Geology and Mineralogy

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

By

James G. Stephens and M. J. Bergin

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Trace Elements Investigations Report 558

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* This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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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 located 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 as a caliche-like deposit on limestone and sandstone directly underlying pediment deposits, as a coating on individual constituents of the pediment gravel, and as disseminated specks in finer-grained material of the pediment gravel. At 30 other localities the uranium is not present in an identifiable mineral but occurs 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 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 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 strata exposed are shown in tables.

INTRODUCTION

The Saratoga area is in Carbon County, south-central Wyoming (fig. 1). An airborne radioactivity survey of part of the area was made by the U. S. Geological Survey in November 1953. The radioactivity anomalies discovered then are shown on plate 1 (Henderson, 1954).

Field work was carried on from July 5 to August 11, 1954. The main objective of the field investigation was to study and sample in detail each of the airborne radioactivity anomaly areas in order to evaluate the possibilities of commercial grade uranium deposits and to obtain information concerning the origin of the anomalies. Detailed work was supplemented by reconnaissance geologic mapping in the northwest quarter of the Saratoga, Wyoming-Colorado 30-minute quadrangle and reconnaissance in adjoining areas to examine other radioactivity anomalies found by aerial surveys.

Rocks exposed in areas of radioactivity anomalies and in numerous prospect pits were examined, and their radioactivity was tested with a scintillation counter. Rock samples from localities shown on plate 1 were collected for radiometric, chemical, and mineralogic analyses (table 3). Samples of water, the locations of which are shown on plate 1 and figure 8, were collected for uranium analysis as a possible aid in outlining areas for more intensive prospecting (table 4).

The writers wish to thank Mr. John de la Montagne, Dr. P. O. McGrew, and Mr. Paul Boden, all of whom gave helpful suggestions and ideas regarding the geology of the area. The samples were analyzed by the Geological Survey laboratory in Denver, Colo.

These investigations were made by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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. 1). The northwestern quarter of the Saratoga, Wyoming-Colorado 30-minute topographic quadrangle map covers the area. Elevations range from 6,750 feet along the North Platte River to 9,050 feet on the northeastern 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 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.

Saratoga is the only town in the area; Encampment is approximately 3 miles south of the southeastern corner; and Rawlins, the county seat of Carbon County, is 43 miles to the northwest.

State Highway 230 crosses the southeastern corner of the area, and State Highway 130 crosses the northeastern quarter. Numerous other improved and unimproved roads make most localities within the area accessible by automobile.

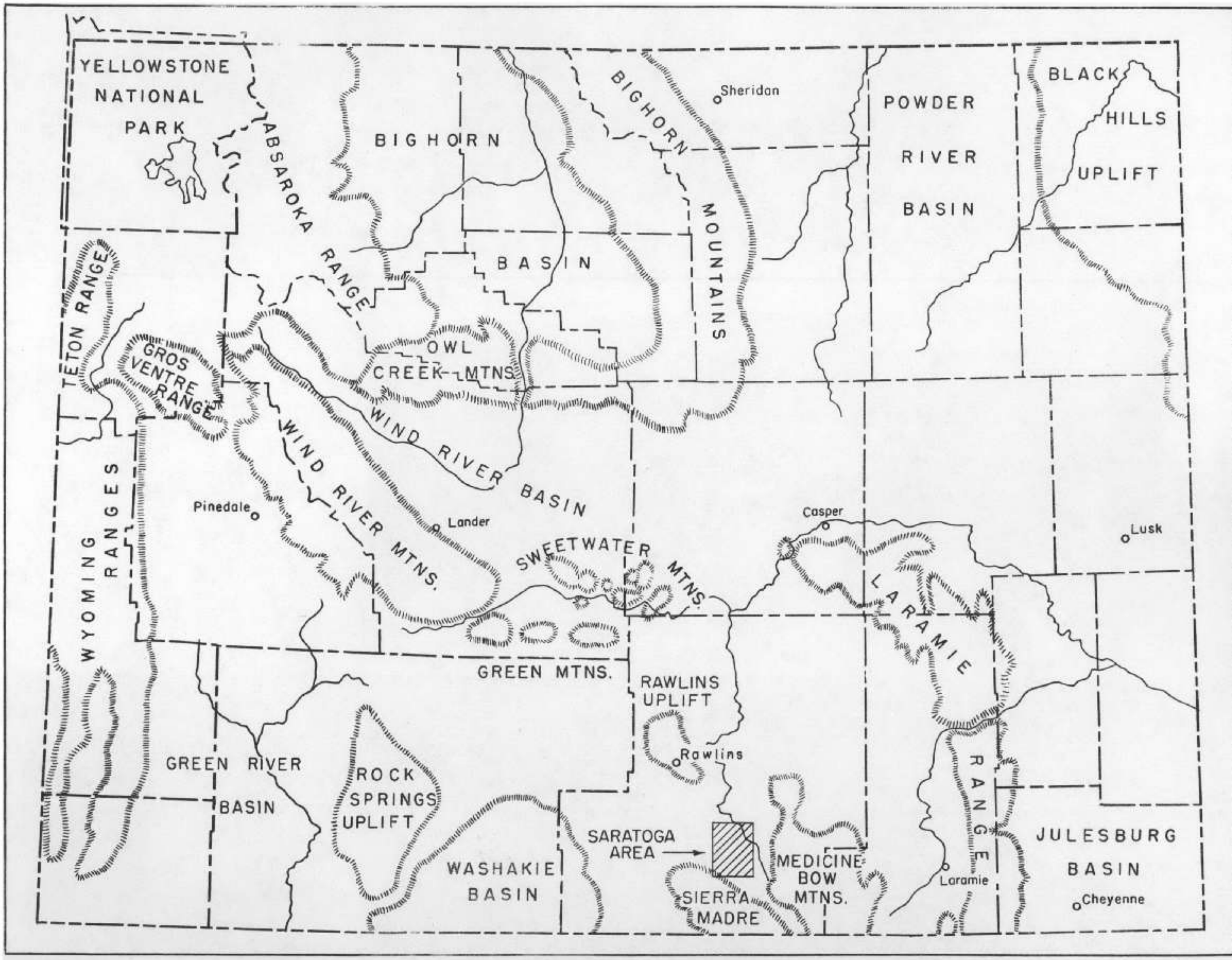


FIGURE 1.—INDEX MAP OF WYOMING SHOWING THE LOCATION OF THE SARATOGA AREA, CARBON COUNTY.

