Greybull Sandstone Petroleum Potential on the Crow Indian Reservation of South-Central Montana

David A. Lopez
Montana Bureau of Mines and Geology

Report of Investigation 9 2000

Cover Photograph: Little Mountain located between the Pryor and Big Horn mountains, looking eastward. The stratigraphic section from the base is Triassic Chugwater Formation (red beds), Jurrassic Ellis Group and Morrison Formation; and Cretaceous Kootenai Formation. The prominent bench just below the top of Little Mountain is the Pryor Conglomerate. Exposures at the top in the pine trees are the Greybull Sandstone.

Disclaimer

Executive Summary

All research and compilation of the final report have been completed for this project. An ACCESS database converted to PC-Arcview was used to manage and interpret data. Logs from most of the oil and gas exploration wells in the area have been correlated and data has been incorporated in the data base.

All of the four 30' X 60' geologic quadrangles have been scanned to produce a digital surface geologic database for the Crow Reservation. These maps have been received from the printer and are being distributed.

Field investigations were completed during the third quarter, 1997. With the help of a student field assistant from the Crow Tribe, the entire project area was inventoried for the presence of valley-fill deposits in the Kootenai Formation. Field inventory has resulted in the identification of nine exposures of thick valley-fill deposits. These represent at least four major westward-trending valley systems. All the channel localities have been measured and described in detail and paleocurrent data has been collected from all but one locality. In addition, two stratigraphic sections were measured in areas where channels are absent. All of these data have been compiled and processed digitally. Some of these channels have been identified in the subsurface. Locally, channels over 150 feet thick have been identified on well logs. Subsurface mapping of valley-fill sequences is complete, as well as subsurface structural maps.

A follow-on proposal to conduct a soil gas geochemical analysis of the reservation has been approved and the contract was received in late August, 1998. Two Native American students were hired to help with this survey; one was a Northern Cheyenne student from Rocky Mountain College, Billings, Montana, and the other was a Crow student from Little Big Horn College, the Crow tribal college. Leads identified by subsurface data and mapping were evaluated using soil-gas geochemistry. The sampling program began in early June and was completed early in August, 1999. A significant soil hydrocarbon geochemical anomaly was identified in one of the geologic leads, the Crow Agency prospect. Follow-up sampling was necessary because the western edge of the anomaly was not defined. The follow-up sampling was completed, as well. The anomaly appears to represent a subsurface hydrocarbon accumulation because no surface conditions can explain the soil hydrocarbon values.

The final report for this project has been completed and was released at a technology transfer workshop on October 24 and 25, 2000. About 50 participants, including Bureau of Indian Affairs employees, Crow and Northern Cheyenne Tribal government employees and Petroleum industry professionals attended the workshop. The tribes are now in the process of determining how they want to structure exploration deals with industry.

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with a chapter on
Soil Hydrocarbon Evaluation of the Crow Indian Reservation

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produced in cooperation with the U.S. Department of Energy,
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Contents

Figures

Appendixes

Abstract

Evaluation of the Lower Cretaceous Greybull Sandstone on the Crow Indian Reservation for potential stratigraphic traps in the valley-fill sandstone was the focus of this project. The Crow Reservation area, located in south-central Montana, is part of the Rocky Mountain Foreland structural province, which is characterized by Laramide uplifts and intervening structural basins. The Pryor and Bighorn mountains, like other foreland uplifts, are characterized by asymmetrical folds associated with basement-involved reverse faults. The reservation area east of the mountains is on the northwestern flank of the Powder River Basin. Therefore, regional dips are eastward and southeastward; however, several prominent structural features interrupt these regional dips.

The nearly 4,000 mi^2 reservation is under explored but has strong potential for increased oil and gas development. Oil and gas production is well established in the Powder River Basin of Wyoming to the south as well as in the areas north and west of the reservation. However, only limited petroleum production has been established within the reservation. Geologic relations and trends indicate strong potential for oil and gas accumulations, but drilling has been insufficient for their discovery.

The Greybull Sandstone, which is part of the transgressive systems tract that includes the overlying Fall River Sandstone, was deposited on a major regional unconformity. The erosional surface at the base of the Greybull Sandstone is the +100 Ma, late Aptian–Early Albian regional unconformity of Weimer (1984). This lowstand erosional surface was controlled by a basin-wide drop in sea level. In areas where incised Greybull channels are absent, the lowstand erosional unconformity is at the base of the Fall River Sandstone and equivalent formations.

During the pre-Greybull lowstand, sediment bypassed this region. In the subsequent marine transgression, streams began to aggrade and deposit sand of the lower Greybull Sandstone. With continued transgression, the Greybull fluvial sand graded upward into marginal marine (probably estuarine) sand (upper Greybull) and finally was capped by marine shale and the Fall River Sandstone. Subsurface mapping, incorporated with surface data, has revealed five major Greybull channels crossing the Crow Reservation.

The Greybull Sandstone is a proven petroleum reservoir in the Crow Reservation region. Greybull combination traps require the presence of channel sandstone as well as structural closure. With sparse reservation well control, subsurface structural and isopach maps are highly interpretive. Three potential Greybull exploration leads were identified where possible structural closures are coincident with mapped Greybull channels: the Little Woody, Woody Dome, and Crow Agency prospects. Of these, the Crow Agency prospect was confirmed by a significant soil-gas anomaly and appears to have the greatest probability of having trapped a hydrocarbon accumulation.

Introduction

The Crow Indian Reservation is situated in south-central Montana, south and southeast of Billings. The Crow Tribe holds the mineral rights for an area to the north, called the *ceded area*, which was removed from the reservation for homesteading. This project study area includes the reservation proper and the ceded area (figure 1). The reservation lies at the northern end of the Powder River Basin, within the Laramide Foreland structural province. It covers a 4,000 mi^2 area and has many known mineral resources and strong potential for increased development.

Oil and gas production is well established in the Powder River Basin of Wyoming to the south as well as in the areas north and west of the reservation; however, the reservation only has limited production. Well-density comparisons, inside and outside the reservation, clearly indicate this area is under explored (plate 1). Well control is more limited when depth-of-penetration is considered. Many reservation exploration wells only penetrate Upper Cretaceous and younger rocks that are not zones of interest to this project (figure 2). Geologic relations and trends indicate that oil and gas accumulations should be present on the reservation, but drilling has been insufficient for their discovery. The primary purpose of this project is to identify exploration leads that the Crow Tribe can present to potential industry partners and stimulate exploration.

Research Objectives

The focus of this project was to explore for stratigraphic traps that may be present in valley-fill sandstone at the top of the Lower Cretaceous Kootenai Formation (figure 3). This sandstone interval, generally known as the Greybull Sandstone,

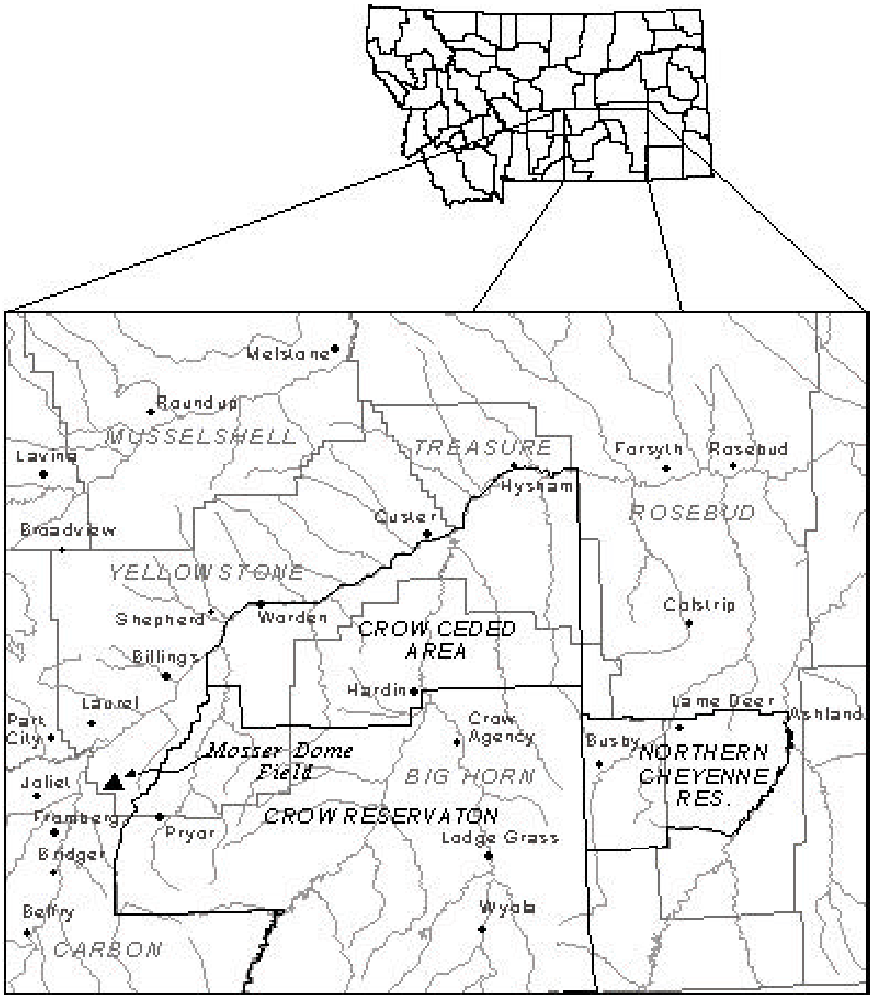

Figure 1. Location and index map of the Crow Reservation Area.

has been identified along the western edge of the reservation (Shelton 1972) and is a known oil and gas reservoir in the surrounding region. The Greybull Sandstone was chosen as the focus of this research because it is an excellent, well-documented, productive reservoir in adjacent areas, such as Elk Basin; Mosser Dome field (Hadley 1954), a few miles northwest of the reservation (figure 1); and several other oil and gas fields in the northern portion of the Bighorn Basin (Stone 1986).

Researchers first located, measured, and described in detail all Greybull Sandstone exposures along the margins of the Pryor and Bighorn mountains. Next, paleocurrent data were collected from dip directions of planar cross stratification. Surface data were incorporated with subsurface data that were collected from all project area oil and gas exploration wells that penetrate the stratigraphic interval of interest. Isopach maps of the Greybull valley-fill interval were then constructed to define the occurrences and trends of Greybull channels. The project area isopach map (plate 2) in conjunction with the structure-contour map (plate 1), which was drawn on the Dakota Silt (a commonly used subsurface marker, see plate 3), were used to identify potential exploration leads. Plates 1, 2, and 4 only show wells that penetrated at least to the level of the Dakota Silt marker. Finally, the identified leads were tested, using a surface soil-gas, geochemical technique.

Structural Geology

The Crow Reservation area is part of the Rocky Mountain Foreland structural province, which is characterized by basement-involved Laramide uplifts and intervening structural basins. The Pryor and Bighorn mountains, like other foreland uplifts, are characterized by basement-involved reverse faults and associated asymmetric folds. They are part of the Pryor-Bighorn structural block (Lopez 1995, 1996), which includes the Bighorn and Pryor mountains and the structurally elevated area north of the mountains that is bounded on the northwest by the Fromberg fault zone and on the northeast by the Wildhorse monocline (figure 4) (Lopez 1995). The Wildhorse monocline is the northwestward extension of folds that forms the northeastern flank of the Bighorn Mountains. The Wildhorse monocline and the Bighorn Mountains folds are fault-propagation folds (McConnell 1994) that resulted from displacement on basement-involved reverse faults (figure 5).

The Pryor Mountains consist of four, uplifted structural blocks. Subsequent erosion exposed various structural levels within the four blocks (Lopez 1996). The fault-propagation model of McConnell (1994) can be applied to all blocks. In two blocks, the basement-involved reverse fault is exposed, but in the others, only folding at shallower structural levels is exposed. Faulting that produced the four differentially uplifted blocks was probably controlled by pre-existing basement zones of weakness. The northern and southern blocks are separated by the eastward extension of the Nye-Bowler fault zone, on which strike-slip and later dip-slip movements have occurred. As suggested by the similar eastward trend, faults along

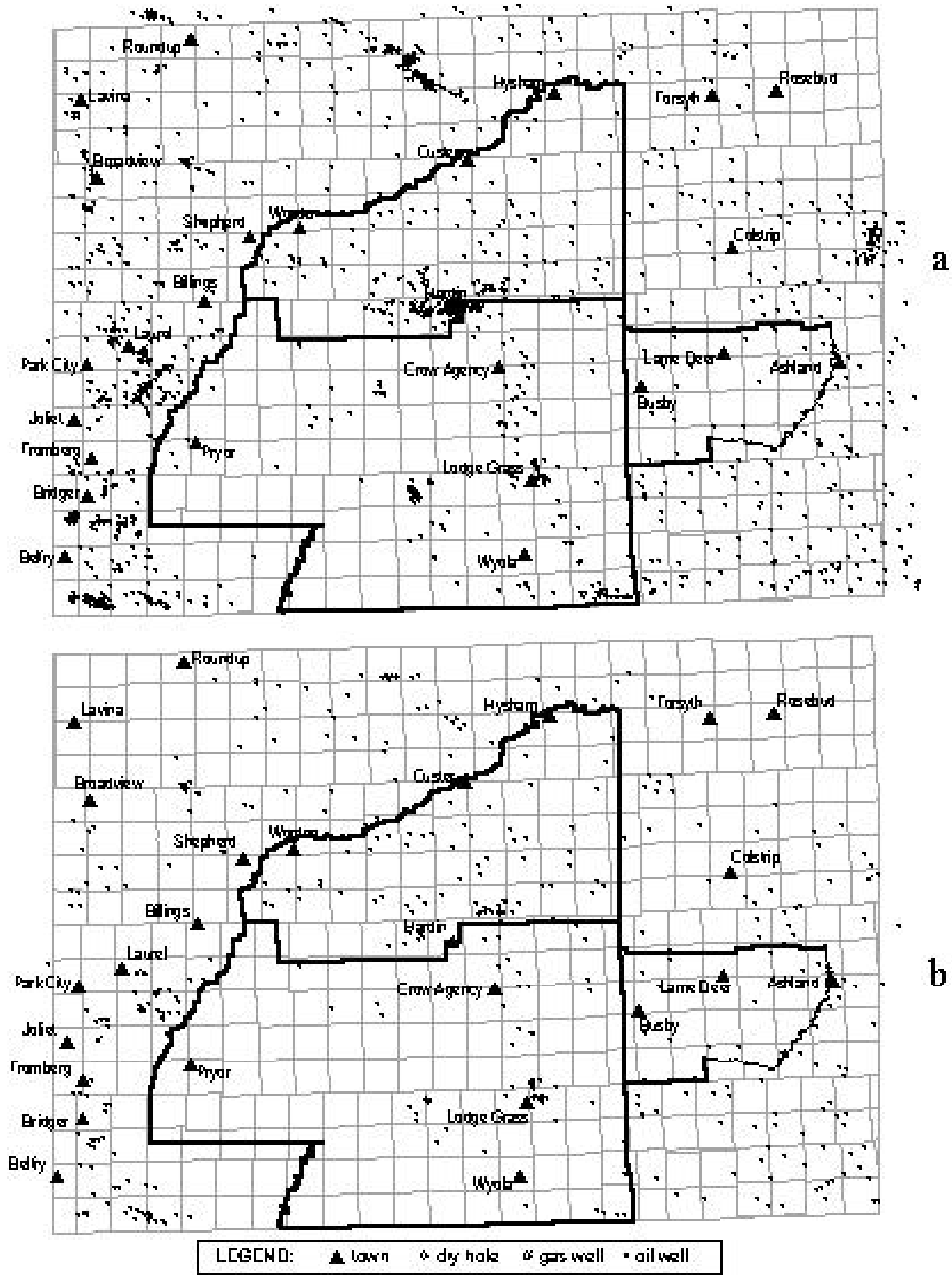

Figure 2. Comparison of drilling density at shallow levels (a) and stratigraphic levels (b) of the Dakota Silt.

the northern mountain front also may be reactivated along older basement zones of weakness. In addition, north and northeast-striking faults that splay off of the Nye-Bowler fault zone appear to merge with these east-trending, range-front faults.

