A URANIUM ANOMALY IN THE SILVER BELL PROSPECT, SWEETWATER COUNTY, WYOMING

by

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STATEMENT BY AUTHOR

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ABSTRACT

The Silver Bell prospect is in the Great Divide Basin, Sweetwater and Fremont Counties, Wyoming, where sedimentary rocks of Tertiary age make up the stratigraphic column. The principal rocks in the local area are sedimentary beds of Eocene age plus some of Miocene age; the principal formation is the Battle Spring Formation of Eocene age.

An evaluation of the prospect was made during the summer 1968 with an intense drilling program and electric logging, coring and logging and analysis of sample cuttings.

The exploration program was based on the assumption that any potential ore bodies would either be formed by association with geologic structures or by a roll-front type deposition. Data from operating mines in similar basin environments in Wyoming was obtained and seem to verify this assumption.

The mineralization occurrences follow the roll-front theory, which best explain the mineralization of orebodies in similar geological environments. Chemical assays, and electrical logging at the Silver Bell prospect indicate that the material is out of equilibrium with a deficiency of gamma radioactivity. This indicates the possible former presence of an orebody that was leached by ground waters, leaving only beta and alpha radiation. Consequently, it was not considered possible to find a mineable ore deposit in the area investigated.

CHAPTER 1

INTRODUCTION

Scope of Investigation and Field Techniques

Field work and interpretation of data collected was directed toward the determination of the distribution of uranium and the possible economic value of the uranium concentrations within 923 claims of Silver Bell Mines Company, Denver, Colorado. Silver Bell Mines arrived at an agreement with W. R. Grace & Company such that the latter company had to do 90% of the assessment work on the claims owned by the former company. Field work was carried out by the writer on behalf of W. R. Grace & Company from May 11, 1968 until August 19, 1968.

An airborne radiation anomaly reported by the United State Geological Survey was studied and was further investigated with a scintillator to produce an isorad map.

A drilling program was planned in such a way that it entailed drilling along east to west lines on mile centers across the upper, middle, and lower portions of the claims. A few additional holes were located in the southernmost claims to check control of mineral concentrations along faults. Depths of the drill holes generally ranged from 1,000 feet to 2,100 feet, however several shallow holes were also drilled.

Gamma ray, self potential and resistivity surveys were made to investigate the radioactivity and to aid in the study of stratigraphy.

Investigations consisted of:

1. Drilling, logging, and sampling of cuttings.
2. Electric logging.
3. Coring.
4. Radiometric surveying.
5. Field checking of claim locations.
6. Geologic mapping.

Location and Access

The Silver Bell prospect is in the Great Divide Basin, an oval-shaped undrained topographic depression on the continental divide embracing about 4,000 square miles in Sweetwater, Carbon and Fremont Counties in south central Wyoming (see Figure 1).

The exact location of the Silver Bell prospect is in T26 and 27N, R 93 and 94 W., Fremont and Sweetwater counties, Wyoming. The claim area is roughly 50 road miles northwest of the town of Rawlins, Wyoming. Geologic features of adjacent and related areas are discussed in the following pages insofar as they affect the geologic interpretation of the studied area.

The prospect may be reached by traveling north from Wamsutter, Wyoming, which is 40 miles west of Rawlins on U. S. Highway 30 and on the main line of the Union Pacific railroad. The road is graded in part and is in part unimproved. Other unimproved roads connect this area with the towns of Bairoil and Lamont and with U. S. Highway 287 to the east; with Crooks Gap and U. S. Highway 287 to the north; with State Route 28 to the west, and with U. S. Highway 30 and Rock Springs to the southwest.

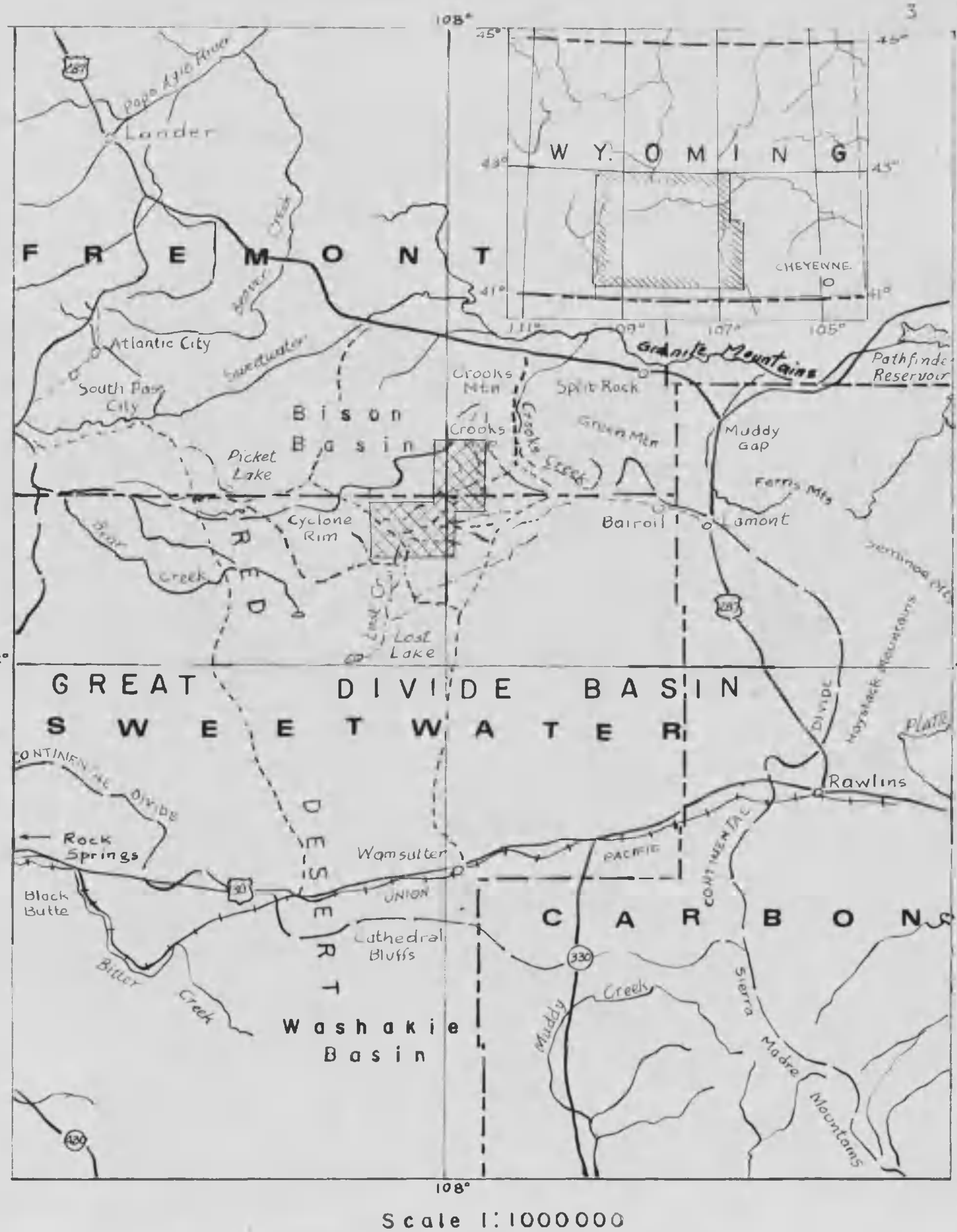
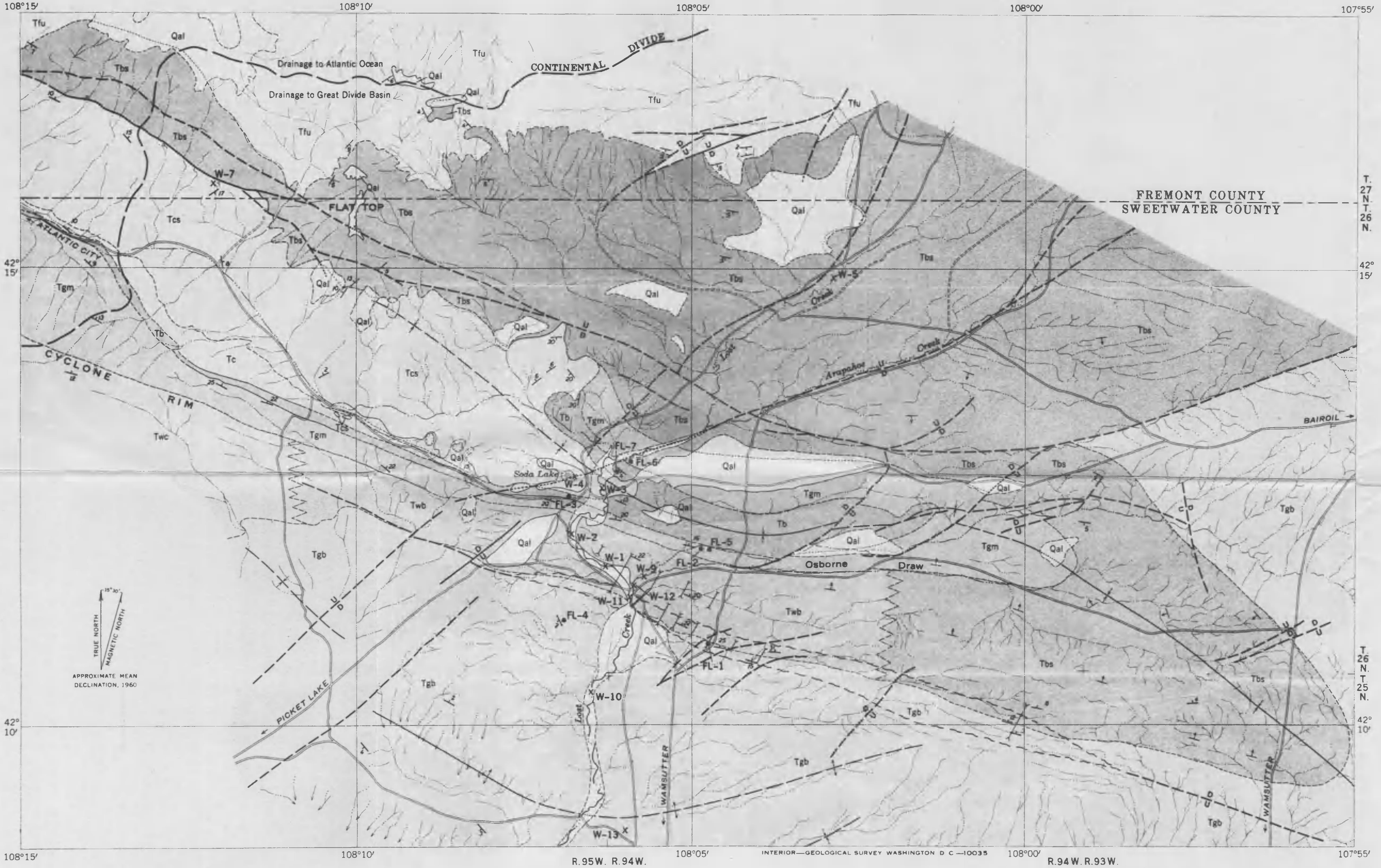


Figure 1. Index Map Showing Area of Prospection

FIGURE 2



EXPLANATION

QUATERNARY

Pleistocene(?) and Recent

Qal — Alluvium, colluvium, and terrace deposits

UNCONFORMITY

TERTIARY

Miocene

Tcs — Conglomerate, sandstone, marl, clay, and volcanic ash

UNCONFORMITY

Oligocene(?)