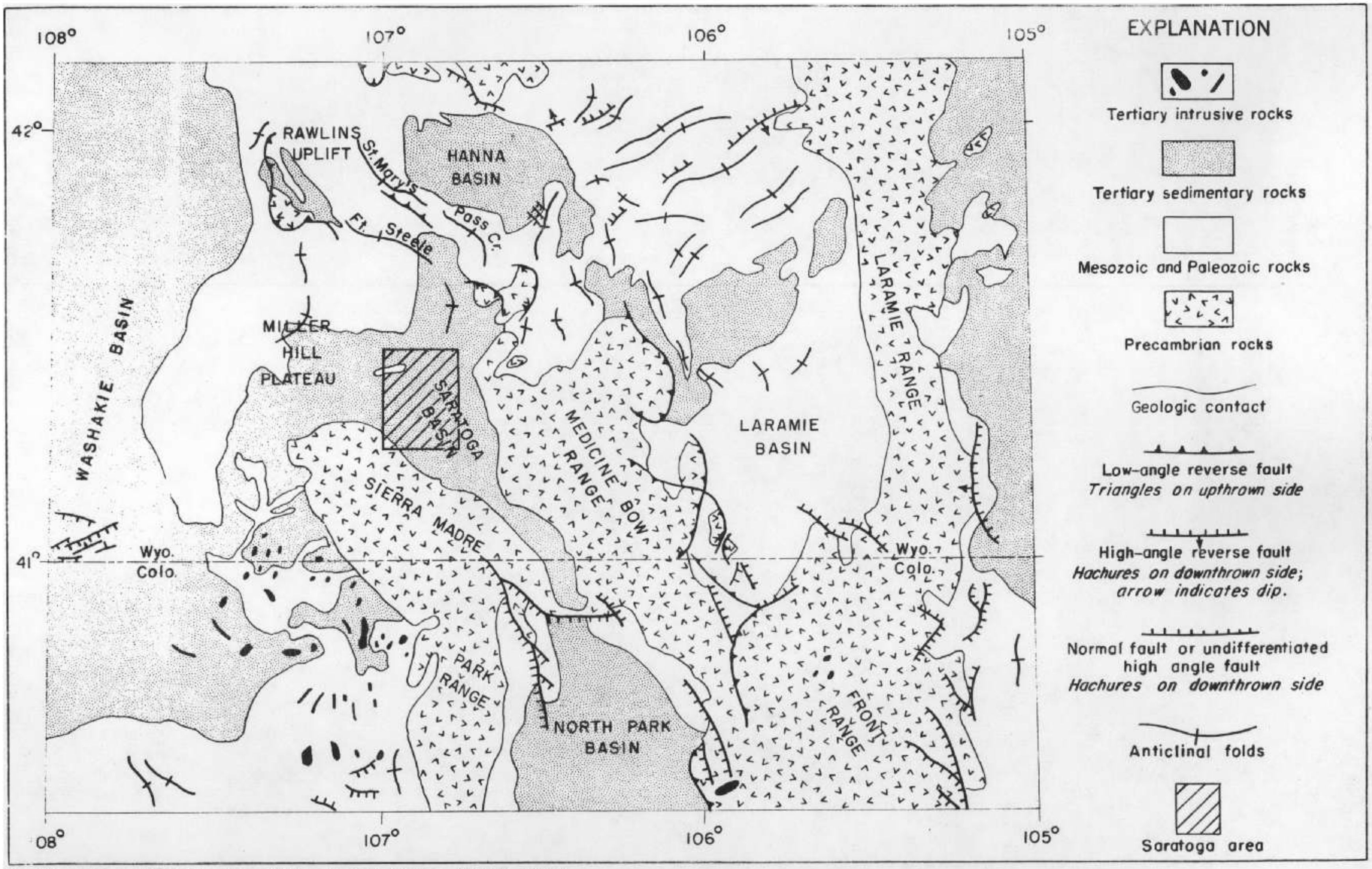
25 0 25 50 Miles

Cattle and sheep ranching are the main industries. Alfalfa and hay are grown in irrigated fields along permanent streams. 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 Range to the east and the Sierra Madre to the southwest (fig. 2). 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 east-trending fault which dips northward at a low angle (Blackstone, 1953).



Modified from Tectonic Map of the United States, A.A.P.G., 1944

FIGURE 2 -SKETCH MAP OF PART OF WYOMING AND COLORADO SHOWING THE GEOLOGIC SETTING OF THE SARATOGA AREA, CARBON COUNTY, WYOMING

20 0 20
Miles

Rocks of Precambrian, Paleozoic, Mesozoic, and Tertiary ages are exposed in the Saratoga Basin. The Tertiary succession, which lies on the eroded surface of Precambrian and gently folded Paleozoic and Mesozoic rocks, is referred to 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 approximately 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

Inasmuch as field work 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), Weitz and Love (1952), Love (1953), and Vine and Prichard (in preparation). Abnormally high radioactivity in rocks older than Tertiary was not detected by the airborne survey or by hand scintillation counter.

System	Series	Formation	Approximate thickness (feet)	General description and remarks
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	?	Post North Park(?) conglomerate	100 ±	Poorly cemented conglomerate composed of rounded rock fragments up to 2' 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 feet 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") 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) 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.
Pre-cambrian		Precambrian rocks undivided	?	Granite, granite gneiss, and schist.

Table 1. --Formations exposed in the Saratoga area

Age and nomenclature of the Tertiary rocks

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

Ashley (1948) states that the Tertiary strata in the Saratoga Basin have been mapped as the North Park(?) formation by various 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 the 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 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.

In 1933, J. D. Love found fossil horse teeth of early Pliocene age about 10 miles northeast of Saratoga, and in 1947, D. L. Blackstone, Jr. found fossil bones of a camel of middle Miocene age northwest of Saratoga (McGrew, 1951).

McGrew 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. A few additional fossils were found to support the age determinations.

The Tertiary formations shown on plate 1 of this report are queried because of the uncertainty of the age relationships 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 et al., 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 5° - 15° to the east. The cherty limestone beds which usually form dip slopes of small cuestas 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 from which Pliocene fossil vertebrates have been found 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 chalky white 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 approximately 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 the North Park(?) formation is marked by a calcareous conglomerate, and Vine and Prichard (in preparation) 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 relationship. The nature of the Miocene-Pliocene boundary 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, approximately 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 (personal communication) the lower conglomerate is similar to that mapped by Vine and Prichard (in preparation) 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 post-North Park(?) gravel described by Vine and Prichard (in preparation) 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 four to seven 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 one 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(?) and North Park(?) formations, 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 1) where it occurs as a caliche-like 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. The limestone itself contains only minor amounts of uranium. Figures 3 and 6 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 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 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 colored chert contains 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 contain only minor amounts of uranium. Sandstone contains as much as 0.002 percent uranium; siltstone, as much as 0.003 percent uranium; and calcite, as vein filling in sandstone, as much as 0.005 percent uranium.

