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PRELIMINARY STUDY OF URANIUM FAVORABILITY OF UPPER CRETACEOUS, PALEOCENE, AND LOWER EOCENE ROCKS OF THE BIGHORN BASIN, WYOMING AND MONTANA

Scott L. Hesse and Joseph F. Dunagan, Jr.

BENDIX FIELD ENGINEERING CORPORATION
Grand Junction Operations
Grand Junction, Colorado 81501

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SUMMARY

This report presents an evaluation of the uranium favorability of continental sediments of the Upper Cretaceous Lance, Paleocene Polecat Bench, and lower Eocene Willwood Formations in the Bighorn Basin of Wyoming and Montana, an intermontane structural basin of Laramide age. Previous work dealing with the Bighorn Basin was reviewed, and field investigations were carried out in the spring and summer of 1976. Subsurface data were collected and results of surface and subsurface investigations were evaluated with respect to uranium favorability.

Precambrian plutonic and metamorphic rocks and Tertiary tuffaceous rocks in the Bighorn Basin and bordering uplifts are considered insignificant as source rocks, although the Wiggins Formation (White River equivalent) cannot be evaluated as a possible source because of a lack of data. Potential host rocks locally show only limited favorability. Lithology of strata exposed along the western and southern basin margins is more favorable than that of rocks in the central and eastern parts of the basin, but there is little organic material, pyrite, or other reducing agents in these rocks. Strata of the Lance, Polecat Bench, and Willwood Formations in the Bighorn Basin are considered generally unfavorable for sandstone uranium deposits.

INTRODUCTION

Upper Cretaceous and lower Tertiary rocks are exposed over a large part of the Bighorn Basin, an intermontane basin in Wyoming and Montana that is bordered by mountain uplifts of Laramide age. Similar basins, such as the Powder River and Wind River Basins, contain significant uranium deposits, primarily in Paleocene and lower Eocene rocks.

The purpose of this study is to provide a general survey of the Lance, Polecat Bench, and Willwood Formations of the Bighorn Basin, with reference to factors favorable to uranium accumulations. The project was initiated in April 1976 and concluded in December 1976. This study was conducted by personnel of Bendix Field Engineering Corporation under the auspices of the U.S. Energy Research and Development Administration.

LOCATION

The project area (Fig. 1) includes parts of Hot Springs, Washakie, Park, and Big Horn Counties, Wyoming, and part of Carbon County, Montana. The boundaries (Fig. 2) are between lats 43°41'17" N. and 45°13'55" N. and between longs. 108°28'8" W. and 109°32'44" W., which encompass an area of 4,700 sq mi (12,000 sq km). The project area includes parts of the Thermopolis (N½NE¼), Arminto (NW¼NW¼), Cody (E½ and E½NW¼), Sheridan (SW¼SW¼), and Billings (SW¼SW¼ and SW¼SE¼) sheets of the National Topographic Map Series 2° maps.

PREVIOUS WORK

Numerous geologic studies deal with the Upper Cretaceous and lower Tertiary rocks of the Bighorn Basin. Fisher (1906) and Hewett (1926) are responsible for much of the early work in the area; later authors, such as Stow (1938, 1952), Jepsen (1930, 1940), and Van Houten (1944, 1952) contributed information concerning the stratigraphy and sedimentology of the basin. Thomas (1965) and Neasham and Vondra (1972) provided more recent studies of the structure, sedimentology, and stratigraphy of the area.

Exploration in the Bighorn Basin has been concentrated primarily on oil and gas resources, although exploration for and development of coal resources has continued to some extent since the 1880s (Glass and others, 1975, p. 224).

U.S. Atomic Energy Commission Preliminary Reconnaissance Reports list only two radiometric anomalies in Upper Cretaceous and lower Tertiary rocks of the Bighorn Basin. Although some probable uranium test holes were found in the field, little information dealing with uranium exploration in Upper Cretaceous and lower Tertiary rocks in the Bighorn Basin was available.

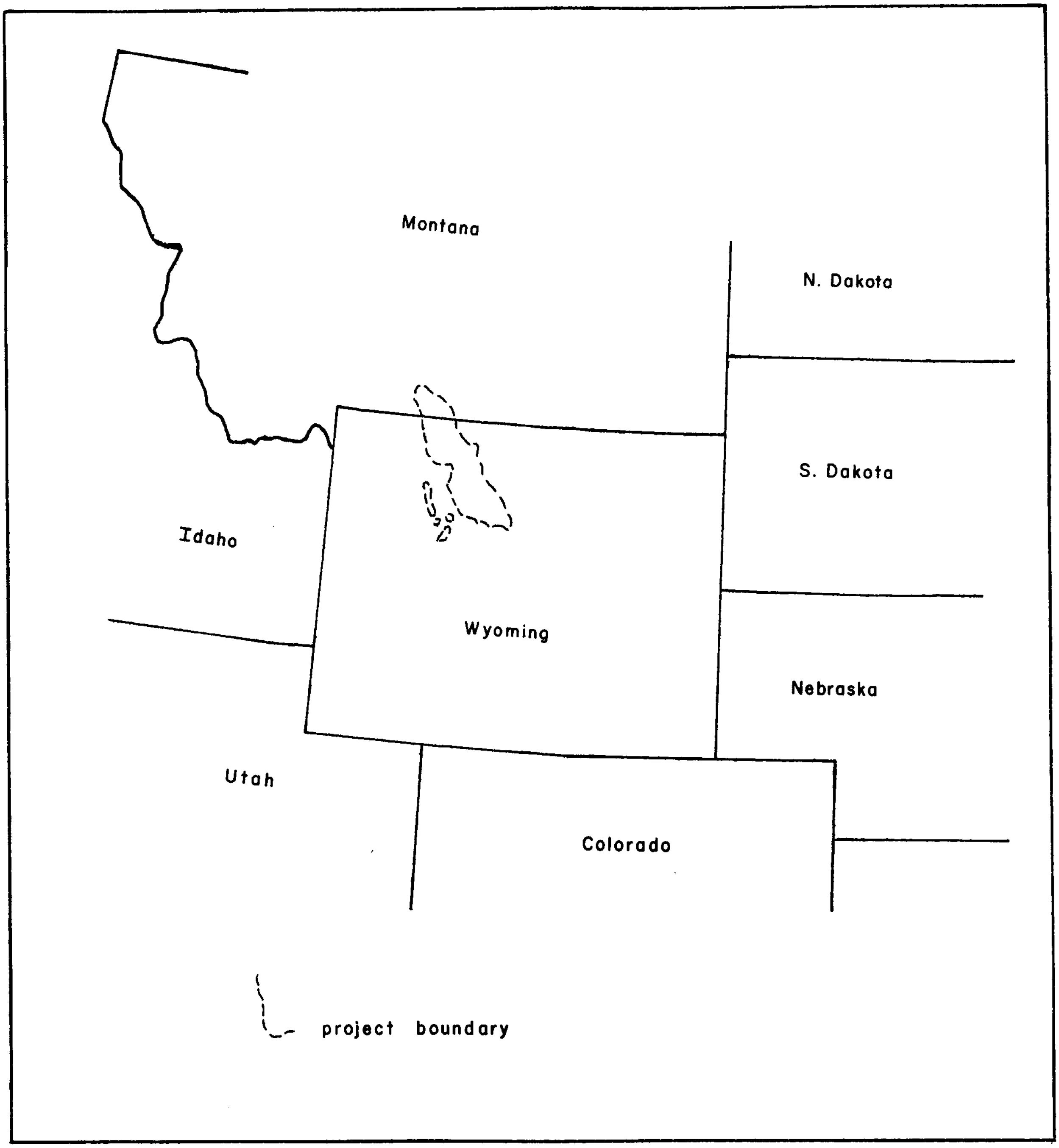

Figure 1. Location index map, Bighorn Basin.

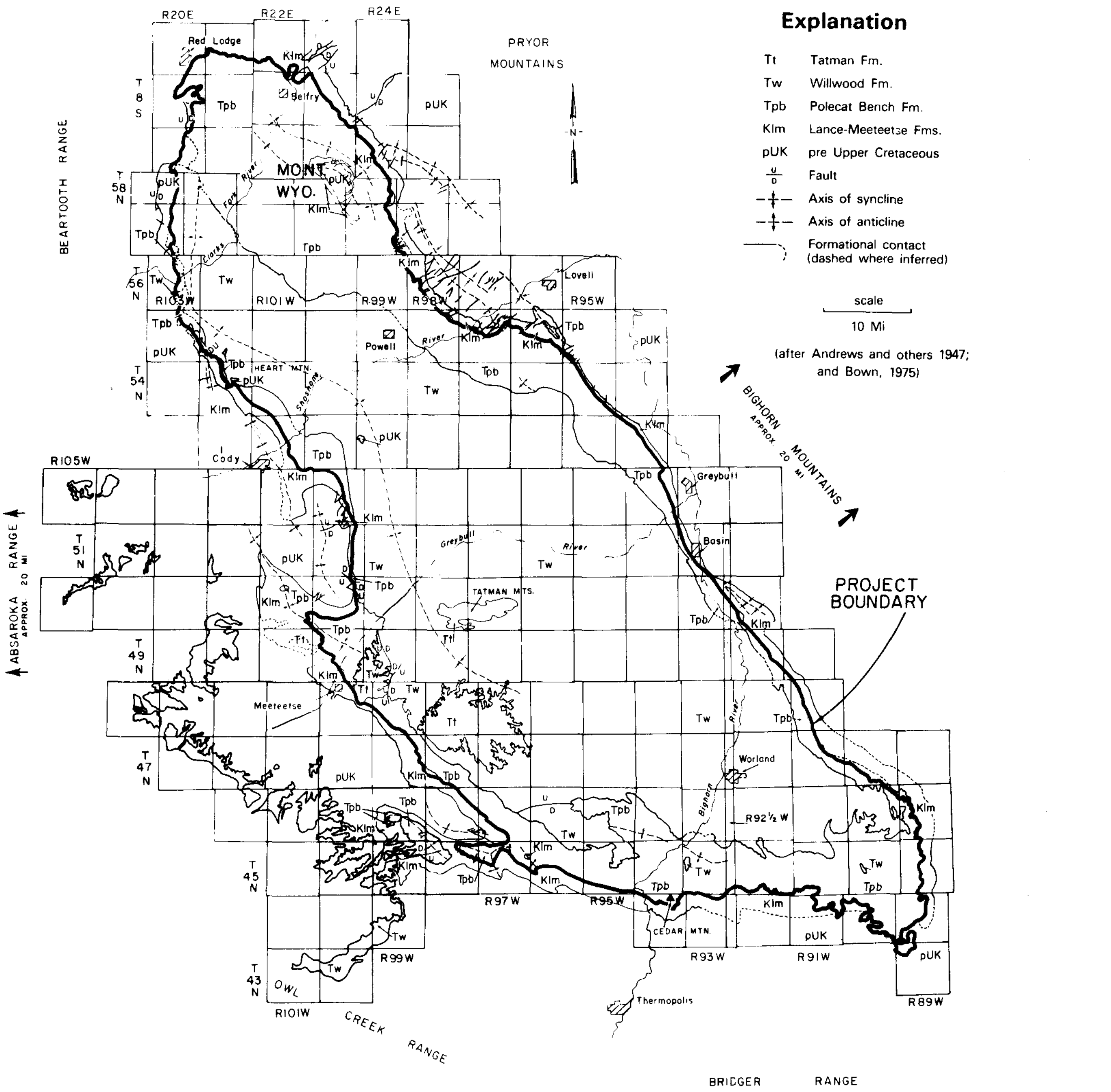

Figure 2. Generalized geology of Upper Cretaceous and lower Tertiary rocks, Bighorn Basin, Wyoming and Montana.

PROCEDURES

LITERATURE STUDY

Literature pertinent to the project was reviewed prior to the start of field work. Readily available publications were studied and used as references for further investigation. U.S. Atomic Energy Commission Preliminary Reconnaissance Reports were examined for information on known uranium occurrences in the project area. Unpublished information, such as doctoral theses, was also studied.

Subsurface data in the form of electrical, gamma-ray, and descriptive lithologic logs were examined for additional data. In-depth study of literature and subsurface data was conducted following the field season.

FIELD INVESTIGATION

Reconnaissance sampling of stream sediments was carried out in April 1976. Follow-up samples were collected in August on Slick Creek, east of Worland, Wyoming.

The major part of the field work began in early June and continued through late August 1976. Samples of potential source rocks were gathered in the mountain uplifts that border the basin. Field procedures in the basin included short traverses of persistent outcrops of sandstone and sampling of sandstone units at varying intervals. Concurrently, a general survey of background radiation in sandstones and finer-grained rocks was conducted, and point readings were recorded at sample locations. Hand-held Mt. Sopris scintillometers (models SC 131A and SC 132) were used for the radiometric surveys. (This is not an endorsement of Mt. Sopris scintillometers.)

ANALYTICAL PROCEDURES

Chemical U_3O_8 assays were made by fluorometric analysis for all sandstone and possible source rock samples, and radiometric (gamma-ray spectroscopic) determinations for equivalent uranium were made for 91 of the 103 sandstone samples. Statistical data were calculated for each set of results (Table 1). Samples of possible source rocks (26) were thin-sectioned for petrographic analyses, and heavy-mineral and sieve analyses were performed on sandstone samples. Stream-sediment samples (41) were analyzed for U_3O_8 by fluorometric methods. All samples and assay results are listed in Appendix A. Sample localities are shown on Figure 3.

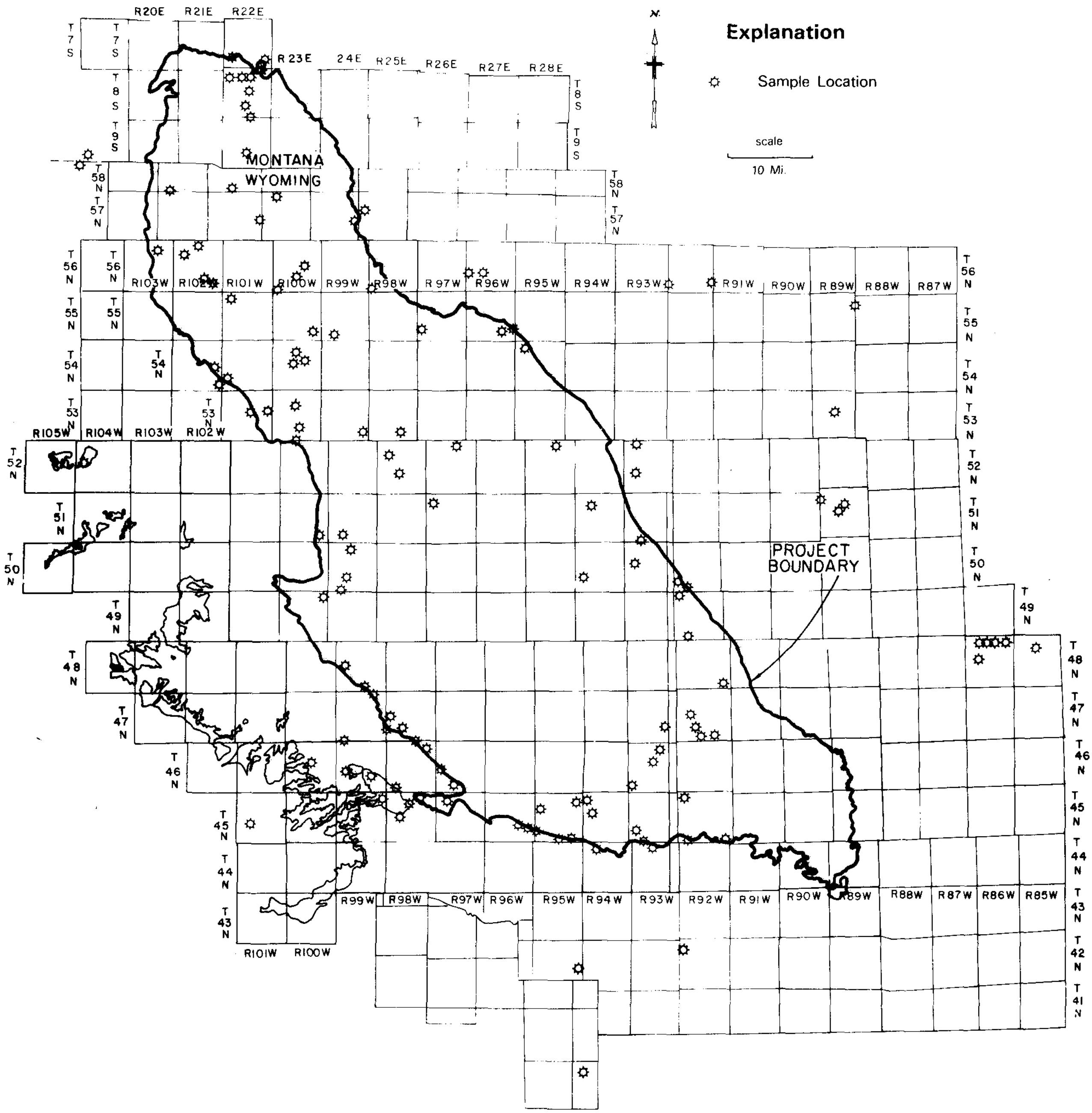

Figure 3. Surface sample locations, Bighorn Basin.

