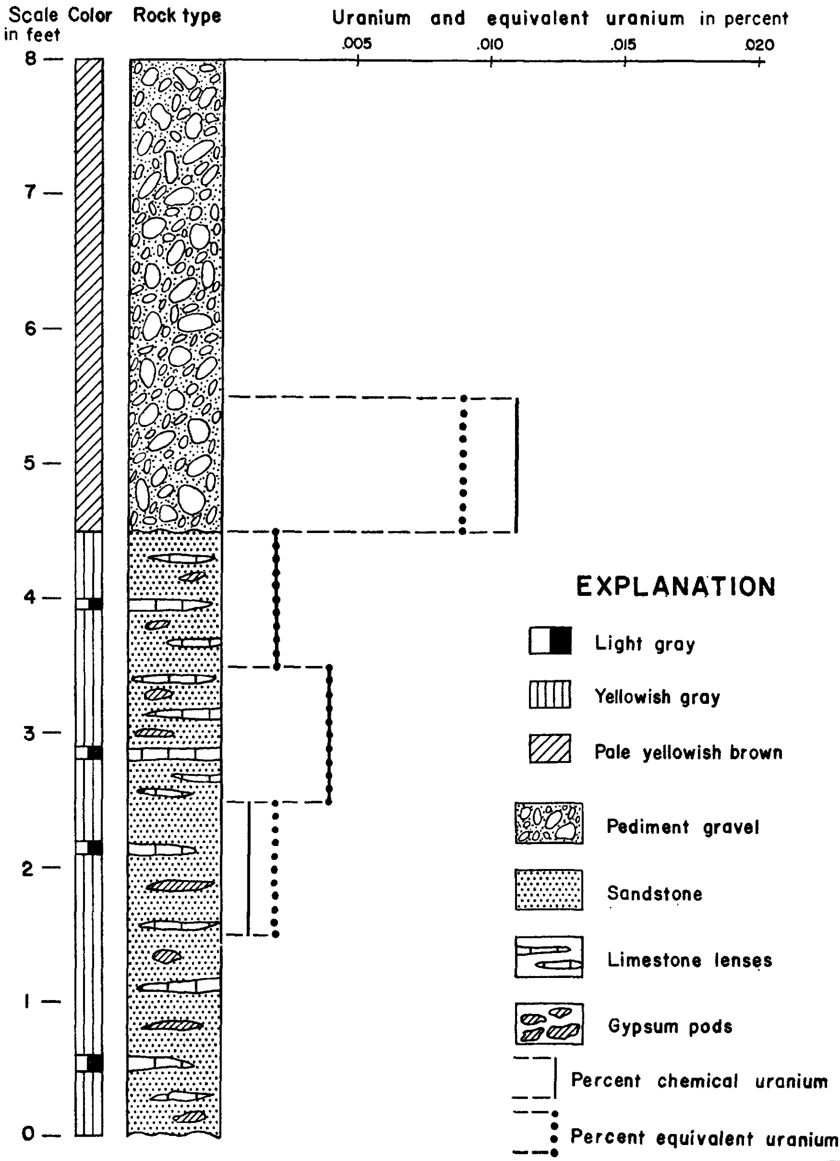


FIGURE 33.—Stratigraphic section showing uranium and equivalent uranium contents in pediment gravel and part of the North Park(?) formation at locality 30.

coatings on the rock fragments and as disseminated specks in the finer grained matrix. A selected sample of the gravel at this locality contains 0.011 percent of uranium.

URANIUM CONTENT OF WATER

Fifty-six samples of natural waters were collected in the Saratoga area in an effort to outline areas in which the rocks have high concentrations of uranium. Water was collected from 36 springs, 14 wells, 3 seeps, 2 reservoirs, and 1 stream. Sample localities are shown on plate 39 and plate 41, and individual analyses are given in table 4. Although some of the wells are located on alluvium, the source of water in them is from formations at depth. The uranium content and pH for each source of water are summarized in the following table.