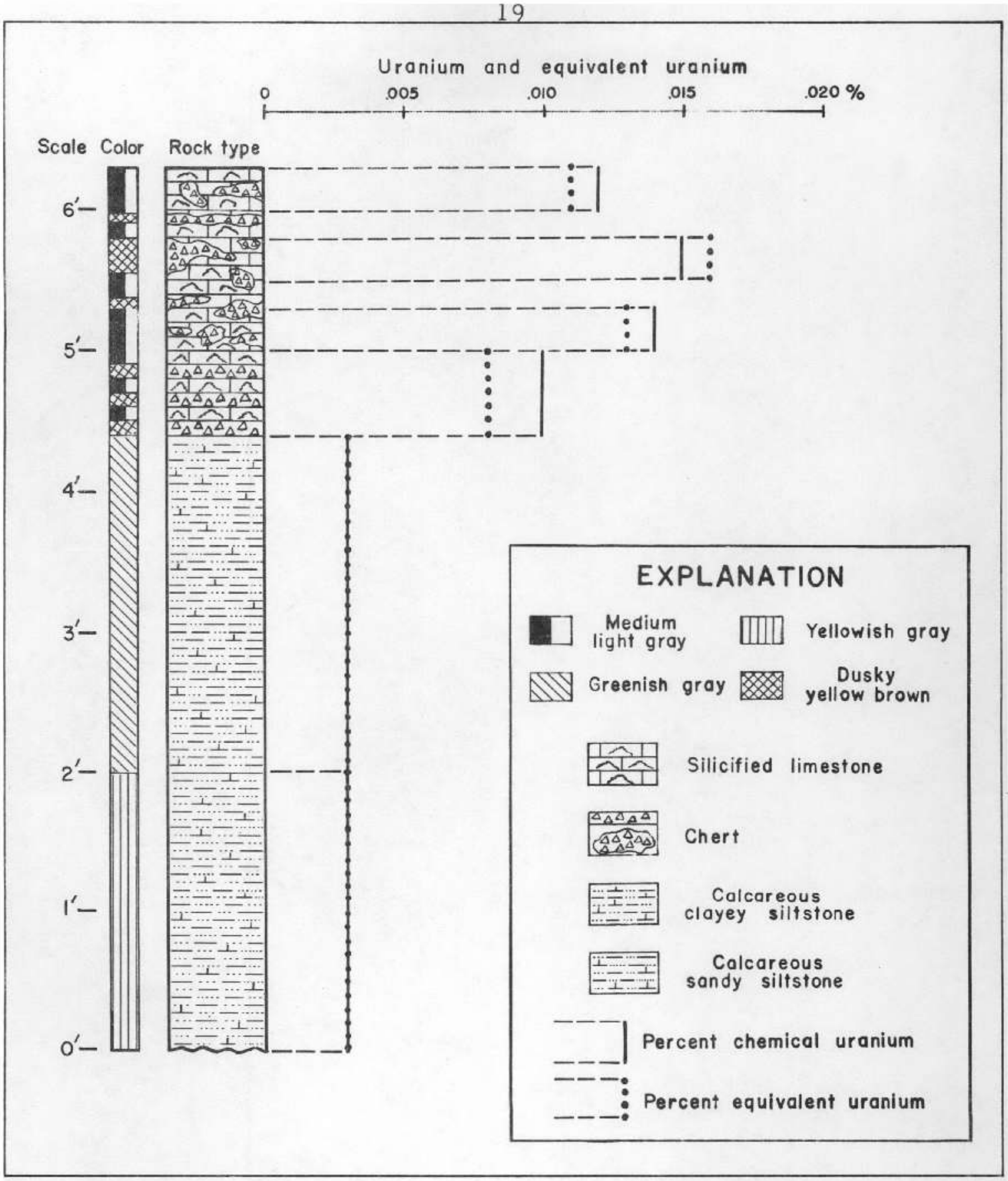


FIGURE 3.—STRATIGRAPHIC SECTION IN THE BROWNS PARK(?) FORMATION SHOWING URANIUM AND EQUIVALENT URANIUM CONTENTS OF ROCKS AT LOCALITY 7.

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 pale yellow-brown, blocky limestone, 0.2 feet thick, contains 0.017 percent uranium and a carbonaceous shale 0.1 foot thick overlying the limestone contains 0.006 percent uranium. A light gray, fine-grained, limy sandstone 1 foot thick at locality 16 contains 0.017 percent uranium. At locality 18 a light gray, soft volcanic ash 1.7 feet thick contains from 0.019 to 0.026 percent uranium (fig. 4). A light gray, clayey siltstone at the same locality contains 0.019 percent uranium. At locality 30 a sandstone 4.5 feet thick, with numerous carnotite-coated lenses of light gray limestone up to 2 inches in thickness, contains as much as 0.004 percent uranium (figs. 5 and 7).

The highest uranium content in pediment gravel in the area was found at locality 30 (figs. 5 and 7). Carnotite is visible as 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 uranium.