TABLE 1. STATISTICAL DATA FOR RESULTS OF URANIUM ASSAYS

Sample	Chemical U_3O_8 (ppm) mean, $\bar{x}$	Chemical U_3O_8 (ppm) std. dev.	Radiometric equivalent U (ppm) mean, $\bar{x}$	Radiometric equivalent U (ppm) std. dev.
Possible source rocks (26	3.58	1.60	--	--
Sandstone samples (103 chemical; 91 γ-spec.)	2.43	0.92	1.99	0.87
Stream-sediment samples (exclusive of follow-up samples)	4.42	1.52	--	--

SUBSURFACE PROCEDURES

Subsurface data were collected from 138 oil-well electric logs and 30 AMSTRAT lithologic logs. In addition, gamma-ray logs from 70 oil wells were examined (Fig. 4; App. B.).

Sand-file data and lithologic data were collected to provide information concerning criteria recognized by Grutt (1972) as being favorable to uranium concentrations. Sand-file data indicate depth below surface and thickness of sand units at least 5 ft thick, were compiled from electric logs. Lithologic data, which include degree of sorting, grain size, and presence of several sandstone constituents, were compiled from AMSTRAT lithologic logs.

The Tertiary and uppermost Cretaceous section in each well was divided into four slices. The Lance Formation was represented by one slice; however, because the contact between the Polecat Bench and Willwood Formations could not be reliably picked on the electric logs, the Tertiary section was divided into three slices, each representing one-third of the section (Fig. 5). Casing was set in many of the wells to a depth of several hundred feet and, as a result, data for the Tertiary section were incomplete. For this reason, the uppermost slice of the Tertiary section was disregarded in the slice method study.

From sand-file data, a set of maps were made for each slice. These maps show: (1) areas where sand-to-nonsand ratios range from 1:1 to 4:1, and (2) distribution of thick sandstones (minimum thickness of 50 ft; modified from Grutt, 1972).

From lithologic data, another set of maps was made for each slice. These maps show areas where 50 percent or more of the sandstone (1) is

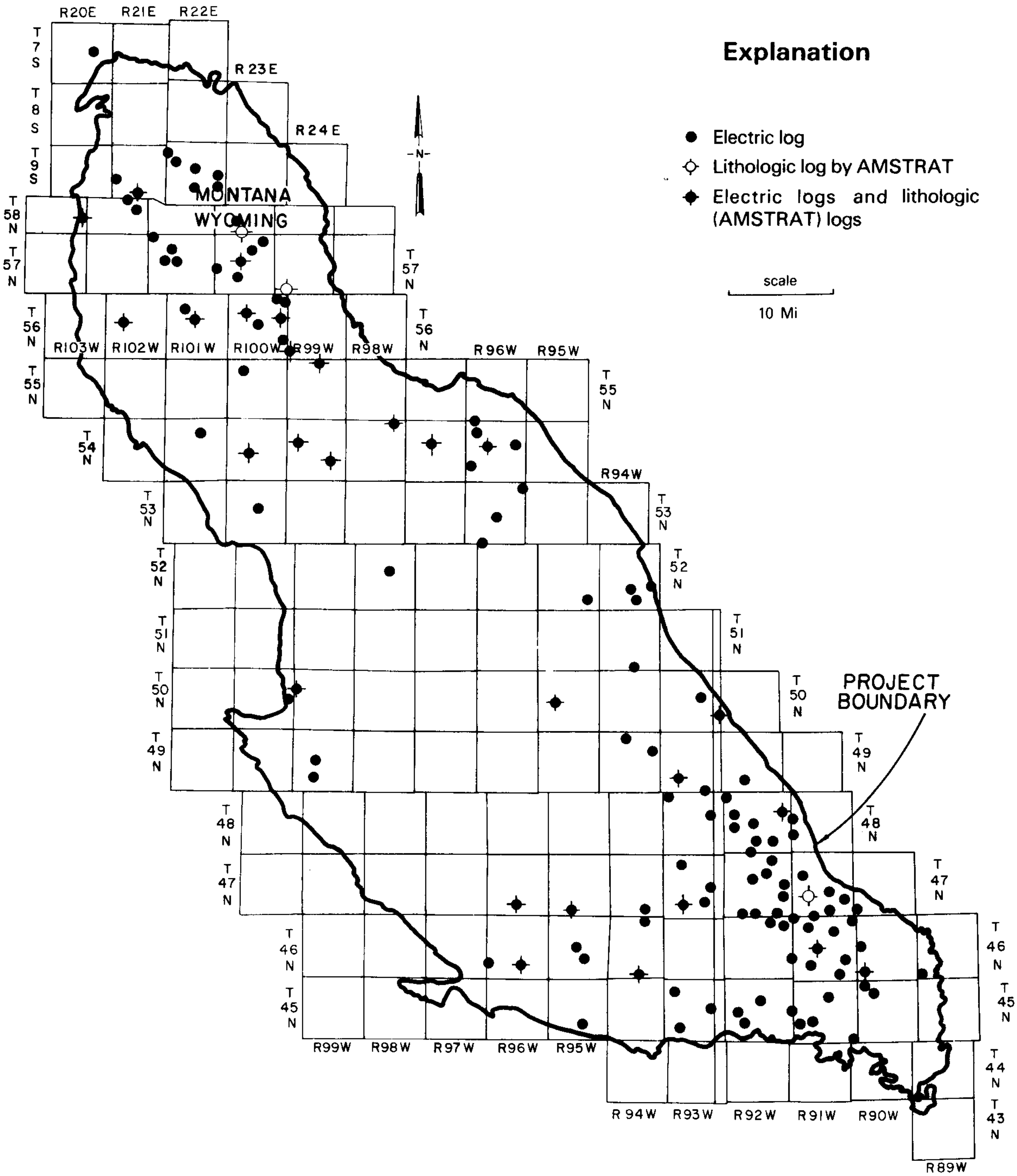

Figure 4. Subsurface control points, Bighorn Basin.

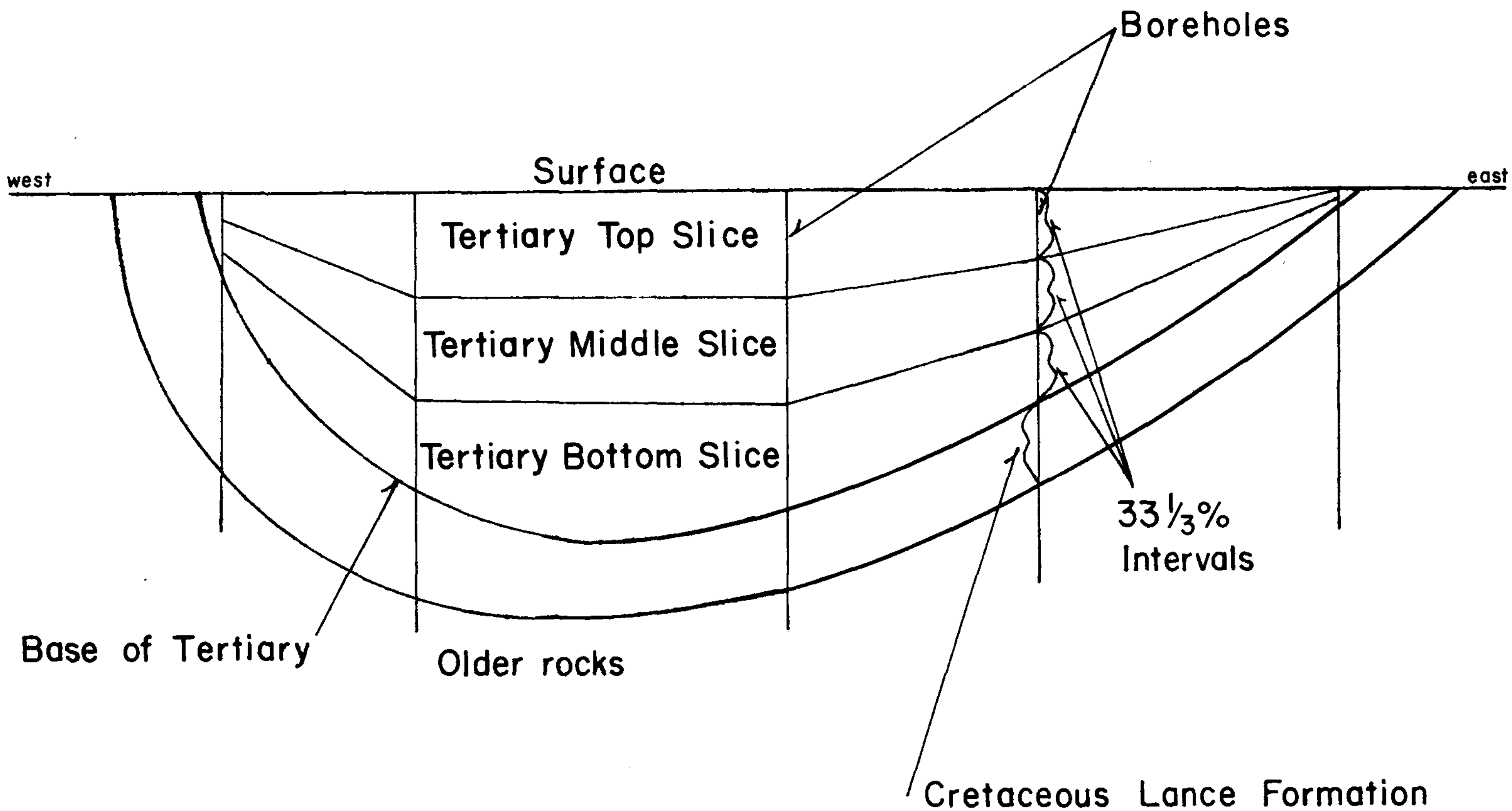

Figure 5. Diagrammatic representation of slice method.

arkosic, (2) is poorly sorted (contains more than four grain-size grades), and (3) is medium grained (0.25 mm or 2ϕ) or coarser.

Sand maps and lithologic maps for each slice were combined to form one map per slice (Figs. 6, 7, 8). Overlapping distribution contours of the various factors mentioned above delineate possible areas favorable for uranium concentration.

GEOLOGY

STRATIGRAPHY

The rock units considered as potential uranium hosts in this study are: the Lance Formation of Late Cretaceous age; the Polecat Bench Formation, primarily of Paleocene age; and the Willwood Formation, primarily of early Eocene age. Younger rocks (Tatman and Pitchfork Formations) were not considered.

Lance Formation

The Lance Formation (Fig. 9) is a sequence of continental sandstones, claystones, and mudstones, ranging in thickness from about 650 ft (200 m) to about 1,400 ft (430 m) (Hewett, 1926, p. 26-30). Sandstones are generally massive but locally exhibit festoon and scour-fill cross-bedding up to about 3 ft (1 m) in height. The sandstones are light buff, gray, or yellowish tan, fine to medium grained, soft, silty, and generally contain carbonate cement. Numerous sandstone layers contain spheroidal gray to light-brown concretions, 2 to 10 ft (0.6 to 3.0 m) in diameter, that are well cemented by calcium and iron carbonates and that weather to dark brown or red brown as a result of oxidation of ferruginous carbonates (Hewett, 1926, p. 29). Claystones and mudstones are soft, drab gray and brown, generally unlaminated, and intertongue with beds of sandstone. Thin coal beds have been noted in the upper part of the Lance in some areas.

Polecat Bench Formation

The Lance Formation is unconformably overlain by the Polecat Bench Formation (Fort Union equivalent) (Fig. 9), a sequence of conglomerates, sandstones, mudstones, and coals that accumulated in an aggrading fluvial environment. The Polecat Bench Formation ranges in thickness from zero, where it has been eroded and is unconformably overlain by the Willwood Formation, to more than 9,200 ft (2,700 m) along part of the depositional axis of the basin (Moore, 1061, p. 204). Conglomerates are developed primarily along the western basin margins and consist of subangular to well-rounded, pebble- to cobble-size fragments of quartzite, chert, sandstone, limestone, and igneous rocks (Hewett, 1926, p. 31-33). Sandstones are white to light gray, medium grained, soft to medium hard, and generally contain carbonate cement. Mudstones are soft, generally unlaiminated, drab, gray, tan, or brown, and are interbedded with the sandstones and conglomerates. Coal beds up to 38 ft (12 m) thick are found in the Polecat Bench in parts of the Bighorn Basin (for example, Coal Mine Draw in the southwest part of the basin); thicker beds commonly are found in the lower part of the section (Glass and others, 1975, p. 222).