Uplift along basement-involved, curved reverse faults that flatten at depth is required by the fault-fold relationships. Straight surface traces indicate the faults must be steep at the surface (Lopez 2000a). Regional tectonic and structural models developed in other Laramide uplifts from drilling and seismic data indicate that the faults flatten at depth. Structural block rotation caused the westward tilt of the Pryor Mountains uplifted blocks and further supports the model of uplift along curved fault surfaces (figure 5). The western margins of the Pryor Mountains are not

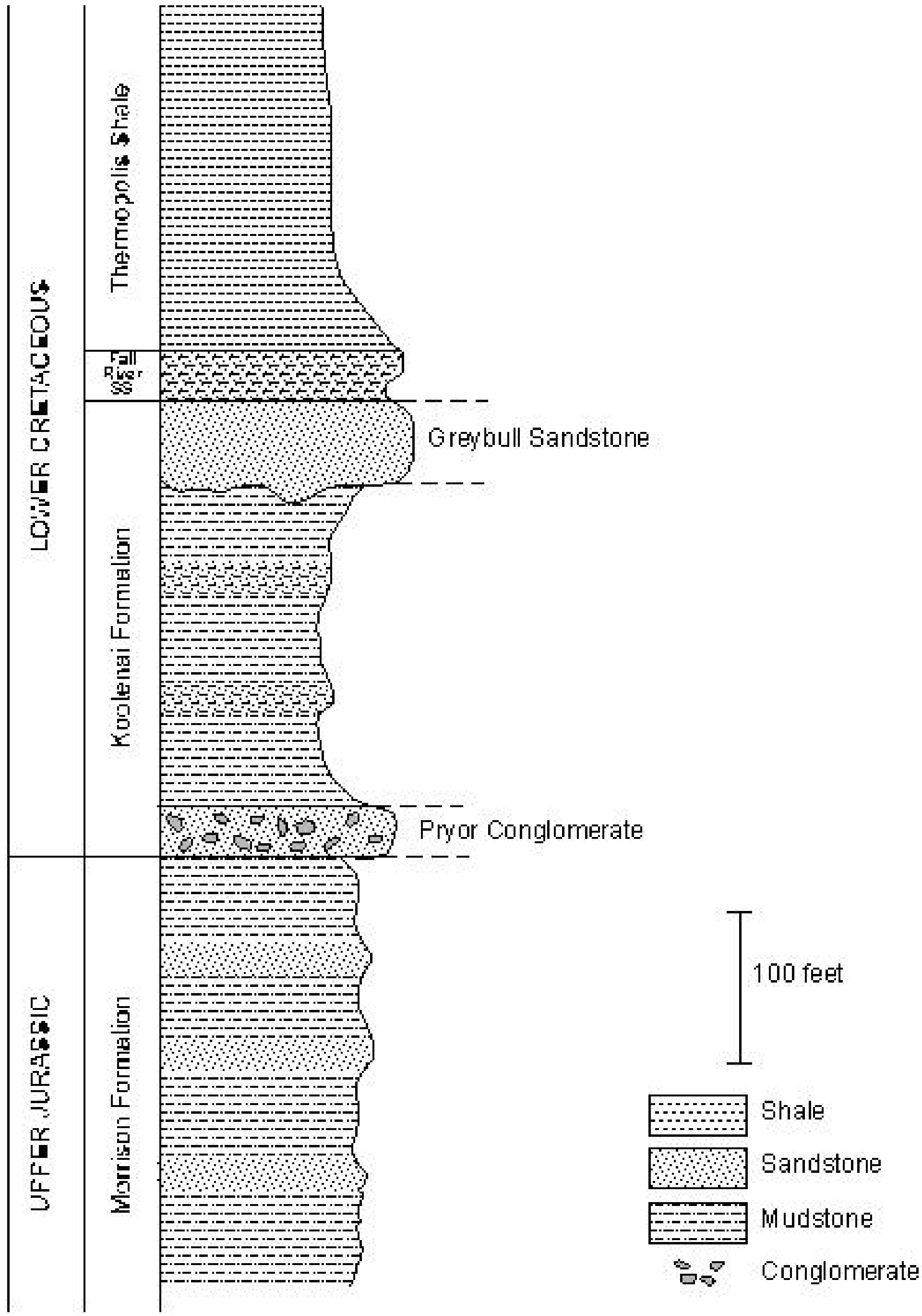

Figure 3. Stratigraphic relationships of the Kootenai Formation and Greybull Sandstone.

fault controlled, instead bedding surfaces, primarily of the Madison Group, form a dip slope into the Bighorn Basin.

On the Crow Reservation, the northern Bighorn Mountains can be described as a broad uplift bounded on the east and west by steep monoclines that plunge northward into the subsurface. The basement-involved, fault-propagation fold model describes the structural geometry along both mountain fronts. The folds along the eastern front of the Bighorn Mountains are probably underlain by a blind reverse fault that flattens with depth (Vuke *et al.* 2000a). The western flank is a fault-propagation fold that resulted from movement along a blind thrust that is probably a back thrust off the main eastward-verging thrust fault (figure 5).

Structural Geology in the Crow Reservation Subsurface

East of the mountains, the reservation area is on the northwestern flank of the Powder River Basin;

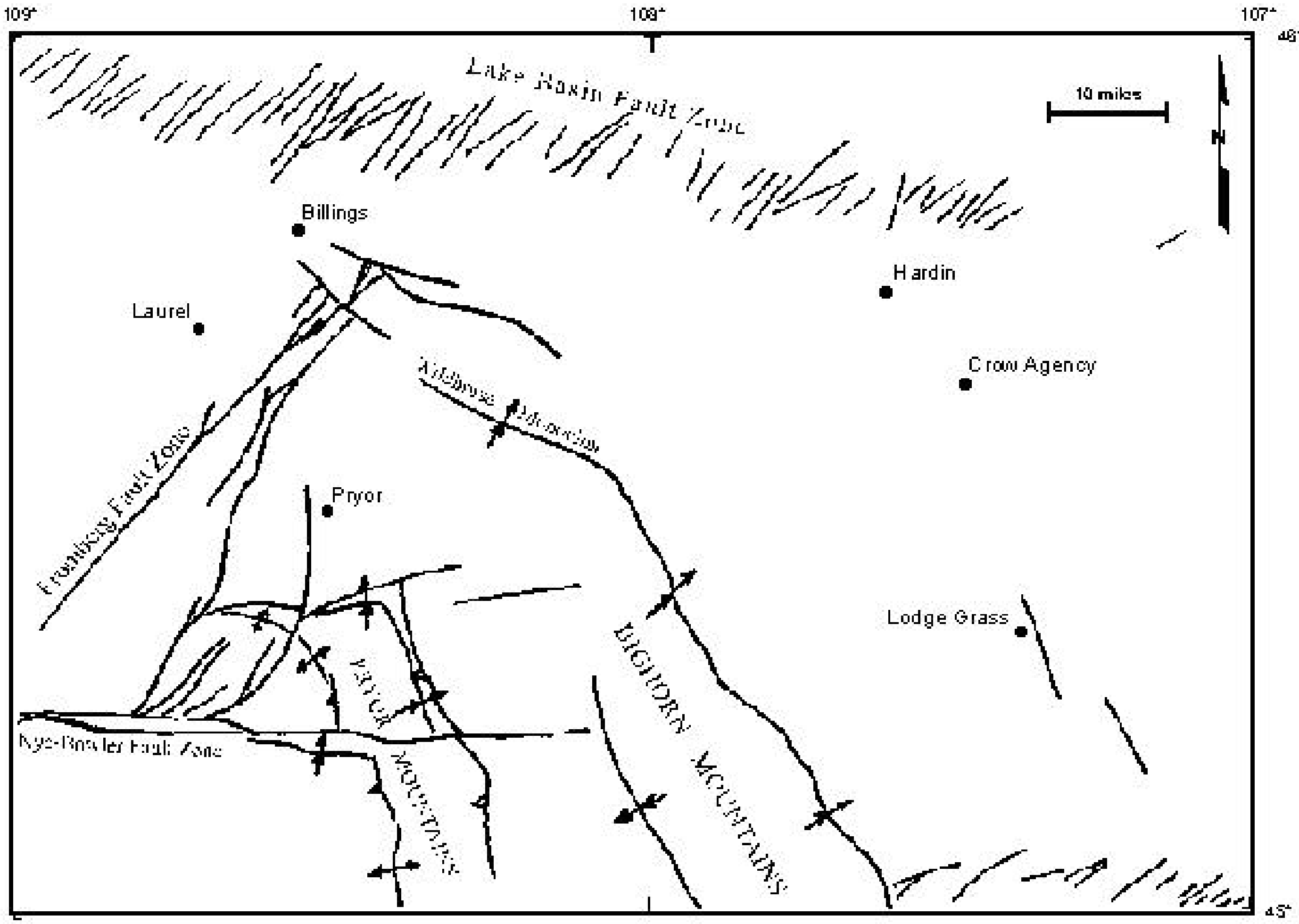

Figure 4. Generalized tectonic map of the Crow Reservation area, after *Lopez (2000a, b) and Vuke* et al. *(2000a, b).*

therefore, regional dips are eastward and southeastward. However, several prominent structural features interrupt these regional dips.

Several folds that roughly parallel the Bighorn Mountain front (Rotten Grass, Soap Creek, and Woody Creek domes) are probably the result of blind reverse faults (plate 1). On the structure contour map (plate 1), Rotten Grass Dome is associated with a reverse fault on the eastern side because of the abrupt tightening of contour spacing. Although at the level of the Dakota Silt, no fault was apparent in the structural elevations at Soap Creek Dome (plate 1); a blind reverse fault is probably present at depth. Similarly on trend to the north, Woody Creek Dome is most likely the result of a blind reverse fault at depth. This structural pattern is common along the western margins of the Bighorn and the Powder River basins.

The Lake Basin fault zone is a prominent, west northwest–trending feature north of the reservation boundary. At the surface, short northeast-trending, en echelon normal faults and folds characterize the zone. At the level of the Dakota Silt (plate 1), this fault zone has structural relief of about 1,000 ft, with the southern block uplifted. The Lake Basin fault zone is generally considered a right-lateral, strike-slip fault system. However, structural mapping presented here (plate 1) indicates oblique slip or differential movement at various times to produce the vertical structural relief.

An important northwest-trending fault extends from T. 9 S., R. 38 E. to T. 2 S., R. 34 E. on plate 1. It is mapped at the surface in the Lodge Grass area (Vuke *et al.* 2000a). Although well control is sparse, the fault's extension to the north and south is interpreted in the subsurface, based on the tight structure contours that would be required without the fault. In the Lodge Grass area, this fault has about 1,000 ft of structural relief at the level of the Dakota Silt. The trend of this fault, parallel to the Rotten Grass–Soap Creek trend, suggests that it is probably a reverse fault as well. Based on fault-fold models in

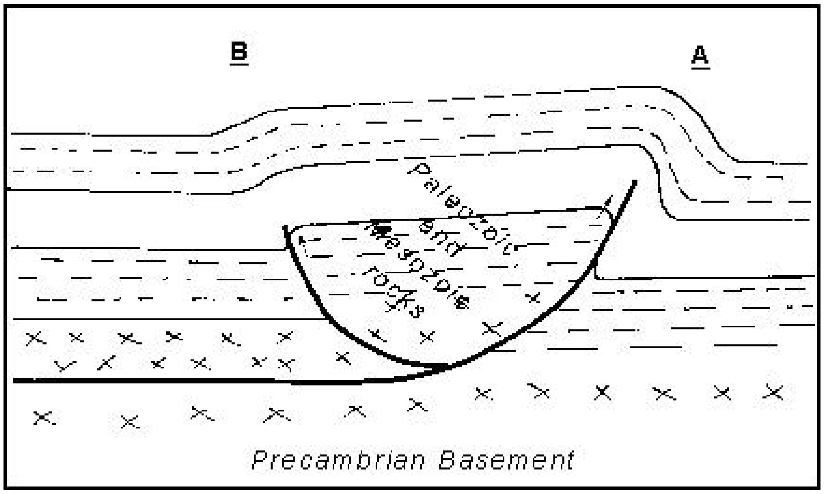

Figure 5. Fault-propagation fold structural model for foreland uplifts in the Crow Reservation area. Area "A" illustrates the fault-fold relationship of the Pryor Mountains and the eastern side of the Bighorn Mountians. Area "B" illustrates the relationships on the western side of the Bighorn Mountains. Brittle basement deformation is by shear along closely spaced fractures in contrast to plastic deformation in the overlying sedimentary section. Modified after *McConnell (1994).*

other foreland basins, asymmetrical folds may be associated with the uplifted block of this fault and could provide traps for oil and gas accumulation.

The structure of the reservation area, therefore, can be described as Laramide basement-involved, fault-propagation folds along the margins of the mountain uplifts and around the flanks of the Powder River Basin. Otherwise, regional dips are east and east–southeast toward the Powder River Basin axis (plate 1).

Stratigraphy of the Greybull Interval

History of Stratigraphic Nomenclature

The Greybull Sandstone occurs at the top of the Kootenai Formation (figure 3), and most previous investigators have included it in the Kootenai, or Cloverly Formation (Wyoming terminology). The stratigraphic name, Greybull, was a drillers' term applied in the subsurface of the northern Bighorn Basin of Wyoming (Lupton 1916). It was named in 1907 in an oil field near the town of Greybull, Wyoming, where gas was discovered in the Greybull Sandstone (Bartow-Campen 1986). The name originates from Grey Bull, a chief of the Crow Tribe. In the early settlement days of the northern Bighorn Basin, Grey Bull's band of Crows spent winters in the present area of Greybull, Wyoming. The Crows and the early settlers became friends. Because of that friendship, when the population grew large enough for the organization of a town, it was named in honor of Chief Grey Bull.

Hewett and Lupton (1917) formally named the Greybull Sandstone after exposures near Greybull, Wyoming, and designated it as the uppermost member of the Cloverly Formation. Confusion remains as to the original application of the name, Greybull, to fluvial lenticular sandstone at the top of the Kootenai Formation or to marine sandstone above the Kootenai that correlates with the Fall River Sandstone (Dakota and Sykes Mountain formations).

Moberly (1960) divided the Cloverly into three members: the basal Pryor Conglomerate Member, Little Sheep Mudstone, and Himes Member. His upper Himes Member is correlative with the Greybull Sandstone. The Little Sheep Mudstone is primarily variegated bentonitic mudstone; colors are mostly medium gray, pale reddish brown, and pale purple gray. The lower Himes is nonbentonitic, mostly gray, pale greenish-gray, and yellowish-brown mudstone interbedded with minor lenticular, salt and pepper, pale greenish-gray sandstone. The upper Himes (Greybull) is fine- to medium-grained, well-sorted, well-rounded quartz sandstone that is commonly planar cross-bedded. Above the Cloverly Formation, Moberly (1960) named rock equivalent to the Fall River Sandstone, the Sykes Mountain Formation. This rock is thin-bedded, fine-grained, argillaceous quartz sandstone and interbedded, medium-gray fissile shale. The sandstone is typically hematitic or limonitic, which led to the early drillers' designation as the *rusty beds*. Marine fossils and trace fossils are common in the Sykes Mountain Formation.

Kvale (1986) and Kvale and Vondra (1993) referred to the Greybull Sandstone as the Upper Himes Member of the Cloverly Formation, following the terminology of Moberly.

The name, Greybull Sandstone, is generally used in the Crow Reservation region by most area geologists; however, Balster (1971) recommended it not be used outside the northern Bighorn Basin (Bartow-Campen 1986, Shelton 1972, John

Mitchell personal communication 1996–2000, and Steve Van de Linder personal communication 1999).

Crow Reservation Stratigraphic Relationships

The Greybull Sandstone Interval on the Crow Reservation has stratigraphic relationships similar to those described in the northern Bighorn Basin by Kvale (1986) and Kvale and Vondra (1993). In the reservation area, the unconformity at the base of the Greybull corresponds to erosional valleys incised into the portion of the Kootenai Formation that is equivalent to the Little Sheep Mudstone, Cloverly Formation of Moberly (1960). This rock is bentonitic, pale red, pale grayish-purple, and gray mudstone. The Kootenai Formation is 250–300 ft thick in areas between channels (see measured sections at Bear Coulee and Rotten Grass Creek, north; appendix A).

In the reservation area, either because of nondeposition or erosion, there is no interval in the Kootenai Formation equivalent to the volcaniclastic Lower Himes Member, Cloverly Formation of Moberly (1960). The generalized sequence of units from the base of the Kootenai Formation is 1) Pryor Conglomerate: brown and brownish-gray, coarse-grained, pebbly sandstone and conglomerate generally about 25–75 ft thick but thinning to a few feet near the Wyoming border on the eastern side of the Bighorn Mountains; 2) bentonitic, pale red, grayish-purple, and gray mudstone, containing thin, interbedded, lithic sandstone and cherty, nodular limestone; 3) Greybull Sandstone (where present): typically a lower fine- to medium-grained, well-sorted, well-rounded, planar cross-bedded quartz sandstone up to 150 ft thick, an interval of brownish-gray marine shale about 20 ft thick, and an upper sandstone about 10–40 ft thick that is similar to the lower sandstone; and 4) Fall River Sandstone: a basal marine shale interval up to 30 ft thick that grades upward into thin-bedded, fine-grained, argillaceous, brownish-gray, fossiliferous, limonitic and hematitic, quartz sandstone interbedded with thin, dark-gray shale (total thickness 75–100 ft).