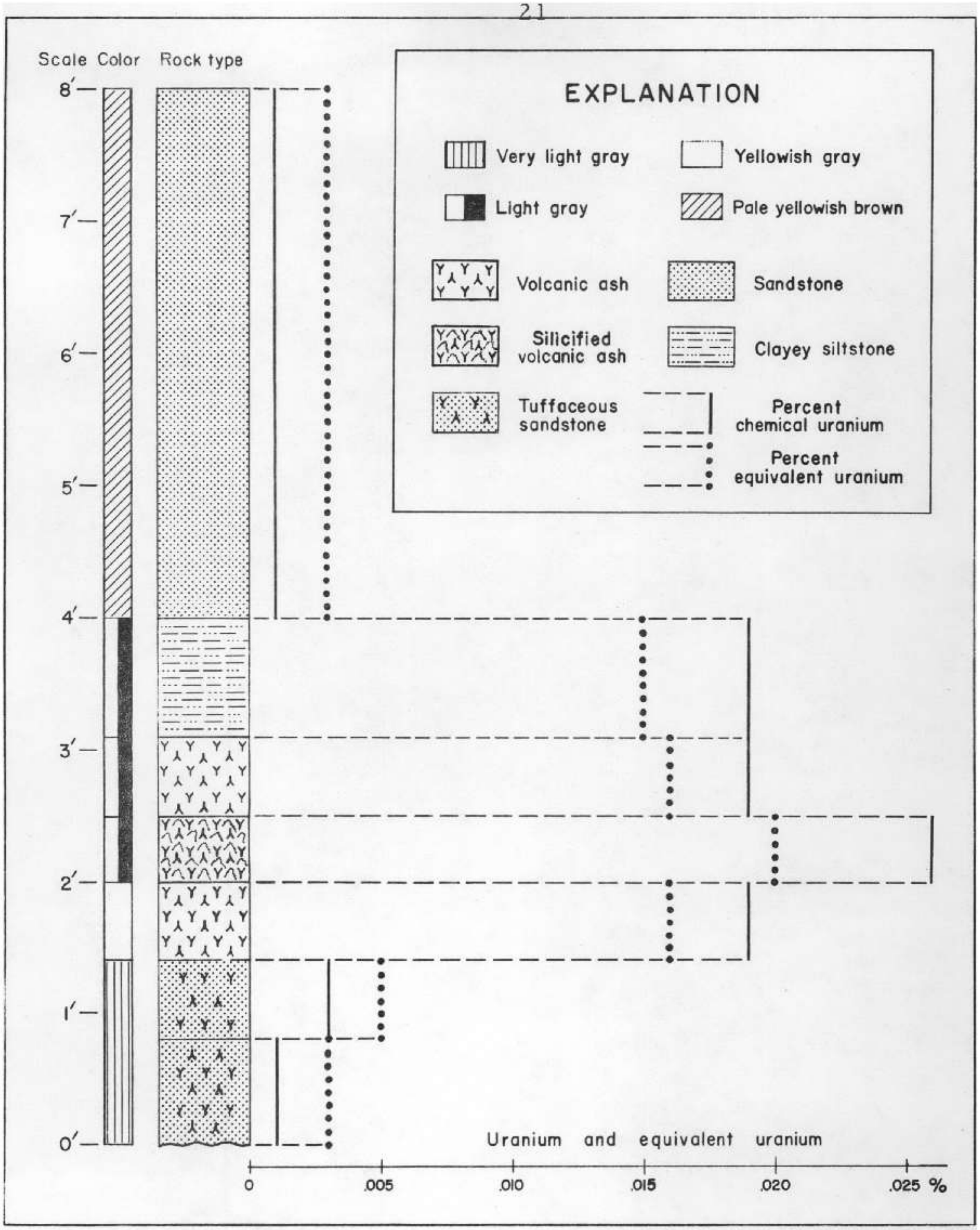


FIGURE 4.—STRATIGRAPHIC SECTION IN THE NORTH PARK(?) FORMATION SHOWING URANIUM AND EQUIVALENT URANIUM CONTENTS OF ROCKS AT LOCALITY 18

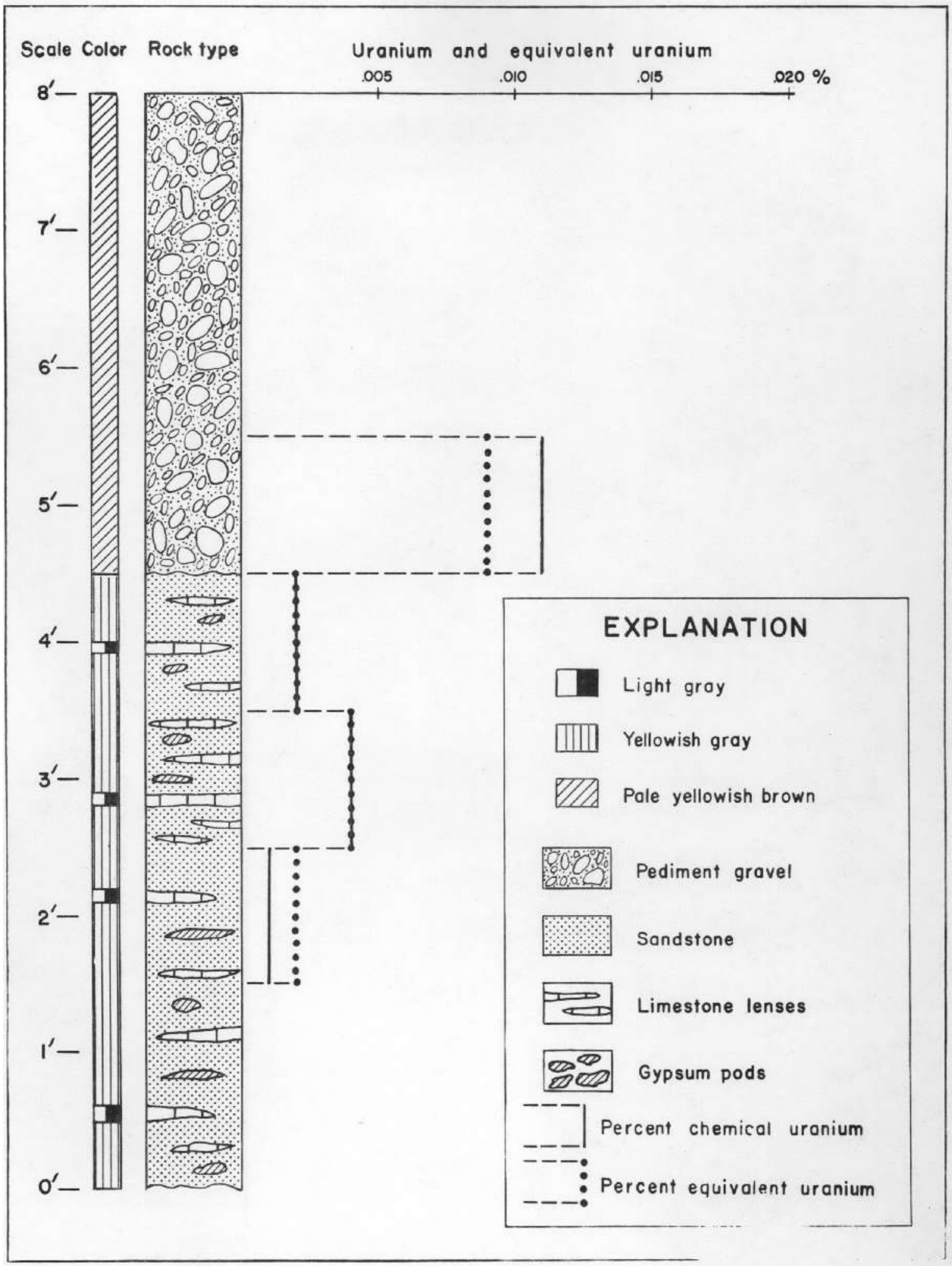


FIGURE 5.—STRATIGRAPHIC SECTION SHOWING URANIUM AND EQUIVALENT URANIUM CONTENTS IN THE NORTH PARK(?) FORMATION AND PEDIMENT GRAVEL AT LOCALITY 30