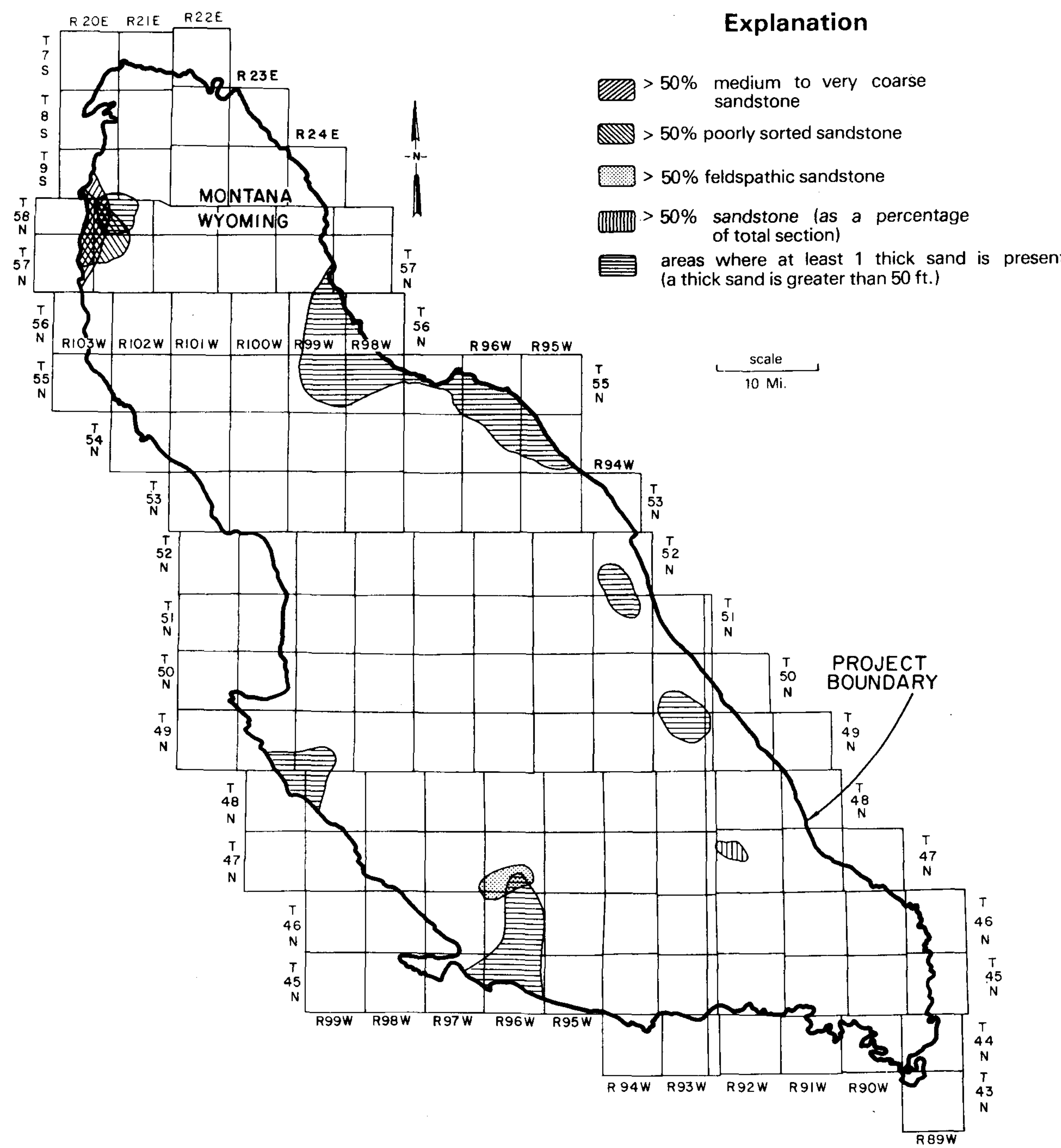

Figure 6. Subsurface lithology, Tertiary middle slice, Bighorn Basin.

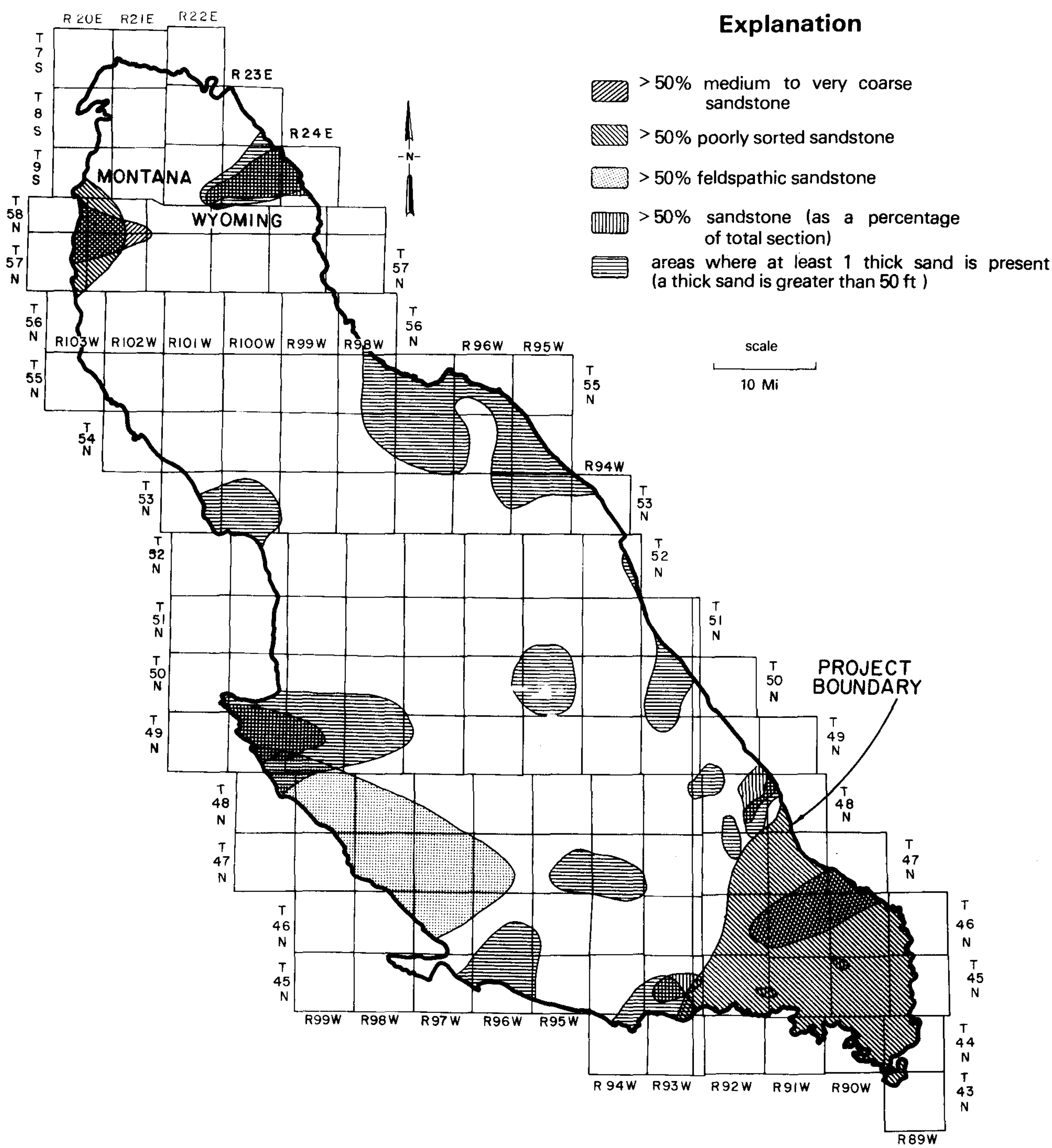

Figure 7. Subsurface lithology, Tertiary bottom slice, Bighorn Basin.

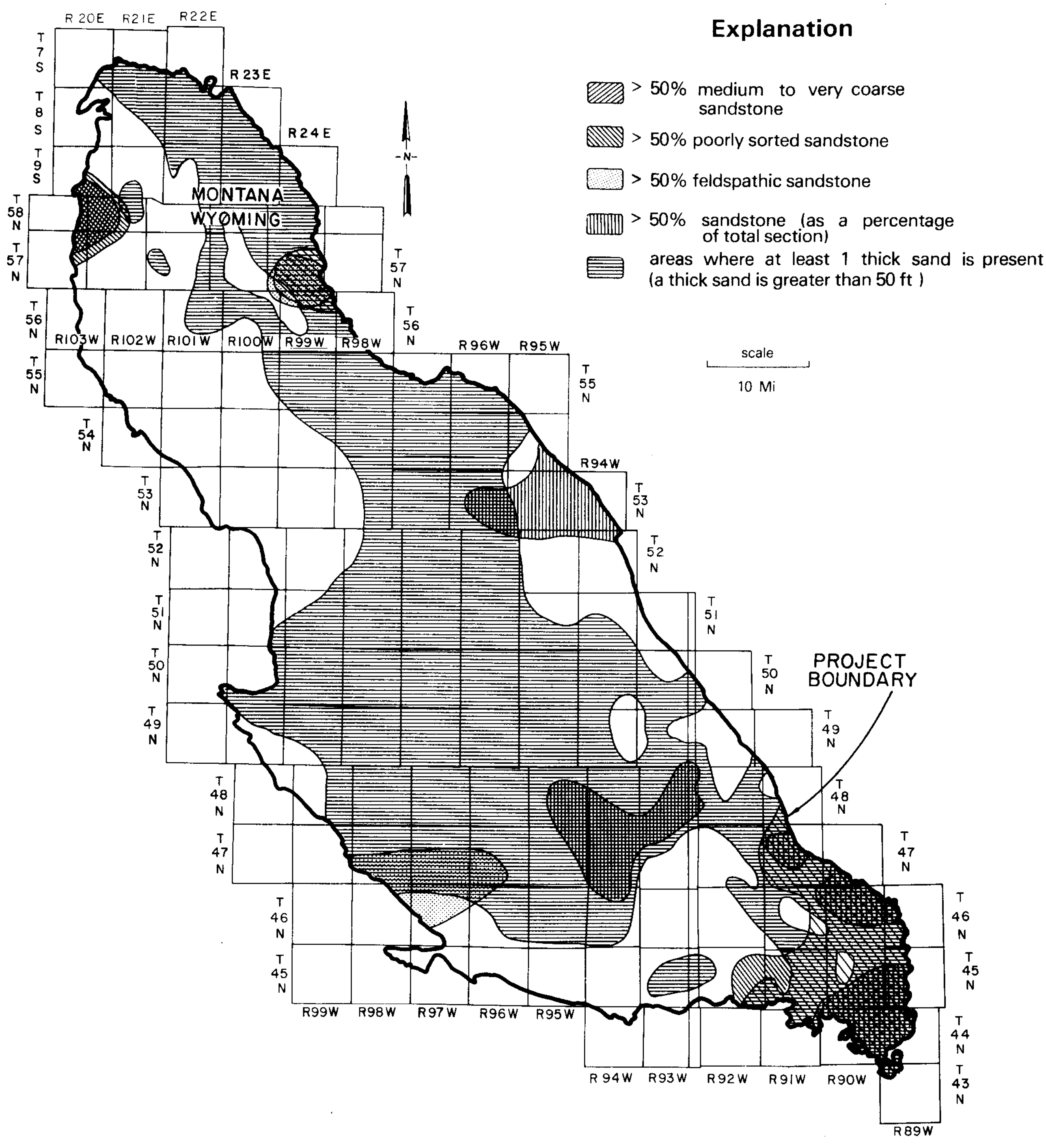

Figure 8. Subsurface lithology, Lance Formation, Bighorn Basin.

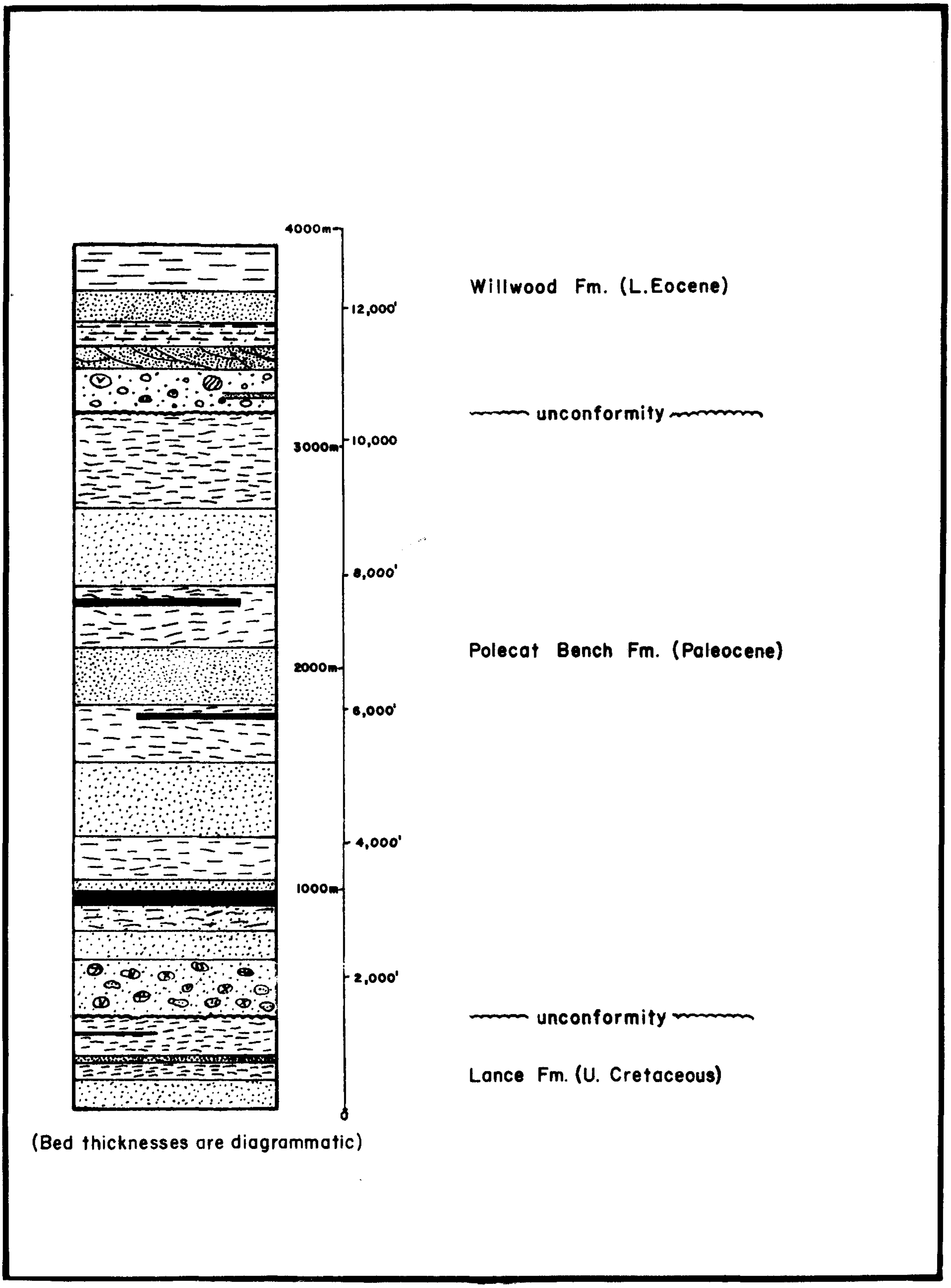

Figure 9. Stratigraphic section, Bighorn Basin

Willwood Formation

The Willwood Formation (Fig. 9) unconformably overlies the Polecat Bench and Lance Foramtions along the basin margins, although the Willwood is conformable with the Polecat Bench in the central part of the basin (Neasham and Vondra, 1972, p. 2169). The Willwood consists of conglomerates, sandstones, and mudstones deposited in a fluvial environment, and ranges in thickness from about 1,300 ft (400 m) to about 2,500 ft (760 m) (Neasham, 1970, p. 7). Conglomerates that were developed along the western basin margin are of two types. One consists of subangular to rounded pebbles and cobbles of granite, andesite, quartzite, and carbonate in an arkosic matrix. The other contains pebble- to boulder-size fragments of carbonates and sandstone in a quartzose sandstone matrix (Neasham and Vondra, 1972, p. 2170-2172). Willwood sandstones are light to medium gray or brown, soft, very fine to medium grained, and commonly calcite cemented. Mudstones are soft, generally unlaminated, and variegated, with individual bands or beds colored gray, red, purple, or brown.