TABLE 2.—*Summation of analyses of water samples from the Saratoga area*

[Analysts: H. Bivens, R. Deming, J. Johnson, D. Stockwell, and J. Wilson, U. S. Geological Survey]

Source of water sample	Number of samples	Uranium content (parts per billion)		pH	
		Range	Average	Range	Average
Alluvium	5	1–31	12	7. 5–7. 9	7. 7
North Park(?) formation	35	1–80	14	6. 8–8. 9	7. 5
Browns Park(?) formation	7	1–21	8	7. 4–8. 0	7. 7
Cloverly formation	2	1–3	2	7. 0–7. 1	7. 1
Precambrian rocks	4	1–6	3	7. 1–7. 8	7. 6
Saratoga hot springs	2	1–3	2	6. 9–7. 0	7. 0
Unknown	1	1	1	7. 7	7. 7

Because analyses of the water samples were not available before fieldwork was discontinued, no detailed investigations were undertaken in areas where the water had a high uranium content. It is believed that the rocks in these areas may contain uranium in even higher concentrations than were found during the present investigation. If detailed work was undertaken in these areas, water sampling might serve as a useful prospecting tool in searching for higher grade deposits.

LOCALIZATION OF URANIUM

Data obtained in the Saratoga area are inadequate to formulate a definite theory for the source of the uranium. The formation of the carnotite in calichelike occurrences in sandstone, limestone, and pediment gravel can best be explained by solution and redeposition by ground water. The source for the uranium in the water is not known, but it may be from tuffaceous beds in Tertiary rocks or from existing uranium occurrences.

At other localities where uranium is present but no minerals can be seen or identified, the uranium may be either syngenetic or epigenetic. Uranium might have been deposited in favorable host rocks by water which leached uranium from tuffaceous beds in the Browns Park(?) and North Park(?) formations. Where uranium is concentrated in chert in limestone beds, possibly the uranium and chert were introduced simultaneously by ground water sometime after the deposition of the limestone. It is also possible that the uranium was adsorbed from uranium-bearing water by the chert after the deposition of both the limestone and chert or that it was deposited with the chert at the time of deposition of the chert and limestone. Conclusive evidence to substantiate any one of these possibilities was not observed.

No evidence for a hydrothermal origin of the uranium was seen, but such an origin should not be excluded because of the inadequate data obtained in the area. Tertiary intrusive rocks occur about 20 miles to the southwest in the Battle Mountain and Elkhead Mountains area, but none were recognized in the Saratoga area. Faults, along which uranium-bearing solutions could move, occur in the area, but none of the observed uranium occurrences appear to be associated with the faults.

TABLE 3.—*Analyses of rock samples from the Saratoga area, Carbon County, Wyo.*
[Analysts: S. Furman, M. Finch, H. Lipp, and J. Wilson, U. S. Geological Survey]

Locality (see pl. 39)	Laboratory sample	Thickness of interval sampled (feet)	Equivalent uranium (percent)	Uranium (percent)	Formation	Description
1	212196	----------	0.005	0.005	Browns Park(?)----	Calcite, vein filling in sandstone.
1	212197	1.0	.001	----------	-----do------------	Marlstone, very light gray, tuffaceous.
2	212198	2	.001	----------	-----do------------	Limestone, medium-light-gray; silicified, contains buff chert.
2	212199	2	.001	----------	-----do------------	Limestone, medium-light-gray, nonsilicified; about 8 ft below sample 212198.
3	212193	1.5	.009	.009	-----do------------	Chert, light-brownish-gray; found in silicified limestone bed.
3	212194	1.5	.010	.010	-----do------------	Chert, dusky yellow-brown; found in silicified limestone bed about 20 ft below sample 212193.
3	212195	1.5	.003	.002	-----do------------	Limestone, medium-light-gray; same bed from which sample 212194 was taken.
4	212174	----------	.005	.006	-----do------------	Chert, dusky-yellow-brown; debris on ridge top.
4	212173	1±	.002	<.001	-----do------------	Sandstone, light-gray, clayey, micaceous.
4	212172	1±	<.001	----------	-----do------------	Limestone, light-gray, some light-gray chert, silicified.
4	212171	1±	.001	----------	-----do------------	Limestone, light-gray, nonsilicified.
5	212178	----------	.003	.001	------------------	Soil.
5	212177	2±	.002	.003	Browns Park(?)----	Limestone, light-gray, slightly silicified.
5	212176	2±	.002	.002	-----do------------	Limestone, medium-light-gray, silicified.
5	212175	2±	.001	----------	-----do------------	Limestone, light-gray, nonsilicified.
6	212189	3±	.012	.013	-----do------------	Limestone, medium-light-gray, silicified.
6	212188	5±	.009	.009	-----do------------	Limestone, medium-light-gray, silicified, contains dusky-yellow-brown chert as layers and irregular masses.