Outside Greybull channel areas, the erosional unconformity occurs at the base of the Fall River Sandstone, where it rests directly on Kootenai Formation mudstone (figure 6). The erosional unconformity is placed at the change from variegated continental deposits of the Kootenai Formation to dark-gray marine shale at the base of the Fall River Sandstone. In Greybull channel areas, the unconformity is marked by a bleached interval up to six feet thick in the Kootenai mudstone.

The Greybull channels identified on the Crow Reservation are sand filled within the lower Greybull portion of the interval, which is as much as 150 ft thick. The base of the lower Greybull Sandstone has rip-up clasts, wood fragments, and a small amount of pebbles locally. The sandstone is fine- to medium-grained, well-sorted, quartzose, with large-scale planar cross-bed sets, one to five feet thick (figure 7). Generally, the sandstone is light-brownish gray because of speckled limonite stain. The cross-beds are strongly unidirectional and are locally over steepened to overturned in the down-flow direction (figure 8); downgradient slumping or current drag on unconsolidated beds may have caused the over steepening.

Similar cross-bedding features are common in the Big Horn Basin Greybull Formation (Kvale and Vondra 1993). Commonly, the variation of cross-bed dip directions from the mean is 30° or less (see appendix B). The overlying upper Greybull includes an interval of brownish-gray fissile shale about 10–20 ft thick that is overlain by cross-bedded, fine-grained sandstone similar to that of the lower Greybull Sandstone. Locally, some horizontal, parallel laminations and bioturbation occur at the top of bed sets in the upper Greybull Sandstone. The maximum channel-fill thickness was measured in a well that was drilled in section 3, T. 8 S., R. 34 E., where the Greybull interval is 215 ft thick.

The geometry and character of the fluvial sandstone indicate deposition in nearly straight, fluvial-dominated channel systems (Kvale and Vondra 1993). The presence of gray fissile shale, parallel lamination, and local bioturbation at the top of the upper Greybull Sandstone indicates the beginning of marginal marine deposition, probably estuarine. Marine influence, at least in the upper Greybull and equivalent rock, has also been proposed by Kvale and Vondra (1993) and Mathison (1999).

Regional Sequence Stratigraphic Relationships of the Greybull Sandstone

Recent work in the Cretaceous rock of the western interior basin, including the results of the research reported here, leads to the conclusion that the Greybull Sandstone is part of the transgressive systems tract (terminology of Van Wagoner *et al.* 1990) that includes the Fall River Sandstone and lies above a major, regional unconformity (Haun and Barlow 1962, Weimer 1984, Kvale and Vondra 1993, Way *et al.* 1994, Mathison and White 1999). This unconformity is the ±100 Ma, late Aptian–early Albian regional unconformity of Weimer (1984) and Sequence

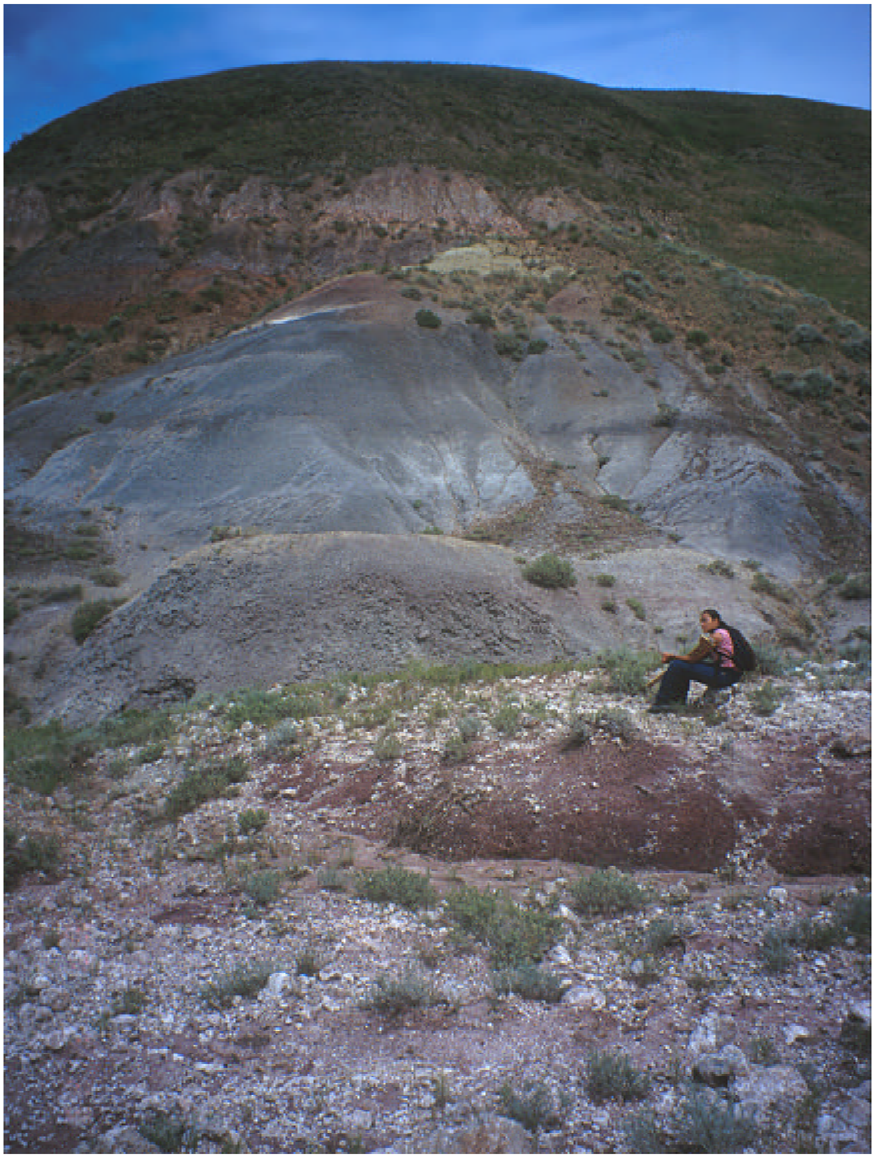

Figure 6. Kootenai and Fall River section outside Greybull channel area. The regional unconformity is at the base of the Fall River Sandstone. (North Rotten Grass measured section)

Similar relationships for the Greybull interval and equivalent rock are evident in the Powder River and Bighorn basins across Montana and in Saskatchewan (Kvale and Vondra 1993, Way *et al.* 1994, Mathison and White 1999, Mathison 1999). Regional stratigraphic relationships are shown in figure 9. Analysis of sparse microflora in samples from within the Greybull interval yield ages of Middle to Early-Late Albian (Lloyd Furer personal communication 1999, Mathison and White 1999, Mathison 1999). Samples from the Crow Reservation project area were barren of microfossils.

Greybull Channel Occurrences

Surface exposures of four separate Greybull channels were identified in the Kootenai–Fall River outcrop belt around the margins of the Pryor and Bighorn mountains on the Crow Reservation (figure 10). Stratigraphic sections of these channel occurrences as well as two sections outside the incised channels were measured and described (appendix A). In addition, planar cross-bedding attitudes were measured at all channel localities to determine transport directions in the channel systems (appendix B). Transport directions are consistently to the west and west-southwest, with the exception of one area that will be described below.

Boundary 1 (SB1) of Porter *et al.(1993),* a lowstand erosional surface controlled by a basin-wide drop in sea level. In areas where incised Greybull channels are absent, the lowstand, erosional unconformity lies at the base of the Fall River Sandstone and equivalent formations. During the pre-Greybull lowstand, sediment bypassed this region, and in the subsequent transgression, streams began to deposit Greybull sand. With the continued transgression, the lower Greybull fluvial sand graded upward to marginal marine sand (probably estuarine) in the upper Greybull that eventually was capped by marine shale. The shale at the base of the Fall River Sandstone represents the initial marine-flooding surface.

Subsurface data were correlated with surface data to define channel distribution in the reservation area. All available data from oil and gas wells drilled to the depth of the Greybull interval were used in subsurface mapping. Isopach maps of the total Greybull valley-fill interval were constructed to interpret the occurrence and likely extent of channels (plate 2). Channel identification in the subsurface was based on geophysical-log character differences as well as standard well-log correlation procedures. Obvious resistivity differences between the Greybull valley-fill and the Kootenai and Fall River rock are shown in plate 3 and figure 11. The Greybull has generally higher resistivity and significant spontaneous potential (SP) log response in addition to the strata truncation as shown by log patterns. Paleocurrent data from surface exposures were used to interpret the most likely correlations of subsurface and surface channel occurrences.

Two subsurface channels were identified on well logs that are not exposed at the surface (figure 10). Two of the channels exposed at the surface appear to merge to result in an interpretation of five major Greybull channels projected beneath the Crow Reservation (figure 10). The channel merging probably represents channel abandonment during the lowstand that produced the valley system.

The Soap Creek channel is the northernmost channel exposed in the outcrop belt and is described by Shelton (1972). Project field work resulted in identification of a much greater channel surface extent than previously described; it is now interpreted to extend about 60 mi. on the surface, from the Soap Creek oil field to just northwest of Pryor, Montana (figure 12).

On the crest of Soap Creek Dome, this channel has been erosionally dissected by Soap Creek. This exposed Greybull section includes 52 ft of the lower Greybull Sandstone, 16 ft of shale, and 10 ft of upper Greybull Sandstone (see Soap Creek oil field measured section, appendix A). At this locality, the basal unconformity is well exposed and is characterized by about six feet of light-gray, bleached mudstone, with fine fractures stained yellow by limonite (figures 13, 14). Below this zone, the Kootenai Formation is reddish-brown and pale red mudstone. Current direction at Soap Creek is west-northwest (figure 12. appendix B).

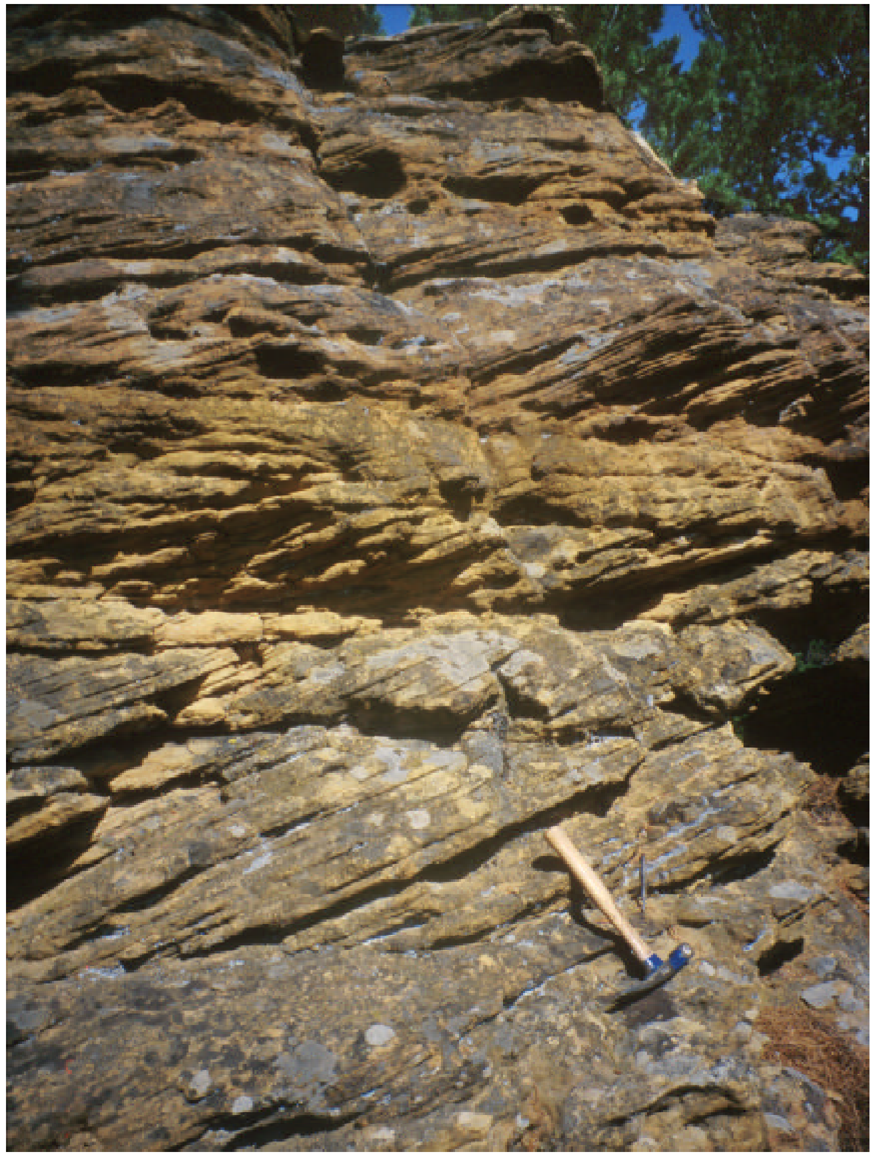

Figure 7. Little Mountain section of the Greybull Sandstone (facing north) shows typical tabular cross-bedding.

The next exposure to the west is in a low hill just south of the town of Yellowtail (formerly Fort Smith). The full Greybull interval is not exposed here, only about the upper 40 ft.

At the top of Little Mountain (figure 12), 100 ft of the lower Greybull Sandstone is well exposed; the top of the section has been eroded. Transport direction from planar cross-bedding attitudes is to the west (figure 12, appendix B).

In the area south and west of Pryor, the Greybull Sandstone is nearly continuously exposed for several miles. A measured section near the channel margin has 50 ft of Greybull Sandstone underlying the Fall River Sandstone (appendix A). The maximum Greybull interval thickness in this area is about 150 ft.

The mapped channel trend is west for several miles and then makes a sharp bend to the north (figure 12). Paleocurrent measurements duplicate this change in trend. South of Pryor, the current directions are westward and then abruptly change to northward (figure 12, appendix B) (Shelton 1972). In the subsurface north of the last surface exposure

Figure 8. Greybull channel sandstone showing over-steepened and overturned cross-bedding in the down-current direction. Location is west of Pryor; view is facing west.

at Cottonwood Creek (northernmost surface exposure marked on figure 12), the channel changes direction again, resuming its westward trend.

Surface geologic mapping in the channel area has identified a fault system that splays off the Nye-Bowler fault zone (Lopez 2000a, b). The abrupt channel-trend change coincides with these faults' location, which suggests they were active during channel formation and controlled channel trend and location (figure 15). Similar rightangle bends of correlative channel-fill deposits in Saskatchewan also are structurally controlled (Mathison 1999, Mathison and White 1999).

Exposures of three additional, major Greybull Sandstone channels occur south of the Soap Creek oil field (figure 10). All are in the steeply dipping hogback along the eastern side of the Bighorn Mountains uplift.

The Deer Creek channel occurs in sections 21 and 22, T. 7 S., R. 32 E., on the northern side of Soap Creek. The channel is about 1.5 mi wide, and the channel-fill is about 150 ft of fine-grained, well-sorted, friable sandstone (see measured section at Deer Creek and upper Soap Creek, appendix A). As in other channel occurrences, planar cross-bedding is prominent. Unlike other channels, this sandstone is argillaceous, causing the rock to be nearly white. Sandstone outcrops form large, white monoliths that are visible for miles. Because of its friable character, a portion of the channel fill is poorly exposed; an interval 80 ft thick within the channel fill is covered near Soap Creek (see Upper Soap Creek measured section, appendix A). The paleocurrent transport direction measured from planar cross-bedding attitudes is west-southwest (Deer Creek, appendix B).

The Rotten Grass Creek channel is well exposed in sections 7 and 18, T. 8 S., R. 33 E., on the southern side of the creek. This channel fill is light brownish-gray, limonite-speckled, fine-grained, well-sorted, cross-bedded sandstone typical of regional Greybull Sandstone. This channel is about two miles wide and about 165 ft thick. Planar cross-bedding yields a paleocurrent transport direction to the southwest (appendix B).

The Lodge Grass Creek channel is about four miles wide, making it the widest channel exposed in the project area. Here the sand-filled channel is typical of regional Greybull Sandstone and has the best exposures in the project area (figure 16). The channel fill is about 175 ft thick (see Lodge Grass Creek measured section, appendix A). Some rip-up clasts and wood fragments occur at the base of the channel fill. Bleached and weathered Kootenai mudstone, below the unconformity, is exposed just north of Lodge Grass Creek. Paleocurrent measurements indicate transport was westward (appendix B).