Younger Rocks

Fine-grained lacustrine sandstone, kerogenic and carbonaceous shales, and marlstones of the Tatman Foramtion (middle Eocene) overlie Willwood strata. The Tatman probably extended over most of the southern Bighorn Basin (Van Houten, 1952, p. 76). Small parts of this formation are preserved as erosional buttes in the central part of the basin (for example, Squaw Buttes, Tatman Mountain) and as small discontinuous remnants along the basin margin.

Sandstones, siltstones, conglomerates, tuffs, and porcelanites of the Pitchfork Formation (middle and late Eocene) were deposited in a dominantly lacustrine environment and overlie the Tatman Formation in remnants along part of the basin margins (Rohrer, 1966, p. A21-A24). As with the Tatman Formation, the Pitchfork was probably widely distributed in the basin, but post-Eocene erosion removed much of this formation.

There are no Oligocene rocks remaining in the Bighorn Basin, but patches of tuffaceous rocks found in the Bighorn Mountains probably represent remnants of widespread deposition of a thick sequence of Oligocene tuffaceous continental sediments (Van Houten, 1952, p. 77-79). The andesite flows, volcanic breccias, tuffs, and tuffaceous sandstones and conglomerates of the Wiggins Formation in the Absaroka Mountains, which Love (1939, p. 79-85) described and correlated with the Oligocene White River Formation of central Wyoming, are further evidence that thick accumulations of Oligocene sediments and volcanic rocks once covered much of the Bighorn Basin.

STRUCTURE

The Bighorn Basin was formed as a structural feature primarily in the Paleocene and Eocene epochs when Laramide orogenesis resulted in differential uplift of the Precambrian basement. The surrounding mountain uplifts were elevated much higher than the basin, but differential uplift also operated throughout the basin and caused fault patterns in the basement rocks which, in turn, controlled deformation in the overlying sedimentary layers (Stearns, 1975, p. 150).

Surface expressions of deformation consist of anticlines, synclines, and high-angle faults. Folds are located around the margins of the basin, and fold axes generally trend northwest, subparallel to the depositional axis of the basin. Most surface faults are also found near basin margins, commonly trend northeast, and cut fold axes at oblique angles. Most of the faults are in the northeastern part of the basin (Fig. 2). Curving detachment faults in Absaroka volcanic rocks near the western basin margin have been reported by Wilson (1975, p. 167). Pierce (1975, p. 139-148) described the Heart Mountain and similar dêcollement faults in the Bighorn Basin.

GEOLOGIC HISTORY

The geologic history of the Bighorn Basin is discussed by several authors. Love (1960a) examined the Cenozoic history of Wyoming and Thomas (1965) presented a brief overview of the history of the Bighorn Basin. Houston (1969) discussed the geologic history of Wyoming as related to uranium deposits. The following summary is derived primarily from these papers.

Deposition in a marine environment dominated in the Bighorn Basin area from Cambrian to middle Late Cretaceous time, with occasional periods of emergence and erosion. Growth of the Bighorn Basin as a structural feature may have begun in Early Cretaceous time. Nonmarine deposition became widespread in middle Late Cretaceous time, and by Late Cretaceous time, nonmarine conditions were permanently established.

Major growth of the uplifts bordering the Bighorn Basin and deformation of the marginal structures was initiated in Paleocene time in response to Laramide orogenic forces, and deformation continued at least through the early Eocene.

During deposition of the Willwood, dêcollements or low-angle thrust faults in the Absaroka and Beartooth Mountains were formed when large blocks of Paleozoic sedimentary rocks moved several miles toward the center of the basin (Pierce, 1975). Heart Mountain and McCulloch Peaks are remnants of these fault blocks.

Volcanic activity began in the Absaroka-Yellowstone province in late early Eocene time and continued through most of the Tertiary and Quaternary, but most of the rocks that might have recorded this activity in the Bighorn Basin have been stripped away by erosion. Volcanic sediments in the upper Tatman Formation and in the Pitchfork Formation are the only remaining record of Absaroka volcanism.

The late Eocene to Pleistocene history of the Bighorn Basin probably involved a period of thick infilling by continental sediments until late Pliocene, when a regional uplift brought the Bighorn Basin and surrounding areas to near their present level. This uplift was followed during Pleistocene time by considerable erosional stripping and by formation of the terraces now observed in the Bighorn Basin (Ritter, 1975).

EVIDENCE OF URANIUM FAVORABILITY

No uranium deposits are known to exist in the project area, although several reports are available concerning radiometric anomalies in the pre-Lance Formation rocks along the eastern margin of the Bighorn Basin. Anomalous radioactivity in Tertiary rocks in Montana was reported by Adams and Fritts (1951) and by Stow (1953), but only the latter anomaly could be found. This anomaly was reported from waste dumps of coal mines in the Polecat Bench Formation near Red Lodge, Montana. Two samples, one from a coal bed (20306) and one from a clinker deposit (20307), were collected in this locality. Both samples contained 5 ppm U_3O_8; the coal sample contained 22 ppm ThO_2, and the clinker sample contained 25 ppm ThO_2. High thorium content is probably responsible for the reported radiometric anomaly.

FAVORABILITY CRITERIA

Favorability criteria used to evaluate Late Cretaceous and early Tertiary strata in the Bighorn Basin are taken directly or modified from Grutt's (1972) guidelines concerning sources of uranium, host lithology, and presence of control factors.

Possible Sources

Precambrian granite in the Granite Mountains of central Wyoming has been postulated as the source of uranium for several sandstone uranium deposits in surrounding areas (Rosholt and others, 1973, p. 1001). Twenty-six samples were collected from plutonic and metamorphic rocks of Precambrian age in the Beartooth, Absaroka, Owl Creek, and Big Horn Mountains in an attempt to determine if these rocks could have been sources of uranium that may have been contributed to Bighorn Basin sediments. U_3O_8 content of these samples ranges from 2 to 8 ppm with a mean of 3.58 ppm (Table 1). Malan and Sterling (1970, p. 30) reported a mean of 2.6 ppm U (3.1 ppm U_3O_8) for seven igneous and metamorphic rock samples from the Beartooth Mountains and a mean of 1.3 ppm U (1.5 ppm U_3O_8) for 19 igneous and metamorphic rock samples from the Big Horn Mountains. These results indicate that the uranium content of the Precambrian rock samples is within the 2 to 5 ppm U (2 to 6 ppm U_3O_8) range established by Rogers and Adams (1969) as the average uranium content of granite. This differs considerably from the range of 20 to 30 ppm U (24 to 25 ppm U_3O_8) reported by Masursky (1962, p. B95) for granite samples from the Granite Mountains. Therefore, it seems unlikely that the mountains bordering the Bighorn Basin were a significant source area for uranium.

Volcanic tuffs superjacent to host sandstones have also been postulated as sources of uranium (Love, 1954; Pipiringos, 1961). Tuffaceous sediments and welded lapilli tuffs of the Pitchfork Formation overlie and intertongue with the Tatman Formation, and both overlie the Lance, Polecat Bench, and Willwood Formations. Three samples from the Pitchfork (18749, 18750, 18751) contained from <1 ppm to 3 ppm U_3O_8. Petrographic inspection of these samples indicates little devitrification of glass shards in the tuffaceous parts of the rocks. Lack of devitrification implies that little leaching of uranium has taken place (Rosholt and others, 1973, p. 1000). If leaching of uranium has been limited throughout the Pitchfork Formation, it is improbable that the tuffs in this unit were significant uranium sources.

The Oligocene Wiggins Formation (White River equivalent), which includes numerous volcanic flows and beds of tuff and tuffaceous sediments, probably covered much of the Bighorn Basin and provided another possible source of uranium. However, Van Houten (1952, p. 78) indicated that glass shards in Oligocene tuffaceous sediments in the Big Horn Mountains are fresh, with little devitrification. As Oligocene rocks were not sampled during this study and erosion of post-Willwood strata has been extensive, it is not possible to conclusively determine the favorability of these rocks as possible uranium sources.

Host Rocks

North of the Greybull River, sandstones in the upper Lance and lower Polecat Bench and conglomerates in the Willwood seem to be more favorable for possible uranium concentrations than other lithologic units in the project area.

Between the towns of Belfry and Red Lodge, Montana, in Tps. 7 and 8 S., Rs. 21 and 22 E., the Polecat Bench Formation contains a sequence of medium-grained sandstone interbedded with muddy siltstone. Sandstone beds average 20 ft (6 m) thick and dip 5° to 10° W. Samples collected in this area (19474 through 19477, 19735, 19736, 19737) contained between 2 and 4 ppm U_3O_8; no reductants were seen.

More than 1,800 ft (550 m) (Flueckinger, 1970, p. 22) of steeply dipping (approx. 50° E.) Willwood conglomerates is exposed at the mouth of Clark Fork Canyon (T. 58 N., R. 102 W.) in a prominent ridge that has been incised by the Clark Fork of the Yellowstone River. The conglomerates are composed primarily of igneous rock fragments (Neasham, 1970, p. 23) and are well cemented in outcrop although cementing may not extend to depth. Two samples collected from these conglomerates (19479, 19480) contained 2 ppm U_3O_8 each.

South of Lovell, Wyoming, and west of Alkali anticline, in T. 55 N., R. 96 W., hematitic alteration was observed in a steeply dipping (approx. 50° W.) sandstone bed of the basal part of the Lance Formation. Two samples collected from this bed (18943, 18944) contained 3 and 2 ppm U_3O_8 respectively. Alteration was also noted in a 30-ft-(9 m)-thick bed of fine- to medium-grained sandstone of the Polecat Bench Formation. Dip of the beds is about 35° W. Samples of this unit (18940, 18941) contained 2 ppm U_3O_8 each. Faults that cut the axis of Alkali anticline could have functioned as pathways for ascending sour gas (H_2S) present in the Alkali anticline oil field, thereby providing a reductant for any uranium-rich solutions migrating through the upper strata.

The remainder of the project area north of the Greybull River appears to be devoid of potential host rocks favorable to sandstone uranium deposits. Most of the sediments in the north-central part of the basin are variegated mudstones of the Polecat Bench and Willwood Formations, with thin (6 ft [2 m] or less) fine-grained, discontinuous overbank and channel-fill sandstone units. Although some organic material is preserved in the fine-grained rocks in the north-central part of the basin, none was seen in the thicker, more persistent sandstone units near the basin margin. The difference in organic content may be attributed to variations in depositional environment such as described by Neasham (1970, p. 82):

> Within the low-lying floodbasin areas impeded drainage conditions and water tables at or near the depositional interface would have favored a reducing environment and preservation of organic matter. Improved drainage and lower water tables in the alluvial ridge and natural levee areas, aided by underlying permeable alluvium, developed oxidizing conditions unfavorable for the preservation of organic materials.

Therefore, less organic trash, which often acts as a reducing agent in sandstone uranium deposits, would be preserved in the more favorable sandstone units in the basin margins.

South of the Greybull River, the proportion of sandstone in the Lance and Polecat Bench Formations is larger in the western and southern parts of the basin than in the eastern and central parts. Sandstone beds of the Lance and Polecat Bench are exposed along the basin margins between Golden Eagle Dome (T. 45 N., R. 97 W.) and Meeteetse, Wyoming (T. 48 N., R. 100 W.), and east-southeast from Golden Eagle Dome in T. 45 N., Rs. 95 and 96 W. These beds are approximately 10 ft (3 m) thick and appear to be discontinuous overbank deposits of very fine- to medium-grained sand with local channel-fill deposits of somewhat coarser material. Irregular patches of hematitic alteration were observed at several localities in the sandstone, but no anomalous radiometric readings were noted. There is little carbonaceous material in the rocks, although one sample (18763) of carbonized wood containing 13 ppm U_3O_8 was collected from a sandstone bed in the basal part of the Lance Formation.

Conglomerate lenses in the basal part of the Willwood were observed in Tps. 45 and 46 N., Rs. 95, 96, and 97 W. The conglomerates are composed of well-rounded pebbles and cobbles of quartzite, chert, and igneous rock fragments and are poorly to well indurated. No organic material or alteration was noted in these rocks. Similar conglomerates in the Polecat Bench Formation were noted in the central part and on the southeast flank of the Grass Creek syncline (Tps. 45 and 46 N., R. 98 W.).

Variegated mudstones and thin channel and overbank sandstones of the Polecat Bench and Willwood Formations, which are similar to rocks in the north-central part of the Bighorn Basin, crop out throughout the basin south of the Greybull River, except at the western and southern borders.

Finch (1967, p. 97) suggested that the red zone of the Wasatch Formation parallel to the Fourbear anticline in Park County, Wyoming, might be favorable for uranium because of its analogy to the uraniferous zone in the Powder River basin. The Willwood Formation (Wasatch of Finch, 1967) on the Fourbear anticline was described by Pierce and Andrews (1941, p. 136) as being "dominantly clays and shales, somewhat sandy in places." Access to this area could not be obtained during the field study. In much of the central Bighorn Basin, the Willwood Formation contains extensive red zones, but it is unfavorable for uranium deposits.

Other Surface Data

One sample (17908) taken at the mouth of Slick Creek (NW¼NE¼SE¼ sec. 7, T. 27 N., R. 92 W.) during the reconnaissance stream-sediment study contained 9 ppm U_3O_8, which indicates a possible anomaly. Follow-up samples taken along Slick Creek (19991 through 19995) contained from 1 to 6 ppm U_3O_8 and were inconclusive.

A mean of 85 gross cps (counts per second) and a standard deviation of 16 cps were calculated for scintillometer readings from 140 locations (including sample sites). On the basis of this data, positive statistical anomalies (mean plus two standard deviations) were recorded at six sample locations (18925, 18936, 18937, 18946, 19479, 19480). No radiometric reading exceeded the mean plus three standard deviations, and no readings approached the level (five times background or greater) that Grutt (1972) indicated as a radiometric anomaly in uranium-bearing host strata.

Subsurface Appraisal

The subsurface aspect of this study is judged to be inconclusive. (Subsurface lithologic maps are shown in Figs. 6, 7, 8.) Because Tertiary rocks of the Bighorn Basin do not produce oil or gas, oil-drilling contractors drill quickly through the Tertiary section. Consequently, sample cuttings of the Tertiary section are incomplete and are not representative of the intervals sampled. The high-velocity jetting action of drilling fluids, combined with sample collecting methods, eliminates the unconsolidated Tertiary sandstones from the samples. Therefore, the lithologic logs that were examined are complete for the oil-producing formations but are abbreviated for the Tertiary. The large, conglomeratic alluvial fans of the Willwood Formation that were seen on the surface at the western margin of the basin were not recognized in subsurface well logs. The map representing the Lance Formation (Fig. 8) is the most complete. Lack of subsurface control points in a large area of the central part of the basin makes correlation between the northern and southern halves of the project area difficult.

CONCLUSIONS

Upper Cretaceous, Paleocene, and lower Eocene rocks in the Bighorn Basin are generally unfavorable for sandstone uranium deposits. Plutonic and metamorphic rocks of Precambrian age in the uplifts bordering the basin contain little uranium and are probably not significant as source rocks. Tuffs and tuffaceous sediments of the Pitchfork Formation of middle and late Eocene age can probably be discounted as source rocks, because they do not contain much uranium and they appear to have been only slightly devitrified. However, there are insufficient data to evaluate the favorability of the Wiggins Formation as a uranium source. Tuffaceous rocks of the Pitchfork Formation have been almost entirely eroded from the Bighorn Basin so that their lack of favorability as source rocks cannot be conclusively determined. Potential host rocks in the Lance, Polecat Bench, and Willwood Formations locally show moderate favorability, but are considered unfavorable because of poor lithology, steep dips, and general absence of general material. Subsurface data, though inconclusive, do not show many potentially favorable areas.