TABLE 3.—*Analyses of rock samples from the Saratoga area, Carbon County, Wyo.*—Continued

Locality (see pl. 39)	Laboratory sample	Thickness of interval sampled (feet)	Equivalent uranium (percent)	Uranium (percent)	Formation	Description
6	212192	.4	.019	.017	Browns Park(?)	Upper 0.4 ft of bed sampled as No. 212188.
6	212191	.4	.007	.006	do	Middle 0.4 ft of bed sampled as No. 212188.
6	212190	.4	.015	.015	do	Lower 0.4 ft of bed sampled as No. 212188.
6	212187	1.0	.002	.002	do	Sandstone, greenish-gray, fine-grained, calcareous. Underlies bed sampled as No. 212188.
7	212182	1.3	.013	.015	do	Limestone, silicified 30 percent. Dusky yellow-brown chert in layers and irregular masses 70 percent.
7	212186	.3	.011	.012	do	Upper 0.3 ft of bed sampled as No. 212182.
7	212184	.3	.013	.014	do	Lower 0.3 ft of bed sampled as No. 212182.
7	212181	.6	.008	.010	do	Chert and interbedded limestone layers, directly below bed sampled as No. 212182.
7	212180	2.4	.003	.003	do	Siltstone, greenish-gray, clayey, calcareous, micaceous.
7	212179	2.0	.003	.003	do	Siltstone, sandy, calcareous.
7	212183		.001		do	Limestone, nonsilicified.
8	212218		.013	.014	do	Chert, dusky-yellow-brown, found in silicified limestone bed.
8	212217		.002	.001	do	Chert, medium-light-gray, from same bed as 212218.
8	212216	3	.001		do	Limestone, medium-light-gray, nonsilicified, about 10 ft below bed 212217 and 212218.
9	212219	1	.014	.012	do	Chert, dusky-yellow-brown, found in medium-light-gray limestone bed.
9	212221	1	.013	.013	do	Chert, dusky-yellow-brown, in limestone bed 10 ft below 212219
9	212220	2	.002	.001	do	Limestone with medium-light-gray chert, 10 ft below 212221.
10	212265	2.4	.002	<.001	North Park(?)	Sandstone, ironstained yellow-brown, fine-grained, argillaceous.
10	212264	0.6	.002	<.001	do	Sandstone, yellow-gray, fine- to medium-grained, irregularly bedded.
10	212263	.7	.003	.004	do	Shale, yellow-gray; contains limy zones.
10	212262	.2	.005	.003	do	Shale, yellow-gray, limy zones.
10	212261	.1	.008	.006	do	Shale, carbonaceous.
10	212260	.2	.012	.014	do	Limestone, light-brownish-gray, blocky.
11	212205	4	.007	.007	do	Chert, dusky-yellow-brown; found in medium-light-gray limestone.
11	212206		<.001		do	Limestone, medium-light-gray, nonsilicified.
12	212207		.008	.006	do	Chert, dusky-yellow-brown, in silicified limestone bed.
12	212208		.002	.003	do	Limestone, nonsilicified.
13	212209		.010	.007	do	Chert, medium-light-gray, in silicified limestone bed.
13	212210		.011	.010	do	Chert, dusky-yellow-brown in same limestone as 212209.
14	212211		.016	.012	Browns Park(?)	Chert, dusky-yellow-brown.
14	212212		.003	.002	do	Limestone, nonsilicified.
14	212213		.032	.027	do	Chert, medium-light-gray.
14	212214		.002	.001	do	Limestone, partially silicified.
14	212215		.028	.022	do	Chert, light-resinous-brown.
15	212222		.002	.001		Alluvium in center of dry lake bed.
15	212223		.001			Alluvium about 15 ft from center of dry lake bed.
15	212224		.001			Alluvium about 25 ft from center of dry lake bed.
16	212226	3	.003	.002	North Park(?)	Sandstone, limy, exposed in bulldozed pit.
16	212227	2	.002	.001	do	Mudstone, sandy, exposed in bulldozed pit.
16	212228	1	.013	.017	do	Sandstone, limy, exposed in creek bed.