Tc — Conglomerate

UNCONFORMITY

Eocene

Tb — Bridger formation

Tgm, Twb, Twc, Tbs, Tgb — Green River, Wasatch, and Battle Spring formations

Morrow Creek member of Green River formation, Tgm; *Cathedral Bluffs tongue of Wasatch formation,* Twc; *Battle Spring formation and Cathedral Bluffs tongue of Wasatch formation, undifferentiated,* Twb; *Battle Spring formation,* Tbs; *Tipton tongue of Green River formation and Battle Spring formation, undifferentiated,* Tgb

UNCONFORMITY

Paleocene

Tfu — Fort Union formation

Contact
Dashed where inferred, dotted where concealed

Fault
Dashed where inferred, dotted where concealed. U, *upthrown side;* D, *downthrown side*

Approximate limits of Cyclone Rim zone of faulting

Anticline
Showing trace of axial plane, dashed where inferred, dotted where concealed

Syncline
Showing trace of axial plane, dashed where inferred, dotted where concealed

Strike and dip of beds

Strike and dip of beds
Determined from aerial photographs

Exploratory trench

FL-2 Fossil locality

W-2 Water sample

Dry lake depression

Map compiled by C. H. Maxwell, partly by photointerpretation and partly from field data collected by D. M. Sheridan, C. H. Maxwell, and J. T. Collier, 1952, and G. N. Pipiringos and H. Masursky 1951–52

AREAL GEOLOGY OF THE LOST CREEK AREA, SWEETWATER AND FREMONT COUNTIES, WYOMING

Scale 1:63 360

1 0 1 2 3 Miles

August 20, 1968

FELIPE MONZON

Previous Work

The Great Divide Basin has been studied continuously since 1909. The Great Divide Basin was mapped in reconnaissance and the main coal-bearing by Smith, Ball, and Schultz in 1909. Schultz in 1920 later completed a more comprehensive report in which he defined and described several aspects of the stratigraphy. Sears in 1924, and Bradley in 1924, 1926, 1945, Nightingale in 1930, and Nace in 1939 have yielded much information concerning the complex stratigraphic relations of the early tertiary rocks of this region (Pipiringos, 1961).

Uranium was first discovered in the north-central part of the Great Divide Basin by Minnie McCormick in 1936(?), who found a yellow green mineral, later identified as schroeckingerite, in the east bank of Lost Creek in the NW1/4 sec 31, T. 26 N., R. 94 W. Radioactive carbonaceous shale and coal were discovered in 1945 by Slaughter and Nelson (Masurky, 1962) at Sourdough Butte. Reconnaissance mapping during parts of 1949 and 1950 by Wyant and Sharp, and Sheridan in 1956 (Pipiringos, 1961) indicated that very large tonnages of uranium-bearing coal underlie parts of the Great Divide Basin. An airborne radio-activity reconnaissance was made by Nelson, Sharp, and Estead in 1951 (Pipiringos, 1961).

Topography and Drainage

The Great Divide Basin constitutes a major physiographic feature of southwestern Wyoming. The Continental Divide splits at the southeast end of the Wind River Range; the north branch trends eastward toward the Seminoe Mountains, then irregularly southward to near Rawlins; the south branch extends southward toward Superior, then eastward along the

Cathedral Bluffs south of Wamsutter, the branches converge again at the north end of the Sierra Madre Mountains (Sheridan, Maxwell, and Collier, 1961). The basin interior drainage enclosed by the above mentioned divergence of the Continental Divide is 3,600 square miles in area; it is not a single topographic depression but includes a number of drainage basins with alkali lakes and playas.

The region comprising the Great Divide Basin is a land of low relief with altitudes ranging between 6,000 and 7,000 feet above sea level. It is broken only by small rounded hills and low buttes.

The principal topographic feature of the Lost Creek area (Sheridan, Maxwell and Collier, 1961, p. 35) in which the prospect occurs is the dissected hogback of Cyclone Rim which lies to the north and west of the schroeckingerite locality. Lost Creek has its source near Crooks Mountain and drains southward into Lost Lake. The creek is seasonally intermittent over most of its course, and the lake is dry except in flood season.

Climate and Vegetation

The area studied is semiarid and semiboreal. The average annual precipitation is equivalent to less than 10 inches. The winters are cold and the summers are warm. The temperature rarely exceeds 90°F in the summer, but temperatures below 0°F are common in the winter. Low humidity and continual breezes result in little discomfort from the heat even in the warmest part of the summer, and there is little interruption of field work in the early winter months, inasmuch as snow in October, November and December is rapidly blown away, melted and evaporated, or sublimated.

The vegetation is sparse and consist of low-growing shrubs of greasewood, saltbrush, sagebrush, and some desert and prairie grasses and herbs. No trees grow in the area, except at some of the railroad stations and locally along the periphery of the basin. Sagebrush is an indicator of deep soils largely free from alkali. The region is primarily used for sheep-grazing.

CHAPTER 2

GEOLOGY

General Geology

Sedimentary rocks of Tertiary age make up most of the exposed bedrock of the Great Divide Basin. Rocks of Eocene age predominant with less abundant rocks of Paleocene, Oligocene, and Miocene age. To the east, the Tertiary rocks are bordered by exposures of Cretaceous sedimentary rocks along the Ferris Mountains and Muddy Gap area, along the Rawlins uplift north of Rawlins, and along the Sierra Madre. Tertiary sedimentary rocks extend southward from the Great Divide Basin and through the Washakie Basin to the Uinta Mountains in Colorado and Utah, where rocks of Precambriam, Paleozoic, Mesozoic, and Cenozoic age are exposed. To the west, the area of Tertiary sedimentary rocks extends nearly to the western border of Wyoming. Its continuity is broken by the Rock Springs anticline and the Leucite Hills, where Cretaceous sedimentary rocks and Tertiary intrusive and extrusive rocks are exposed. To the northwest, Precambrian granitic rocks occupying the core of the Wind River Range border the Great Divide Basin. The Tertiary sedimentary rocks of the Great Divide Basin consist predominantly of lacustrine and fluviatile sandstone, siltstone, claystone, and shale. Coal beds and volcanic effusive material are also found in parts of the Tertiary section.

Quaternary deposits consisting of fluviatile, lacustrine, alluvial, colluvial, and eolian material are widespread in the Great Divide Basin, and in many areas obscures the earlier geologic record.

No single structural feature, interrupts the Great Divide Basin, rather, it is a region of relatively minor disturbance (see Figure 2).*

Local Geology

The principal rocks in the area studied are sedimentary beds of Eocene age, plus some beds of Miocene age which rest unconformably on the Eocene rocks. Rocks of Paleocene age are exposed in the northern part of the area along the northern branch of the Continental Divide, and consist, predominantly of interbedded buff to gray massive coarse to fine-grained sandstone, buff and gray shale, and siltstone. These Paleocene rocks are known as the Fort Union Formation. The formation is 1,000 feet thick in Bison Basin north of the area studied.

The Eocene rocks in the Great Divide Basin include the Battle Spring, Wasatch, Green River, and Bridger formations, totalling about 4,200 feet in thickness, and consisting of sandstone, siltstone, oil shale, clay shale, limestone, conglomerate and coal beds.

In the Silver Bell prospect area, representatives of the Eocene units are, in stratigraphic sequence from oldest to youngest: the Battle Spring formation, the Tipton tongue, of the Green River formation, the Cathedral Bluffs tongue of the Wasatch formation, the Morrow Creek member and Laney shale member of the Green River formation, and the Bridger formation.

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*Figures 2, and 7-18 are in pocket.

To the west of the area studied a series of boulder conglomerate beds of Oligocene age separated by unconformities from the Bridger formation below and from the Miocene rocks above. Above the Oligocene rocks is a lenticular series of conglomerate and coarse-grained sandstone beds ranging in thickness from 0 to 100 feet this is followed by a sequence of tuffaceous sedimentary rocks ranging in thickness from about 40 feet, east of Lost Creek to a probable maximum of about 400 feet, west of Lost Creek. This sequence of rocks is of Miocene age.

Quaternary deposits consisting of fluviatile, lacustrine, colluvial, and eolian sediments overlie much of the Tertiary bedrock.

During Pleistocene and Recent time a number of extensive terraces, both depositional and erosional, were formed. Remmants of these deposits are still discernibles over most of the Great Divide Basin. In some parts of the basin the sites of Pleistocene lakes are indicated by broad shallow depressions.

The major structural features of the area constitute a northwestward trending syncline, a northwesternly set of faults, and a northeasterly set of faults (see Figure 2).

Stratigraphy

Sedimentary rocks exposed in the Silver Bell prospect area comprise a fluviatile and lacustrine sequence that ranges in age from Paleocene to Miocene and has an aggregate thickness of about 5,200 feet. A mantle of alluvium, colluvium, and stream terrace material of Quaternary age covers most of the area.

The sequence of Tertiary sedimentary rocks may be divided into six formations. The oldest is the Fort Union formation of Paleocene age, which is about 1,100 feet thick in the western part of the Great Divide Basin and about 1,000 feet thick in the northern part (Shawe, 1956). Unconformably overlying the Fort Union formation is an intertonguing sequence assigned to the Wasatch, Green River, and Battle Spring formations of Eocene age. Boulder and pebble conglomerates of Oligocene age, and conglomerate and tuffaceous sandstone of Miocene age overlie the Eocene formations.

Older sedimentary rocks that range in age from Pennsylvanian to Late Cretaceous are exposed on the western, northern, and eastern margins of the Great Divide Basin. They probably underlie the Lost Creek area at depth (Sheridan et al., 1961 and Figure 3).

The Fort Union formation is about 1,000 feet thick in Bison Basin north of the mapped area, the upper 50 feet is exposed in the Lost Creek area. The formation crops out in the northern part of the area along the northern branch of the Continental Divide. It consists predominantly of interbedded buff to gray, massive, coarse to fine grained sandstone; buff and gray shale, and siltstone.

Eocene rocks in the Great Divide Basin include the Battle Spring, Wasatch, Green River and Bridger formations. They total about 4,200 feet in thickness, and consist of sandstone, siltstone, oil shale, clay shale, limestone, conglomerate, and coal beds. Eight stratigraphic units have been recognized in the sequence underlying the Bridger formation (Pipiringos, 1955, p 100-103; 1956, p 434-435). Three are made up predominantly of claystone, siltstone, and sandstone with subordinate