Rocks of the Lance, Polecat Bench, and Willwood Formations in the Bighorn Basin do not sufficiently fulfill favorability criteria for sandstone uranium deposits (Grutt, 1972) to consider them as uranium hosts.

BIBLIOGRAPHY

Adams, J. W., and Fritts, P. J., 1951, Green Streak claim: U.S. Atomic Energy Comm. Prelim. Reconn. Rept. D-223, Open-File Rept., 1 p.

Alpha, A. G., and Fanshawe, J. R., 1954, Tectonics of northern Bighorn Basin area, in Billings Geol. Soc. Guidebook 5th Ann. Field Conf., Pryor Mountains - Northern Bighorn Basin, 1954: p. 72-79.

Andrews, D. A.; Pierce, W. G.; and Eargle, D. H., 1947, Geologic map of the Bighorn Basin, Wyoming and Montana, showing terrace deposits and physiographic features: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 71, scale 1:126,720.

Bown, T. M., 1975, Paleocene and lower Eocene rocks in the Sand Creek - No Water Creek area, Washakie County, Wyoming, in Wyoming Geol. Assoc. Guidebook 27th Ann. Field Conf., Geology and Mineral Resources of the Bighorn Basin, 1975: p. 55-61.

Casella, C. J., 1964, Geologic evolution of the Beartooth Mountains - Pt. 4, Relationship between Precambrian and Laramide structures in the Line Creek area: Geol. Soc. American Bull., v. 75, p. 969-986.

Darton, N. H., 1906, Geology of the Bighorn Mountains: U.S. Geol. Survey Prof. Paper 51, 129 p.

Fanshawe, J. R., 1952, Bighorn Basin tectonics, in Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Bighorn Basin, Wyoming, 1952: p. 19-21.

______1971, Structural evolution of the Bighorn Basin, in Wyoming Geol. Assoc. Guidebook 23rd Ann. Field Conf., Symposium on Wyoming Tectonics and Their Economic Significance, 1971: p. 35-37.

Finch, W. I., 1967, Geology of epigenetic uranium deposits in sandstone in the United States: U.S. Geol. Survey Prof. Paper 538, 121 p.

Fisher, C. A., 1906, Geology and water resources of the Bighorn Basin, Wyoming: U.S. Geol. Survey Prof. Paper 53, 52 p.

Flueckinger, L. A., 1970, Stratigraphy, petrology, and origin of Tertiary sediments off the front of the Beartooth Mountains, Montana - Wyoming [Ph.D. thesis]: State College, Pennsylvania State Univ., 249 p.

Gingerich, P. D., 1967, Pollen stratigraphy of the Polecat Bench Formation, Paleocene, Park County, Wyoming [B.A. thesis]: Princeton, N. J., Princeton Univ., 80 p.

Glass, G. B.; Westervelt, Katherine; and Oviatt, C. G., 1975, Coal mining in the Bighorn Coal Basin of Wyoming, in Wyoming Geol. Assoc. Guidebook 27th Ann. Field Conf., Geology and Mineral Resources of the Bighorn Basin, 1975: p. 221-228.

Grutt, E. W., Jr., 1972, Prospecting criteria for sandstone type uranium deposits, in Uranium prospecting handbook: London Inst. Mining and Metallurgy, p. 47-74.

Hay, R. L., 1956, Pitchfork Formation, detrital facies of Early Basic Breccia, Absaroka Range, Wyoming: Am. Assoc. Petroleum Geologists Bull., v. 40, p. 1863-1898.

Hewett, D. F., 1926, Geology and oil and coal resources of the Oregon Basin, Meeteetse, and Grass Creek quadrangles, Wyoming: U.S. Geol. Survey Prof. Paper 145, 111 p.

Horn, G. H., 1963, Geology of the East Thermopolis area, Hot Springs and Washakie Counties, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM-213, scale 1:48,000.

Houston, R. S., 1969, Aspects of the geologic history of Wyoming related to the formation of uranium deposits, in Parker, R. B., ed., Contributions to geology, Wyoming uranium issue: Laramie, Univ. Wyoming, v. 8, no. 2, pt. 1, p. 67-79.

Hughes, R. V., 1933, The geology of the Beartooth Mountain front in Part County, Wyoming: Natl. Acad. Sci. Proc., v. 19, p. 239-253.

Jepsen, G. L., 1930, Stratigraphy and paleontology of the Paleocene of northeastern Park County, Wyoming: Am. Philos. Soc. Proc., v. 69, p. 463-528.

_____1940, Paleocene faunas of Polecat Bench Formation, Park County, Wyoming: Am. Philos. Soc. Proc., v. 83, no. 2, p. 217-340.

Jepsen, G. L., and Van Houten, F. B., 1947, Early Tertiary stratigraphy and correlations, in Wyoming Geol. Assoc. Guidebook 2nd Ann. Field Conf., Big Horn Basin, Wyoming, 1947: p. 142-149.

Jobling, J. L., 1974, Stratigraphy, petrography, and structure of the Laramide (Paleocene) sediments marginal to the Beartooth Mountains, Montana [Ph.D. thesis]: State College, Pennsylvania State Univ., 102 p.

Loomis, F. B., 1907, Origin of the Wasatch deposits: Am. Jour. Sci. 4th ser., v. 23, p. 356-364.

Love, J. D., 1939, Geology along the southern margin of the Absaroka Range, Wyoming: Geol. Soc. America Spec. Paper 20, 123 p.

BIBLIOGRAPHY (continued)

Love, J. D., 1952, Chart showing correlations of Upper Cretaceous and Paleocene rocks in the southern part of the Bighorn Basin and adjacent areas, in Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Bighorn Basin, Wyoming, 1952: p. 89.

_____1954, Preliminary report on uranium in the Gas Hills area, Fremont and Natrona Counties, Wyoming: U.S. Geol. Survey Circ. 352, 11 p.

_____1960a, Cenozoic sedimentation and crustal movement in Wyoming [Bradley Vol.]: Am. Jour. Sci., v. 258-A, p. 203-214.

_____1960b, Cenozoic geology of the Granite Mountains area central Wyoming: U.S. Geol. Survey Prof. Paper 495-C, 154 p.

Mackin, J. H., 1937, Erosional history of the Bighorn Basin, Wyoming: Geol. Soc. America Bull., v. 48, p. 813-893.

Malan, R. C., and Sterling, D. A., 1970, Distribution of uranium and thorium in the Precambrian of the west-central and northwest United States: U.S. Atomic Energy Comm. AEC-RD-11, Open-File Rept., 63 p.

Masursky, Harold, 1962, Uranium-bearing coal in the eastern part of the Red Desert area, Wyoming: U.S. Geol. Survey Bull. 1099-B, 152 p.

Moore, D. A., 1961, Isopachous map -- Fort Union Formation, Bighorn Basin, in Wyoming Geol. Assoc. Guidebook 16th Ann. Field Conf., Symposium on Early Cretaceous Rocks of Wyoming and Adjacent Area, 1961: p. 200-201.

Nace, R. L., 1936, Summary of Late Cretaceous and early Tertiary stratigraphy of Wyoming: Wyoming Geol. Survey Bull. 26, 271 p.

Neasham, J. W., 1970, Sedimentology of the Willwood Formation (Lower Eocene): An alluvial molasse facies in northwestern Wyoming, U.S.A. [Ph.D. theses]: Ames, Iowa State Univ., 98 p.

Neasham, J. W., and Vondra, C. F., 1972, Stratigraphy and petrology of the Lower Eocene Willwood Formation, Bighorn Basin, Wyoming: Geol. Soc. America Bull., v. 83, p. 2167-2180.

Pierce, W. G., 1965, Geologic map of the Clark quadrangle, Park County, Wyoming: U.S. Geol. Survey Geol. Quad. Map GQ-477.

_____1969, Geologic map of the Wapiti quadrangle, Park County, Wyoming: U.S. Geol. Survey Geol. Quad. Map GQ-778.

_____1975, Principal features of the Heart Mountain Fault and the mechanism problem, in Wyoming Geol. Assoc. Guidebook 27th Ann. Field Conf., Geology and Mineral Resources of the Bighorn Basin, 1975: p. 139-148.

Pierce, W. G., and Andrews, D. A., 1941, Geology and coal resources of the region south of Cody, Park County, Wyoming: U.S. Geol. Survey Bull. 921-B, p. 99-180.

Pierce, W. G., and Nelson, W. H., 1968, Geologic map of the Pat O'Hara Mountain quadrangle, Park County, Wyoming: U.S. Geol. Survey Geol. Quad. Map GQ-755.

Pipiringos, G. N., 1961, Uranium-bearing coal in the central part of the Great Divide Basin: U.S. Geol. Survey Bull. 1099-A, 104 p. [1962].

Ritter, D. F., 1975, New information concerning the geomorphic evolution of the Bighorn Basin, in Wyoming Geol. Assoc. Guidebook 27th Ann. Field Conf., Geology and Mineral Resources of the Bighorn Basin, 1975: p. 221-228.

Rogers, C. P., Jr.; Richards, P. W.; Conant, L. C.; Vine, J. D.; and Notley, D. F., 1948, Geology of the Worland-Hyattville area, Big Horn and Washakie Counties, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 84, scale 1:48,000.

Rogers, J.J.W., and Adams, J.A.S., 1969, Uranium in Wedepohl, L. H., ed., Handbook of geochemistry: New York, Springer-Verlag, v. 2., pt. 1, chap. 92, 50 p.

Rohrer, W. L., 1964a, Geology of the Tatman Mountain quadrangle, Wyoming: U.S. Geol. Survey Geol. Quad. Map GQ-311.

_____1964b, Geology of Sheep Mountain quadrangle, Wyoming: U.S. Geol. Survey Geol. Quad. Map GQ-310.

_____1966, Geology of the Adam Weiss Peak quadrangle, Hot Springs, and Park Counties, Wyoming: U.S. Geol. Survey Bull. 1241-A p. A1-A39.

Rosholt, J. N.; Zartman, R. E.; and Nkomo, I. T., 1973, Lead isotope systematics and uranium depletion in the Granite Mountains, Wyoming: Geol. Soc. America Bull., v. 84, p. 989-1002.

Sinclair, W. J., and Granger, Walter, 1911, Eocene and Oligocene of the Wind River and Bighorn Basins: Am. Mus. Natl. Hist. Bull. 30, p. 83-117.

_____1912, Notes on the Tertiary deposits of the Bighorn Basin: Am. Mus. Natl. Hist. Bull. 31, p. 57-67.

BIBLIOGRAPHY (continued)

Stearns, D. W., 1975, Laramide basement deformation in the Bighorn Basin - the controlling factor for structures in the layered rocks, in Wyoming Geol. Assoc. Guidebook 27th Ann. Field Conf., Geology and Mineral Resources of the Bighorn Basin, 1975: p. 149-158.

Stow, M. H., 1938, Dating Cretaceous-Eocene tectonic movements in the Bighorn Basin by heavy minerals: Geol. Soc. American Bull. 49, p. 731-762.

_____ 1952, Results of some heavy mineral studies in the Bighorn Basin, Montana and Wyoming, in Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Bighorn Basin, Wyoming, 1952: p. 80-88.

_____ 1953, Brophy property: U.S. Atomic Energy Comm. Prelim. Reconn. Rept. HH-B-46, Open-File Rept., 1 p.

Thomas, H. D., 1949, The goelogical history and geological structure of Wyoming: Wyoming Geol. Survey Bull. 42, 28 p.

Thomas, L. E., 1965, Sedimentation and structural development of the Bighorn Basin: Am. Assoc. Petroleum Geologists Bull., v. 49, p. 1867-1877.

Van Houten, F. B., 1944, Stratigraphy of the Willwood and Tatman Formations in northwestern Wyoming: Geol. Soc. American Bull., v. 55, p. 165-210.

_____ 1952, Sedimentary record of Cenozoic orogenic and erosional events, Bighorn Basin, Wyoming, in Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Bighorn Basin, Wyoming, 1952: p. 74-79.

Wilson, W. H., 1975, Detachment faulting in volcanic rocks, Wood River area, Park County, Wyoming, in Wyoming Geol. Assoc. Guidebook 27th Ann. Field Conf., Geology and Mineral Resources of the Bighorn Basin, 1975: p. 167-171.

APPENDIX A.

SAMPLE LOCATIONS AND ASSAY RESULTS

Results of analytical determinations of U_3O_8 and U and the sample locations are presented in this appendix. Fluorimetric chemical assay was performed for each sample, and the results are indicated in the column "U_3O_8(ppm)." For stream-sediment samples (Qal), the chemical assay indicates leached U_3O_8 content. Radiometric determinations of equivalent uranium were made for 91 sandstone samples. These results are indicated in the column "Equivalent uranium (ppm)."

APPENDIX A. SAMPLE LOCATIONS AND ASSAY RESULTS

Sample no.	Formation*	Equivalent uranium (ppm)	U_3O_8 (ppm)	Location
17699	Qal	-	6	NW¼ sec. 24, T. 42 N., R. 95 W.
17700	Qal	-	4	NW¼ sec. 2, T. 46 N., R. 93 W.
17701	Qal	-	4	NW¼ sec. 2, T. 46 N., R. 93 W.
17902	Qal	-	4	NW¼ sec. 24, T. 42 N., R. 95 W.
17903	Qal	-	3	SE¼SE¼SE¼ sec. 17, T. 45 N., R. 94 W.
17904	Qal	-	3	NE¼SE¼SE¼ sec. 30, T. 46 N., R. 93 W.
17905	Qal	-	6	NW¼ sec. 2, T. 46 N., R. 93 W.
17906	Qal	-	5	SW¼ sec. 25, T. 47 N., R. 93 W.
17907	Qal	-	4	NW¼NE¼ sec. 11, T. 46 N., R. 93 W.
17908	Qal	-	9	NW¼NE¼SE¼ sec. 7, T. 47 N., R. 92 W.
17909	Qal	-	3	C of S line sec. 36, T. 48 N., R. 92½ W.
17910	Qal	-	4	SW¼NW¼SE¼ sec. 32, T. 49 N., R. 92 W.
17911	Qal	-	5	SE¼SE¼NW¼ sec. 30, T. 50 N., R. 92 W.
17912	Qal	-	7	NW¼NW¼NE¼ sec. 33, T. 51 N., R. 93 W.
17913	Qal	-	2	SE¼NW¼NE¼ sec. 20, T. 52 N., R. 93 W.
17914	Qal	-	3	SE¼NW¼NW¼ sec. 13, T. 53 N., R. 101 W.
17915	Qal	-	5	SW¼NE¼SW¼ sec. 9, T. 54 N., R. 100 W.
17916	Qal	-	8	SW¼SE¼SE¼ sec. 32, T. 55 N., R. 99 W.
17917	Qal	-	4	SW¼NW¼SE¼ sec. 30, T. 55 N., R. 97 W.
17918	Qal	-	5	T. 56 N., R. 96 W.
17919	Qal	-	6	T. 56 N., R. 96 W.
17920	Qal	-	4	T. 55 N., R. 100 W.
17921	Qal	-	3	T. 53 N., R. 101 W.
17922	Qal	-	4	SE¼NW¼ sec. 8, T. 56 N., R. 102 W.
17923	Qal	-	4	NW¼NW¼NE¼ sec. 8, T. 56 N., R. 102 W.
17924	Qal	-	5	SW¼SE¼SE¼ sec. 28, T. 8 S., R. 22 E.
17925	Qal	-	4	C N½SW sec. 35, T. 7 S., R. 22 E.
17926	Qal	-	4	SW¼NW¼SW¼ sec. 25, T. 7 S., R. 22 E.