TABLE 3.—*Analyses of rock samples from the Saratoga area, Carbon County, Wyo.*—Continued

Locality (see pl. 39)	Laboratory sample	Thickness of interval sampled (feet)	Equivalent uranium (percent)	Uranium (percent)	Formation	Description
17	212237	1	.001	----------	North Park(?)-----	Sandstone, conglomeratic, calcareous.
17	212236	2	.003	<.001	-----do------------	Sandstone, conglomeratic.
17	212235	.5	.001	----------	-----do------------	Limestone, sandy, nodular.
17	212234	1.2	.001	----------	-----do------------	Sandstone, brown.
17	212233	1.2	.001	----------	-----do------------	Limestone, nodular.
18	212253	2	.005	.002	-----do------------	Limestone, yellow-green silicified.
18	212251	.9	.015	.019	-----do------------	Siltstone, light-gray, clayey, thin-bedded.
18	212252	4	.003	.001	-----do------------	Sandstone, pale-yellowish-brown, cross-laminated.
18	212250	.6	.016	.019	-----do------------	Ash, light-gray.
18	212249	.5	.020	.026	-----do------------	Ash, light-gray, silicified.
18	212248	.6	.016	.019	-----do------------	Ash, very light gray, silty.
18	212247	.6	.005	.003	-----do------------	Sandstone, fine-grained, tuffaceous, carbonaceous.
18	212246	.8	.003	.001	-----do------------	Sandstone, fine-grained, tuffaceous, carbonaceous.
19	212245	1	.002	<.001	-----do------------	Limestone, silicified.
20	212244	.3	.004	.003	-----do------------	Coaly silicified material.
20	212243	1	.004	.002	-----do------------	Conglomerate, silicified.
20	212242	1	.005	.002	-----do------------	Sandstone, silicified, with chunks from ¼ in. to ½ in. of soft charcoal.
21	212254	1	.003	.002	-----do------------	Conglomerate, silicified.
22	212255	1	.002	<.001	-----do------------	Sand, yellow-green, unconsolidated.
22	212256	1.5	.002	<.001	-----do------------	Sand, chalky-white, unconsolidated.
23	212240	2	.001	----------	-----do------------	Sandstone, limy, fine-grained.
23	212241	----------	.005	.004	-----do------------	Limestone, silicified.
24	214206	2	.002	----------	Pediment----------	Soil and gravel of pediment surface.
25	214205	1.5	.001	----------	-----do------------	Soil and gravel of pediment surface.
26	214209	3.5	.001	----------	-----do------------	Soil, fine sand and gravel of pediment surface.
26	214208	1.5	.001	----------	-----do------------	Coarse unconsolidated sand with pebbles and boulders and gypsum.
26	214207	2	.002	----------	-----do------------	Fine unconsolidated sand, calcareous, some pebbles.
27	214212	3	.001	----------	-----do------------	Soil, sand and gravel of pediment surface.
27	214211	.5	.001	----------	North Park(?)-----	Sandstone, olive-green, soft, friable.
27	214214	2	.002	----------	-----do------------	Limestone, silicified.
27	214213	5	.001	----------	-----do------------	Siltstone, pale-green, laminated.
28	214219	2	.005	.007	Pediment----------	Soil. sand and boulders of pediment surface.
28	214218	2	.004	.003	-----do------------	Sand and gravel with lenses of green sandy siltstone, unconsolidated.
28	214217	.4	.003	----------	North Park(?)-----	Sandstone, olive-green, silicified, fine-grained.
28	214216	.4	.003	----------	-----do------------	Gypsum.
28	214215	2	.002	----------	-----do------------	Sandstone, olive-green, fine-grained.
29	212257	1	.001	----------	Pediment----------	Sand and gravel of pediment surface.
30	212259	1	.009	.011	-----do------------	Sand, gravel and gypsum of pediment surface, contains carnotite, as coating on gravels and as disseminated specks.
30	212258	4.5	.002	.001	North Park(?)-----	Sandstone with layers and lenses of limestone from ⅛ in. to 2 in. in thickness, contains carnotite as coating material on limestone.
30	139083	1	.002	.002	-----do------------	Upper 1 ft of unit sampled as 212258.
30	139084	1	.004	.004	-----do------------	Second 1 ft from top of unit sampled as 212258.
30	139085	1	.002	.001	-----do------------	Third 1 ft from top of unit sampled as 212258.
30	139086	----------	.002	.002	-----do------------	Gypsum.
31	214229	4	.002	----------	Pediment----------	Soil, sand and gravel of pediment surface.
31	214230	2	.002	----------	-----do------------	Gravel and boulders of pediment surface.
31	214231	1	.002	----------	North Park(?)-----	Silty sandstone, light-green, fine-grained.