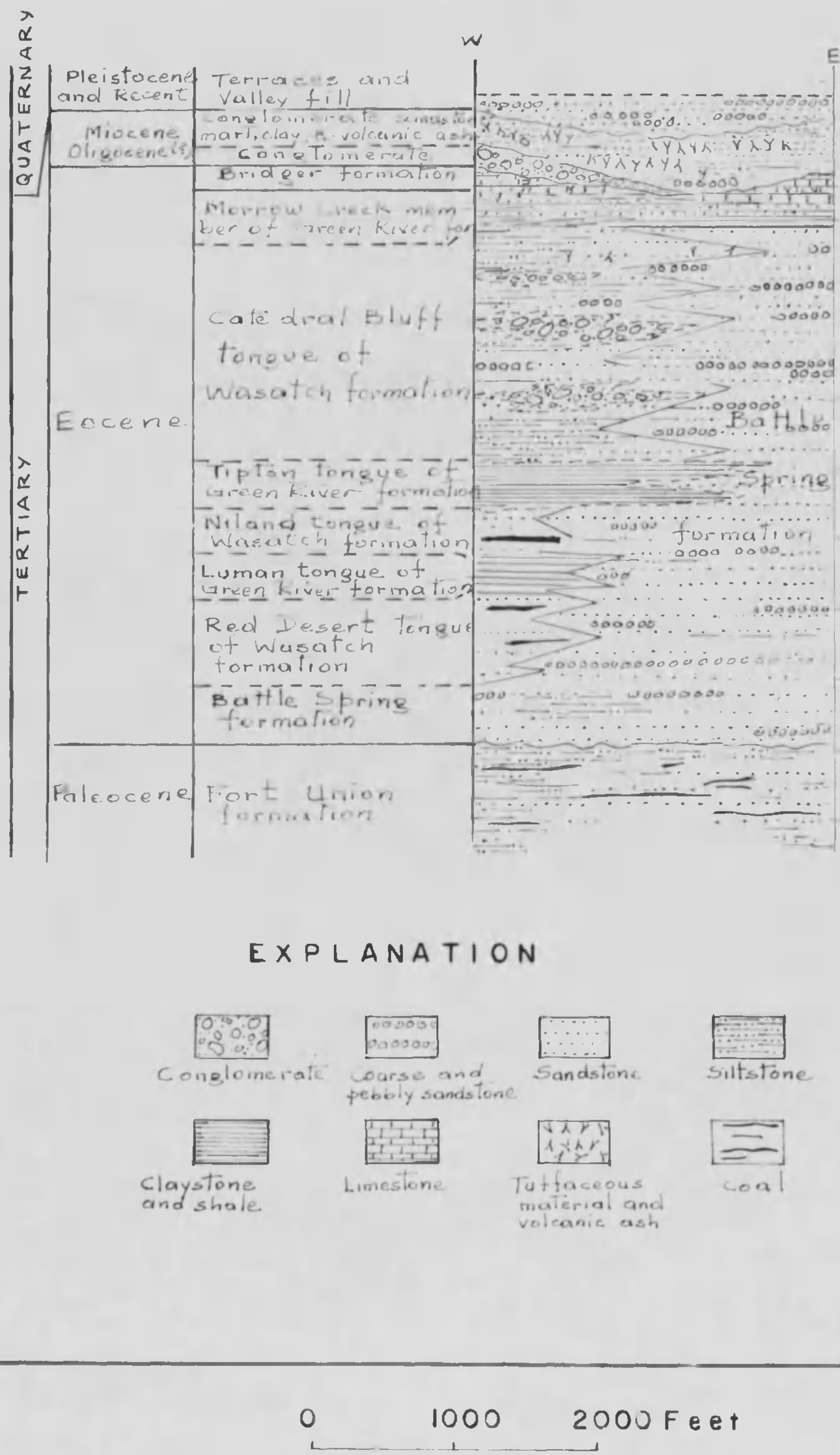

Figure 3. Stratigraphic Column

amounts of shale and coal; from oldest to youngest, they are the Red Desert, Niland, and Cathedral bluffs tongues of the Wasatch formation. Grading into and intertonguing with these are four units consisting predominantly of paper shale with subordinate amounts of sandstone, siltstone, and limestone. From oldest to youngest, they are the Luman and Tipton tongues, and the Laney shale and Morrow Creek members of the Green River formation. These units grade laterally into and intertongue with the coarse arkosic sandstone of the Battle Spring formation (Pipiringos, 1955, p 101 - see Figure 3).

A formation which is believed by some geologists to be either late Eocene or Oligocene age, or both (U.S.G.S. Bul 1099-A), is the Browns Park formation which unconformably overlies the Bridger formation. It is a conglomerate generally ranging from about 10 to 20 feet in thickness, with constituents locally as large as boulder size. The conglomerate intertongues with an interbedded sequence of very coarse-grained sandstone and fine-grained tuffaceous sandstone. These units are lenticular, but together they are at least 110 feet thick and locally may be as much as 220 feet thick (U.S.G.S. Bul 1099-A). They can be traced from the extreme northwest corner of the area to a point south of Soda Lake in the NE1/4SW1/4 sec 24. T 26 N., R. 95 W. . . East of this point the conglomerate and coarse-grained sandstone beds are absent and the overlying homogeneous sequence beds are fine-grained tuffaceous rocks resting directly on the Bridger formation.

The Browns Park formation is important because it is the most probable source of the uranium mineralization in the coal beds and in the shroeckingerite deposits of this area, (Pipiringos, 1961).

The stratigraphy encountered in drilling on the Silver Bell property is basically that of the Battle Spring formation. In the southern part of the claims, south of the major east-west normal fault (see Figure 2), the Battle Springs formation is overlain and intertongued with the Wasatch and Green River formations. Drill information shows that the beds in section 23, T.26 N. R 94 W., south of the normal fault, strike about N 45° W and dip about 4° to the southwest.

Geologic cross sections showing formational contacts are shown in Figures 12 to 18. The following interpretation was based on electric log interpretation and a geologic log of drill hole cuttings.

1. <u>Upper Battle Springs Formation</u>. Mainly clay with some clayey sand, moderate gamma radioactivity 50 to 100 C.P.S. (counts per second).
2. <u>Middle Battle Springs Formations</u>. Mainly clayey sand with moderate gamma radioactivity 50 to 100 C.P.S.
3. <u>Lower Battle Spring Formation</u>. Clay, clayey sands, sand, carbonaceous material, and some coal. In the upper part of this section, erratic high gamma radioactivity 50 to 400 C.P.S. is due to uraniferous carbon material.
4. <u>Fort Union Formation</u>. Clay, clayey sand, sand, and carbonaceous material, very low gamma radioactivity.

In summary, the pre-Bridger Eocene rocks of this area may be thought of as products of three environments. The Green River formation is of lacustrine origin. It interfringes with the Wasatch formation of fluviatile origin. The Battle Spring formation of delta-fluviatile origin interfringes with the Wasatch and Green River formations. In general, the Laney shale member of the Green River formation thins northeastward, whereas the Tipton and Luman tongues of the Green River formation, the Niland and Red Desert tongues of the Wasatch, and the Battle Spring formation thin southwestward.

Structural Geology

The Great Divide Basin is a region of relatively minor structural elements. It may be a part of the Washakie Basin to the south. Structural uplifts forming the other boundaries of the basin are: the Rock Springs anticline to the west, the Wind River uplift to the northwest, the Sweetwater uplift to the north and northeast, and the Rawlins uplift to the east. Northeast-trending normal faults are common at the western edge of the basin along the flank of the Rock Springs uplift. Along the east side of the basin, faults are associated with the Rawlins uplift. Many faults occur along the north side of the basin around the nose of the Wind River Range and along the Green Mountains-Crooks Mountain area. The major part of the basin south of the Lost Creek area is characterized by gentle folds and a minor faulting, whereas the northern part of the basin is characterized by more complex folding and faulting. These faults are probably structurally related to the Continental fault mapped by Nace (1939), to the northwest of the Lost Creek area.

The main structural feature across the central part of the Silver Bell Prospect area is a broad eastward-plunging arch with a poorly defined axis that trends about N 70° E. Several subsidiary folds are superimposed on the crest of the main arch as shallow anticlines and synclines with diverse axial trends. Folding of the synclines probably began in Late Cretaceous time and continued during deposition of lower Eocene rocks (see Figure 2).

The exposed formations are cut by many normal faults that can be traced for several miles. Most of the faults trend northeastward; a few, however, trend northwestward at about right angles to the first set of faults. A normal fault with a displacement of about 3,000 feet, downthrown on the south, can be traced in T.26 N., Rs. 94 and 95 W. Structures trending northwestward appear to be older than those trending northeastward.

Major structures mapped by the United States Geological Survey are shown on Figure 2. The East Antelope Anticline is a dominant feature in the northern part of the claims and a major syncline is a dominant feature in the southernmost claims. The major east-west normal fault with 3,000 feet displacement is shown in secs. 22, 23, and 24, T.26 N., R 94 W. Grace Company's drilling indicates major movement along this fault, but insufficient data were obtained to determine the true amount of displacement (see Figures 7 and 16).

CHAPTER 3

ECONOMIC GEOLOGY

Roll-Front Theory - Geochemical Cell

For many years (Shawe and Granger, 1965), it has been known that uranium and vanadium deposits in sedimentary rocks occur locally in the form of rolls curved ore layers which are not concordant with the enclosing strata but assume discordant C-shaped or S-shaped cross sections. Within the last 15 years the roll has been recognized as the dominant form of many uranium deposits in sandstone.

In the illustration of the Roll-Front Theory we might consider the deposits: Rifle Deposit, Colorado; Uravan Mineral Belt, Colorado; and the Tertiary Basin Deposits of Wyoming (Shirley Basin, Gas Hill, Crooks Gap, etc.).

Two distinct types of uranium deposits that commonly occur in the form of rolls are recognized: (1) a type common on the Colorado Plateau, and (2) a type best exemplified in the Tertiary Basins of Wyoming, each with its associated altered rocks (Shawe and Granger, 1965). In Colorado Plateau, mudstone that contains iron predominantly in the reduced form and sandstone that contains pyrite are conventionally referred to as being altered. Such reduced sandstone may be of either diagenetic or epigenetic origin. Rolls of Tertiary Basins of Wyoming form the boundary between altered and unaltered sandstone. Altered sandstone is typically greenish and pyrite free, whereas unaltered sandstone is pyrite bearing.

Details of the form and habitat of roll orebodies, regardless of locality, are compatible with a theory that rolls were deposited at an interface between two environments of different chemical and physical properties. Both Eh and pH differences were among the chemical differences that were likely at the interface marked by the roll. The degree of difference on opposite sides of the interface probably varied considerably from district to district. This assumption is suggested when we note:

a. That in the Shirley Basin altered sandstone (Harshman, E. N. 1962) on the concave side of rolls is greenish suggesting ferrous iron, but there is as yet no evidence that ferric iron occurs in significantly greater proportion on one side of the rolls than on the other.

b. That in the Uravan mineral belt most of the iron on both sides of unweathered rolls is in the ferrous state.

c. That at Ambrosia Lake ferrous iron (as pyrite) is dominant on both sides of the primary ores, and that also at Ambrosia Lake iron near one redistributed crudely formed roll type body is largely in the ferrous state on the dominantly concave side and mostly in the ferric state on the other side.

Differences among roll type deposits just described can be summarized briefly.

1. Rolls of the type exemplified in the Shirley Basin form the boundary between altered and unaltered sandstone, whereas rolls such as in the Uravan mineral belt and at the Rifle

mine are entirely surrounded by a wide halo of altered ground.

2. In addition to differences in host-rock alteration, most rolls seem to form originally as primary deposits, as at Rifle in the Shirley Basin, and in the Uravan mineral belt these are probably at least 10 million years old or older. Only rarely, and in imperfect form, do the rolls develop as distinctly secondary or redistributed bodies, such as found at Ambrosia Lake where they may be much less than 10 million years old (Shawe and Granger, 1965).
3. Rolls that occupy a large part of the thickness of thick permeable sandstone units, as in the Shirley Basin, at the Rifle Mine, and at Ambrosia Lake, may or may not reflect by their orientations the gross trends of paleoground water movement. However rolls that occur in small permeable sandstone lenses complexly divided by numerous thin impermeable mudstone layers, such as in the Uravan mineral belt, probably indicate by their orientation merely local diversions of the gross paleo-drainage-vagaries of a complex natural plumbing system.
4. Some rolls constitute virtually an entire ore deposit (Shirley Basin), and others are merely boundary modifications of, or connecting links between, large tabular orebodies (Rifle deposit; Ambrosia Lake primary ores).

5. Although some rolls might appear to be related in position and orientation to zones of movement of ground water controlled by structure and the present or recent topography (Ambrosia Lake postfault ores), most exhibit no discernible relation to these (Uravan mineral belt; Rifle deposit; Ambrosia Lake primary ores).

The principles of the Roll Front Theory were originally applied to roll deposits elsewhere, but they also pertain to the ore deposition of the Gas Hills, Shirley Basin, and Crooks Gap Uranium Deposits and Silver Bell uranium prospect in Wyoming.