*Qal, Quaternary alluvium; pЄ, Precambrian; Kl, Cretaceous Lance Fm.; Tpb, Tertiary Polecat Bench Fm.; Tw, Tertiary Willwood Fm.; Tp, Tertiary Pitchfork Fm.

APPENDIX A. (continued)

Sample no.	Formation*	Equivalent uranium (ppm)	U_3O_8 (ppm)	Location
17927	Qal	-	2	SW¼SW¼SW¼ sec. 25, T. 7 S., R. 22 E.
17928	Qal	-	4	NE¼SE¼SE¼ sec. 21, T. 52 N., R. 98 W.
17929	Qal	-	4	NE¼NW¼SE¼ sec. 33, T. 58 N., R. 101 W.
17930	Qal	-	4	SW¼ sec. 3, T. 52 N., R. 95 W.
17931	Qal	-	4	NW¼SW¼ sec. 5, T. 52 N., R. 93 W.
17932	Qal	-	4	S½ SW¼NW¼ sec. 8, T. 51 N., R. 94 W.
17933	Qal	-	3	SE¼NE¼SE¼ sec. 3, T. 52 N., R. 97 W.
17934	Qal	-	5	SW¼NW¼ sec. 32, T. 50 N., R. 99 W.
18522	pЄ	-	2	NW¼NW¼NE¼ sec. 9, T. 48 N., R. 85 W.
18523	pЄ	-	2	SE¼NW¼NW¼ sec. 1, T. 48 N., R. 86 W.
18524	pЄ	-	2	SW¼NE¼SW¼ sec. 2, T. 48 N., R. 80 W.
18525	pЄ	-	4	SE¼NW¼SW¼ sec. 3, T. 48 N., R. 86 W.
18526	pЄ	-	8	T. 49 N., R. 86 W.
18527	pЄ	-	4	SE¼NE¼NW¼ sec. 4, T. 48 N., R. 86 W.
18528	pЄ	-	8	NW¼NW¼NW¼ sec. 12, T. 6 N., R. 6 E.
18529	pЄ	-	3	SW¼SW¼ sec. 30, T. 56 N., R. 92 W.
18530	pЄ	-	3	SW¼SW¼ sec. 30, T. 56 N., R. 92 W.
18531	pЄ	-	2	SW¼SW¼ sec. 30, T. 56 N., R. 92 W.
18532	pЄ	-	2	SE¼NW¼ sec. 20, T. 56 N., R. 92 W.
18533	pЄ	-	4	SE¼SW¼SE¼ sec. 1, T. 52 N., R. 103 W.
18534	pЄ	-	3	SE¼SW¼SE¼ sec. 1, T. 52 N., R. 103 W.
18535	pЄ	-	4	NE¼NW¼ sec. 25, T. 56 N., R. 92 W.
18536	pЄ	-	3	NE¼NW¼ sec. 25, T. 56 N., R. 92 W.
18537	pЄ	-	4	Lat 44°33'42", long. 107°33'45"
18538	pЄ	-	3	NE¼NE¼ sec. 12, T. 55 N., R. 89 W.
18539	pЄ	-	2	Lat 44°34'32", long. 107°32'51"
18540	pЄ	-	5	Lat 44°35'11", long. 107°36'41"
18541	pЄ	-	4	Lat 44°34'32", long. 107°32'51"
18739	Tpb	-	2	C SE¼ sec. 2, T. 46 N., R. 98 W.
18740	Tpb	-	2	NW¼NW¼SE¼ sec. 34, T. 47 N., R. 98 W.
18741	Tpb	-	2	NE¼NW¼SW¼ sec. 35, T. 45 N., R. 95 W.

*Qal, Quaternary alluvium; pЄ, Precambrian; Kl, Cretaceous Lance Fm.; Tpb, Tertiary Polecat Bench Fm.; Tw, Tertiary Willwood Fm.; Tp, Tertiary Pitchfork Fm.

APPENDIX A. (continued)

Sample no.	Formation*	Equivalent uranium (ppm)	U_3O_8 (ppm)	Location
18742	Tpb	-	3	SW¼SW¼NW¼ sec. 34, T. 45 N., R. 95 W.
18743	Tpb	-	3	C W½ sec. 30, T. 45 N., R. 95 W.
18744	Tpb	-	3	C W½ sec. 30, T. 45 N., R. 95 W.
18745	Tpb	-	<1	NW¼NW¼NW¼ sec. 25, T. 45 N., R. 96 W.
18746	Tpb	1.7	1	SE¼NW¼ sec. 4, T. 44 N., R. 93 W.
18747	Tpb	2.2	1	SW¼SW¼ sec. 32, T. 45 N., R. 93 W.
18748	Tpb	1.8	<1	SW¼SW¼ sec. 32, T. 45 N., R. 93 W.
18749	Tp	-	3	C NW¼ sec. 20, T. 45 N., R. 101 W.
18750	Tp	-	<1	C NW¼ sec. 20, T. 45 N., R. 101 W.
18751	Tp	-	2	C NW¼ sec. 20, T. 45 N., R. 101 W.
18763	Kl	-	13	SW¼SE¼SW¼ sec. 28, T. 46 N., R. 97 W.
18920	Kl	2.7	2	NW¼NW¼NE¼ sec. 9, T. 45 N., R. 98 W.
18921	Kl	2.2	3	NW¼SW¼NW¼ sec. 2, T. 45 N., R. 98 W.
18922	Tpb	1.6	3	SE¼SW¼SW¼ sec. 5, T. 45 N., R. 97 W.
18923	Tpb	3.9	4	SE¼SW¼SW¼ sec. 5, T. 45 N., R. 97 W.
18924	Tpb	3.9	6	W½SW¼NE¼ sec. 1, T. 45 N., R. 99 W.
18925	Tpb	2.4	3	W½SW¼NE¼ sec. 1, T. 45 N., R. 99 W.
18926	Tpb	1.9	2	NW¼SE¼NE¼ sec. 31, T. 46 N., R. 98 W.
18927	Kl	4.0	4	S½NE¼SW¼ sec. 23, T. 46 N., R. 99 W.
18928	Kl	2.4	2	C NW¼NW¼ sec. 20, T. 46 N., R. 99 W.
18929	Kl	1.9	2	NW¼SE¼SE¼ sec. 17, T. 45 N., R. 98 W.
18930	Kl	1.8	2	SE¼SE¼SE¼ sec. 31, T. 47 N., R. 99 W.
18931	Kl	2.3	2	SE¼SW¼NW¼ sec. 15, T. 46 N., R. 100 W.
18932	Tw	-	1	SE¼SW¼NE¼ sec. 15, T. 54 N., R. 100 W.
18933	Tw	1.5	1	NW¼NE¼NE¼ sec. 15, T. 54 N., R. 100 W.
18934	Tpb	-	2	C SW¼ sec. 5, T. 55 N., R. 101 W.
18935	Tpb	2.3	1	NE¼NE¼SE¼ sec. 31, T. 56 N., R. 100 W.
18936	Tpb	-	2	NE¼SE¼SE¼ sec. 7, T. 57 N., R. 98 W.
18937	Tpb	-	2	NE¼SE¼SE¼ sec. 7, T. 57 N., R. 98 W.
18938	Tpb	3.2	3	NE¼SE¼NE¼ sec. 24, T. 57 N., R. 99 W.

*Qal, Quaternary alluvium; pG, Precambrian; Kl, Cretaceous Lance Fm.; Tpb, Tertiary Polecat Bench Fm.; Tw, Tertiary Willwood Fm.; Tp, Tertiary Pitchfork Fm.

APPENDIX A. (continued)

Sample no.	Formation*	Equivalent uranium (ppm)	U_3O_8 (ppm)	Location
18939	Tpb	-	3	NW¼SW¼NW¼ sec. 31, T. 56 N., R. 98 W.
18940	Tpb	1.9	2	NW¼SW¼NE¼ sec. 25, T. 55 N., R. 96 W.
18941	Tpb	1.3	2	NW¼SW¼NE¼ sec. 25, T. 55 N., R. 96 W.
18942	Tpb	-	4	C NE¼SW¼ sec. 25, T. 55 N., R. 96 W.
18943	Kl	3.0	3	SE¼SE¼NW¼ sec. 5, T. 54 N., R. 95 W.
18944	Kl	2.8	2	SE¼SE¼NW¼ sec. 5, T. 54 N., R. 95 W.
18945	Tpb	-	4	SE¼NW¼SE¼ sec. 28, T. 56 N., R. 100 W.
18946	Tpb	-	4	SE¼NW¼SE¼ sec. 28, T. 56 N., R. 100 W.
18947	Tpb	2.9	3	NW¼SE¼SE¼ sec. 15, T. 56 N., R. 100 W.
18948	Tpb	1.9	3	NW¼SE¼SE¼ sec. 15, T. 56 N., R. 100 W.
19456	p€	3.3	5	NW¼NW¼ sec. 7, T. 56 N., R. 103 W.
19457	Tpb	1.5	1	C NW¼ sec. 25, T. 45 N., R. 96 W.
19458	Tpb	1.5	1	C NW¼ sec. 25, T. 45 N., R. 96 W.
19459	Tpb	1.7	3	SE¼NW¼SW¼ sec. 23, T. 45 N., R. 96 W.
19460	Tpb	1.4	3	SE¼NW¼SW¼ sec. 23, T. 45 N., R. 96 W.
19461	Kl	1.9	3	SW¼NW¼NW¼ sec. 30, T. 42 N., R. 98 W.
19462	Tpb	1.3	2	SW¼NW¼SW¼ sec. 18, T. 47 N., R. 98 W.
19463	Tpb	1.1	3	SW¼NW¼SW¼ sec. 18, T. 47 N., R. 98 W.
19464	Tpb	1.2	2	SW¼NE¼SE¼ sec. 29, T. 47 N., R. 98 W.
19465	Tpb	1.2	1	SE¼NE¼NW¼ sec. 2, T. 47 N., R. 99 W.
19466	Tpb	0.9	3	SE¼NW¼NW¼ sec. 34, T. 48 N., R. 99 W.
19467	Tpb	2.7	3	SE¼NW¼NW¼ sec. 34, T. 48 N., R. 99 W.
19468	Tpb	1.1	2	NW¼SW¼NE¼ sec. 18, T. 48 N., R. 99 W.
19469	p€	2.3	3	Lat 45°01'26", long. 109°25'33"
19470	p€	1.9	4	Lat 45°01'26", long. 109°25'33"
19471	p€	1.4	2	Lat 45°01'26", long. 109°25'33"
19472	p€	1.9	3	Lat 45°01'43", long. 109°24'48"
19473	p€	1.2	4	Lat 45°01'43", long. 109°24'48"
19474	Tpb	1.4	3	NE¼SW¼SW¼ sec. 10, T. 8 S., R. 22 E.
19475	Tpb	1.4	3	SE¼NW¼NW¼ sec. 4, T. 8 S., R. 22 E.
19476	Tpb	1.5	4	SW¼SW¼NW¼ sec. 3, T. 8 S., R. 22 E.

*Qal, Quaternary alluvium; p€, Precambrian; Kl, Cretaceous Lance Fm.; Tpb, Tertiary Polecat Bench Fm.; Tw, Tertiary Willwood Fm.; Tp, Tertiary Pitchfork Fm.

APPENDIX A. (continued)

Sample no.	Formation*	Equivalent uranium (ppm)	U_3O_8 (ppm)	Location
19477	Tpb	2.7	3	SW¼SW¼NW¼ sec. 3, T. 8 S., R. 22 E.
19478	Tw	2.7	3	NE¼NE¼NW¼ sec. 18, T. 52 N., R. 104 W.
19479	Tw	1.3	2	C NE¼SW¼ sec. 32, T. 58 N., R. 102 W.
19480	Tw	1.0	2	C NE¼SW¼ sec. 32, T. 58 N., R. 102 W.
19481	Tw	1.7	3	SE¼SW¼SE¼ sec. 26, T. 56 N., R. 102 W.
19482	Tw	1.5	3	NW¼NW¼NE¼ sec. 27, T. 56 N., R. 102 W.
19483	Tw	1.7	3	SW¼SW¼SW¼ sec. 2, T. 56 N., R. 103 W.
19729	Tpb	1.7	3	SW¼SE¼SE¼ sec. 18, T. 46 N., R. 97 W.
19730	Tpb	1.2	2	NE¼SE¼SE¼ sec. 30, T. 45 N., R. 93 W.
19731	Tpb	1.2	2	SW¼NW¼NW¼ sec. 36, T. 45 N., R. 92 W.
19732	Tpb	1.4	2	SW¼NW¼NW¼ sec. 36, T. 45 N., R. 92 W.
19733	Tpb	1.0	2	NE¼SE¼SE¼ sec. 31, T. 45 N., R. 92 W.
19734	Tpb	1.7	3	NW¼NE¼SE¼ sec. 31, T. 44 N., R. 94 W.
19735	Tpb	2.6	2	SE¼NW¼SW¼ sec. 29, T. 7 S., R. 22 E.
19736	Tpb	1.4	2	NW¼SE¼NE¼ sec. 6, T. 8 S., R. 22 E.
19737	Tpb	2.7	3	NW¼NE¼NE¼ sec. 28, T. 8 S., R. 22 E.
19738	Tpb	2.5	2	C NW¼NE¼sec. 5, T. 57 N., R. 100 W.
19739	Tpb	0.8	2	NE¼NW¼SW¼ sec. 22, T. 9 S., R. 22 E.
19740	Tw	1.2	2	NE¼SE¼NE¼ sec. 4, T. 56 N., R. 102 W.
19741	Tw	1.8	2	SW¼SW¼NE¼ sec. 24, T. 57 N., R. 101 W.
19742	Tpb	3.4	4	NE¼NW¼SE¼ sec. 25, T. 54 N., R. 102 W.
19743	Tpb	2.9	3	NE¼NW¼SE¼ sec. 25, T. 54 N., R. 102 W.
19744	Tpb	3.7	4	SE¼SW¼SW¼ sec. 13, T. 54 N., R. 102 W.
19745	Tpb	2.1	3	NE¼SE¼SE¼ sec. 19, T. 54 N., R. 101 W.
19746	Tpb	1.4	3	NW¼SE¼SE¼ sec. 33, T. 53 N., R. 100 W.
19747	Tpb	2.0	3	C SE¼NW¼ sec. 27, T. 53 N., R. 100 W.
19748	Tw	1.5	2	SW¼SE¼SE¼ sec. 9, T. 53 N., R. 100 W.
19991	Qal	-	4	NW¼SW¼NW¼ sec. 17, T. 47 N., R. 92 W.
19992	Qal	-	1	SE¼SE¼SW¼ sec. 27, T. 47 N., R. 92 W.

*Qal, Quaternary alluvium; pЄ, Precambrian; Kl, Cretaceous Lance Fm.; Tpb, Tertiary Polecat Bench Fm.; Tw, Tertiary Willwood Fm.; Tp, Tertiary Pitchfork Fm.