TABLE 3.—*Analyses of rock samples from the Saratoga area, Carbon County, Wyo.*—Continued

Locality (see pl. 39)	Laboratory sample	Thickness of interval sampled (feet)	Equivalent uranium (percent)	Uranium (percent)	Formation	Description
32	214225	0-2	.002	----------	North Park(?)	Sandstone, fine- to coarse-grained, cross-laminated.
32	214224	.5	.001	----------	do	Clay, dark-green, nonbedded, gypsum pods.
32	214223	.5	.001	----------	do	Sand, yellow-gray, fine-grained, unconsolidated.
32	214222	1.0	.004	.002	do	Siltstone, pale-green, tuffaceous, planar-bedded.
32	214221	1.5	.001	----------	do	Siltstone, light-gray, tuffaceous, planar-bedded, contains gastropods.
32	214220	.5	.002	----------	do	Siltstone, light-olive-green, tuffaceous, calcareous.
32	214228	20	.005	.001	do	Sandstone, fine- to coarse-grained, massive- to cross-bedded with silicified conglomeratic zones.
32	214227	15	.003	----------	do	Sandstone, fine- to coarse-grained, massive-to cross-bedded with silicified conglomeratic zones.
32	214226	15	.003	----------	do	Sandstone, fine- to coarse-grained, massive- to cross-bedded with silicified conglomeratic zones.

TABLE 4.—*Analyses of water samples from the Saratoga area, Carbon County, Wyo.*

[Analysts: H. Bivens, R. Deming, J. Johnson, D. Stockwell, and J. Wilson, U. S. Geological Survey]