In some Tertiary basins of central Wyoming (Shirley Basin, Gas Hills, Crooks Gap and the Silver Bell uranium prospect), uraniferous Precambrian granitic source rocks were transformed into extremely lean arkosic uranium protore that was permeable, carbonaceous and pyritiferous. With ingress of oxygenated groundwater, geochemical cells developed in the source beds or protore. Water and oxygen reacted with disseminated diagenetic and epigenetic pyrite to form an acid wave that moved generally downdip to leach uranium and other susceptible elements from the protore. These elements were deposited from solution in roll fronts where Eh and pH changes caused precipitation at the edges of geochemical cells.

In the course of physical and chemical weathering, the uraniferous source rocks were broken down and the uranium in solution, and as both primary and secondary particles together with comminuted matrix material ultimately was transported to adjacent topographic and structural basins. Thus the uraniferous granitic source rocks were transformed into source beds of uraniferous arkose and related finer-grained interfluve deposits. In other words, the impermeable, non-amenable granitic uranium source rocks became permeable, amenable arkosic uranium source beds or protore. Some disolved uranium may have been lost (leaked) from the system at this stage. An aggradational sedimentary environment was necessary for preservation of the arkosic protore. In this paleoenvironment under discussion, climate, physiography, and sedimentation allowed the development and preservation of vegetable carbon, which is now manifest mainly as fossil organic trash is arkosic channels and as carbonaceous or lignitic clayey interfluve deposits. This carbonaceous environment probably helped originally to hold syngenetic uranium in the continental sediments.

Anaerobic bacteria thriving on abundant disseminated and bedded carbon generated ubiquitous hydrogen sulfide, which combined with iron in formation water to form diagenetic and epigenetic pyrite. This pyrite, totalling about 0.5-1% by volume, is disseminated generally through the source beds or protore. At this stage, the granitic source rock had been transformed into extremely lean arkosic uranium protore that was permeable, carbonaceous and pyritiferous. The protore might have remained unenriched and of no economic significance, however, subsequent tectonic events triggered structural adjustments that revitalized formation-water gradients and ultimately (as erosion progressed) allowed ingress of oxygenated groundwater into the permeable protore. The formation-water system as far down-dip as is of present concern was open to the surface. Recharge water is considered generally not to have been anomalously metalliferous (although metalliferous recharge water presumably would enhance the situation). With ingress of oxygenated groundwater, geochemical cells developed. It should be pointed out that these cells are finite and three dimensional. Starting at the first point of access of oxygenated groundwater into the unoxidized protore and spreading from this point into a tongue-shaped cell, water and oxygen reacted with disseminated diagenetic and epigenetic pyrite to form ferric sulfate and sulfuric acid. Thus, an advancing acid wave, driven (down-dip generally) by gravity and guided by permeability, leached uranium and other susceptible elements from the protore. Around the outer margins of the acid wave the previously described carbonaceous, anaerobe-rich environment sustained a retreating physiochemical interface or solution front, where Eh-pH changes caused precipitation of uranium and other elements brought to the front in the ferric sulfate and sulfuric acid solutions. Data from the Shirley Basin deposits suggest that uranium was transported in low-temperature neutral to weakly alkaline solutions and oxidizing ground water. Likewise the destruction of pyrite and of carbonized plant debris by the ore-bearing solution implies that the solution was oxidizing. Deposition of uranium and elements associated with it in the Shirley Basin deposits appears to have resulted principally from a decrease in the Eh of the ore-bearing solution, although a moderate drop or rise in its pH may have been a contributing factor (see Figure 4). Strongly reducing conditions in the zone of deposition are indicated by: (1) the decrease in ferric iron content of samples of altered sandstone taken progressively closer to ore, (2) the low ferric and high ferrous iron content of ore, (3) the high pyrite content of ore. The reducing agent for the Shirley Basin deposits may have been H_2S of biogenic origin

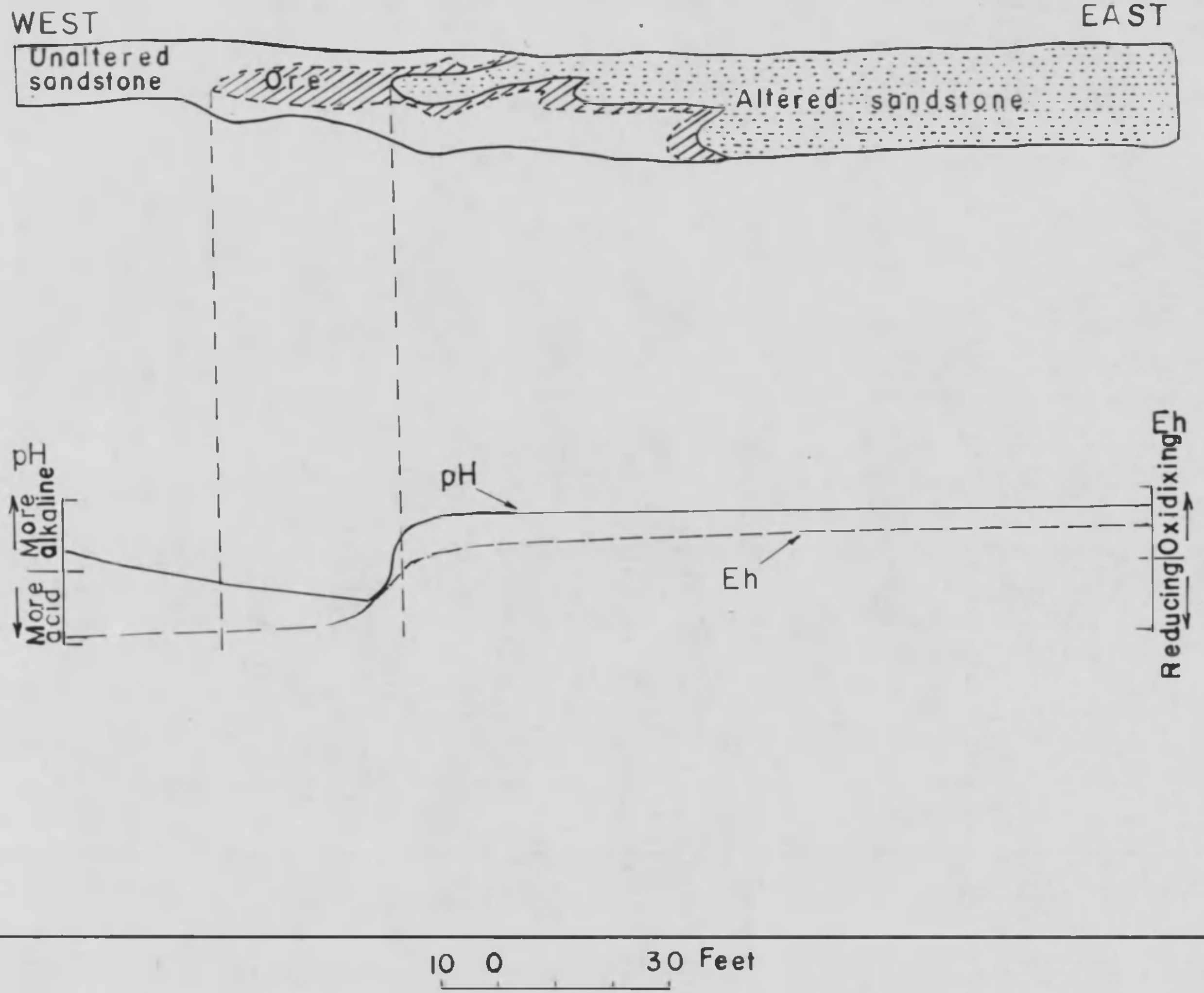

Figure 4. . Eh and pH during transportation and deposition of uranium, Shirley Basin, Wyoming

as suggested by Lindgren in 1910 (Harshman, 1966). The result was an ever growing (except where restricted by permeability barriers) terminal, lateral, "roof", and "floor" solution fronts consisting of the elements flushed from up-dip and deposited in their relative order of solubility. Obviously, several separate cells might coalesce and lateral and vertical differences in permeability might produce complex variations of the simple picture presented here.

A well developed geochemical cell is tongue-shaped, with the tongue pointing down-dip generally. Models of geochemical cells have been recognized in the Crooks Gap, Shirley Basin, and Gas Hill districts of central Wyoming (see Figure 5). In distinctly channeled sandstone, the tongue-shaped cell may be considerably elongated parallel to the channel. Gross permeability patterns and of the length of time cell activity seem to be major factors controlling overall cell shape.

Ideally, the lateral edges of the cell are convex in vertical section, but the solution or roll-front interface is complex in both sections and plan, so that perfect C-shaped rolls are not common. In cross section, rolls commonly show C, S, and "socket" shapes (King and Austin, 1965), but in plan are linear; many elongate rolls curve abruptly at their extremities into "noses." Roll surfaces are fractures that separate mineralized rock from barren. Although rolls commonly terminate against an upper and lower mudstone layer, in places they are split into two distinct rolls by a third thin mudstone layer along their axes (Figure 6). Rolls may bulge above places where thick parts of sandstone strata are in direct contact termed "puncture points", and