APPENDIX A. (continued)

Sample no.	Formation*	Equivalent uranium (ppm)	U_3O_8 (ppm)	Location
19993	Qal	-	6	SW¼NW¼SE¼ sec. 28, T. 47 N., R. 92 W.
19994	Qal	-	2	NE¼NE¼NE¼ sec. 29, T. 47 N., R. 92 W.
19995	Qal	-	4	SE¼SW¼SW¼ sec. 17, T. 47 N., R. 92 W.
19996	Tpb	1.3	4	NE¼NW¼SW¼ sec. 32, T. 50 N., R. 92 W.
19997	Tw	1.5	2	NW¼SW¼SE¼ sec. 19, T. 50 N., R. 94 W.
19998	Kl	2.0	2	NW¼NW¼SE¼ sec. 30, T. 47 N., R. 98 W.
19999	Tpb	1.4	1	SW¼SE¼NW¼ sec. 32, T. 50 N., R. 92 W.
20000	Tw	1.5	2	C W½NW¼NE¼ sec. 18, T. 50 N., R. 93 W.
20001	Tpb	2.2	2	SE¼SE¼SE¼ sec. 6, T. 45 N., R. 94 W.
20002	Tw	1.2	2	NW¼NE¼NE¼ sec. 12, T. 45 N., R. 95 W.
20003	Tw	1.6	2	NW¼NE¼NE¼ sec. 12, T. 45 N., R. 95 W.
20004	Tw	1.8	1	NE¼NE¼SE¼ sec. 7, T. 45 N., R. 95 W.
20005	Tw	2.2	1	NE¼NE¼SE¼ sec. 7, T. 45 N., R. 95 W.
20006	Tw	1.3	2	C NW¼NW¼ sec. 8, T. 52 N., R. 98 W.
20007	Tw	1.2	3	SW¼NE¼SW¼ sec. 25, T. 53 N., R. 99 W.
20008	Tw	1.1	2	C NW¼SE¼ sec. 27, T. 53 N., R. 98 W.
20009	Tw	1.1	2	C NW¼SE¼ sec. 27, T. 53 N., T. 98 W.
20010	Kl	1.8	2	SE¼SW¼SW¼ sec. 26, T. 51 N., R. 100 W.
20011	Tw	2.2	3	NE¼SW¼SE¼ sec. 29, T. 51 N., R. 99 W.
20012	Tw	2.3	3	NE¼SW¼SE¼ sec. 29, T. 51 N., R. 99 W.
20013	Tw	2.3	4	NE¼NW¼SE¼ sec. 4, T. 50 N., R. 99 W.
20014	Tw	1.7	2	NE¼SW¼SE¼ sec. 6, T. 51 N., R. 97 W.
20015	Tw	2.1	2	NW¼NW¼NE¼ sec. 1, T. 49 N., R. 100 W.
20016	Tw	2.3	2	NE¼NE¼SW¼ sec. 21, T. 50 N., R. 99 W.
20017	Tw	1.5	2	NE¼NE¼SW¼ sec. 21, T. 50 N., R. 99 W.
20306	Tpb	4.8	5	SW¼NE¼NW¼ sec. 1, T. 8 S., R. 20 E.
20307	Tpb	5.5	5	SW¼NE¼NW¼ sec. 1, T. 8 S., R. 20 E.

*Qal, Quaternary alluvium; pЄ, Precambrian; Kl, Cretaceous Lance Fm.; Tpb, Tertiary Polecat Bench Fm.; Tw, Tertiary Willwood Fm.; Tp, Tertiary Pitchfork Fm.

APPENDIX B. SUBSURFACE DATA REFERENCE POINTS

Well ref. no. WO-11-	Location	Operator and well no.	Depth range (ft)	Elevation (ft) KB	AMSTRAT lithlog
374	sec. 33, T. 9 S., R. 21 E., NW¼NE¼ Mont.	Phillips #1 NP	488-13,830	4,680	X
375	sec. 30, T. 9 S., R. 21 E., NE¼NE¼ Mont.	Union #1 A 30	315-10,767	5,006	
376	sec. 28, T. 9 S., R. 22 E., SE¼SE¼NE¼ Mont.	McDermott #3 Unit	1,004- 6,885	4,376	
379	sec. 27, T. 9 S., R. 22 E., NW¼SW¼ Mont.	Texaco #1-C Govt.	590-10,581	4,510	
380	sec. 26, T. 9 S., R. 22 E., SW¼NE¼ Mont.	Nyvatex #2 UP	580- 9,464	4,927	
381	sec. 26, T. 9 S., R. 22 E., NE¼NE¼ Mont.	Brit. Am. #1 McCellan Govt.	503- 9,053	4,733	
383	sec. 25, T. 9 S., R. 22 E., NW¼NW¼ Mont.	Nyvatex UP #1 Fed.	539- 9,500	4,765	
385	sec. 25, T. 9 S., R. 22 E., NW¼SW¼ Mont.	Nyvatex #3 Fed.	591- 8,212	5,011	
386	sec. 24, T. 9 S., R. 22 E., C SW¼NW¼ Mont.	Warren #1 Govt. Lupton	683- 7,905	4,415	
387	sec. 17, T. 9 S., R. 22 E., NW¼NW¼ Mont.	Carter #2 Belfry	797-10,087	3,958	
390	sec. 16, T. 9 S., R. 22 E., C NE¼SE¼ Mont.	Brit. Am. #1 State	785-10,876	4,351	
395	sec. 7, T. 9 S., R. 22 E., NW¼NW¼ Mont.	Carter #1 Wheatly-Govt.	825-10,120	4,146	
396	sec. 23, T. 7 S., R. 20 E., NW¼NW¼ Mont.	Tyler Oil #23-4 Olcott Foard	194- 7,207	5,453	
398	sec. 35, T. 6 S., R. 21 E., C SE¼SW¼ Mont.	Arco #1 NP	239- 9,303	4,517 DF	
399	sec. 33, T. 6 S., R. 21 E., NW¼SW¼ Mont.	Cities Service #1 Govt.	0- 8,258	5,268	
400	sec. 28, T. 6 S., R. 20 E., C NW¼NE¼ Mont.	Phillips #1-A Louma	61-11,797	5,126	
401	sec. 25, T. 6 S., R. 20 E., SE¼SW¼ Mont.	Great Northern #1 Olcott	332- 7,499	5,052	
403	sec. 5, T. 45 N., R. 90 W., C SW¼SE¼ Wyo.	Tomberlin #1 Govt.	473- 6,545	4,580 GL	
404	sec. 6, T. 45 N., R. 90 W., NE¼NE¼ Wyo.	Ambassador #1 Fed.	264- 6,696	4,439	
408	sec. 10, T. 45 N., R. 91 W., SW¼NW¼ Wyo.	Amoco #1 USA - Ozman	596-10,696	4,592	
409	sec. 29, T. 45 N., R. 91 W., C NE¼NW¼ Wyo.	Texaco #1 Govt. - McGrady	923-10,215	4,776	
411	sec. 30, T. 45 N., R. 91 W., NW¼NW¼NE¼ Wyo.	Calco #8 Unit	1,208-10,541	4,833	
412	sec. 36, T. 45 N., R. 91 W., NW¼SE¼ Wyo.	Pan Am #1 Wagon Prong Unit	507-10,983	4,818	
413	sec. 9, T. 45 N., R. 92 W., NE¼SW¼SE¼ Wyo.	Calco #1 Unit	1,232-11,540	4,452	
415	sec. 19, T. 45 N., R. 92 W., NW¼NE¼SW¼ Wyo.	Tenneco #1 Neiber 11	593-10,496	4,373	
416	sec. 19, T. 45 N., R. 92 W., C SE¼SE¼ Wyo.	Calco #2 Neiber Dome	726-10,198	4,394 DF	
417	sec. 19, T. 45 N., R. 92 W., NE¼NE¼NE¼ Wyo.	Calco #10 Unit	1,194-10,257	4,275	
418	sec. 19, T. 45 N., R. 92 W., SE¼NE¼NW¼ Wyo.	G & G Drlg. #1 Unit	515-10,320	4,448 DF	
422	sec. 24, T. 45 N., R. 92 W., NE¼NE¼ Wyo.	Tenneco #1 Coutis	469-10,950	4,667	
423	sec. 7, T. 45 N., R. 93 W., NE¼NE¼ Wyo.	Cabot #1 Neiber-Fed.	503- 8,726	4,501	

APPENDIX B. (continued)

Well ref. no. WO-11-	Location	Operator and well no.	Depth range (ft)	Elevation (ft) KB	AMSTRAT lithlog
424	sec. 14, T. 45 N., R. 93 W., NE¼SW¼SE¼ Wyo.	Calco #3 Unit	1,497-10,298	4,539	
426	sec. 29, T. 45 N., R. 93 W., NE¼NE¼SW¼ Wyo.	Sinclair #1 Winchester	398-11,921	4,717	
428	sec. 12, T. 45 N., R. 97 W., NW¼SE¼NW¼ Wyo.	Phillips #6 Unit	0-10,083	5,039	
434	sec. 18, T. 46 N., R. 90 W., SE¼NW¼ Wyo.	Conoco #18-1 Fed.	343- 9,932	4,612	
435	sec. 31, T. 46 N., R. 90 W., C NE¼NE¼ Wyo.	Conoco #1 Govt.	490- 9,322	4,462	X
437	sec. 1, T. 46 N., R. 91 W., NE¼NE¼ Wyo.	Tenneco #1 Lowe-Fed.	467- 9,402	4,673	
439	sec. 5, T. 46 N., R. 91 W., SW¼NE¼ Wyo.	Phillips #15 Nowater Cr.	474-10,740	4,581	
444	sec. 6, T. 46 N., R. 91 W., NW¼NW¼ Wyo.	Tenneco #2 USA-Nowater Cr.	478-11,093	4,512	
445	sec. 10, T. 46 N., R. 91 W., NE¼SE¼ Wyo.	Helmerich & Payne #1-10 Cabin	559- 9,995	4,548	X
446	sec. 16, T. 46 N., R. 91 W., C SE¼NW¼ Wyo.	Texaco #1 State "F"	924-10,286	4,551	
447	sec. 23, T. 46 N., R. 91 W., NE¼SE¼SE¼ Wyo.	Gen. Pet. #77X 23-G	297- 7,080	4,550	
455	sec. 29, T. 46 N., R. 91 W., SW¼NE¼ Wyo.	Helmerich & Payne #1-29 Sundown	533-10,298	4,354	
456	sec. 35, T. 46 N., R. 91 W., NE¼NW¼NW¼ Wyo.	Gen. Pet. #21-35 G	273- 6,929	4,371 DF	
458	sec. 1, T. 46 N., R. 92 W., SE¼NW¼SW¼ Wyo.	Gen. Pet. #26-1 G	509-10,534	4,317	
459	sec. 2, T. 46 N., R. 92 W., SE¼NW¼NW¼ Wyo.	Gen. Pet. #22-2 G	516-10,513	4,333	
465	sec. 24, T. 46 N., R. 92 W., SE¼SE¼SE¼ Wyo.	Gen. Pet. #88-24 G	30-10,589	4,237 GL	
466	sec. 2, T. 46 N., R. 94 W., SE¼NW¼ Wyo.	Gulf #1 Stockham Fed.	604-13,331	4,543	
468	sec. 34, T. 46 N., R. 94 W., C SE¼SW¼ Wyo.	Pan Am #1 Unit	1,007- 9,511	4,362	X
469	sec. 22, T. 46 N., R. 95 W., SW¼SE¼ Wyo.	Equity Oil #1 Winchester	525-11,934	4,687	
470	sec. 22, T. 46 N., R. 95 W., SE¼NW¼NW¼ Wyo.	Tenneco #1 Winchester	626-13,874	4,778	
471	sec. 27, T. 46 N., R. 96 W., NE¼NW¼SW¼ Wyo.	Phillips #1-A Mesa	42-14,459	5,440	X
472	sec. 30, T. 46 N., R. 96 W., NW¼SW¼ Wyo.	Oil Dev. Tex. #1 Blue Mesa	1,040-10,520	5,298	
477	sec. 31, T. 47 N., R. 90 W., NE¼NW¼NW¼ Wyo.	Lion #1 Fogarty	360- 9,459	4,807	
480	sec. 8, T. 47 N., R. 91 W., C NW¼SW¼ Wyo.	Pan Am #76 Unit	377-10,208	4,424	
488	sec. 22, T. 47 N., R. 91 W., NW¼SE¼ Wyo.	Elliott #1 Govt.	318- 9,783	4,534	
491	sec. 25, T. 47 N., R. 91 W., NW¼NW¼NW¼ Wyo.	Elliott #1-B	332- 9,487	4,695	
494	sec. 31, T. 47 N., R. 91 W., C SW¼NE¼ Wyo.	Phillips #8 Nowater Cr.	468-10,969	4,606	
496	sec. 33, T. 47 N., R. 91 W., SW¼SW¼ Wyo.	Tenneco #2 Schrantz - USA	468-10,396	4,543	
498	sec. 34, T. 47 N., R. 91 W., SW¼SW¼ Wyo.	Frio Drlg. #1-34 Fed.	495-10,100	4,518	
499	sec. 35, T. 47 N., R. 91 W., NW¼SW¼ Wyo.	Tenneco #1 USA - Brown	430- 9,589	4,475	
502	sec. 2, T. 47 N., R. 92 W., NW¼NW¼ Wyo.	Tenneco #1 Faure "A" - USA	464-11,234	4,553	

APPENDIX B. (continued)