The apparent southward bend of the Rotten Grass channel probably indicates merging with the Lodge Grass channel to the south. These two channels probably connect with those described in the northern Bighorn Basin of Wyoming (Kvale 1986, Kvale and Vondra 1993) because no outcrops occur on the western side of the Pryor Mountains between a channel just north of the Wyoming border and the westward extension of the channel at Pryor.

In the Crow Reservation subsurface, five major Greybull channels have been interpreted (figure 10, plate 2). The Soap and Deer creeks channels appear to merge in T. 6 S., R. 34 E. The typical geophysical-log character of Greybull channel fill is illustrated by a stratigraphic cross section in the Lodge Grass oil field, which produces from a much deeper level in Pennsylvanian rock (figure 11). With the aid of paleocurrent indicators, the subsurface channel-fill occurrences were correlated with the channels identified at the surface. This interpretation resulted in isopach mapping of five channels, all with east–northeastern trends (transport to the west) (plate 2). A regional-log cross-section shows several channel occurrences and more detailed comparison of channel and nonchannel areas (plate 3). The three southern, subsurface channels surface at Soap, Rotten Grass, and Lodge Grass creeks.

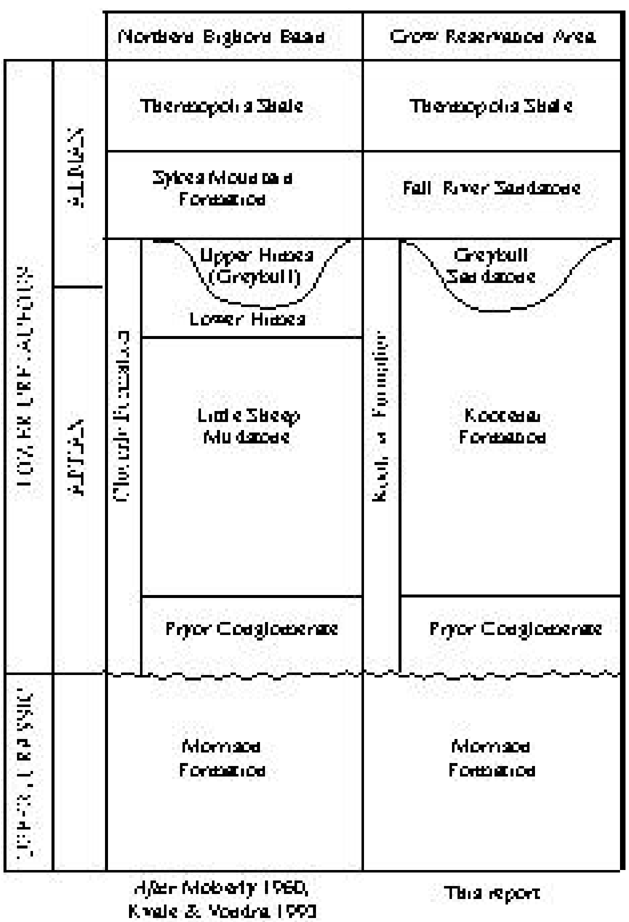

Figure 9. Regional stratigraphic nomenclature and correlations.

The two northern channels are not exposed at surface. One of these channels was interpreted to extend from T. 3 S., R. 30 E. to the edge of the project area in T. 2 S., R. 38 E. Because of the lack of well control, the western channel extension is uncertain; it may connect with the Soap Creek channel in the Mosser Dome oil field area southwest of Billings. This (Crow Agency) channel averages about three miles wide, and the channel fill may be as much as 150 ft thick.

The northernmost channel identified in the subsurface extends from T. 2 N., R. 30 E. to T. 4 N., R. 38 E. at the eastern edge of the project area. Lack of well control makes the western extent uncertain; however, it does not appear to cross an area of relatively dense drilling along the Lake Basin fault zone and may be controlled by the down-dropped side of the fault zone (plate 3). The channel is generally two to three miles wide and has fill up to 100 ft thick.

Petroleum Potential in the Greybull Sandstone

As previously discussed, the Greybull Sandstone is a proven petroleum reservoir in the Crow Reservation region. It produces oil and gas at Mosser Dome, Elk Basin, Golden Dome, and several other fields in the northern Bighorn Basin. Regionally, the Greybull Sandstone has excellent reservoir qualities, up to 30% porosity and up to one darcy of permeability (Bartow-Campen 1986). The Mosser Dome oil field has produced about 400,000 barrels of oil (Montana Board of Oil and Gas Conservation data) from Greybull channel sandstone about 50 ft thick, with a domal structural closure of about 60 acres (Hadley 1954). At Elk Basin, 51.4 billion cubic feet of gas was produced from the Greybull between

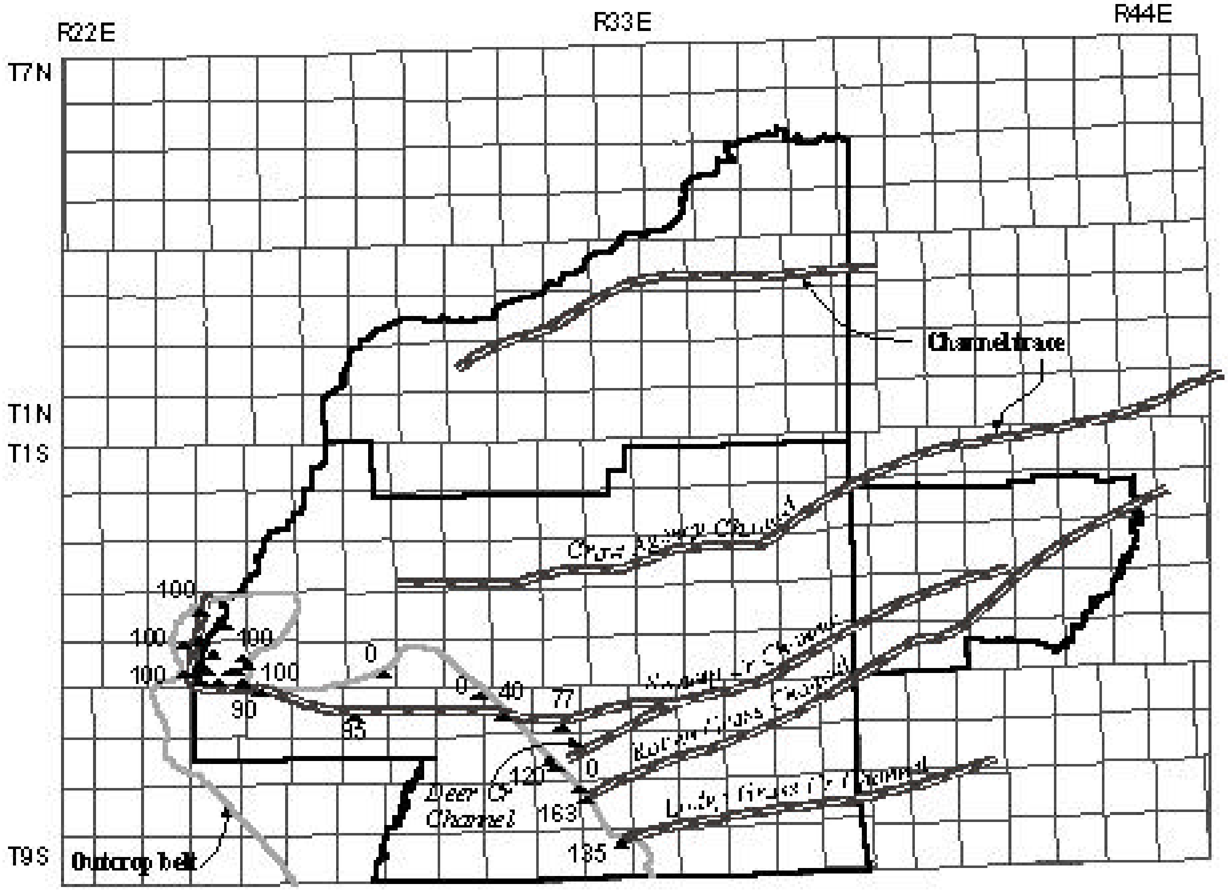

Figure 10. Greybull channel occurrences on the Crow Reservation; triangles along outcrop belt indicate locations of surface exposures examined with thickness (in feet) of corresponding Greybull channel fill.

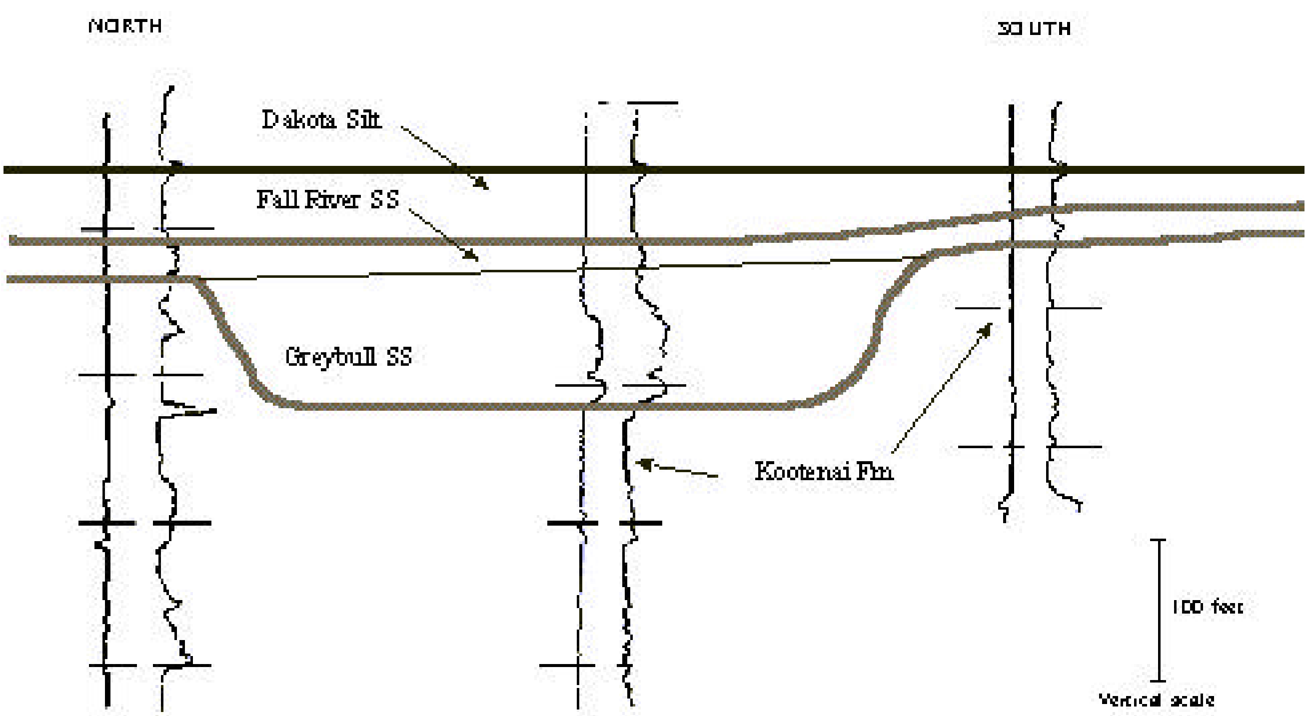

Figure 11. Subsurface log character of Greybull channel at Lodge Grass oil field, Crow Reservation, Montana. Stratigraphic cross section hung on the Dakota Silt marker.

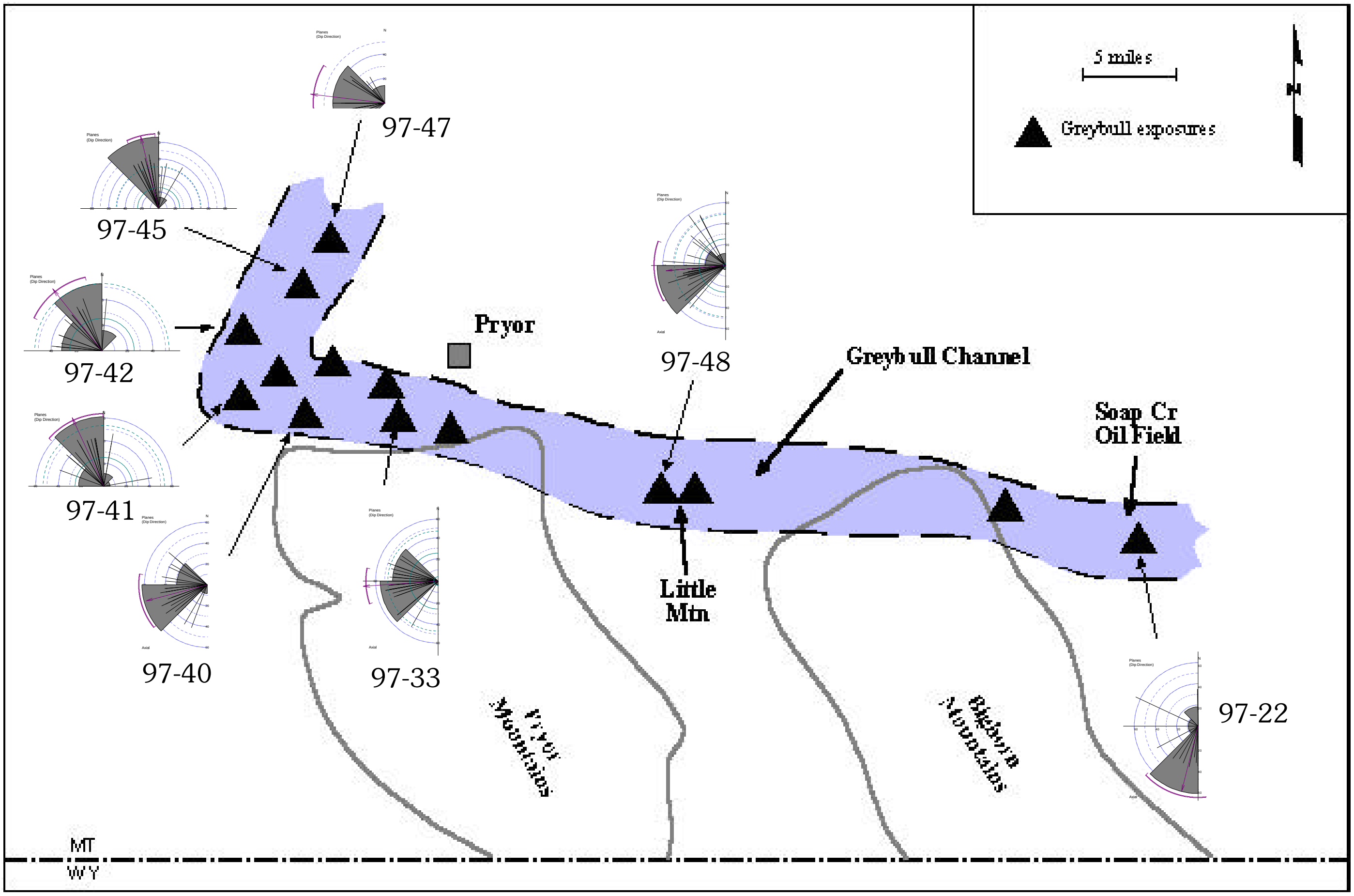

Figure 12. Northernmost Greybull channel surface exposures on Crow Reservation. Rose diagrams indicate transport directions measured from planar cross-bedding attitudes.

1922 and 1949, after which the reservoir was converted to gas storage (Stone 1986). Production was from about 30 ft of upper Greybull Sandstone in a structural closure of about 2,000 acres (Stone 1986). The total Greybull channel fill is up to 150 ft thick in the Elk Basin field area (Stone 1986).

As can be seen in the Elk Basin and Mosser Dome examples as well as other fields in the Bighorn Basin that produce from the Greybull Sandstone, their combination traps require not only the presence of the channel sandstone but also structural closure. In the dome crest at the Soap Creek oil field on the Crow Reservation, the Greybull Sandstone is oil stained and was apparently oil saturated, but it has been breached by erosion along Soap Creek. This is significant in evaluating the Greybull potential on the Crow Reservation because it establishes that 1) oil was generated and migrated into the Greybull Sandstone and 2) an oil accumulation is possible in a favorable structural-trapping configuration.

Therefore, potential Greybull exploration leads on the Crow Reservation were identified where mapped structural closures are coincident with mapped Greybull channels. The identified leads probably will require seismic confirmation because they have poor geologic control.

The structure contour map was constructed on the surface of the Dakota Silt marker, a regional marker about 200 ft above the Greybull interval (plates 1, 3). Because of sparse well control in the project area, surface structural features (Lopez, 2000a, b; Vuke *et al.* 2000a, b), regional structural trends, and foreland fault-fold models were incorporated in the structural interpretation.