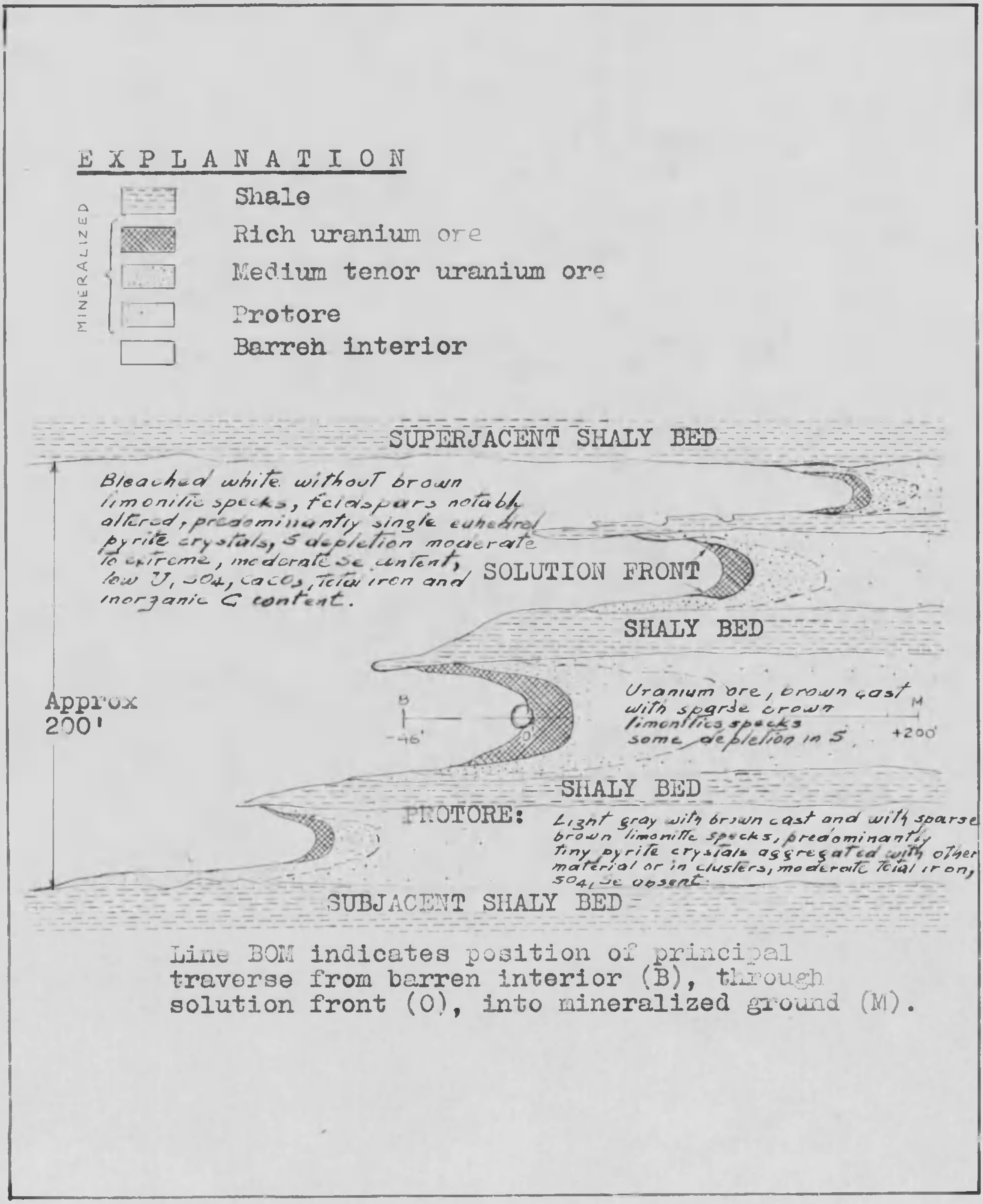

Figure 5. Idealized vertical section across a solution front Gas Hill, Wyoming

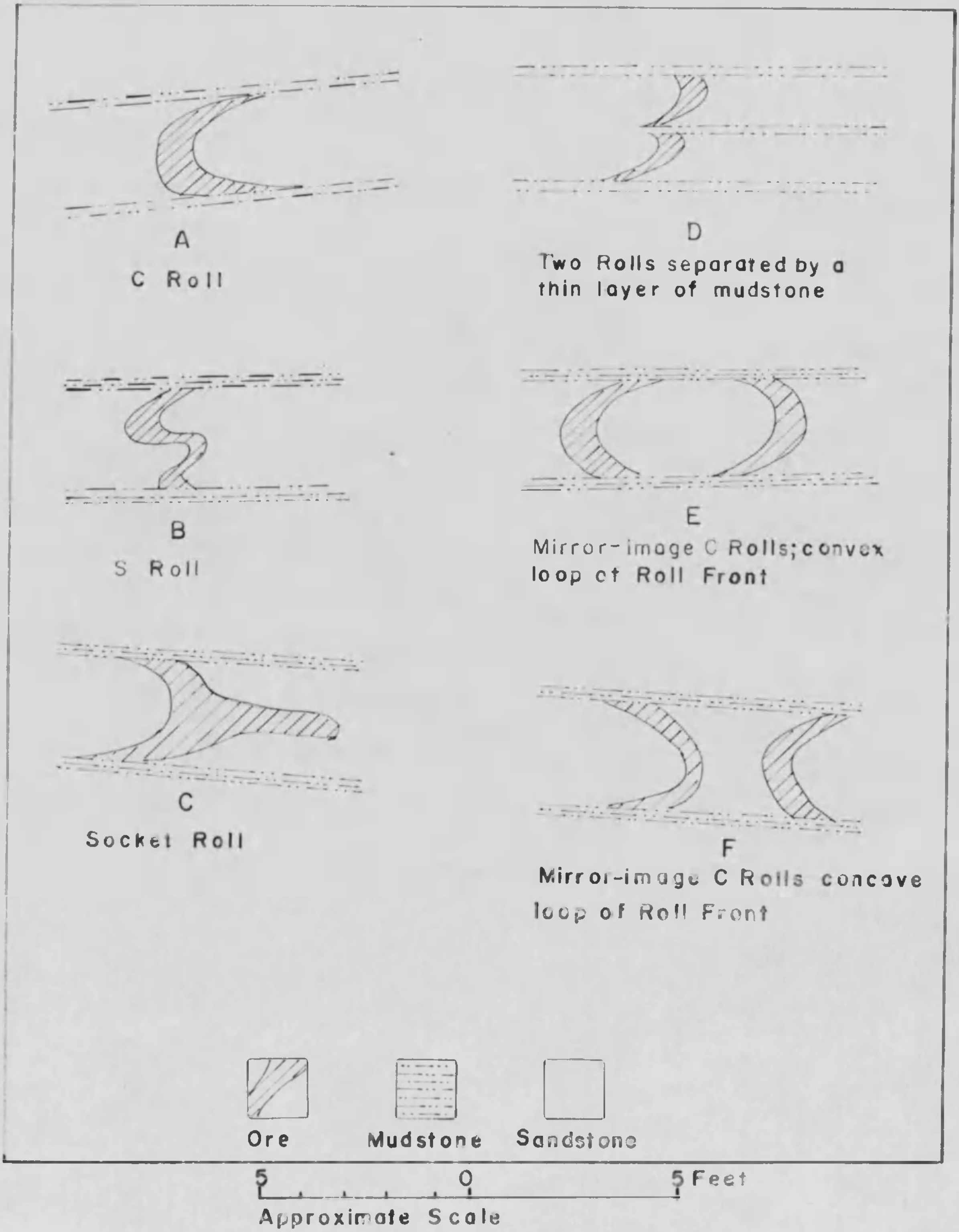

Figure 6. · Cross sectional forms of Roll Ore bodies

noses of rolls may be situated under these places. Essentially, roll orebodies in any particular sandstone layer are all segments of a continuous roll front, and in places appear to be lacking as a result of flattening of rolls into tabular form. The axis are characteristically sinuous in plan and commonly double back on themselves so that cross sections through loops in the roll fronts show mirror images of the roll shapes on either side of the loops (Figure 6, E, F). Individual roll fronts in different sandstone layers show little similarity in local distribution. In many places rolls grade into tabular orebodies which are essentially parallel to bedding planes (Figure 6, A, C).

The width of the ore zone apparently is controlled by the rate of change of Eh and pH; the more rapid and intense the changes (laterally), the more immediate the dumping of metals. Thus, the rate of change of Eh and pH may make the difference between high-grade ore spread over a few tenths of feet (laterally) or no economic concentration of metals where Eh and pH changes are too gradual.

A geochemical cell essentially is a leached, locally gossan bearing with secondarily enriched ore around the margins. The secondarily enriched ore grades into extremely lean protore (the source bed). A geochemical cell may have transverse and longitudinal dimensions of a few to ten or more miles and a thickness of as much as 300 feet. To form such tongues, uranium and other metals were flushed from tens of billions of tons of extremely lean source beds to be concentrated around the margins (especially the terminal and lateral margins).

Where uraniferous source terrane has shed sediments into more than one flanking basin, economically important geochemical cells may develop in each basin. Examples are Crooks Gap and Gas Hills districts on either side of the Granite Mountains in Fremont County, Wyoming (Figure 5).

Size of Uranium Orebodies in the Neighborhood

The major uranium orebodies in the Wyoming Tertiary Basins were concentrated by the geochemical cell mechanism. Uranium has been concentrated and deposited in solution-fronts at the margins of the cell. The roll-front deposits are continuous, more or less, over distances of five or six miles in the Gas Hills and Shirley Basin areas of Central Wyoming. They are interrupted intermittently by variations in grade which may drop below economic levels or "belly-out" into broad low-grade lenses. In some cases faulting may offset orebodies; or a sharp shift in the transmissive lithology may dislocate or interrup deposition. However, generally, the orebodies are shoestring-shaped deposits, uninterrupted over many thousands of feet.

The width and thickness of orebodies are determined primarily by the width of the geochemical cell. The concentration of uranium solute present in the arkosic-sand host may also be a major factor in some deposits. This latter factor no doubt has an important influence on the average grade obtained, along with the factors of relative abundance of organic trash, pyrite, and the transmissivity of the host rock.

Information available on the size of orebodies in Wyoming is complicated by the general confidential nature of the data, multiple ownership of orebodies possibly measuring miles in length, and the fact that few orebodies in the Gas Hills, Shirley Basin, and Crooks Gap have at this time been completely drilled-out over their entire length. It is estimated that the Gas Hills trends have been explored less than 70% over their probable extent, those in Shirley Basin less than 50%, the Powder River Basin deposits are probably less than 10% delineated. The Crooks Gap may be 1/3 delimited or less.

The apparent size of individual orebodies may be further distorted when stacked orebodies are found at several horizons, reflecting the fact that there is a tendency for more than one geochemical cell to develop in vertical succession where there are a series of transmissive host beds separated by impervious beds, and where a pervious zone such as a fault has given them a common source of oxygenated surface runoff to charge the cells. Such a phenomenon is present in both Gas Hills and Shirley Basins.

Presently developed ore reserves plus past production in the Gas Hills uranium district total between 15 and 20 million tons of ore containing .25% U_3O_8 as an average grade. Three ore trends are situated 3 miles apart. Three individual properties contain as much as 2 to 3 million tons of uranium ore at the above grade. These three properties when fully explored will probably interconnect resulting in one orebody totaling between 5 and 7 million tons .25% uranium ore. There is no way with the data at hand for an estimate to be made of the average size of orebodies in the Gas Hill District. However, the interconnected orebodies mentioned above extend over a distance of 3 to 4 miles, vary in width from 10 to 150 feet wide, and vary in thickness up to 50 to 70 feet maximum thickness. The averages of other orebodies would lay considerably closer to the minimum than to the maximum dimensions indicated above. The Shirley Basin has been under development for a shorter period than the Gas Hills District and its ore therefore, has been less completely delineated. Its reserves, including past production, range between 12 and 15 million tons of .25% U308 ore. The width and thickness range are the same as the Gas Hills. The Shirley Basin has 2 or 3 sand units, separated by impervious beds which have been penetrated by a geochemical cell. The result is one set of dual trend underlaid by at least one other set, both sets stretching between 4 and 5 miles into the Basin.

At the current stage of development the Ore Reserves including past production in the Crooks Gap area are between 500 and 600 thousand tons. One major body is being developed on at least four properties. The ore lies close to the surface near the base of the Battle Springs formation. The same formation body was once probably a classic roll-front type orebody. However, because it is near-surface there has been much post deposition mineral movement which has resulted in a lenticular, multiple-horizon, orebody, difficult to delineate, and costlier to mine than in the Gas Hills and Shirley Basin. Deeper Horizons to the south of the Gap in the area where W. R. Grace & Company explored should probably yield classic roll-front orebodies, similar in configuration to those found in the Tertiary basins. However, they could be considerably smaller than those found in the larger Gas Hills and Shirley Basin deposit. Geochemical cells in the Shirley Basin and Gas Hills are on the order of one to five miles wide, which offers greater scope to concentration of uranium at the margin of the cell (see Figure 4).

A Schroeckingerite deposit is present at the ground surface about 5 to 7 miles southwest of the Silver Bell property, but it has not been mined because of its concentration of uranium.

Several major mining companies have initiated extensive exploration programs for uranium deposits in the Red Desert area, but, from all information available at the present time, no commercial ore orebodies have been discovered.

Detectability and Source of Uranium in a Sandstone-Type Uranium Deposit

The detectability of uranium in the Silver Bell prospect area must be interpreted on the basis of information from experiences in the uranium discovered in Shirley Basin, Gas Hill and Crooks Gap deposits, where ore deposits now being mined are in Tertiary Basins were deposited by solution fronts (roll-front theory). This theory is now widely accepted and the Silver Bell property occurs in a geologic environment similar to these aforementioned deposits.

The radiometric anomaly was first detected by United States Geological Survey in 1951 by airborne surveying. W. R. Grace & Company ran a ground radiometric over the anomalous area using a 111-B Precision Scintillation counter. Radiometric reading were taken on a 200 foot grid. Contours of these readings developed the anomalous area shown on Figures 7 and 8.

It is assumed that the uranium causing the anomaly detected was probably dissolved, together with other elements, from tuffaceous and arkosic sedimentary rocks. The solutions migrated through the porous sandy Battle Spring Formation and moved from the flank of the basin down the hydraulic gradient toward the lower part of the basin. The arkosic sandstone beds were derived from the Granite Mountains north and northeast of the area.