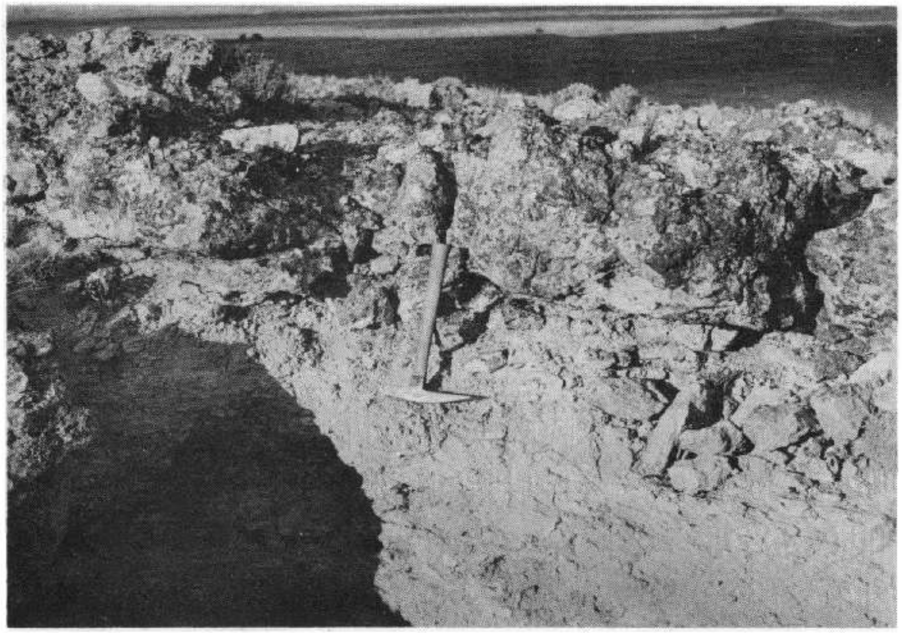


Figure 6.--Pit at locality 7 (sec. 20, T. 17 N., R. 84 W.) in the Browns Park(?) formation 3 miles west of Saratoga. Radioactive cherty limestone bed (limestone appears light and chert dark) overlies siltstone (lower light area). Base of cherty limestone is near center of hammer handle. See figure 3 for description and analyses.

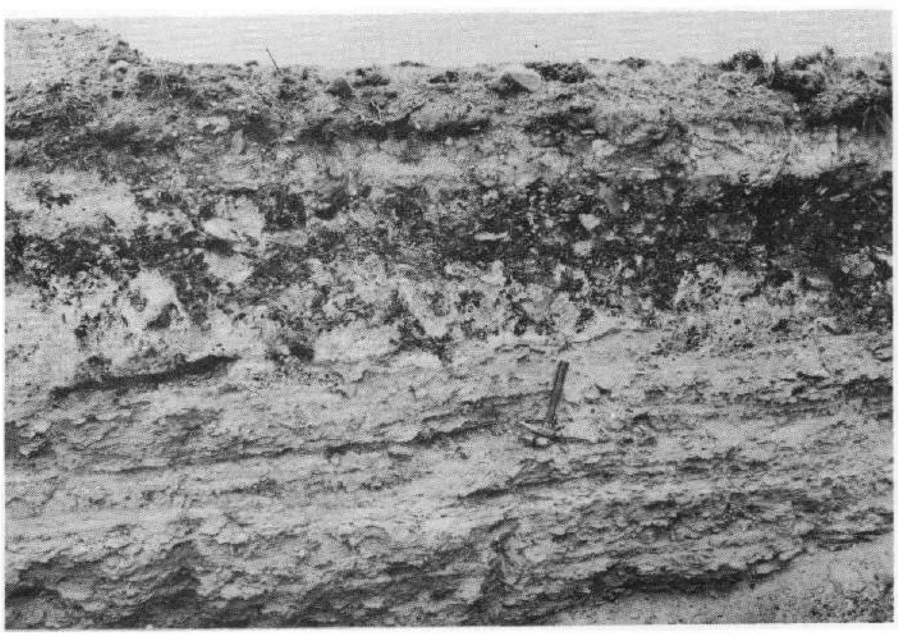


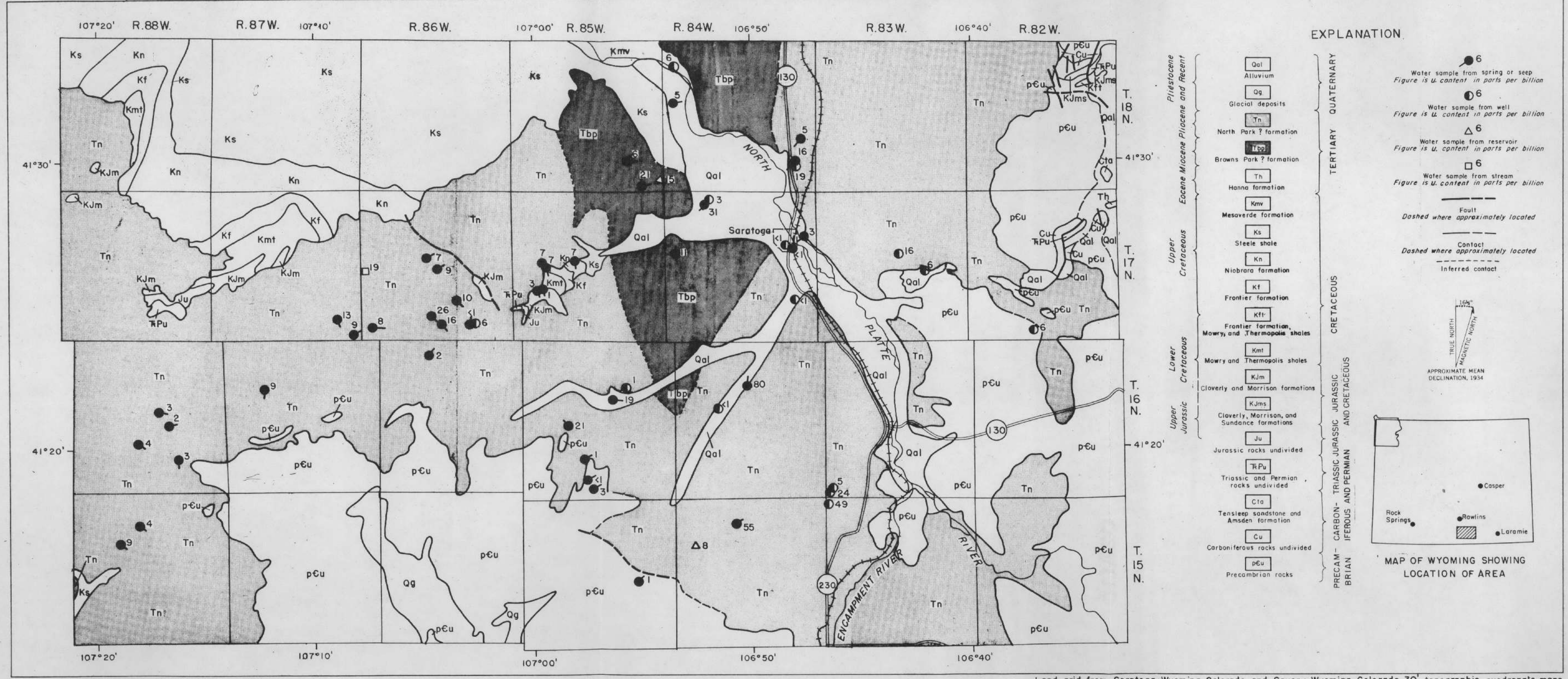
Figure 7.--Bulldozed cut on pediment surface 6 miles south of Saratoga at locality 30 (sec. 13, T. 16 N., R. 84 W.). Carnotite coatings occur on both the pediment gravel and thin limestone lenses in the underlying sandstone of the North Park(?) formation. Base of the pediment gravel is just above the hammer handle. Hammer is resting on one of the limestone lenses. See figure 5 for description and analyses.