Isopach mapping of channel fill resulted in the interpretation of five major channels crossing the reservation (plate 2). The three southern channels come to the surface along the margin of the Bighorn Mountains, and no structures appear to have trapped oil east of the outcrop belt. Resistivity and SP logs from wells that penetrated thick, Greybull valley fill indicate that the sandstones are water saturated in these three channel systems. SP log response is probably due to fresh water in these

Figure 13. Northwest view of the regional unconformity at the base of the Greybull Sandstone (Soap Creek oil field measured section).

Greybull Sandstone wells, which indicates that they probably have been flushed by ground water. In addition, prominent structural closures do not coincide with the valley-fill deposit locations that were not shown to be water saturated.

However, the Crow Agency channel (fourth from the south) appears to have petroleum potential. This channel extends from T. 3 S., R. 30 E. to the eastern boundary of the reservation in T. 2 S., R. 38 E. The Crow Agency channel crosses three structural features that could potentially provide traps for hydrocarbon accumulations.

The Crow Agency lead is defined just west of Crow Agency in T. 3 S., R. 34 E., where it crosses a fault projected into the area that could provide a trap on the downthrown and upthrown sides (plates 1, 2, 4). On the downthrown (east) side, the fault truncation of the east-dipping channel may form a structural trap against the fault. On the upthrown (west) side, similar to the small domal closure on the upthrown side of a Mosser Dome oil-field fault, a structural closure may exist that could trap a hydrocarbon accumulation (plate 4). Assuming a conservative productive area of 640 acres and a reservoir pay thickness of about 50 ft, potential reserves for this lead could be 6.4 million barrels of oil (mmbo).[1]

The Woody Dome lead is a few miles west, where the Crow Agency channel crosses Woody Dome in T. 3 & 4 S., R. 31 E. (plates 1, 2, 4). The potential closure is 100–200 ft where the channel crosses the structure. Assuming 640 productive acres and 50 ft of net sandstone reservoir thickness, the potential reserves could be 6.4 mmbo. However, two wells on the western flank of the structure indicate that it could be barren; but because this area is only about 10 miles from outcrops along the Bighorn uplift, hydrodynamic offset of the accumulation east of the structural crest would be expected.

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1 This number is based on a recovery factor of 200 barrels of oil per acre-ft derived from Mosser Dome, which produced 400,000 barrels of oil from 60 acres and 30 ft of pay; recovery factor of 222 barrels of oil per acre-ft.

At the Little Woody lead in T. 3 S., R. 30 E., the Crow Agency channel crosses a small anticlinal nose that extends northeastward from the Wild Horse monocline (Lopez 1995) (plates 1, 2, 4). About 100 ft of closure is possible on this structure. Assuming a productive area of 320 acres and a reservoir thickness of 50 ft, potential reserves could be 3.2 mmbo.

The northernmost channel does not appear to cross any significant structural closures, therefore, no leads in that channel have been identified (plates 1, 3).

Because well control is limited, soil-gas, geochemical-lead evaluations were conducted to provide additional confirmation of their potential. The soil-hydrocarbon geochemical data confirm the identified leads' potential, especially for Crow Agency. Discussion of these results is provided in the final section of the report.

Figure 14. Close up view of the base of the Greybull Sandstone unconformity (Soap Creek oil field measured section).

Conclusions

The Lower Cretaceous Greybull Sandstone was evaluated for potential stratigraphic traps in valley-fill sandstone. The Greybull Sandstone is part of the transgressive systems tract (terminology of Van Wagoner *et al.* 1990) that includes the Fall River Sandstone and lies above a major regional unconformity. The ±100 Ma, late Aptian–Early Albian regional unconformity of Weimer (1984), a lowstand erosional surface that lies at the base of the Greybull Sandstone, was formed by a basin-wide sea level drop. In areas where incised Greybull channels are absent, the lowstand erosional unconformity lies at the base of the Fall River Sandstone. During the pre-Greybull lowstand, sediment bypassed this region. In the subsequent transgression, streams began to aggrade and to deposit Greybull sand. With the continued transgression, the Greybull fluvial sand graded upward into marginal marine (probably estuarine) sand and finally was capped by marine shale. Subsurface mapping incorporated with surface data has revealed five major Greybull channels crossing the Crow Reservation (figure 10).

The Greybull Sandstone is a proven petroleum reservoir in the Crow Reservation region. As can be seen in the Elk Basin and Mosser Dome examples as well as other Bighorn Basin fields, Greybull production is from combination traps that require not only the presence of channel sandstone but also structural closure. Therefore, potential Greybull exploration leads on the Crow Reservation were identified where mapped structural closures are coincident with mapped Greybull channels. Three exploration leads were identified: the Little Woody, Woody Dome, and Crow Agency. Of these, the Crow Agency lead was confirmed by a significant, soil-gas anomaly and appears to have the greatest probability of trapped hydrocarbons.

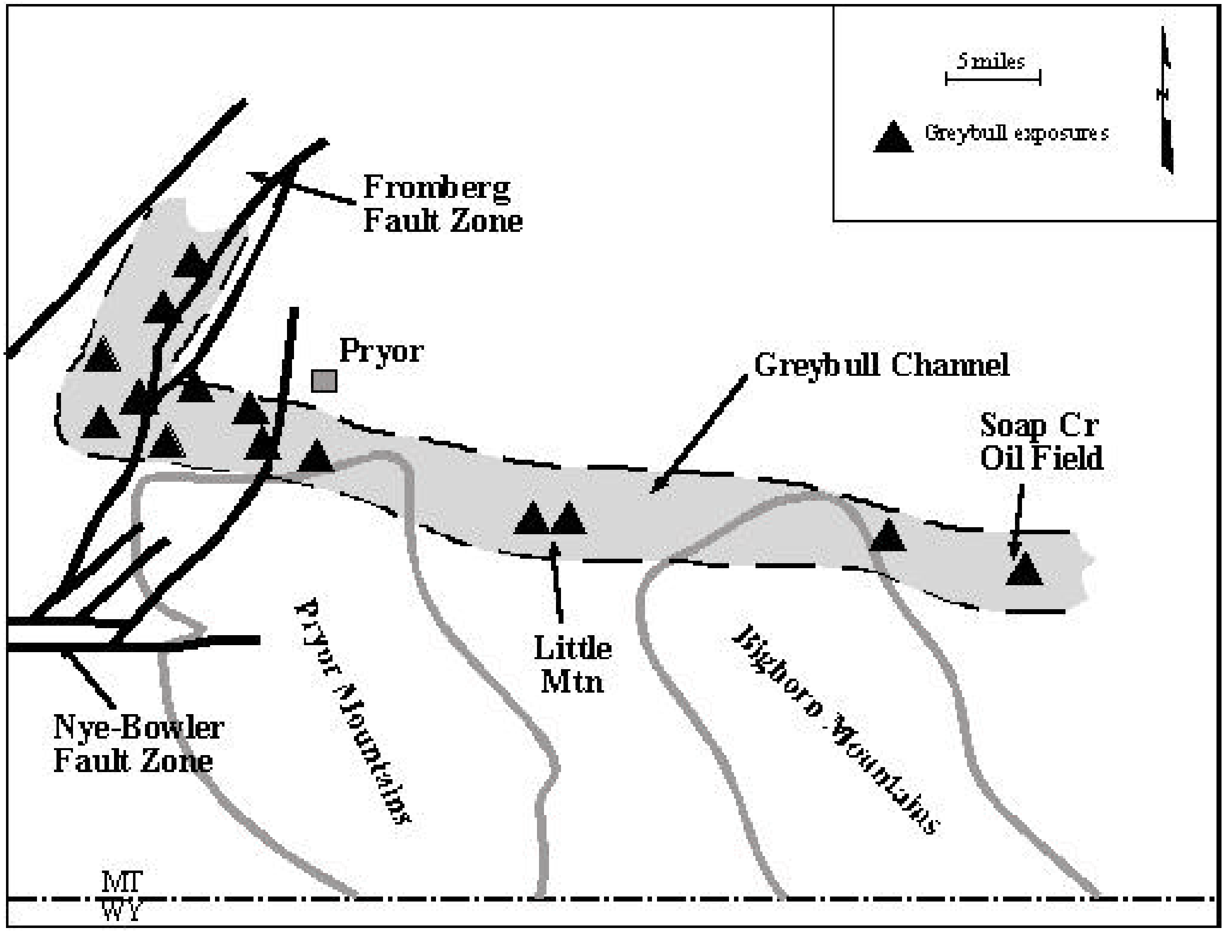

Figure 15. Structural control on Greybull channel trend shown in figure 12 in the Pryor area. See figure 12 for paleocurrent data within the channel.

Soil Hydrocarbon Evaluation of the Crow Indian Reservation

Introduction

Surface geochemical procedures have been used for oil and natural gas exploration for more than 50 years (Horvitz 1981). These methods involve analysis of free-gas in in-place soils or analysis of soil samples for indicators of subsurface oil and natural gas accumulations. Numerous procedures have been developed. We used the ead-space gas method described by Vice and Hallek (1999), which directly detects light alkanes (methane, ethane, propane, and butane + pentane) that have leaked from the reservoir. These light hydrocarbons appear to migrate from the subsurface reservoir to the surface because their low density makes them buoyant.

Surface geochemical procedures are used are used to locate trace amounts of alkane hydrocarbons in the soil that represent leakage from an oil or gas reservoir. These relatively inexpensive methods can be used to focus more expensive exploration methods, such as three-dimensional seismic surveys.

Statistical procedures were used in this study to separate unusual or anomalous light alkane concentrations in the soil from the normal background amounts. Other investigators have used pattern recognition for evaluation (see Klusman 1993, Tedesco 1995).

Although surface geochemistry has been used in oil and natural gas exploration for many years, it has not been widely accepted. In some cases, the results have been difficult to interpret, and repeat surveys were inconsistent. In addition, many people are reluctant to accept that light hydrocarbons, such as methane, ethane, propane, and butane, migrate from the reservoir to the surface through several thousand feet of sedimentary rock.

Figure 16. Greybull channel exposure; view is north across Lodge Grass Creek.

However, numerous examples of light hydrocarbon soil anomalies due to microseepage from subsurface hydrocarbon accumulations have been documented. Saunders *et al.* (1999) provide an excellent summary of research that documents vertical hydrocarbon microseepage (see also Schumacher and Abrams 1996). Several studies document hydrocarbon soil anomalies directly above producing reservoirs that were defined seismically and geologically (Rice 1986, Price 1993, Saunders *et al.* 1993). Carbon isotopes also provide evidence of vertical migration of light hydrocarbons. Soil-gas hydrocarbons have carbon-isotope ratios similar to those of subsurface hydrocarbon accumulations. In contrast, biogenic gas in the near surface has carbon isotope ratios that greatly differ from those derived from subsurface hydrocarbon accumulations (Horvitz 1981, Reitsema *et al.* 1981, Stahl *et al.* 1981, Saunders *et al.* 1999).

Hydrocarbon microseepage from subsurface petroleum accumulations most likely "involves buoyant colloidal-size microbubbles of light hydrocarbons (principally methane through butane) ascending relatively rapidly through a water-filled network of fractures, joints, and bedding planes" (Saunders *et al.* 1999, p. 170).

Survey Procedures

Lines A through G were designed to test the Little Woody, Woody Dome, and Crow Agency leads (see locations on plate 5). About 900 samples were collected and analyzed in this evaluation (data are tabulated in appendix C).

The survey procedure used to evaluate Crow Reservation leads was based on the work of Vice and Hallek (1999), which involved collecting numerous, closely spaced samples along lines above the target areas. The samples were collected with a ¾-in. diameter soil probe from approximately 12 in. deep; sample spacing was approximately 250 ft. About 50 grams of soil were placed in a 40-mL glass vial and sealed with a plastic lid.

Numerous samples (close spacing) ensure accuracy of the statistical significance of anomalies that may occur in target areas and usually result in several anomalous samples, even if the anomaly is relatively small. Such a multi-point anomaly is more valid than a single-point anomaly because it is more likely to reflect a subsurface hydrocarbon accumulation than local surface conditions.

Soil-Gas Analytical Procedures

A commercial laboratory that routinely analyzes soil hydrocarbons was contracted for the analytical work. Samples were tested for methane, ethane, propane, and butane+ (this included butane and pentane), using a standard gas-chromatographic procedure. The analytical procedure began with heating weighed samples for one hour at 80°C to drive off light hydrocarbons adsorbed on the soil particles. Then, 500 microliters of head-space gas (gas underneath the cap at the top of the sample vial) were extracted, using a precision syringe, and immediately injected into a gas chromatographer. A packed column was used for these analyses. Conventional gas chromatography, with flame-ionization detection, was used to test for methane, ethane, propane, and butane + pentane. Accuracy was controlled with hydrocarbon standards-in-air, measured in parts per million (ppm), provided by commercial suppliers. Samples also were weighed initially and after drying, which allowed soil moisture to be calculated using a weight-loss method.

Initial Detection of Anomalies

The soil-hydrocarbon concentration data for sample sites along each of the survey lines were visually examined for anomalous values. The propane and butane data from the east-west Crow Agency line (F) had a significant anomaly (figure 17, plates 4, 5). Line F is along Squaw Creek in sections 19–24, T. 3 S., R. 34 E. The anomaly extends two miles west of the fault shown on plate 4 that indicates a structural closure may be present on the upthrown block. Soil conditions and slope were constant along the line, which is in the Squaw Creek flood plain for its entire length. These data were statistically examined to determine whether this is a valid anomaly, caused by an underlying hydrocarbon accumulation, or caused by surface soil factors and conditions (see Statistical Procedures below).

An area of erratic, but higher values, occurs in the butane data for the Little Woody prospect at the intersection of lines A and B (figure 18, plate 5). These anomalies were not investigated statistically because they are relatively weak. A variable and weak anomaly is also present in the methane, ethane, propane, and butane data sets at the Woody Dome prospect (figures19, 20, plate 5).

Statistical Procedures

To confirm that a soil-gas anomaly was produced by a subsurface hydrocarbon accumulation, all significant surface factors had to be evaluated and eliminated as the cause of the anomaly. Soil and surface factors can affect light hydrocarbon concentrations, including soil type, moisture, and temperature; land use; vegetation; organic matter in bedrock and soil; and slope aspect and degree (Vice 1996, Vice and Hallek 1999).

Sampling for an entire line was completed within a short time period, usually two days, so soil temperature was approximately constant and would have no discernible effect. As part of the sampling procedure, surface conditions were recorded by assigning numerical values to variations within each category. For example, clay, silty clay, gravel, or loam soil types were assigned values of 1–4, respectively, and the numerical value was recorded for each sample site. Similar numerical assignments were made for each of the soil and surface condition categories mentioned above. In addition to a qualitative soil moisture estimation in the field, a quantitative value was determined, using a weight-loss procedure by the analytical laboratory.

The initial plan was to evaluate the light alkane concentrations by statistical analysis of covariance (ANCOVA) to separate surface effects from effects originating from a subsurface hydrocarbon accumulation. ANCOVA relates the dependent variables (hydrocarbon concentrations) to the independent variables (surface and soil conditions) by using covariance and regression techniques (Vice 1996) to determine the possible direct controls of surface and soil conditions on the hydrocarbon soil concentrations. For the Crow Reservation survey, there were insufficient categories for the ANCOVA method to be used because soil type, slope, and land-use factors within individual lines were uniform.

Therefore, a regression procedure was used that included the weight-loss soil-moisture data from the laboratory analysis. A statistical software package (Minitab 1991) was used to complete the regression calculations (appendix C). One additional factor, collection date, also was considered in the regression equation because of possible differences in either sample collection procedure or sample storage from one day to another.