The Granite Mountains are capped by a minimum of 900 feet of weakly uraniferous tuffaceous rocks (Pipiringos, 1961) that at one time almost completely covered them. It is difficult to determine how much of the interstitial uranium that is present in the granite was derived from magma and how much was derived from the overlying uranium-bearing tuffaceous rocks.

It is likewise difficult to explain on the basis of structural control of uranium distribution the widespread occurrence of uranium in in coal so far removed from the Battle Spring Formation and in a structurally unfavorable positions in relation to the source formation (Pipiringos, 1961). But according with the study done by W. R. Grace it seems that the solutions migrated from north to south and it seems that these solutions passed through the Battle Spring Formation in the area of Silver Bell prospect and deposited uranium in the south west near the contact with the Wasatch and Green River formations. These have impermeable beds favorable for the uranium deposition. This hypothesis is based on the idea that the mineralized solutions traveled down dip along permeable beds in the Battle Springs formation until they reached the less permeable intertongued beds of the Wasatch formation where the uranium was precipitated and concentrated.

In the Great Divide Basin transfer of the uranium from the source rocks directly downward was prevented throughout most of the coal-bearing area by intervening thick sequences of nearly impermeable beds of the Green River formation. Where these impermeable beds were absent (as at the Silver Bell prospect), and the source rocks rested on the permeable Battle Spring formation, uranium-bearing water percolated downward and laterally for several miles in response to structural and permeability controls such as the Red Desert syncline. The coal beds nearest the permeable tongues of the Battle Spring Formation accumulated higher concentrations of uranium than did the coal beds farther away.

Miocene and Pliocene rocks northeast, southeast, and south of the central part of the Great Divide Basin are known to contain uranium. Pliocene rocks of the Split Mountain area (part of the Granite Mountains) contain as much as 0.005 percent uranium and 0.016 percent equivalent uranium (Pipiringos, 1961).

The east flank and the trough of the Red Desert syncline offer the best possibilities for the commercial development of uranium-bearing coal if such an operation becomes economically feasible. No uranium minerals have been as yet identified in the coarse-grained rocks that crop out in the coal bearing part of the area, but it seems reasonable to suppose that prospecting might in the future disclose occurrences of uranium minerals in the coarse sandstone associated with coal beds within the central part of the Great Divide Basin and in the sandstone beds in the area adjacent to the northeast.

Sandstone-type deposits are related to geochemical cells (roll-front theory). If conditions are right for development of a geochemical cell, not only uranium but other metals such as selenium, molybdenum or whatever is in the source bed, may be concentrate around the margins of these cells. Therefore this theory may be applicable broadly in the search for uranium, vanadium, copper, silver and other metalliferous sandstone-type deposits in divers stratigraphic and geographic situations.

Uranium is an exceptional element insofar as it can be detected remotely by gamma rays and other sensors. Even trace amounts of uranium intercepted in an exploratory drill hole are relatively easy to detect. This makes it simple to define a sandstone-type uranium deposit in three dimensions.

Scattering of the Mineralization

In the Crooks Gap area the ore lies close to the surface and near the base of the Battle Spring formation, with indication that the body was once probably of classic roll-front type. However, because it is near surface there has been much post-deposition mineral movement which has resulted in a lenticular, multiple-horizon, orebody, difficult to delineate and expensive to mine. To the southeast of this deposit is the Silver Bell property, which has almost the same characteristics as those of the Crooks Gap deposit. The mineralization is found in different horizons in small sizes. W. R. Grace & Company was prospecting in deeper horizons in the arkosic sandstone of the Battle Spring Formation. Holes drilled by the company into radioactive zones were checked by closely spaced drill holes, 25 feet apart, to show any mineral trends. Radioactive zones 0 to 100 feet in depth could be traced fairly well showing the same trend as the surface anomaly, however, radioactivity below 100 feet in depth could not be correlated as to grade, thickness or elevation. For example, a core hole was offset 3 feet from another hole which had indicated 5 feet of 900 CPS (see Table 1 and 2) at a depth of 320 feet. The electric log of the second core hole showed the mineralization had dropped to 1 foot of 700 CPS and had dropped 18 feet in elevation. This same situation was enclountered in many other drill holes. Drift of the drill holes may account for partial elevation discrepancies, but a close evaluation of electric logs, cuttings, and observations of the drill operation indicates drift to be an insignificant factor.

Figures 15 to 17 show that on the Silver Bell property, the mineralization is more or less continuous across the aforementioned fault with no offsetting. Therefore, it appears that no movement along this fault has occurred since the mineralized solutions passed through and that it had no genetic relationship to mineral deposition.

Results of the extensive exploration and drilling program conducted indicate that it is unlikely that uranium has been concentrated enough to form a minable ore deposit on the Silver Bell property.

The northern and middle portions of the area has only minor alteration and mineralization (see Figures 9 and 10). The southern portion of the claims has intense alteration and anomalous radioactivity indicating that mineralizing solutions have passed through. Although arkosic sands, pyrite, and carbonaceous material are present in addition to intense alteration and high anomalous radioactivity, no ore was encountered by closely spaced drilling. This area is potentially the most favorable portion of the Silver Bell property. However, due to discontinuity of the radioactivity grade, thickness, and elevation, it is likely to assume that the mineralized solutions passed on to the southwest of the property without forming a commercial orebody.

Table 1. Holes and Footage

The drill program at the Silver bell property consisted of:

	Depth				
No. of Holes	0-300'	300-600'	600-1000'	1000+	Core
26	5736'				
49		25,585'			
41			34,913'		
22				26,250'	
4					102.8'

Total No. of Drill Holes: 142

Total Drill Footage: 92,587

Total Electric Log Footage: 89,232 (excluding reruns)

Table 2. Gamma Electric Log Interpretation

Counts Per Second	Approximate % eU308
480	0.02
1150	0.05
2350	0.10
3500	0.15
4700	0.20

Description and Valuation of the Anomaly

One of the basic reasons for exploring the Silver Bell property was the presence of surface radioactivity which extended to a depth of 35 feet, as indicated by two drill holes. W. R. Grace representatives felt that this anomaly might yield a heap leach type mining operation for low grade ore.

A ground radiometric survey was conducted over the anomalous area using 111-B Precision Scintillation counter. Radiometric readings were taken on a 200 foot grid (see Figures 7 and 8). Drill holes in this area showed anomalous radioactivity to 35 feet, but gamma-electric log interpretations indicated less than 0.04% eU308. To accurately verify the presence or absence of a low grade deposit, the material was cored from 7.0 to 32.0 feet in GX-core 3 and chemical assays for U308 obtained. Core hole GX-core 3 chemical assays for core showed a maximum of 0.016% U308.

Assuming that any potential orebody in this area would be deposited by solution fronts similar to most uranium deposits in Wyoming, careful consideration was given to material alteration and radioactive trends.

The trend of the surface anomaly is N60°W. Four lines of drill holes perpendicular to this trend (see Figures 12 to 18) showed thick zones of high alteration and many radioactive zones. As shown on the geologic sections (Figures 12-18), the radioactivity from the surface can be traced downdip of the bedding.

Gamma-electric logs indicated uranium ore of 0.10 to 0.30% eU308. However, four core holes (Figure 8) were drilled to check the chemical values of these zones and the highest chemical assay was 0.058% U308 (see Table 3, p. 38). Chemical assays showed the material to be out of equilibrium in favor of the gamma radioactivity. This disequilibrium indicates the possible former presence of an orebody that has been leached by ground waters, leaving only beta and alpha radiation. The possibility of an orebody having been formed where these mineralized solutions encountered the water table down dip along bedding planes was investigated by drill holes, but no ore was found. The water table along the northern claims is at about 6,945 feet elevation and drops to 6,830 feet elevation along the GX-50 drill hole line in the south (see Figure 11).

Observations of the core and electric logs showed that the mineralized zones are along silty or clayey sand-clay contacts with the mineralization occurring mainly in the clay. This is a logical explanation as the clay would be an impermeable barrier to the mineralized solutions whereas the sandier fraction would be permeable. In the area of the surface anomaly, no correlation of lithologic units could be made, but south of the east-west normal fault in sec 23, T.26N and R. 94W, a radioactive zone can be traced for about one mile (see Figure 15-17) at the contact of a distinct sand and clay zone.

A former shallow orebody in the Silver Bell area has been completely leached by ground water solutions. It is probable that this mineral was redeposited in the southwest of the area prospected in the contact and intertonguing between the Battle Springs, Green River and Wasatch formations.

Table 3. Chemical Assays U308

Hole No.	Depth (ft.)	U308 (%)	eU	Samples
GX-Core 1	56.7-57.0'	0.021		Core
"	57.1-58.3'	0.027		"
"	59.9-62.0'	0.007		"
"	62.0-63.0'	0.005		"
"	65.9-67.9'	0.007		"
"	67.9-68.5	0.002		"
"	68.5-69.1	0.001		"
"	68.6-68.9	0.007		"
"	69.2-70.0	0.024		"
"	69.9-71.9	0.003		"
GX-Core 2	56.0-58.0	0.028		"
"	77.5-80.5	0.058		"
"	82.0-84.0	0.017		"
"	88.0-89.0	0.039		"
GX-Core 3	7.0-11.2	0.005		"
"	11.2-13.0	0.016		"
"	13.9-14.2	0.001		"
"	22.0-23.0	0.001		"
"	23.0-25.5	0.004		"
GX-163-3	66.0-68.0	-0.01		Air
"	68.0-70.0	-0.01		"
"	70.0-72.0	0.005		"

Table 3. Chemical Assays U308--Continued

GX-163-3	70.0-72.0	0.004	0.003	Air
"	72.0-74.0	-0.01		"
"	74.0-76.0	-0.01		"
"	76.0-78.0	0.006		"
GX-163-4	61.0-63.0	-0.01		"
"	63.0-65.0	-0.01		"
"	63.0-65.0	0.017	0.014	"
"	65.0-67.0	0.005		"
"	65.0-67.0	0.01	0.06	"
"	65.0-67.0	0.008	0.007	"
"	67.0-69.0	-0.01		"
"	67.0-69.0	0.008	0.007	"
"	69.0-70.0	0.002		"
GX-163-5	60.0-65.0	-0.01		"
"	65.0-70.0	-0.01		"
"	65.0-70.0	0.016	0.014	"
GX-163-6	55.0-60.0	0.022		"
"	60.0-65.0	-0.01		"
GX-51	0.0- 5.0	0.002		Wash
"	5.0-10.0	0.001		"
"	10.0-15.0	0.005		"
"	15.0-20.0	0.012		"

Table 3. Chemical Assays U308--Continued

GX-51	20.0- 25.0	0.005	Wash
"	25.0- 30.0	0.009	"
GX-146	0.0- 5.0	0.001	"
"	5.0- 10.0	0.003	"
"	10.0- 15.0	-0.001	"
"	15.0- 20.0	-0.001	"
"	20.0- 25.0	0.003	"
GX-151	150.0-155.0	Not Detected	"
"	155.0-160.0	-0.001	"

The lack of sufficient uranium concentration in the Silver Bell property because of the scattering of the mineralization makes it uneconomical and the lack of equilibrium in favor of beta and alpha and gamma radiation with only minor amounts of chemical U308 (Table 3, p. 38) produces a misleading radiometric anomaly.

Alteration and Mineralization

Alteration features associated with uranium mineralization usually have received less attention merited because radioactivity counters and scintillation devices often furnish a direct indication of orebodies. Uranium is an exceptional element insofar as it can be detected by gamma ray and other sensors. Even minute amounts of uranium intercepted in an exploratory drill hole are relatively easy to detect. Whereas, in thick sedimentary sections alteration criteria often are not recognized; some very localized effects such as the red stain that accompanies some pitchblende veins may be recognized.