URANIUM CONTENT OF WATER

In hopes of outlining areas in which the rocks have high concentrations of uranium, 56 samples of natural waters were collected in the Saratoga area. Water was collected from 36 springs, 14 wells, 3 seeps, 2 reservoirs, and 1 stream. Sample localities are shown on plate 1 and figure 8, 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.

Source of water sample	No. of samples	Uranium content (parts per billion) Range	Uranium content (parts per billion) Average	pH Range	pH 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



Geology from State Geologic Map of Wyoming, 1952
Geology modified by J. G. Stephens and M. J. Bergin, 1954
Water samples collected by J. G. Stephens and M. J. Bergin, 1954

Land grid from Saratoga, Wyoming-Colorado and Savery, Wyoming-Colorado 30' topographic quadrangle maps.

FIGURE 8.—GEOLOGIC SKETCH MAP SHOWING THE DISTRIBUTION AND URANIUM CONTENT OF WATER IN THE SARATOGA AREA, CARBON COUNTY, WYOMING

1 0 5 10 Miles

Inasmuch as analyses of the water samples were not available before field work 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 caliche-like 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 had 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 approximately 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, Wyoming 1/

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
1	212196	---	0.005	0.005	Browns Park(?)	Calcite, vein filling in sandstone.
1	212197	1.0	.001	---	do.	Marlstone, tuffaceous, very light gray.
2	212198	2	.001	---	do.	Limestone, silicified, medium light gray; contains buff colored chert.
2	212199	2	.001	---	do.	Limestone, nonsilicified, medium light gray, approximately 8' below sample 212198.
3	212193	1.5	.009	.009	do.	Chert, light brownish-gray; occurs in silicified limestone bed.
3	212194	1.5	.010	.010	do.	Chert, dusky yellow-brown; occurs in silicified limestone bed approximately 20' 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.

1/ Analyzed in Denver Laboratory, U. S. Geological Survey. Analysts: S. Furman, M. Finch, H. Lipp, and J. Wilson.

Table 3.--Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
4	212173	1 ±	0.002	<0.001	Browns Park(?)	Sandstone, light-gray, clayey, micaceous.
4	212172	1 ±	<.001	---	do.	Limestone, silicified, light-gray, some light-gray chert.
4	212171	1 ±	.001	---	do.	Limestone, nonsilicified, light-gray.
5	212178	---	.003	.001	---	Soil.
5	212177	2 ±	.002	.003	do.	Limestone, slightly silicified, light-gray.
5	212176	2 ±	.002	.002	do.	Limestone, silicified, medium light gray.
5	212175	2 ±	.001	---	do.	Limestone, nonsilicified, light-gray.
6	212189	3 ±	.012	.013	do.	Limestone, silicified, medium light gray.
6	212188	5 ±	.009	.009	do.	Limestone, silicified, medium light gray; contains dusky yellow-brown chert as layers and irregular masses.

1/ Analyzed in Denver Laboratory, U. S. Geological Survey. Analysts: S. Furman, M. Finch, H. Lipp, and J. Wilson.

Table 3.--Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
6	212192	0.4	0.019	0.017	Browns Park(?)	Upper 0.4 foot of bed sampled as No. 212188.
6	212191	.4	.007	.006	do.	Middle 0.4 foot of bed sampled as No. 212188.
6	212190	.4	.015	.015	do.	Lower 0.4 foot 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%. Dusky yellow-brown chert in layers and irregular masses 70%.
7	212186	.3	.011	.012	do.	Upper 0.3 foot of bed sampled as No. 212182.
7	212184	.3	.013	.014	do.	Lower 0.3 foot 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.

1/ Analyzed in Denver Laboratory, U. S. Geological Survey. Analysts: S. Furman, M. Finch, H. Lipp, and J. Wilson.

Table 3.--Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Locality See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
7	212179	2.0	0.003	0.003	Browns Park(?)	Siltstone, sandy, calcareous.
7	212183	---	.001	---	do.	Limestone, nonsilicified.
8	212218	---	.013	.014	do.	Chert, dusky yellow-brown, occurs in silicified limestone bed.
8	212217	---	.002	.001	do.	Chert, medium light gray, from same bed as 212218.
8	212216	3	.001	---	do.	Limestone, nonsilicified, medium light gray, approximately 10' below bed of 212217 and 212218.
9	212219	1	.014	.012	do.	Chert, dusky yellow-brown, occurs in medium light gray limestone bed.
9	212221	1	.013	.013	do.	Chert, dusky yellow-brown, in limestone bed 10 feet below 212219.
9	212220	2	.002	.001	do.	Limestone with medium light gray chert, 10' 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.

/ Analyzed in Denver Laboratory, U. S. Geological Survey. Analysts: S. Furman, M. Finch, H. Lipp, and J. Wilson.

Table 3. --Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
10	212263	0.7	0.003	0.004	North Park(?)	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; occurs in medium light gray limestone.
11	212206	---	<.001	---	do.	Limestone, nonsilicified, medium light gray.
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.

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Table 3. --Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
14	212211	---	0.016	0.012	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 approximately 15' from center of dry lake bed.
15	212224	---	.001	---	---	Alluvium approximately 25' from center of dry lake bed.
16	212226	3	.003	.002	North Park(?)	Sandstone, limy, exposed in bull-dozed pit.
16	212227	2	.002	.001	do.	Mudstone, sandy, exposed in bull-dozed pit.
16	212228	1	.013	.017	do.	Sandstone, limy, exposed in creek bed.
17	212237	1	.001	---	do.	Sandstone, conglomeratic, calcar-eous.