Results and Discussion

One outstanding feature of the geochemical data is the low concentrations of methane and ethane,

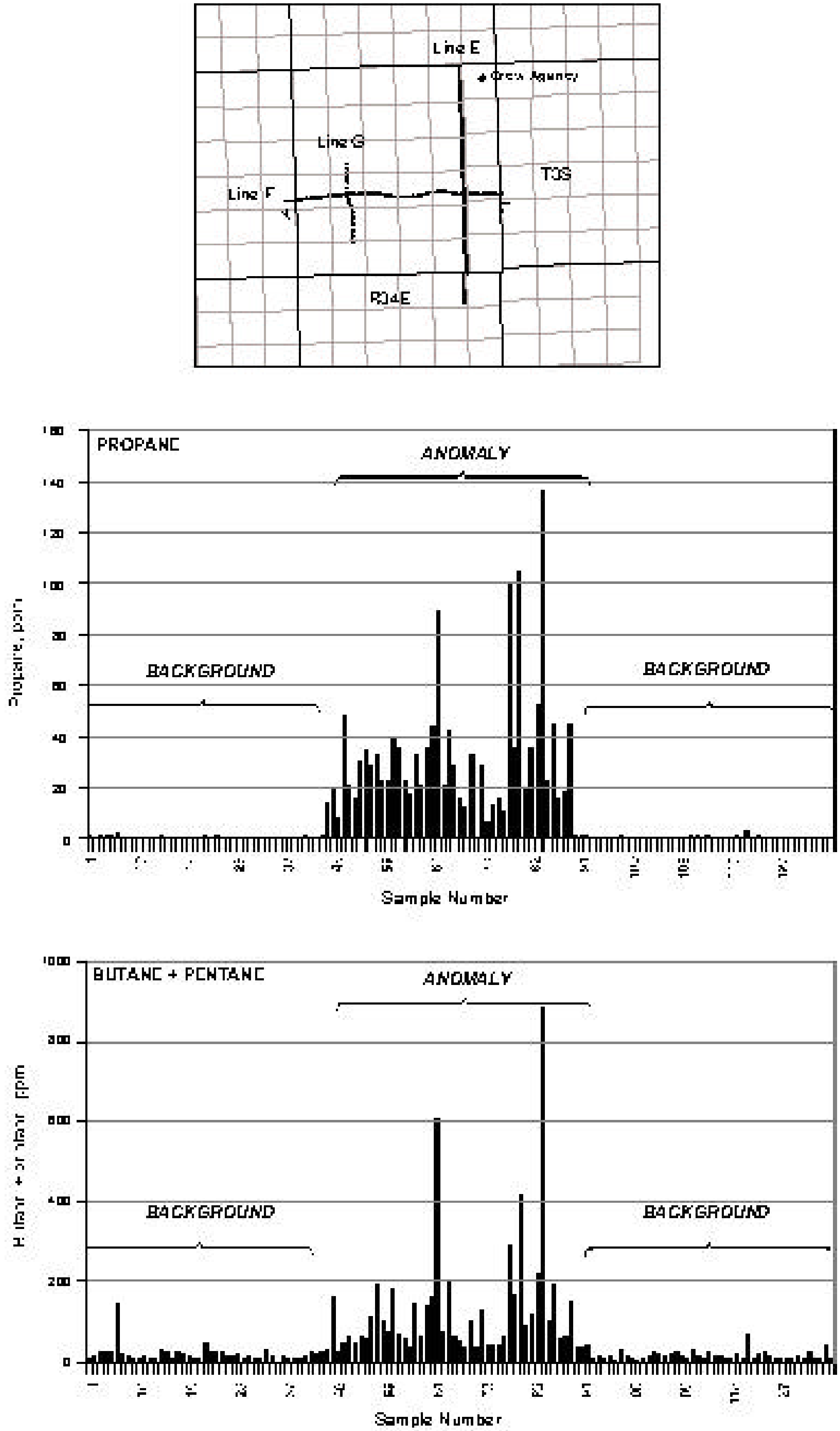

Figure 17. Locations and graphs of line F, Crow Agency prospect, showing anomoly in propane and butane data.

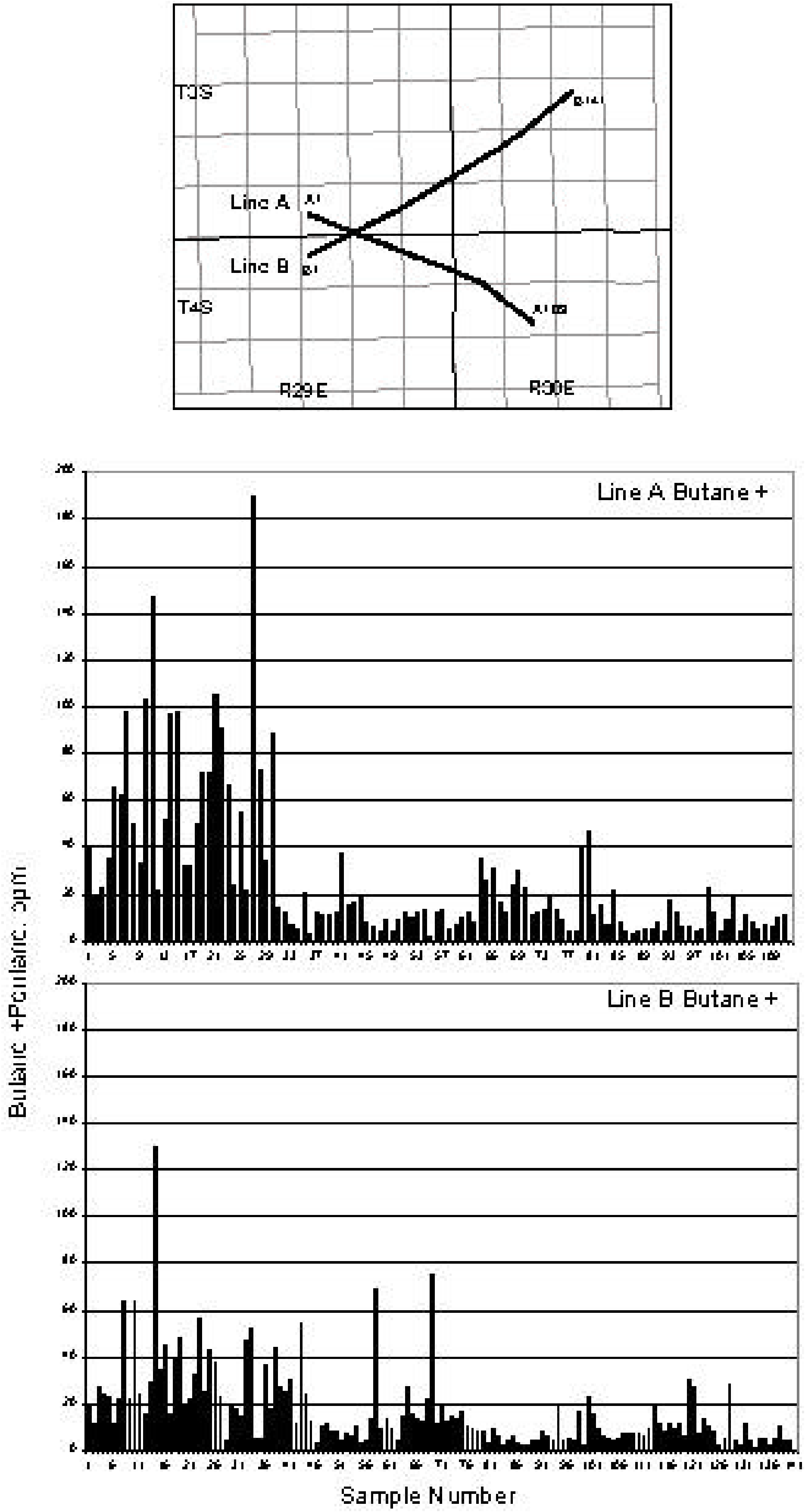

Figure 18. Butane data for lines A and B, Little Woody prospect.

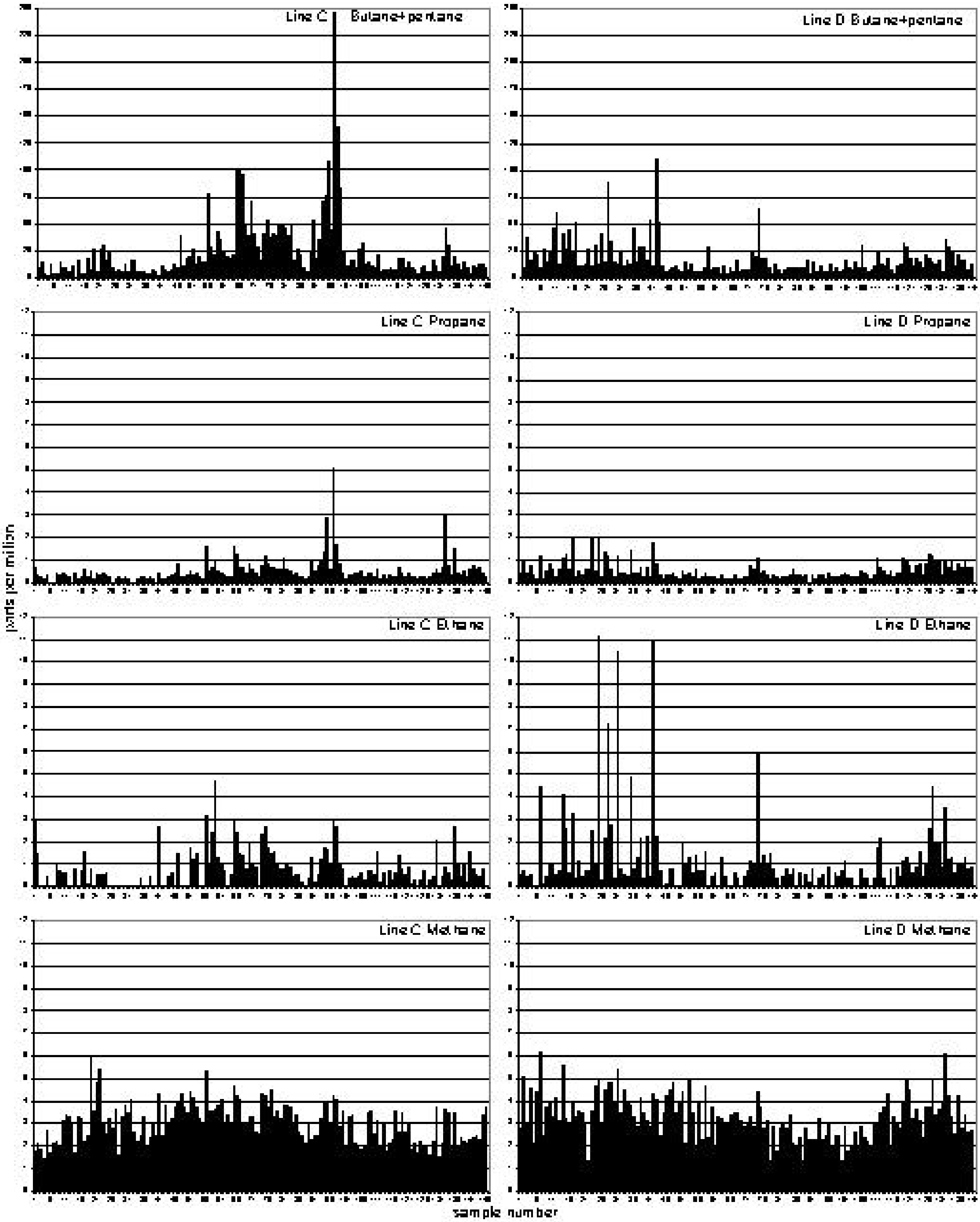

Figure 19. Data sets for lines C and D, Woody Dome prospect.

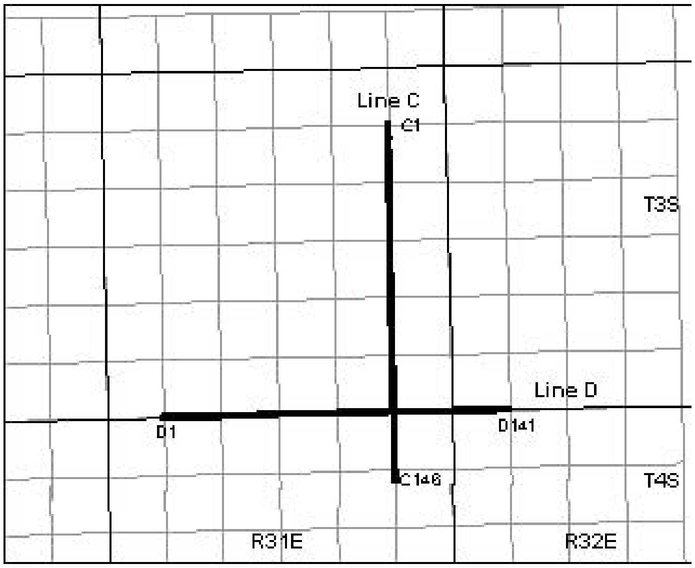

Figure 20. Location of lines C and D, Woody Dome prospect.

whereas the values for butane + pentane concentrations, and locally for propane, are significantly higher. Some of this concentration-level variation may be due to chromatographic effect in the soil. The low densities of the methane and ethane species would allow them to travel through the soil more rapidly. These alkanes would remain as gases at all normal temperatures within the atmosphere and soil environments because of their low-boiling points, which would allow them to escape from the soil quite easily.

Propane's low-boiling temperature also means that it would remain a gas at normal temperatures within the soil and atmosphere, but its heavier weight would mean that it could be retained within the soil longer than methane and ethane. However, this should not cause abnormally high concentrations unless a large amount of propane is being contributed to the soil from an underlying hydrocarbon accumulation.

The heavier weight of the butane and pentane species allows them to remain in the soil longer (Vice 1996). In addition, these species can accumulate in the soil at lower temperatures because of their higher boiling points. This is particularly true for pentane because it remains a liquid until nearly 100°F (38°C). However, the field conditions for the Crow Agency survey were quite warm, suggesting that the air and soil temperatures were well above the boiling point for butane (about 31°F). Therefore, anomalous butane accumulations within the soil may be contributed by an underlying hydrocarbon accumulation.

As described above, a significant anomaly occurs along line F of the Crow Agency lead (see section on initial detection of anomalies). A two-sample t-test was used to compare the anomaly (samples F44–F88) within the propane data to the nonanomalous portion of the line (samples F1–F43) and with the F extension and G lines (see appendix C). These tests indicate that the anomaly represents a separate and distinct population, i.e., it truly represents an anomalous population. The same test was performed on the butane data, and the result was equivalent. The anomaly was truly a separate anomalous population, rather than a group of samples that had slightly higher butane (appendix C).

To determine if any portion of the propane and butane data anomalies from line F are due to surface factors, a regression study was conducted (see Crow Agency regression and Crow Agency butane analysis, appendix C). Only the factors of weight-percent soil moisture and the sample date were used in the regression equation. These analyses indicate that approximately 45% of the variability within the propane data and approximately 23% of the variability within the butane data are related to surface factors.

In summary, the propane and butane data anomalies from the Crow Agency prospect are a separate population and are truly anomalous. Only a portion of the data variability can be related to soil moisture and/or sample date. The remaining variability probably represents a hydrocarbon-accumulation flux in the subsurface. The lack of anomalous methane and ethane data suggests that the underlying hydrocarbon reservoir may contain relatively heavy crude oil without natural gas.

Acknowledgements

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Appendix A

Measured Sections of the Kootenai Formation and Greybull Sandstone

Measured section locations are shown in figure A1. Measured sections color designations and color numerical values are from Rock-Color Chart (Goddard *et al.* 1948, Geological Society of America 1975).