Few of the alteration criteria associated with uranium deposits differ appreciably from those of copper, zinc, tungsten, and other metals. However, their applicability to uranium is selective. The term alteration is applied to the development of clay mineral halos, chloritization, alunitization, fluoritization, carbonatization, silicification, and ferrugination.

The criteria of rock alteration that are most useful in the search for uranium bear a striking resemblance to those for other metals. However, conditions may vary with the locality, and render recognition much more difficult. This is true of the Colorado Plateau (Shawe, 1956), sediments in comparison with areas of igneous or metamorphic rocks.

Exploration and drill program in the Silver Bell prospect were based on the assumption that any potential ore bodies would either be formed by association with geologic structures or by a roll-front type deposition. Data from operating mines in similar basin environments in Wyoming was obtained and seem to verify this assumption.

As was pointed out, the drill program was laid out with three lines of holes in an east-west direction on one mile centers across the upper, middle, and lower part of the claims. A few holes were located in the southernmost claims to check possible structural ore control along faults. The upper and middle line of holes showed very little anomalous radioactivity with only minor alteration, whereas, the lower line had higher radioactivity and more intense alteration. The mineralization map (Figure 9) shows the areas of higher radioactivity, and the alteration map (Figure 10) shows areas of high alteration.

The following criteria were used to delineate the higher radioactive areas:

Drill holes with one or more zones of 200 - 400 CPS

Drill holes with one or more zones of 400 - 700 CPS

Drill holes with one or more zones of 700 + CPS.

The alteration map is based on the following criteria:

Drill holes with any alteration 0 - 300 feet in depth

Drill holes with any alteration 300 - 600 feet in depth

Drill holes with any alteration 600 - 900 feet in depth

Drill holes with any alteration 900 + feet in depth.

Figures 9 and 10 show that heavier concentrations of alteration and mineralization roughly coincide and are both in the southern part of the claims.

Although arkosic sands with pyrite and carbonaceous material are present (deemed favorable host material for uranium deposition by most geologists, Harshman, 1961), the lack of alteration and the anomalous character of the radioactivity make the area relatively unfavorable for a possible ore body.

The southern portion of the claims has intense alteration and anomalous radioactivity showing that mineralized solutions have passed through the area. Although arkosic sands, pyrite, and carbonaceous material are present in addition to intense alteration and high anomalous radioactivity, no ore was encountered by close spaced drilling. This area is potentially the more favorable portion of the Silver Bell property. However, due to discontinuity of the radioactivity highs as to grade, thickness, and elevation and the intense alteration, it is likely that the mineralized solutions passed on to the southwest of the property without forming a commercial ore body. This hypothesis is based on the concept that the mineralized solutions would travel down dip along permeable beds in the Battle Springs Formation until they reach the less permeable intertongued beds of the Wasatch formation where the uranium would be precipitated and concentrated.

Local sedimentary features such as crossbedding have little influence (Harshman, 1962) on the position of the altered-sand tongues and only a minor influence on the character of the sharp contacts between altered and unaltered sand.

Preliminary observations to establish the differences between altered and unaltered sandstone are: (see Table 4, p. 45)

	Altered Sandstone	Unaltered Sandstone
Color	Greenish-yellow	Gray
Heavy Minerals	Pyrite, magnetite, and ilmenite, largely removed	Pyrite, magnetite, and ilmenite present in significant amounts
Clay Minerals	High-iron montmorillonite	Low-iron montmorillonite
Cement	Little or no calcite cement	Considerable calcite cement
Carbonaceous Trash	Incoherent and sooty	Coherent, vitreous coalified

Table 4. Description of Core

	Geologic Log	GX-Core No. 1
Depth (ft.)	Core Recovery (%)	Description
56.7-57.0	90	Sandstone: medium brown and dark brown. Claystone: 57.0-57.5 - reddish-brown and dusky brown staining, very strongly oxidized. 57.5-58.6 drab-gray, ochre-gray. At 58.6, 0.05' white bentonite.
59.0-61.0	0	
61.0-62.0	100	Sandstone: light gray to light brownish-gray.
62.0-63.0	100	Sandstone: brown, strongly oxidized.
63.0-65.9	0	
65.9-68.5	90	Sandstone: brown, strong limonite staining.
68.5-68.7	100	Claystone: drab gray.
68.7-68.9	100	Sandstone: brown, strongly oxidized.
68.9-69.4	100	Claystone: gray.
69.4-71.3	100	Sandstone: light brown.
71.3-71.8	100	Siltstone: grayish-brown.
71.8-72.1	100	Sandstone: brown with brown staining.
72.1-73.1	100	Siltstone: gray.
73.1-74.5	100	Sandstone and claystone: light brown.
74.5-74.9	100	Claystone: gray, speckled brown.

Table 4. Description of Core--Continued

		GX-Core No. 2
52.0-52.3	100	Sandstone: gray, with limonite specks, very fine-grained.
52.3-56.4	100	Siltstone: gray, slightly oxidized at bottom.
56.4-57.2	100	Sandstone: gray, very fine-grained, with thin clay seams, limonite staining 57.0-57.2.
57.2-57.9	100	Siltstone: light gray.
57.9-59.1	100	Claystone: blue-gray, oxidized at top and bottom.
59.1-59.6	100	Claystone: drab gray.
59.6-60.0	100	Sandstone: gray, limonite staining.
60.0-60.5	100	Claystone: drab gray to blue-gray.
60.5-62.0	100	Sandstone: gray, very fine-grained with considerable clay.
62.0-64.5	0	No recovery.
64.5-66.5	62	Siltstone: green-gray, with considerable clay.
66.5-67.0	62	Sandstone: white to whitish-gray, very fine-grained, koolinized.
67.0-67.5	100	Sandstone: gray, very fine-grained.
67.5-68.1	100	Claystone: drab gray to blue-gray.
68.1-72.0	100	Sandstone: gray, very fine-grained, very few limonite specks.
72.0-78.5	100	Sandstone: gray-medium-grained, minor rusty-brown specks, strong limonite specks 78.0-78.5.
78.5-80.8	100	Sandstone: gray, very fine-grained, interbedded with .05' clay seams, considerable clay.

Table 4. Description of Core--Continued.

80.8-82.0	100	Sandstone: gray, clean, bottom 0.2' limonite staining.
82.0-84.0	95	Sandstone: brown and light gray, 70° fracture at bottom, strongly oxidized-water course.
84.0-86.6	95	Sandstone: light brownish-gray to light gray at bottom, with very sticky clay.
86.6-91-3	100	Sandstone: gray, very fine-grained, and with very sticky clay.
91.3-91.6	100	Claystone: blue-gray.
		GX-Core No. 3
7.0-11.3	50	Sandstone: light brown, limonite specks, local oxidized streaks.
11.3-12.0	50	Siltstone: gray, some sand grains, locally oxidized.
12.0-12.2	94	Siltstone: gray, some sand grains, locally oxidized.
12.2-13.2	94	Claystone: olive drab.
13.2-13.4	94	Sandstone: gray, brown staining.
13.4-15.3	94	Siltstone: gray, brown staining.
15.3-17.0	94	Sandstone: brown-gray, 15.3-15.6 very firm, compact and well cemented by oxidized material, rest sample has oxidized specks.
17.0-19.2	85	Sandstone: brown-gray-oxidized specks.
19.2-19.7	85	Sandstone: gray, no staining.
19.7-20.0	85	Sandstone: brown, highly oxidized.
20.0-22.0	85	Sandstone: brown-gray, limonite stained.

Table 4. Description of Core--Continued

22.0-22.5	100	Sandstone: brown-gray, strong limonite staining.
22.5-24.0	100	Siltstone: gray to gray-brown, oxidized streaks.
24.0-24.5	100	Claystone: gray to buff-brown.
24.5-25.5	100	Claystone: olive-grown, maroon-gray at 25.0'.
25.5-25.6	100	Bentonite: gray-white
25.6-26.8	100	Sandstone: brown-gray, limonite staining.
26.8-27.0	100	Sandstone: medium brown, strongly oxidized.
27.0-28.0	95	Sandstone: brown, with .05' gray claystone at 27.3' and a .01 claystone seam at 29.8'.
28.0-30.6	95	Sandstone: medium brown at top to brown-gray at bottom.
30.6-32.0	95	Claystone: olive-gray, purple, gray, a .05' highly oxidized cemented sand seam at 31.7'.

CHAPTER 4

CONCLUSION AND RECOMMENDATIONS

The Silver Bell prospect lies on the Great Divide Basin in T. 26 and 27 N., R.93 and 94 W., Fremont and Sweetwater counties, Wyoming in an area known as Red Desert. This area is covered by Tertiary sedimentary rocks which range in age from Paleocene to Pleistocene and Recent.

Radioactive carbonaceous shale and coal were discovered in 1945 by Slaughter and Nelson (Pipiringos, 1961) in the Great Divide Basin. An anomaly detected by the United States Geological Survey in 1951 in the Great Divide Basin was investigated by W. R. Grace in 1968 with the idea that this anomaly might yield a heap leach type mining operation for low grade ore. A ground radiometric survey conducted over the anomaly gave the contours shown on Figures 7 and 8. Drill holes in this area showed anomalous radioactivity to 35 feet. Gamma-electric logs indicated uranium ore of 0.10 to 0.30% eU308. However, four core holes (Figure 8) were drilled to check the chemical values of these zones and the highest chemical assay was 0.058% U308. Chemical assays showed the radioactivity encountered from 0 to 100 feet is out of equilibrium, and only minor amounts of chemical U308 are present. This suggests the presence of a former shallow orebody that has been leached by ground water solutions. Therefore it is unlikely that uranium has been concentrated enough to form an orebody to be mined economically. The possibility of an orebody being formed where these mineralized solutions encountered the water table downdip along bedding planes was investigated by drill holes, but no ore was found.

Radioactive zones 0 to 100 feet in depth could be traced fairly well showing the same trend as the surface anomaly, however radioactivity below 100 feet in depth could not be correlated as to grade, thickness, or elevation. Drift of the drill holes may account for partial elevation discrepancies, but a close evaluation of electric logs, cuttings, and observations of the drill operation indicates this to be an insignificant factor.

Observations of the core and electric logs showed that the mineralized zones are along silty or clayey sand-clay contacts with the mineralization occurring mainly in the clay. In the area of the surface anomaly, no correlation of lithologic units could be made, but south of the east-west normal fault in section 23, T.26 N. and R.94 W. a radioactive zone can be traced for about one mile (Figure 15) at the contact of a distinct sand and clay zone.

Although there are differences in detail the Roll Front - Geochemical Cell concept which is applicable in the Lower Cretaceous Lakota formation in the Black Hills and in the sandstone-type uranium deposits in Mesozoic rocks of the Colorado Plateau may be applied here.

Uranium is an exceptional element insofar as it can be readily detected by gamma rays and other sensors. However, other elements that have been detected partly because the metals involved do not radiate their three-dimensional distribution might be related to geochemical cells. If conditions are right for development of a geochemical cell, other metals such as copper, silver, selenium, molybdenum, or whatever is in the source bed, may be concentrated around the margins of geochemical cells.

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FIGURE 7
DRILL HOLE LOCATION MAP
SILVER BELL PROPERTY
GREAT DIVIDE BASIN--RED DESERT AREA
Sweetwater County, Wyoming
FELIPE MONZON
August 20, 1968
SCALE: 1" = 2000'
Miles
0 1/4 1/2 1 1 1/2
EXPLANATION
Non-Conflicting External Claim Boundaries
Section lines with numbers
Completed Drill Hole showing Hole No. and total depth (logged depth)
Fault (from U.S.G.S. map)
Syncline (from U.S.G.S. map)
Anticline (from U.S.G.S. map)
Geologic Cross-section
WESTERN NUCLEAR
HOMESTAKE MINING CO.
SILVER BELL & W. R. GRACE
NEW PARK MINING CO.
CALUMET & HECLA MINING CO.
AMAX CORP.
SEE FIGURE 8 INSET
SURFACE RADIOACTIVITY ANOMALY
East Antelope Anticline
Arapahoe Creek
T.27N.
T.26N.
R.94W.
R.93W.