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Table 3.--Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
17	212236	2	0.003	<0.001	North Park(?)	Sandstone, conglomeratic.
17	212235	0.5	.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, silicified, yellow-green.
18	212251	0.9	.015	.019	do.	Siltstone, light-gray, clayey, thin-bedded.
18	212252	4	.003	.001	do.	Sandstone, pale yellowish-brown, cross-laminated.
18	212250	0.6	.016	.019	do.	Ash, light-gray.
18	212249	0.5	.020	.026	do.	Ash, silicified, light-gray.
18	212248	0.6	.016	.019	do.	Ash, silty, very light gray.
18	212247	0.6	.005	.003	do.	Sandstone, fine-grained, tuffaceous, carbonaceous.
18	212246	0.8	.003	.001	do.	Sandstone, fine-grained, tuffaceous, carbonaceous.

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Table 3.--Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/-- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
19	212245	1	0.002	<0.001	North Park(?)	Limestone, silicified.
20	212244	0.3	.004	.003	do.	Coaly silicified material.
20	212243	1	.004	.002	do.	Conglomerate, silicified.
20	212242	1	.005	.002	do.	Sandstone, silicifed, with chunks (1/4"-1/2") 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	---	do.	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.

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Table 3.--Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/-- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
26	214207	2	0.002	---	---	Fine unconsolidated sand, calcareous, some pebbles.
27	214212	3	.001	---	---	Soil, sand and gravel of pediment surface.
27	214211	0.5	.001	---	North Park(?)	Sandstone, olive-green, soft, friable.
27	214214	2	.002	---	do.	Limestone, silicified.
27	214213	5	.001	---	do.	Siltstone, laminated, pale-green.
28	214219	2	.005	0.007	---	Soil, sand and boulders of pediment surface.
28	214218	2	.004	.003	---	Sand and gravel with lenses of green sandy siltstone, unconsolidated.
28	214217	0.4	.003	---	North Park(?)	Sandstone, silicified, fine-grained, olive-green.
28	214216	0.4	.003	---	do.	Gypsum.
28	214215	2	.002	---	do.	Sandstone, olive-green, fine-grained.
29	212257	1	.001	---	---	Sand and gravel of pediment surface.

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Table 3.--Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/-- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
30	212259	1	0.009	0.011	---	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 1/8"-2" in thickness; contains carnotite as coating material on limestone.
30	139083	1	.002	.002	do.	Upper 1' of unit sampled as 212258.
30	139084	1	.004	.004	do.	Second 1' from top of unit sampled as 212258.
30	139085	1	.002	.001	do.	Third 1' from top of unit sampled as 212258.
30	139086	---	.002	.002	do.	Gypsum.
31	214229	4	.002	---	---	Soil, sand and gravel of pediment surface.
31	214230	2	.002	---	---	Gravel and boulders of pediment surface.
31	214231	1	.002	---	North Park(?)	Silty sandstone, fine-grained, light-green.

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Table 3.--Analyses of rock samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Locality (See pl. 1)	Laboratory sample no.	Thickness of interval sampled (feet)	Equivalent uranium	Uranium (percent)	Formation	Rock type and other data
32	214225	0-2	0.002	---	North Park(?)	Sandstone, fine- to coarse-grained, cross-laminated.
32	214224	0.5	.001	---	do.	Clay, non-bedded, dark-green, gypsum pods.
32	214223	0.5	.001	---	do.	Sand, yellow-gray, fine-grained, unconsolidated.
32	214222	1.0	.004	0.002	do.	Siltstone, tuffaceous, pale-green, planar-bedded.
32	214221	1.5	.001	---	do.	Siltstone, tuffaceous, light-gray, planar-bedded; contains gastropods.
32	214220	0.5	.002	---	do.	Siltstone, tuffaceous, light olive-green, 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.

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Table 4.--Analyses of water samples from the Saratoga area, Carbon County, Wyoming 1/

Location (See pl. 1, fig. 8)	Laboratory sample no.	Type of sample	U content (ppb)	pH	Formation and other data
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	Storage of water from spring sampled as no. 210637. Browns Park(?) formation.
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	Well depth 35'. Water probably from North Park(?) formation. Frank Schilt Ranch.
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.

1/ Analyzed in Denver Laboratory, U. S. Geological Survey, Analysts: H. Bivens; R. Deming, J. Johnson; D. Stockwell; and J. Wilson.

Table 4.--Analyses of water samples from the Saratoga area, Carbon County, Wyoming 1/-- Continued

Location (See pl. 1, fig. 8)	Laboratory sample no.	Type of sample	U content (ppb)	pH	Formation and other data
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' 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".

1/ Analyzed in Denver Laboratory, U. S. Geological Survey. Analysts: H. Bivens, R. Deming; J. Johnson; D. Stockwell; and J. Wilson.

Table 4.--Analyses of water samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Location (See pl. 1, fig. 8)	Laboratory sample no.	Type of sample	U content (ppb)	pH	Formation and other data
NW 4 20-17N-85W	210643	spring	7	7.5	Contact of Frontier formation and North Park(?) formation.
SW 4 20-17N-85W	210641	spring	1	7.1	Sulphur spring in Cloverly formation.
NE 4 5-17N-84W	213341	well	3	7.9	Browns Park(?) formation. Reported to be artesian well drilled to depth of 60'. Four Bar Ranch.
NE 4 5-17N-84W	213342	seep	31	7.6	Alluvium.
SW 4 12-17N-84W	210657	spring	3	7.0	Hot water spring probably associated with faulting. Formations involved not determined.
NW 4 13-17N-84W	210656	spring	<1	6.9	"Hobo Pool". Hot water spring probably associated with faulting. Formations involved not determined.
NW 4 14-17N-84W	210681	well	<1	7.9	Water probably in alluvium in flood plain of North Platte River.
NW 4 18-17N-84W	213343	seep	11	7.4	Tuffaceous sandstone in Browns Park(?) formation.
NW 4 25-17N-84W	213348	well	<1	7.8	Browns Park(?) formation. Well reported to be drilled to depth of 110'.
NW 4 15-17N-83W	210680	well	16	7.7	North Park(?) formation. Well reported to be 47' deep.