Location (see pl. 39 and 41)	Laboratory sample	Type of sample	U content (ppb)	pH	Description
NW 4 26-18N 85W	213340	Spring	6	7.8	Browns Park(?) formation.
SW 4 36-18N-85W	210637	Spring	21	7.5	Browns Park(?) formation.
SE 4 36-18N-85W	210638	Reservoir	15	8.0	Browns Park(?) formation. Storage of water from spring sampled as no. 210637.
NE 4 7-18N-84W	213338	Well	6	7.5	No report of depth of well or rock type which contains water. Probably flood plain deposits of North Platte River.
NE 4 18-18N-84W	213339	Spring	5	7.6	Water from terrace(?) gravels along North Platte River.
NE 4 24-18N-84W	213347	Spring	5	7.8	Limestone in North Park(?) formation. William N. Eaton Ranch.
SW 4 25-18N-84W	213344	Well	19	7.7	Water probably from North Park(?) formation. Frank Schilt Ranch. Well depth 35 ft.
SW 4 25-18N-84W	213345	Spring	16	7.4	Spring from calcareous sandstone of North Park(?) formation. Frank Schilt Ranch.
NW 4 36-17N-87W	210655	Spring	13	8.0	North Park(?) formation.
SE 4 36-17N-87W	210654	Spring	9	7.0	Spring from sandstone in North Park (?) formation.
SE 4 16-17N-86W	210648	Spring	7	7.4	North Park(?) formation.
NW 4 19-17N-86W	210649	Stream	19	7.9	Perennial stream draining area of North Park(?) formation.
NE 4 21-17N-86W	210647	Spring	9	7.4	North Park(?) formation.
NE 4 27-17N-86W	210646	Spring	10	7.4	North Park(?) formation.
SW 4 31-17N-86W	210653	Spring	8	7.5	Sandstone in North Park(?) formation.
NE 4 33-17N-86W	210644	Spring	26	7.2	North Park(?) formation.
NW 4 34-17N-86W	210645	Spring	16	7.3	North Park(?) formation.
NW 4 35-17N-86W	210651	Seep	<1	7.1	North Park(?) formation.
NW 4 35-17N-86W	210650	Well	6	7.5	North Park(?) formation. Well reported to be 50 ft deep and water from conglomerate at bottom. Paul Boden Ranch.
SW 4 16-17N-85W	210639	Spring	7	7.6	Contact of Niobrara formation and North Park(?) formation.
SW 4 17-17N-85W	210640	Spring	7	7.0	North Park(?) formation.
SE 4 19-17N-85W	210642	Spring	3	7.0	Cloverly formation. Locally named Iron Spring.

TABLE 4.—*Analyses of water samples from the Saratoga area, Carbon County, Wyo.*—Continued

Location (see pl. 39 and 41)	Laboratory sample	Type of sample	U content (ppb)	pH	Description
NW ¼ 20-17N-85W	210643	Spring	7	7.5	Contact of Frontier formation and North Park(?) formation.
SW ¼ 20-17N-85W	210641	Spring	1	7.1	Sulphur spring in Cloverly formation.
NE ¼ 5-17N-84W	213341	Well	3	7.9	Browns Park(?) formation. Reported to be artesian well drilled to depth of 60 ft. Four Bar Ranch.
NE ¼ 5-17N-84W	213342	Seep	31	7.6	Alluvium.
SW ¼ 12-17N-84W	210657	Spring	3	7.0	Formations involved not determined. Hot water spring probably associated with faulting.
NW ¼ 13-17N-84W	210656	Spring	<1	6.9	Formations involved not determined. Hobo Pool. Hot water spring probably associated with faulting.
NW ¼ 14-17N-84W	210681	Well	<1	7.9	Water probably in alluvium in flood plain of North Platte River.
NW ¼ 18-17N-84W	213343	Seep	11	7.4	Tuffaceous sandstone in Browns Park (?) formation.
NW ¼ 25-17N-84W	213348	Well	<1	7.8	Browns Park(?) formation. Well reported to be drilled to depth of 110 ft.
NW ¼ 15-17N-83W	210680	Well	16	7.7	North Park(?) formation. Well reported to be 47 ft deep.
NW ¼ 23-17N-83W	210678	Well	6	7.7	North Park(?) formation. Well reported to be 50 ft deep.
SE ¼ 33-17N-82W	210679	Well	6	7.8	Precambrian rocks undivided.
SW ¼ 15-16N-88W	210661	Spring	3	7.1	Limy sandstone in North Park(?) formation.
NW ¼ 22-16N-88W	210660	Spring	2	7.2	Limestone in North Park(?) formation.
SE ¼ 27-16N-88W	210659	Spring	3	7.0	Limestone in North Park(?) formation.
NW ¼ 28-16N-88W	210662	Spring	4	7.0	Limestone in North Park(?) formation.
SW ¼ 8-16N-87W	210658	Spring	9	6.9	Tuffaceous sandstone in North Park(?) formation.
SW ¼ 4-16N-86W	210652	Spring	2	7.3	North Park(?) formation.
SW ¼ 11-16N-85W	210668	Well	1	7.7	Artesian well of unknown depth. Abandoned oil test. Source of water unknown.
NE ¼ 15-16N-85W	210667	Spring	19	7.8	Alluvium.
NE ¼ 20-16N-85W	210669	Spring	21	8.1	North Park(?) formation.
NW ¼ 28-16N-85W	210670	Spring	1	7.6	North Park(?) formation.
NE ¼ 33-16N-85W	210671	Spring	<1	7.1	Precambrian rocks undivided.
SE ¼ 33-16N-85W	210672	Spring	3	7.7	Precambrian rocks undivided.
NE ¼ 9-16N-84W	213349	Spring	80	7.7	Limestone in North Park(?) formation.
NE ¼ 17-16N-84W	210673	Well	<1	7.7	Browns Park(?) formation. Well reported to be 225 ft deep.
SW ¼ 31-16N-83W	213350	Well	5	8.0	North Park(?) formation. Well at house on Throwbridge Ranch. Reported to be dug to depth of 81 ft. Bottom in conglomerate.
SW ¼ 31-16N-83W	213351	Well	24	7.5	North Park(?) formation. Well at dairy farm on Throwbridge Ranch reported to be drilled to depth of 34 ft. May be alluvium.
NW ¼ 9-15N-88W	210663	Spring	4	6.8	Limestone in North Park(?) formation.
NE ¼ 17-15N-88W	210664	Spring	9	7.2	North Park(?) formation.
NW ¼ 23-15N-85W	210674	Spring	1	7.8	Precambrian rocks undivided.
SW ¼ 4-15N-84W	210676	Spring	55	7.7	North Park(?) formation.
SE ¼ 7-15N-84W	210675	Reservoir	8	8.9	Storage of water drained from area of North Park(?) formation.
NW ¼ 6-15N-83W	213352	Well	49	7.6	North Park(?) formation. Irrigation well on Throwbridge Ranch. Reported to be drilled to depth of 101 ft.