Well ref. no. WO-11-	Location	Operator and well no.	Depth range (ft)	Elevation (ft) KB	AMSTRAT lithlog
505	sec. 10, T. 47 N., R. 92 W., SE¼NW¼ Wyo.	Union #45-E Worland Unit	472-10,398	4,232	
512	sec. 13, T. 47 N., R. 92 W., NW¼SW¼ Wyo.	Tenneco #2 Lacoy-Fed.	457-11,109	4,550	
514	sec. 16, T. 47 N., R. 92 W., NE¼NW¼ Wyo.	Tiger #1 Gorst	485-11,137	4,121	
515	sec. 24, T. 47 N., R. 92 W., NW¼SE¼SW¼ Wyo.	Mobil #37X-24 G	27-11,278	4,342	
519	sec. 32, T. 47 N., R. 92 W., SE¼SE¼NW¼ Wyo.	Gen. Pet. #44-32 P	532-10,977	4,167	
522	sec. 33, T. 47 N., R. 92 W., SE¼SE¼NW¼ Wyo.	Gen. Pet. #44-33 G	509-10,542	4,199 GL	
524	sec. 35, T. 47 N., R. 92 W., SE¼SE¼NW¼ Wyo.	Gen. Pet. #44-35 G	537-10,549	4,299	
527	sec. 5, T. 47 N., R. 93 W., NE¼SE¼ Wyo.	Cities Service #F-1 Govt.	360- 7,070	4,445	
528	sec. 28, T. 47 N., R. 93 W., SE¼NW¼ Wyo.	Gulf #1 Teeters	1,204-12,209	4,358	X
529	sec. 26, T. 47 N., R. 93 W., SE¼NW¼ Wyo.	Tiger #1 Holly Sugar	637-11,690	4,084	
530	sec. 35, T. 47 N., R. 94 W., SE¼NW¼ Wyo.	Gulf #1 Butler-Fed.	1,201-13,181	4,588	
531	sec. 33, T. 47 N., R. 95 W., W½NW¼NW¼ Wyo.	Anderson-Pritchard #1 Unit	1,265-14,770	4,665	X
532	sec. 28, T. 47 N., R. 96 W., SW¼NE¼SE¼ Wyo.	Pan Am #1 Gillies Draw	178-14,307	4,862	X
534	sec. 18, T. 48 N., R. 91 W., NW¼SW¼ Wyo.	Union Texas #1-18 USA	425- 9,716	4,357	
535	sec. 19, T. 48 N., R. 91 W., NW¼NW¼ Wyo.	Union Texas #1 USA	417-10,090	4,360	
537	sec. 30, T. 48 N., R. 91 W., NW¼NW¼ Wyo.	Union Texas #1-30 USA	415- 9,934	4,376	
541	sec. 12, T. 48 N., R. 92 W., NW¼SW¼ Wyo.	Mobil #80 Unit	388-10,302	4,464	X
542	sec. 16, T. 48 N., R. 92 W., SW¼NW¼SW¼ Wyo.	Pure #33-F-2	186- 7,964	3,979 GL	
545	sec. 18, T. 48 N., R. 92 W., NE¼NE¼NW¼ Wyo.	Pure #1 Worland Unit	625- 8,102	4,035 DF	
550	sec. 20, T. 48 N., R. 92 W., SW¼NW¼ Wyo.	Trigood #1 Tolman	1,023-10,275	3,990	
555	sec. 26, T. 48 N., R. 92 W., NW¼SW¼ Wyo.	Union Texas #1-26 Bradley	454-11,009	4,517	
560	sec. 28, T. 48 N., R. 92 W., NE¼SW¼ Wyo.	Pure #11 Worland Unit	126-10,190	4,039	
563	sec. 32, T. 48 N., R. 92 W., NE¼SE¼ Wyo.	Sharples #11 Holly Sugar	2,000-10,595	4,031	
566	sec. 1, T. 48 N., R. 92½ W., SW¼NE¼ Wyo.	Pure #38-F-2	861- 7,989	4,092	
570	sec. 6, T. 48 N., R. 93 W., NW¼NE¼ Wyo.	Union #1 Five Mile Unit	454-10,375	4,404	
571	sec. 14, T. 48 N., R. 93 W., NE¼NE¼ Wyo.	Clayton #1 Hurd-Fed.	294- 8,767	4,278	
578	sec. 5, T. 49 N., R. 92 W., SE¼NW¼ Wyo.	Universal Resources #1-5 Hocker	310-6,150	3,993	
581	sec. 31, T. 46 N., R. 89 W., SW¼SW¼NE¼ Wyo.	McDermott #1 Govt.	78- 8,137	4,708	
583	sec. 28, T. 49 N., R. 92 W., SE¼SW¼ Wyo.	Davis #1 Vigil	317-10,617	3,967	
584	sec. 34, T. 51 N., R. 94 W., SE¼NW¼ Wyo.	Farmers Union #1 Jones Res.	601- 8,390	4,181	
585	sec. 4, T. 49 N., R. 94 W., SW¼SE¼NW¼ Wyo.	Anadarako #1-A Red Butte Fed.	599-10 ,921	4,632	

APPENDIX B. (continued)

Well ref. no. WO-11-	Location	Operator and well no.	Depth range (ft)	Elevation (ft) KB	AMSTRAT lithlog
589	sec. 28, T. 49 N., R. 93 W., NW¼NW¼SW¼ Wyo.	Union #39F Worland Unit	306- 9,283	4,188	
590	sec. 29, T. 49 N., R. 93 W., NE¼NE¼ Wyo.	Husky #1 Torgeson	312-10,128	4,226 GL	X
591	sec. 35, T. 49 N., R. 93 W., NE¼SW¼ Wyo.	Pure #34-T	2,900-11,251	4,209	
592	sec. 12, T. 49 N., R. 94 W., SE¼NW¼SW¼ Wyo.	Husky #1 Govt.	189- 12,771	4,358	
593	sec. 16, T. 49 N., R. 99 W., SE¼SW¼ Wyo.	Wilshire #1 Meeteetse	24-11,447	5,968 GL	
608	sec. 12, T. 50 N., R. 93 W., SE¼NW¼ Wyo.	Kimbark F-22-12	290- 9,345	4,214	
614	sec. 15, T. 50 N., R. 93 W., NE¼SE¼ Wyo.	Tenneco #1 Mockler	510- 9,149	3,943	
617	sec. 25, T. 50 N., R. 93 W., NE¼NE¼ Wyo.	Stanolind #1 Sykes-Mobley	423- 6,794	3,901	X
618	sec. 17, T. 50 N., R. 95 W., SE¼SE¼ Wyo.	Davis #1 Fed. Elk Creek	308-10,496	4,505	X
619	sec. 18, T. 50 N., R. 99 W., SW¼NW¼NW¼ Wyo.	Sohio #1 Boyle	298- 7,456	5,649	X
620	sec. 13, T. 50 N., R. 100 W., NW¼NW¼SE¼ Wyo.	Sohio #1 Govt. Simmons	90- 9,144	5,723	
624	sec. 27, T. 52 N., R. 94 W., NW¼NE¼SE¼ Wyo.	Trigood #1 Govt.	86-12,169	4,057	
625	sec. 13, T. 52 N., R. 94 W., SW¼SW¼ Wyo.	Gulf #1 Emmett	0-11,761	4,074	
626	sec. 22, T. 52 N., R. 94 W., SW¼SW¼SW¼ Wyo.	Trigood #2 Govt.	368-10,554	4,174	
627	sec. 23, T. 52 N., R. 94 W., NE¼SE¼ Wyo.	A. G. Hill #1 Govt.	622-10,122	4,018	
628	sec. 26, T. 52 N., R. 95 W., SE¼SE¼ Wyo.	Gulf Oil #1 NE Otto Fed.	1,446-12,544	4,002	
630	sec. 1, T. 53 N., R. 96 W., SW¼SE¼NE¼ Wyo.	Sinclair #1 Govt.	596-13,285	4,474 GL	
631	sec. 22, T. 53 N., R. 96 W., SW¼NW¼ Wyo.	Anadarko #2 Bridger Butte	623-10,623	4,482	
632	sec. 32, T. 53 N., R. 96 W., SE¼SE¼ Wyo.	Anadarko #1 Beard 44-32	617-10,625	4,465	
633	sec. 15, T. 53 N., R. 100 W., SE¼SW¼ Wyo.	Jerry Chambers #1-15 Fed.	1,223-13,264	5,342	
634	sec. 6, T. 54 N., R. 96 W., NW¼NE¼ Wyo.	Mule Creek #1-316	360- 7,227	4,370	
635	sec. 8, T. 54 N., R. 96 W., NW¼NW¼ Wyo.	Anadarko #A-1 Foster Gulch Fed.	548- 6,379	4,395	
636	sec. 1 , T. 54 N., R. 96 W., NW¼SW¼NW¼ Wyo.	Webb Resources #13-6 Fed.	330-10,132	4,616	
637	sec. 16, T. 54 N., R. 96 W., SW¼NW¼ Wyo.	Kewanee #1 Gulch	996-12,374	4,599 GL	X
638	sec. 30, T. 54 N., R. 96 W., SW¼SE¼ Wyo.	Anadarko #3 Bridger Butte	591-11,396	4,494	
639	sec. 16, T. 54 N., R. 97 W., NW¼SW¼NE¼ Wyo.	Anadarko #1 Bridger Butte	623-10,109	4,311	
640	sec. 1, T. 54 N., R. 98 W., NW¼SW¼ Wyo.	Conoco #1 Farwell	366-10,594	4,314	X
641	sec. 17, T. 54 N., R. 99 W., NE¼NW¼ Wyo.	Miami Oil #509-1 Fed.	493- 8,598	4,494	X
642	sec. 26, T. 54 N., R. 99 W., NW¼NE¼ Wyo.	Gulf #1 Red Point Fed.	604-10,503	4,587	X
643	sec. 21, T. 54 N., R. 100 W., NE¼SW¼ Wyo.	Atlantic #1 Govt.	522- 9,899	4,807	X
649	sec. 8, T. 55 N., R. 100 W., SE¼NE¼ Wyo.	Stanolind #1 Unit	125-13,107	4,751 GL	

APPENDIX B. (continued)

Well ref. no. WO-11-	Location	Operator and well no.	Depth range (ft)	Elevation (ft) KB	AMSTRAT lithlog
651	sec. 1, T. 56 N., R. 99 W., NW¼NE¼NE¼ Wyo.	Amoco #1 USA Chandler	309- 4,383	4,410	
653	sec. 1, T. 56 N., R. 100 W., SE¼NE¼ Wyo.	Mt. States #1 Manning	220- 6,122	5,006	
654	sec. 8, T. 56 N., R. 100 W., NE¼SE¼ Wyo.	Chorney #1 Sand Coulee	623-10,347	4,511	X
656	sec. 13, T. 56 N., R. 100 W., NE¼NW¼ Wyo.	Mobil #F-21-13 P Taggart	505-10,122	5,074	X
658	sec. 25, T. 56 N., R. 100 W., SE¼NW¼ Wyo.	Kewanee #1-A Clarke	475- 8,813	5,132	
659	sec. 15, T. 56 N., R. 101 W., NW¼SW¼ Wyo.	Sun #3 Govt. Ralston	862-12,818	4,512	
660	sec. 16, T. 56 N., R. 101 W., SE¼NW¼ Wyo.	Sun #2 State	1,037-12,779	4,468	X
661	sec. 16, T. 56 N., R. 101 W., NE¼NW¼ Wyo.	Sun Oil #1 State	20-13,201	4,432	
662	sec. 17, T. 56 N., R. 102 W., NW¼SE¼ Wyo.	North Nat. Gas #1 State	560-10,878	4,474	X
663	sec. 31, T. 56 N., R. 99 W., NW¼SE¼ Wyo.	North. Nat. Gas #1-22 FEE	566- 8,241	5,096	
664	sec. 31, T. 56 N., R. 99 W., SE¼NW¼ Wyo.	Mull Drlg. #1 State	330- 8,370	4,591	X
670	sec. 17, T. 57 N., R. 99 W., SW¼SE¼SW¼ Wyo.	Conoco #13 NP	0- 7,196	4,881	
672	sec. 23, T. 57 N., R. 99 W., SW¼NW¼ Wyo.	Pan Am #1 NP	412- 8,559	4,899	
679	sec. 10, T. 57 N. R. 100 W., SW¼SE¼ Wyo.	Phillips #1 Silver	545- 9,850	4,656	
680	sec. 11, T. 57 N., R. 100 W., W½NW¼NE¼ Wyo.	Mobil #31-11 NP	508- 9,161	4,868	
681	sec. 21, T. 57 N., R. 100 W., NW¼NE¼ Wyo.	Texaco #1 NP	521-10,285	4,450	X
682	sec. 6, T. 57 N., R. 101 W., NW¼NE¼SW¼ Wyo.	Tyler #1 Badura	329- 8,250	4,145	
690	sec. 16, T. 57 N., R. 101 W., SW¼SW¼ Wyo.	Resolute #2 State	615-10,106	4,291	
691	sec. 17, T. 57 N., R. 101 W., SE¼SW¼ Wyo.	Resolute Oil #13	396- 8,566	4,237 GL	
693	sec. 17, T. 57 N., R. 101 W., NE¼NE¼ Wyo.	Williston #4-A NP	384- 8,550	4,231 GL	
701	sec. 33, T. 58 N., R. 100 W., SE¼NW¼NW¼ Wyo.	Seaboard #22-33 NP	275- 6,350	4,519	
707	sec. 34, T. 58 N., R. 100 W., NW¼SW¼NW¼ Wyo.	Conoco #1 Hall-Goodstein	0- 9,120	5,602	
708	sec. 23, T. 58 N., R. 102 W., NW¼NW¼NE¼ Wyo.	Stanolind #1 NPA	150-10,280	4,538	
710	sec. 23, T. 58 N., R. 102 W., NE¼NW¼ Wyo.	Gas Prod. Ent. #1 Burl. No.	902-13,586	4,729	
711	sec. 25, T. 58 N., R. 103 W., NE¼SW¼ Wyo.	Carter #1 Line Ditch	414-11,327	5,369	X
714	sec. 21, T. 48 N., R. 98 W., SE¼SW¼ Wyo.	Am. Quasar #1 Sellers Draw	200-19,631	5,840 GL	
715	sec. 14, T. 47 N., R. 93 W., SE¼SE¼ Wyo.	Tenneco #1 Crooked Draw	619-12,704	4,236	
716	sec. 28, T. 47 N., R. 91 W., NW¼SW¼ Wyo.	Tenneco #2 USA Tolmer	0-10,482	4,425	
717	sec. 23, T. 47 N., R. 91 W., SE¼SE¼NE¼ Wyo.	Pan Am #90	0- 9,459	4,823	
718	sec. 14, T. 46 N., R. 92 W., SE¼NE¼ Wyo.	Huber #1 Nowater B	0-10,929	4,463	
719	sec. 22, T. 46 N., R. 91 W., SW¼NW¼ Wyo.	Huber #1 Fed. Apostolos	0-10,044	4,558	

APPENDIX B. (continued)

Well ref. no. WO-11-	Location	Operator and well no.	Depth range (ft)	Elevation (ft) KB	AMSTRAT Lithlog
723	sec. 12, T. 45 N., R. 97 W., NW¼SE¼SW¼ Wyo.	Phillips #1 Unit	0- 6,248	5,029	
724	sec. 15, T. 53 N., R. 100 W., SE¼NE¼NW¼ Wyo.	Midwest #1 USA	993- 9,635	5,207	
727	sec. 28, T. 49 N., R. 99 W., C SE¼NW¼ Wyo.	Trigood #1 Govt.	103-11,469	5,951	
728	sec. 3, T. 55 N., R. 99 W., NE¼SE¼ Wyo.	Tidewater #1 Atteberry	1,004-13,095	4,387	X
729	sec. 15, T. 52 N., R. 98 W., NE¼NE¼ Wyo.	Mich.-Wis. #1-10 Gilmore Hill	1,532-14,184	4,968	
732	sec. 19, T. 57 N., R. 100 W., NE¼SW¼ Wyo.	Kewanee #1 Burlington	485- 8,065	4,223	
733	sec. 8, T. 56 N., R. 101 W., SE¼NE¼SE¼ Wyo.	Anderson #1 Ogle-Fed.	503-12,834	4,436	
734	sec. 10, T. 54 N., R. 100 W., NW¼SE¼ Wyo.	C I G Exp. #1 McCulloch Peak	2,492-15,266	4,977	
738	sec. 14, T. 58 N., R. 102 W., SW¼SW¼ Wyo.	C I G Exp. #14-58-102 US	950-11,684	4,816	
740	sec. 27, T. 45 N., R. 95 W., NE¼NE¼SW¼ Wyo.	Conoco #1 Boulder Gulch	501-11,592	4,615	
747	sec. 16, T. 57 N., R. 100 W., NE¼SW¼ Wyo.	True Oil #23 Champlin State	512- 9,353	4,420	
749	sec. 28, T. 57 N., R. 100 W., SE¼NW¼ Wyo.	True #22-28 McMoran Fed.	518- 8,604	4,366	
751	sec. 27, T. 9 S., R. 20 E., NW¼SW¼ Mont.	Shell #13X-27 Unit	580-10,512	6,432	
755	sec. 20, T. 47 N., R. 91 W., E½NW¼SE¼ Wyo.	Pan Am #1 Hawks	0-10,420	4,392	X
756	sec. 33, T. 58 N., R. 100 W., C NW¼SE¼ Wyo.	Texaco #55-33 Silver Tip	0-11,630	4,530	X
757	sec. 32, T. 57 N., R. 99 W., SE¼NE¼SW¼ Wyo.	Conoco #27 Unit	0- 8,400	4,988	X
758	sec. 22, T. 58 N., R. 99 W., NE¼NW¼ Wyo.	Royal Res. #22-1 Lewis Estate	510- 8,388	4,861	X