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Table 4.--Analyses of water samples from the Saratoga area, Carbon County, Wyoming 1/ -- Continued

Location (See pl. 1, fig. 8)	Laboratory sample no.	Type of sample	U content (ppb)	pH	Formation and other data
NW 4 23-17N-83W	210678	well	6	7.7	North Park(?) formation. Well reported to be 50' deep.
SE 4 33-17N-82W	210679	well	6	7.8	Precambrian rocks undivided.
SW 4 15-16N-88W	210661	spring	3	7.1	Limy sandstone in North Park(?) formation.
NW 4 22-16N-88W	210660	spring	2	7.2	Limestone in North Park(?) formation.
SE 4 27-16N-88W	210659	spring	3	7.0	Limestone in North Park(?) formation.
NW 4 28-16N-88W	210662	spring	4	7.0	Limestone in North Park(?) formation.
SW 4 8-16N-87W	210658	spring	9	6.9	Tuffaceous sandstone in North Park(?) formation.
SW 4 4-16N-86W	210652	spring	2	7.3	North Park(?) formation.
SW 4 11-16N-85W	210668	well	1	7.7	Artesian well of unknown depth. Abandoned oil test. Source of water unknown.
NE 4 15-16N-85W	210667	spring	19	7.8	Alluvium.
NE 4 20-16N-85W	210669	spring	21	8.1	North Park(?) formation.
NW 4 28-16N-85W	210670	spring	1	7.6	North Park(?) formation.
NE 4 33-16N-85W	210671	spring	<1	7.1	Precambrian rocks undivided.

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Table 4.--Analyses of water samples from the Saratoga area, Carbon County, Wyoming 1/-- Continued

Location (See pl. 1, fig. 8)	Laboratory sample no.	Type of sample	U content (ppb)	pH	Formation and other data
SE 4 33-16N-85W	210672	spring	3	7.7	Precambrian rocks undivided.
NE 4 9-16N-84W	213349	spring	80	7.7	Limestone in North Park(?) formation.
NE 4 17-16N-84W	210673	well	<1	7.7	Browns Park(?) formation. Well reported to be 225' deep.
SW 4 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'. Bottom in conglomerate.
SW 4 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'. May be alluvium.
NW 4 9-15N-88W	210663	spring	4	6.8	Limestone in North Park(?) formation.
NE 4 17-15N-88W	210664	spring	9	7.2	North Park(?) formation.
NW 4 23-15N-85W	210674	spring	1	7.8	Precambrian rocks undivided.
SW 4 4-15N-84W	210676	spring	55	7.7	North Park(?) formation.
SE 4 7-15N-84W	210675	reservoir	8	8.9	Storage of water drained from area of North Park(?) formation.
NW 4 6-15N-83W	213352	well	49	7.6	North Park(?) formation. Irrigation well on Throwbridge Ranch. Reported to be drilled to depth of 101'.

1/ Analyzed in Denver Laboratory, U. S. Geological Survey. Analysts: H. Bivens; R. Deming; J. Johnson; D. Stockwell; and J. Wilson.

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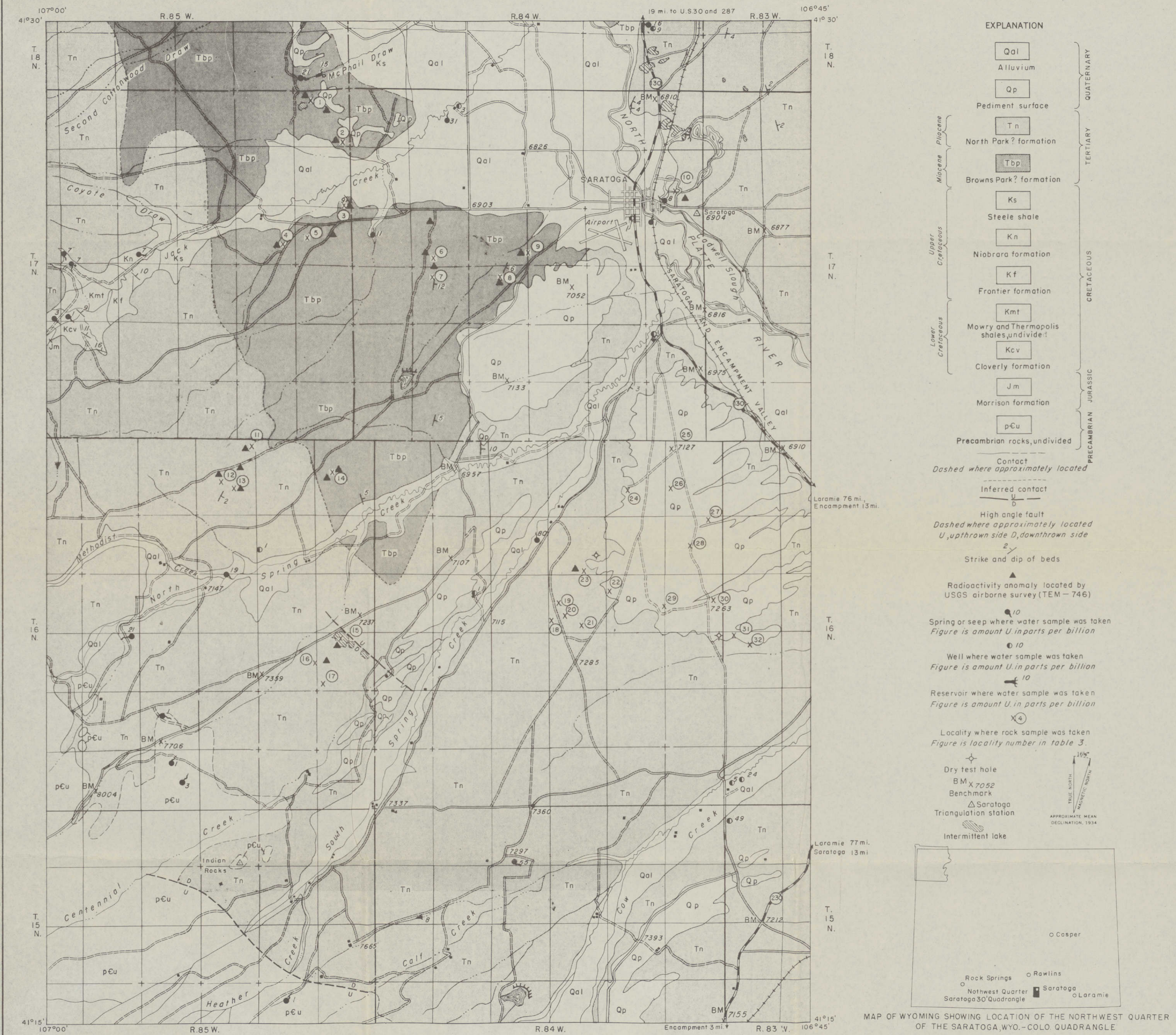

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Base from Saratoga, Wyo-Colo. 30' topographic quadrangle map 1939 edition; reprinted 1949.

PLATE I.—RECONNAISANCE GEOLOGIC MAP OF THE NORTHWEST QUARTER OF THE SARATOGA WYOMING—COLORADO 30 MINUTE QUADRANGLE SHOWING LOCATIONS OF WATER AND ROCK SAMPLES AND RADIOACTIVITY ANOMALIES.

1 1/2 0 1 2 3 4 5 Miles