FIGURE 8 INSET DRILL HOLE LOCATION MAP

FIGURE 9

MINERALIZATION MAP
SILVER BELL PROPERTY
GREAT DIVIDE BASIN--RED DESERT AREA
Sweetwater County, Wyoming
August 20, 1968
FELIPE MONZON

FIGURE 10

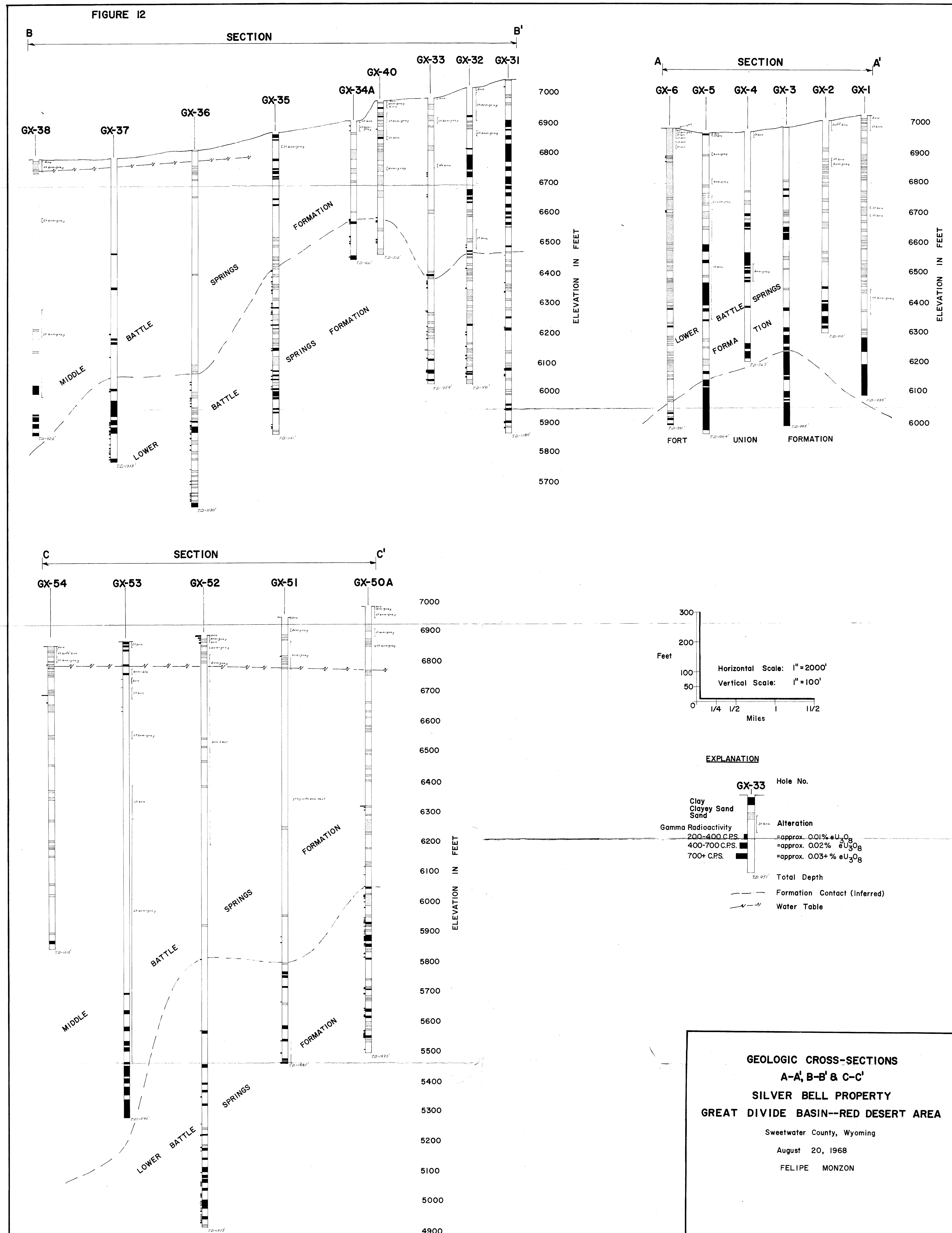
ALTERATION MAP
SILVER BELL PROPERTY

GREAT DIVIDE BASIN--RED DESERT AREA
Sweetwater County, Wyoming
August 20, 1968

FELIPE MONZON

FIGURE 11


SCALE: 1" = 2000'
1/2 1/4 0 1
MILES
EXPLANATION
Drill hole location with water table elevation
Water table, dashed where inferred
GX-1
6850'
6800'
7000'
6950'
6900'
6850'
6800'
6750'
GX-6
GX-5
GX-4
GX-3 6988'
GX-2
GX-1 7005'
GX-17
GX-16
GX-15
GX-38 6854'
GX-37 6865'
GX-36 6882'
GX-35
GX-34
GX-34A
GX-40
GX-41 6850'
GX-33
GX-32
GX-31
GX-150-16
GX-150-14
GX-150-12 6853'
GX-150-10 6851'
GX-128 6826'
GX-135
GX-159
GX-54 6794'
GX-53
GX-73 6791'
GX-51 6788'
GX-56
GX-55A
GX-50A 6868'
GX-55
GX-50 6785'
GX-174 - 6785'
GX-173
GX-172
GX-75
GX-71 6786'
GX-70
GX-150-3
GX-72 6834'
GX-150-1
GX-150-20 6820'
WATER TABLE MAP
SILVER BELL PROPERTY
GREAT DIVIDE BASIN--RED DESERT AREA
Sweetwater County, Wyoming
August 20, 1968
FELIPE MONZON



GEOLOGIC CROSS-SECTIONS
A-A', B-B' & C-C'
SILVER BELL PROPERTY
GREAT DIVIDE BASIN--RED DESERT AREA

Sweetwater County, Wyoming

August 20, 1968

FELIPE MONZON

FIGURE 13

D SECTION D'
F SECTION F'
GX-141 GX-142 GX-143 GX-144 GX-145 GX-146
6900
6800
6700
6600
GX-161A GX-162 GX-163 GX-164 GX-166
MIDDLE BATTLE SPRINGS FORMATION
MIDDLE BATTLE SPRINGS FORMATION
Feet
300
200
100
50
0
1/4 1/2 1 1 1/2
Miles
Horizontal Scale: 1" = 2000'
Vertical Scale: 1" = 100'
EXPLANATION
GX-141 Borehole No.
Clay
Clayey sand
Sand
Alteration
Gamma Radioactivity
200-400 C.P.S. = approx. 0.01 % eU3O8
400-700 C.P.S. = approx. 0.02% eU3O8
700+ C.P.S. = approx. 0.03+% eU3O8
Mineralization Correlation
GEOLOGIC CROSS SECTIONS
DD' & FF'
SILVER BELL PROPERTY
GREAT DIVIDE BASIN RED DESERT AREA
Sweetwater County, Wyoming
August 20, 1968
FELIPE MONZON

FIGURE 14
G SECTION G'
H SECTION H'
GX-172
GX-173
GX-174
GX-153
GD-112
GD-192
GD-272
GX-163
GD-533
GD-613
GX-173
6900
6800
6700
6600
MIDDLE BATTLE SPRINGS FORMATION
MIDDLE BATTLE SPRINGS FORMATION
Feet
300
200
100
50
0
1/4
1/2
1
11/2
Miles
Horizontal Scale 8 1" = 2000'
Vertical Scale 8 1" = 100'
EXPLANATION
GD-112 Borehole No.
Clay
Clayey sand
Sand
Alteration
Gamma Radioactivity
200-400 C.P.S. = approx. 0.01% eU3O8
400-700 C.P.S. = approx. 0.02% eU3O8
700+ C.P.S. = approx. 0.03% + eU3O8
Water Table
Mineralization Correlation
GEOLOGIC CROSS SECTIONS
GG' & HH'
SILVER BELL PROPERTY
GREAT DIVIDE BASIN RED DESERT AREA
Sweetwater County, Wyoming
August 20, 1968
FELIPE MONZON

FIGURE 15
E
GX-150-20
GX-150-1
GX-150-3
GX-150-17
GX-150-5
GX-150-21
GX-150-18
GX-150-19
O
ELEVATION IN FEET
6900
6800
6700
6600
6500
6400
6300
6200
6100
6000
5900
5800
5700
FORMATIONS UNDIFFERENTIATED
LANEY SHALE AND BRIDGER
UPPER BATTLE SPRINGS FORMATION
SECTION CONTINUED ON FIGURE 16
T.D. 986
T.D. 1178
T.D. 924
T.D. 613
T.D. 972
T.D. 610
T.D. 609
T.D. 603
Feet
300
200
100
50
0
100 200 400 600
Feet
Horizontal Scale: 1" = 200'
Vertical Scale: 1" = 100'
EXPLANATION
GX-150 Hole Number
Clay
Clayey sand
Sand
Alteration
Gamma Radioactivity
200-400 C.P.S. = approx. 0.01% eU_3O_8
400-700 C.P.S. = approx. 0.02% eU_3O_8
700+ C.P.S. = approx. 0.03+% eU_3O_8
T.D. 505 Total Depth
Formation Contact (inferred)
Lithologic Correlation
Water Table
GEOLOGIC CROSS SECTION
E-E'
PARTIAL SECTION E-O
SILVER BELL PROPERTY
GREAT DIVIDE BASIN--RED DESERT AREA
Sweetwater County, Wyoming
August 20, 1968
FELIPE MONZON

FIGURE 16

GEOLOGIC CROSS SECTION
E-E'
PARTIAL SECTION O-P
SILVER BELL PROPERTY
GREAT DIVIDE BASIN--RED DESERT AREA

Sweetwater County, Wyoming

August 20, 1968

FELIPE MONZON

FOR EXPLANATION SEE FIGURE 15

GEOLOGIC CROSS SECTION
E-E'
PARTIAL SECTION P-E'
GREAT DIVIDE BASIN--RED DESERT AREA
SILVER BELL PROPERTY
Sweetwater County, Wyoming
August 20, 1968
FELIPE MONZON


FIGURE 18
SECTION
J J'
GX-72 GX-73 GX-53 GX-38
6900'
6800'
6700'
6600'
WASATCH & GREEN RIVER Fms.
UPPER BATTLE SPRINGS Fm.
MIDDLE BATTLE SPRINGS Fm.
T.D.-1007
T.D.-1489
T.D.-1590
T.D.-924
SECTION
K K'
GX-56 GX-50A GX-34A GX-16 GX-17 GX-2
MIDDLE BATTLE SPRINGS Fm.
LOWER BATTLE SPRINGS Fm.
T.D.-992
T.D.-1490
T.D.-461
T.D.-855
T.D.-844
T.D.-710
EXPLANATION
GX-30 Hole No.
Clay
Clayey Sand
Sand
Lt. brn Alteration
Gamma Radioactivity
200-400 C.P.S. =approx. 0.01% eU3O8
400-700 C.P.S. =approx. 0.02% eU3O8
700+ C.P.S. =approx. 0.03+% eU3O8
T.D.-300 Total Depth
Fault
Water Table
Formation Contact
Vertical Scale 1" = 100'
Horizontal Scale 1" = 2000'
Feet
200
100
50
0
1/4 1/2 1 1 1/2
Miles
GEOLOGIC CROSS-SECTIONS J-J' & K-K'
SILVER BELL PROPERTY
GREAT DIVIDE BASIN--RED DESERT AREA
Sweetwater County, Wyoming
August 20, 1968
FELIPE MONZON