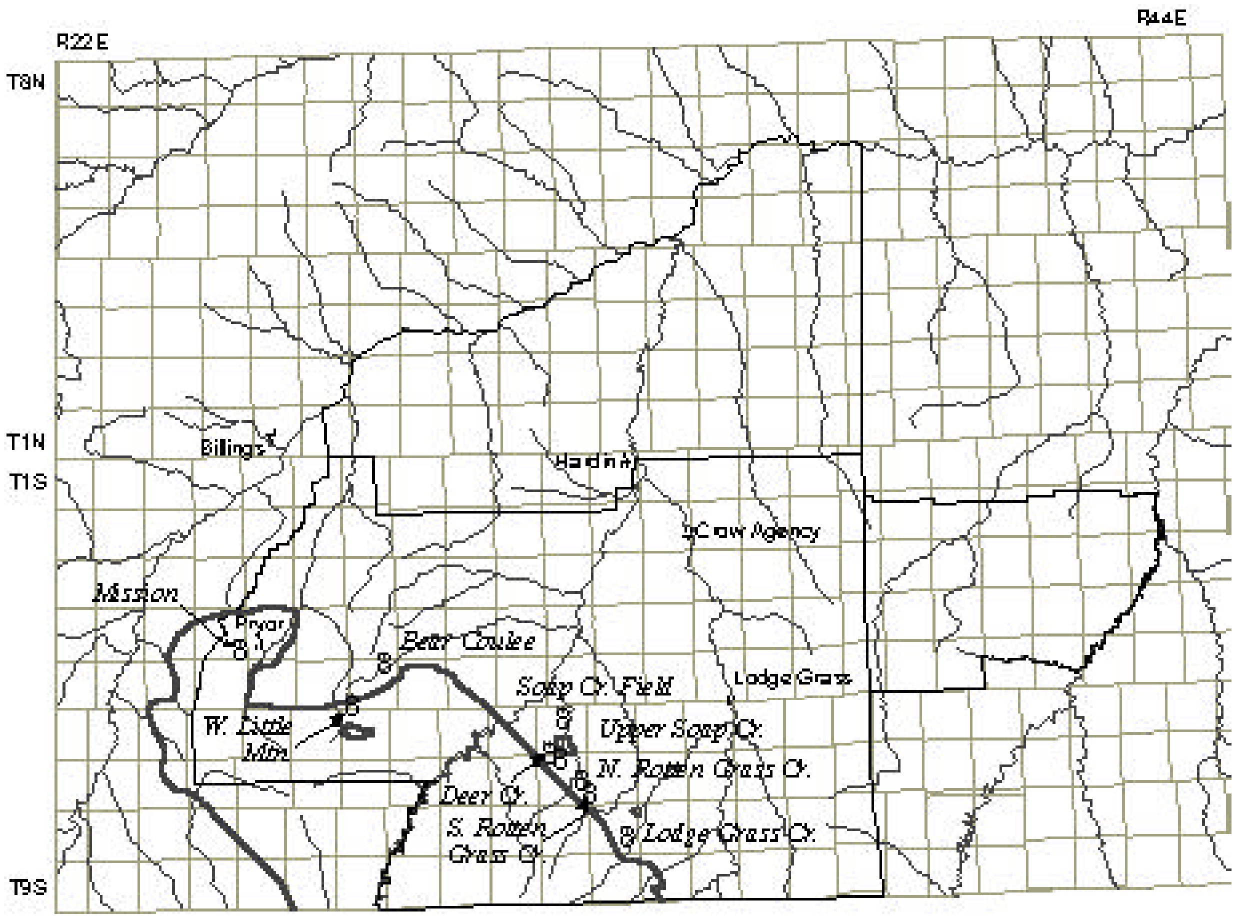
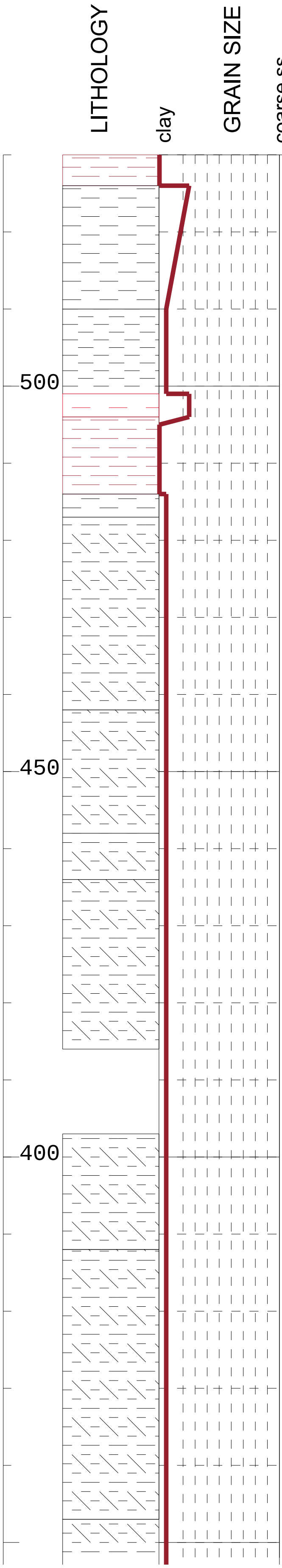


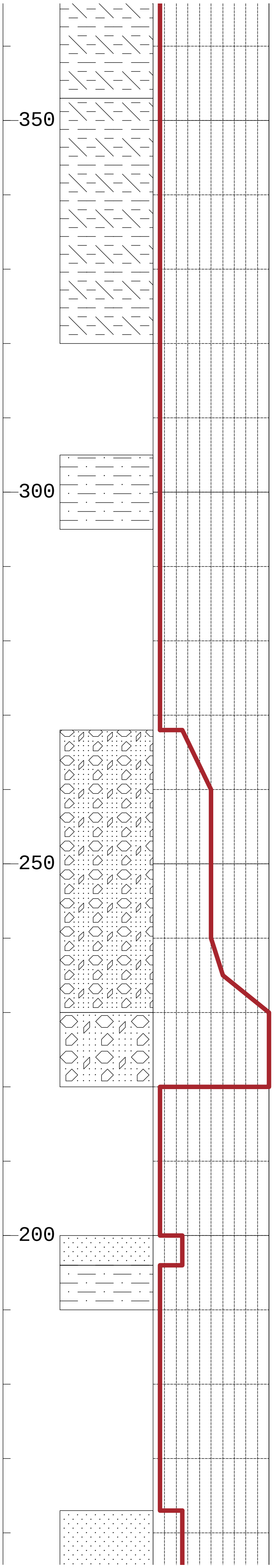
Figure A1. Locations of measured sections.

BEAR COULEE SECTION

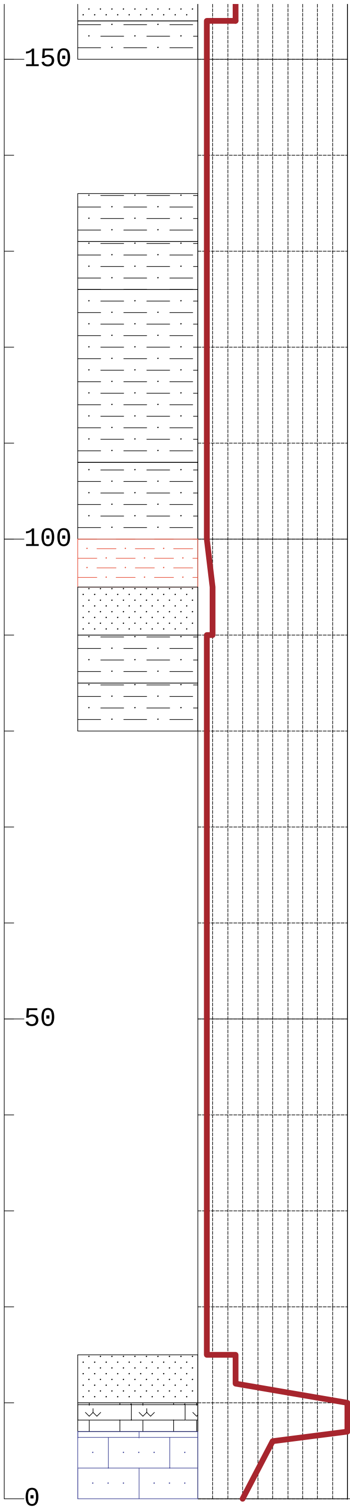
Location: SE1/4 23 & E1/2 24-T5S-R28E



COLOR	AGE & FORMATION	LITHOLOGIC DESCRIPTION
N5	Kt	Shale: medium gray, fissile
5YR6/1	Kfr	Sandstone & Shale, interbedded: sandstone thickens and is less argillaceous upward, thin bedded, 1 ft sandstone bed at top, light brownish gray, shale medium gray to medium dark gray, fissile, unit is burrowed to bioturbated
5YR6/1 to 5Y8/1		Sandy Shale: fissile, light brownish gray to yellowish gray
5YR6/1		Argillaceous Sandstone: light brownish gray, fine grained, hematitic, resistant
N5 to N4		Shale: fissile, medium gray, becomes sandy upward
N6 to 10YR4/2	Kk	Mudstone: oxidized, medium light gray and dark yellowish brown
5R5/4 & N6		Bentonitic Mudstone: mottled moderate red and medium light gray
5R5/4		Bentonitic Mudstone: moderate red
5P4/2		Bentonitic Mudstone: grayish purple
5R5/4		Bentonitic Mudstone: moderate red
Covered		Covered
10R5/4		Bentonitic Mudstone: pale reddish brown
5YR4/1 to 5YR3/1		Bentonitic Mudstone: brownish gray to dark brownish gray with purplish cast on weathered surfaces



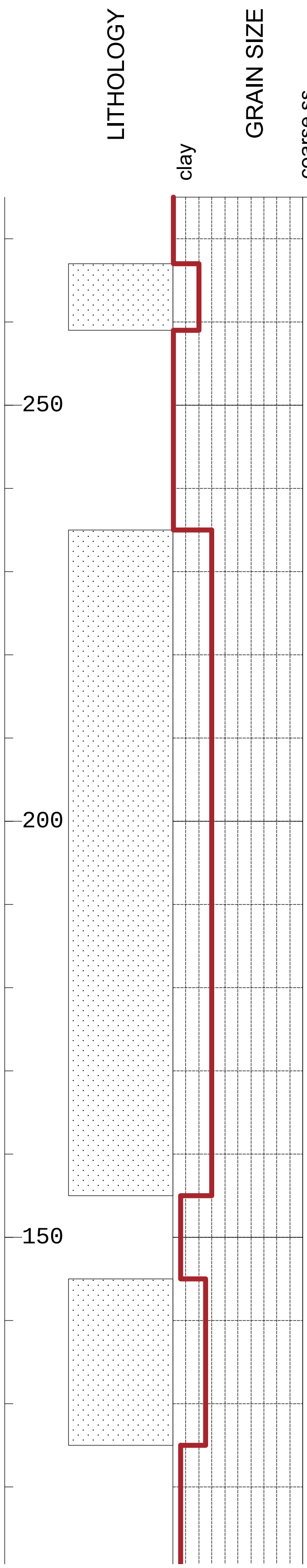
5R3/4 to 10R3/4		Bentonitic Mudstone: dusky red to dark reddish brown, dinosaur bone fragments
Covered		Covered
10R5/4		Mudstone: pale reddish brown, poorly exposed
Covered		Covered
5YR6/1 to 5YR4/1	Kpc	Sandstone coarse: fine to coarse grained sandstone, trough cross bedded, light brownish gray, weathering moderate brown to light brown, salt and pepper, contains feldspar, chert and other lithic fragments
	Kpc	Conglomeratic Sandstone: chert pebbles predominant, conglomerate is interbedded with coarse sandstone, light brownish gray to brownish gray cut and fill common, trough cross-bedded
Covered	Jm	Covered: probably greenish gray mudstone (soil color)
N7		Sandstone: fine to very fine grained, quartzose, calcareous, cross bedded, light gray
5GY6/1		Mudstone: greenish gray, poorly exposed
Covered		Covered
N7		Sandstone: fine grained, quartzose, calcareous, trough cross bedded, light gray



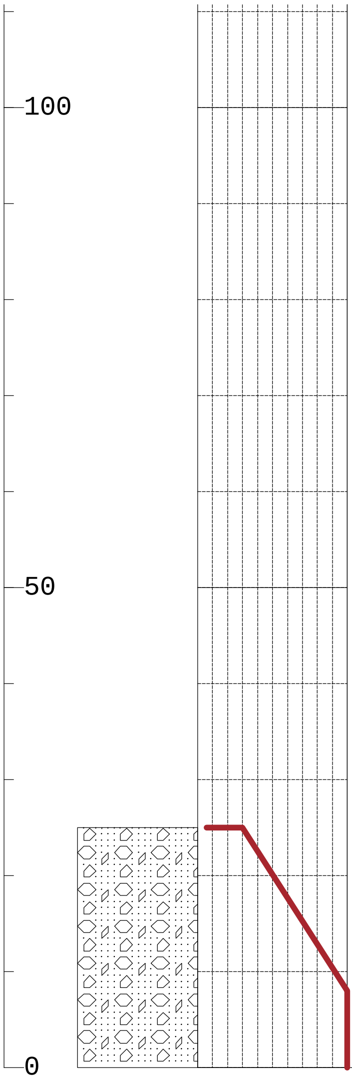
5G5/2		Mudstone: grayish green, poorly exposed
Covered		Covered
10R5/4		Mudstone: moderate reddish brown mottled with minor grayish green mudstone
5G5/2		Mudstone: grayish green
10GY5/2 & 10R5/4 to 10R3/4		Mudstone: grayish green and dark reddish brown to pale reddish brown mudstones interbedded on 1 to 2 ft intervals, thin nodular limestones common at color changes
10GY5/2 & 5RP6/2		Mudstone: variegated grayish green and pale red purple
5G8/1		Sandy Mudstone: light greenish gray
N7		Sandstone: lenticular, light gray, very fine grained, well sorted, quartzose, trough cross bedded
5GY8/1		Mudstone: light greenish gray
5R4/2		Mudstone: grayish red to pale reddish brown
10R5/4 Covered		Covered: soils indicate probabe interbedded greenish gray and reddish brown mudstones
Covered		Covered: probably greenish gray mudstone
5G8/1 to 5YR6/1	Jm / Js	Sandstone: fine grained, light greenish gray to lt brownish gray, rippled
5YR6/1		Fossiliferous Limestone: sandy, partly coquina, light brownish gray
N6 to 5GY6/1		Sandy Limestone: fine to coarse grained, medium light gray greenish gray, rippled

DEER CREEK SECTION

Location: NE 1/4 Sec. 20-T7S-R32E



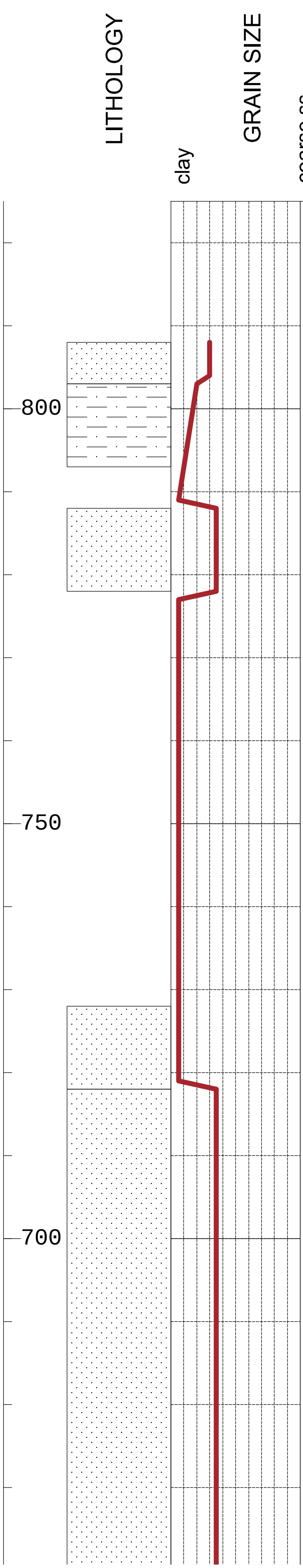
COLOR	AGE & FORMATION	LITHOLOGIC DESCRIPTION
Covered	Kfr	Covered
5Y8/1	Kgb	Sandstone: fine to very fine grained, yellowish gray, limonite speckled, partly bioturbated, silicified
Covered		Covered
N8 to 5Y8/1		Sandstone: fine grained, yellowish gray to very light gray, friable, planar cross bedded, in bed sets 6 in to 3 ft, cut and fill common, forms "white" cliffs
Covered		Covered
N8	Kgb	Sandstone: as above at 155, very light gray
Covered	Kk	Covered



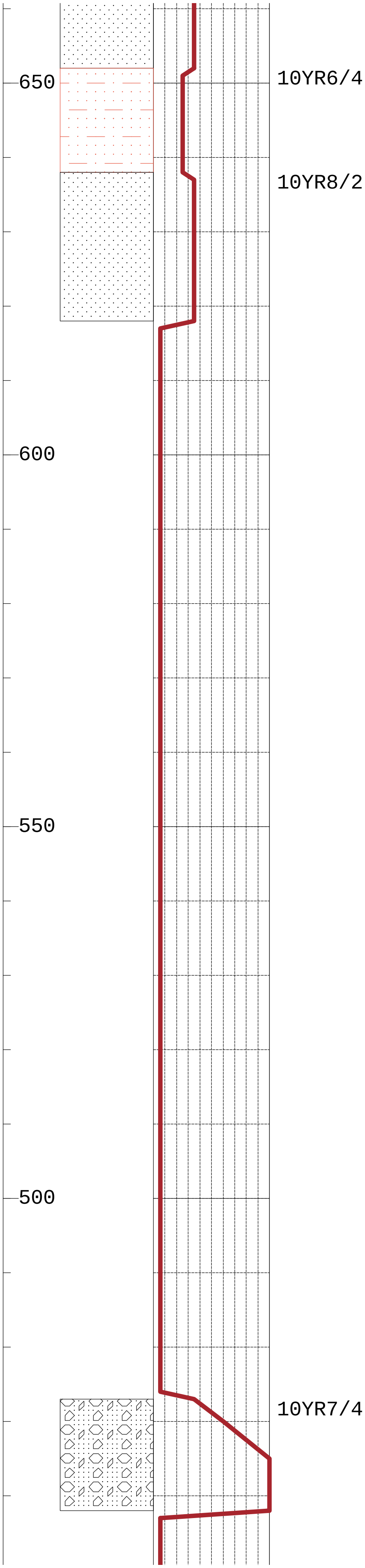
5YR6/1	Kpc	Sandstone coarse: light brownish gray, trough cross bedded, rippled, fine to coarse grained, clay rip up clasts, salt and peeper, chert and other lithic fragments, minor amounts of feldspar

LODGE GRASS CREEK SECTION

Location: Sec. 11-T9S-R33E



COLOR	AGE & FORMATION	LITHOLOGIC DESCRIPTION
		Covered
10YR6/2	Kfr	SANDSTONE: fine grained, parallel laminated, yellow brown, burrowed
10YR6/2		SANDSTONE & SHALE, INTERBEDDED: "rusty beds', fine to very-fine grained sandstone, burrowed to bioturbated, interbedded with med dark gray shale
		Covered
10YR6/4	Kgb	SANDSTONE: fine grained, planar cross-bedded in sets 6 in. to 2 ft, parallel laminated and bedded at top, yellowish brown, sharp scoured base
		Covered
10YR6/4		SANDSTONE: limonite stained, poorly exposed
10YR7/4		SANDSTONE: fine grained, planar cross bedded in sets 6 in. to 3 ft, scoured cut and fill surfaces common, rip clasts, limonite stained, fresh sands tone light gray, otherwise yellowish brown to grayish orange, base moderate red brown.