REFERENCES CITED

Ashley, W. H., 1948, The Tertiary of the Saratoga basin, Carbon County, Wyoming: Soc. of Vertebrate Paleontology Third Ann. Field Conf. Guidebook, p. 25–26.

Beekly, A. L., 1915, Geology and coal resources of North Park, Colorado: U. S. Geol. Survey Bull. 596.

Blackstone, D. L., Jr., 1953, Notes on the tectonic map on a portion of southern Wyoming and northern Colorado: Wyoming Geol. Assoc. Eighth Ann. Field Conf. Guidebook, p. 85–86.

Henderson, J. R., 1954, Airborne radioactivity survey of part of Saratoga NW quadrangle, Carbon County, Wyoming: U. S. Geol. Survey open file report.

Love, J. D., 1953, Preliminary report on uranium deposits in the Miller Hill area, Carbon County, Wyoming: U. S. Geol. Survey Circ. 278.

Love, J. D., Weitz, J. L., and Hose, R. K., 1952, Geologic map of Wyoming: U. S. Geol. Survey.

McGrew, P. O., 1951, Tertiary stratigraphy and paleontology of south-central Wyoming: Wyoming Geol. Assoc. Sixth Ann. Field Conf. Guidebook, p. 54–57.

——— 1953, Tertiary deposits of southeastern Wyoming: Wyoming Geol. Assoc. Eighth Ann. Field Conf. Guidebook, p. 61–64.

Montagne, John de la, 1954, Tertiary structure, fauna, and lithology in the upper Saratoga Valley-Big Creek Park area, Wyoming and Colorado [abs.]: Geol. Soc. America Bull., v. 65, p. 1384.

——— 1957, Cenozoic structural and geomorphic history of northern North Park and Saratoga Valley, Colorado and Wyoming: Rocky Mountain Assoc. of Geologists, Guidebook to the geology of North and Middle Parks basin, Colorado, p. 36–41.

Veatch, A. C., 1907, Coal fields of east-central Carbon County, Wyoming: U. S. Geol. Survey Bull. 316, p. 244–260.

Walters, R. F., 1957, The Independence Mountain area, North Park, Colorado: Rocky Mountain Assoc. of Geologists, Guidebook to the geology of North and Middle Parks basin, Colorado, p. 85–89.

Weitz, J. L., and Love, J. D., 1952, Geologic map of Carbon County, Wyoming: Wyoming Geol. Survey.

O