ARGILLACEOUS SANDSTONE: poorly exposed, friable

SANDSTONE: fine grained, but medium to coarse at base, planar cross bedded, scoured base, very pale orange but mottled reddish brown and dark yellowish orange at base.

Kk

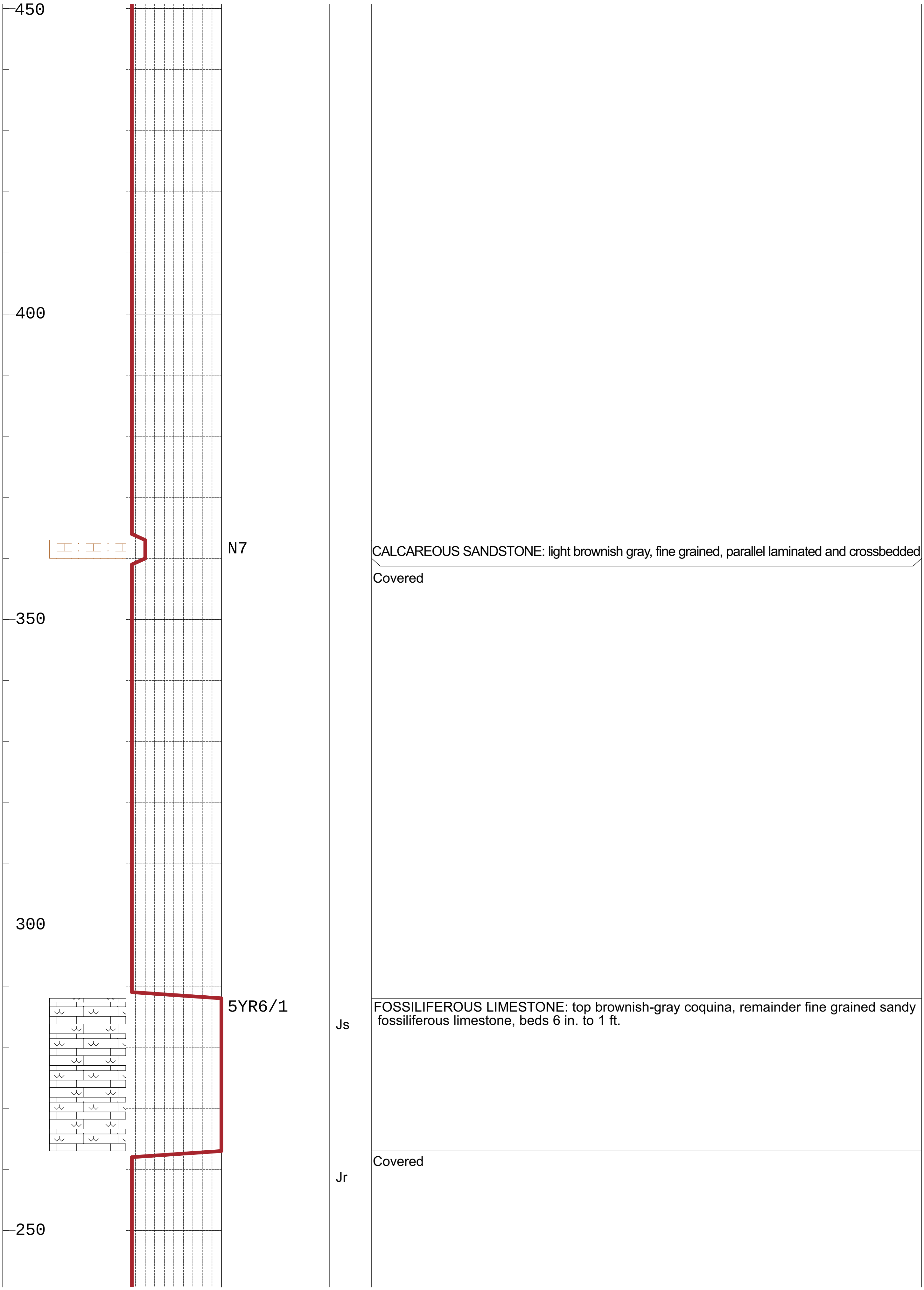
Covered: soil reddish brown, probably reddish brown bentonitic mudstone

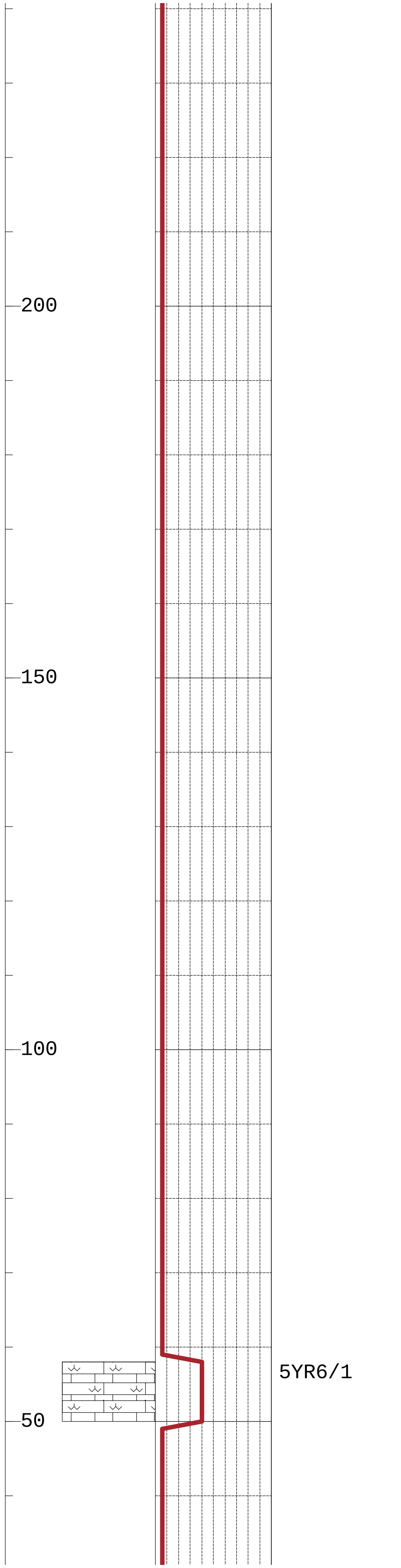
Kpc

SANDSTONE COARSE: light brown, "salt and pepper",medium grained at top, coarse grained at base, some clay rip-up clasts, trough cross bedding, planar bedding at top

Jm

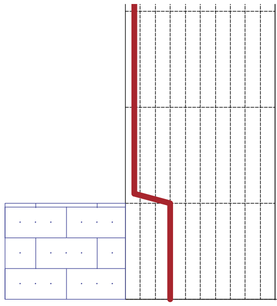
Covered: greenish-gray soils


450
400
N7
CALCAREOUS SANDSTONE: light brownish gray, fine grained, parallel laminated and crossbedded
Covered
350
300
5YR6/1
Js
FOSSILIFEROUS LIMESTONE: top brownish-gray coquina, remainder fine grained sandy fossiliferous limestone, beds 6 in. to 1 ft.
Covered
Jr
250



FOSSILIFEROUS LIMESTONE: brownish gray, medium gray on fresh surfaces

Covered



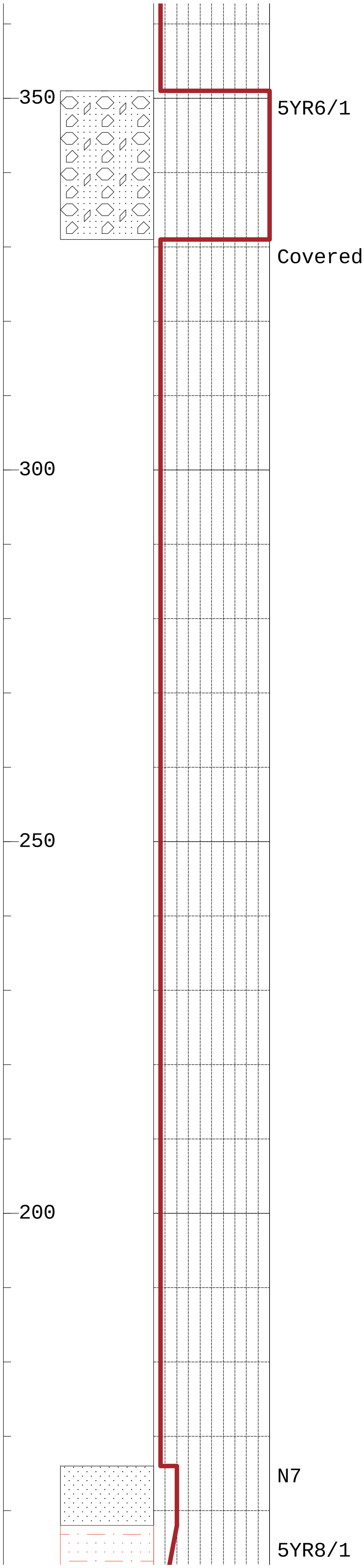
0

10YR7/4	Jp	SANDY LIMESTONE: weathers grayish-orange to moderate yellowish brown, medium gray to brownish gray on fresh surfaces, sandy, fossiliferous

MISSION SECTION, PRYOR, MT

Location: S/2 NE Sec. 13-T5S-R25E

LITHOLOGY	GRAIN SIZE (clay – coarse ss)	COLOR	AGE & FORMATION	LITHOLOGIC DESCRIPTION
		5YR4/1	Kfr	Sandstone & Shale, interbedded: mostly covered, thickness estimated, float chippy hematitic ss typical of Fall River Sandstone
		5YR7/1	Kgb	Sandstone: fine grained, quartzose, well sorted, well rounded, poorly exposed, probably interbedded with shale
500		5Y8/1 to 5YR7/1	Kgb	Sandstone: fine grained, well sorted, well rounded, massive appearing but bed sets are 6 in to 3 ft, planar cross beds, cut and fill structures common, yellowish gray to light brownish gray, limonitic, some beds stained brownish gray by hematite
450		Covered	Kk	Covered
400				



Kk

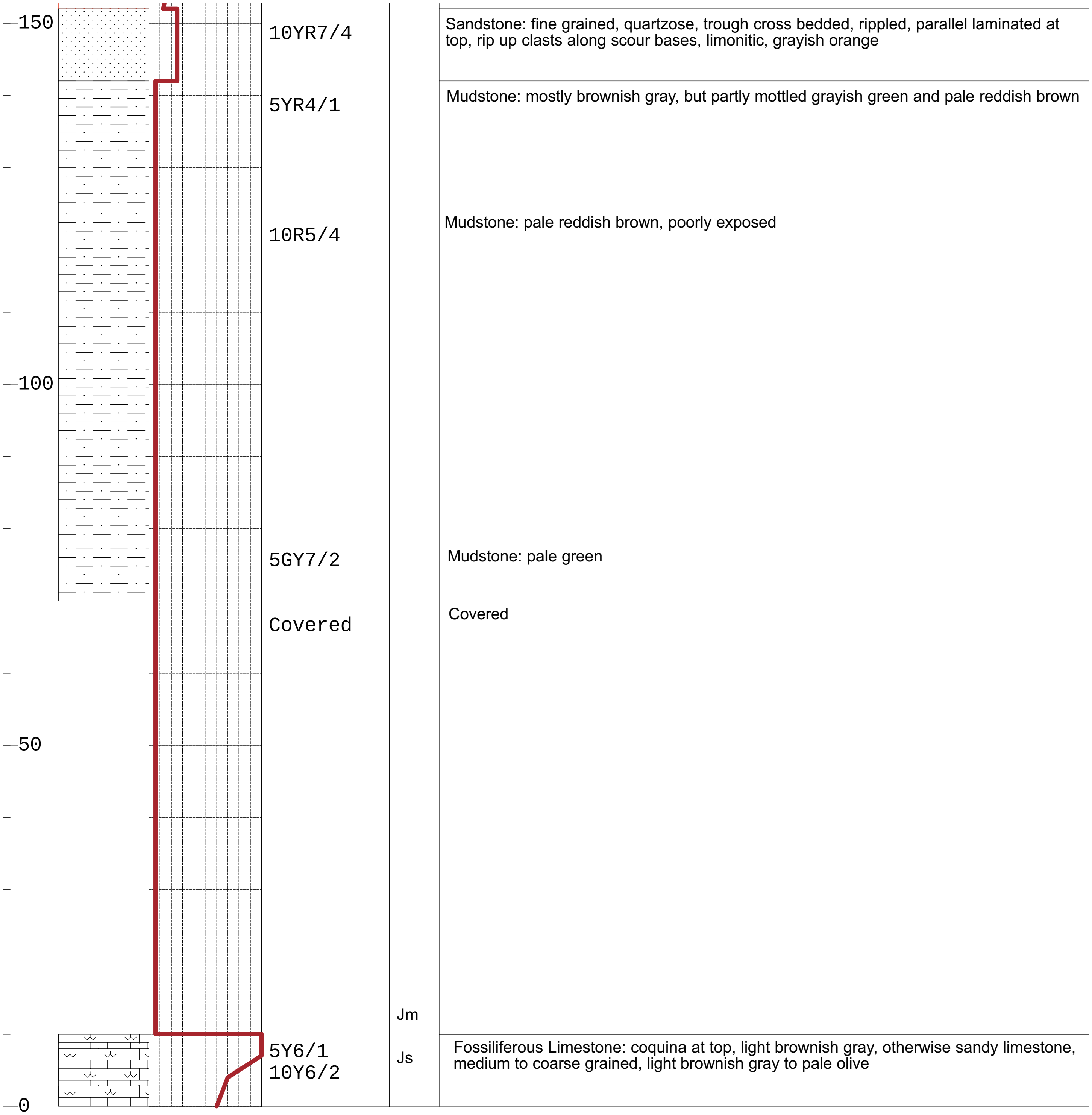
Kpc — Conglomeratic Sandstone: interbedded coarse to medium grained sandstone and chert pebble conglomerate, trough cross bedded, cut and fill structures common, light brownish gray, weathering lt yellow brown to brownish gray

Kpc

Jm — Covered

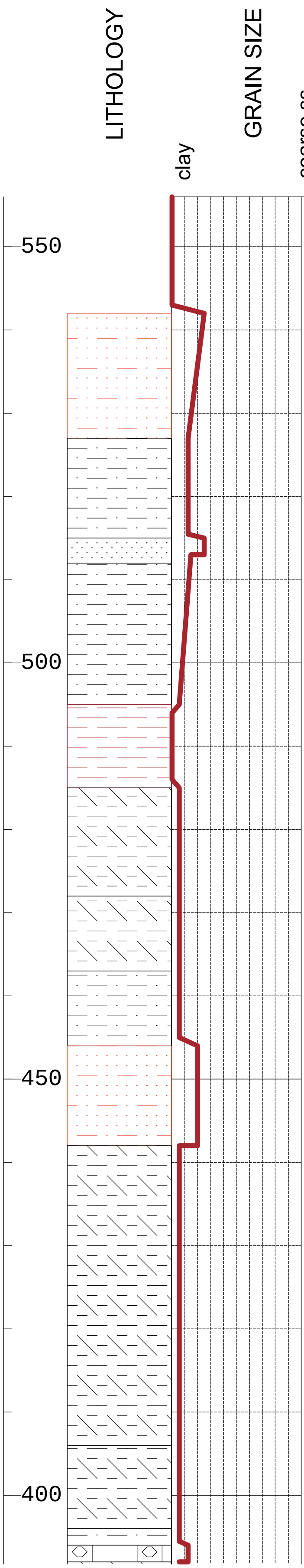
Sandstone: very fine to fine grained, light gray, cross bedded, parallel laminated at top, bed sets 1 to 2 ft but get very thin at top

Argillaceous Sandstone: very fine to fine grained, light brownish gray, thin bedded

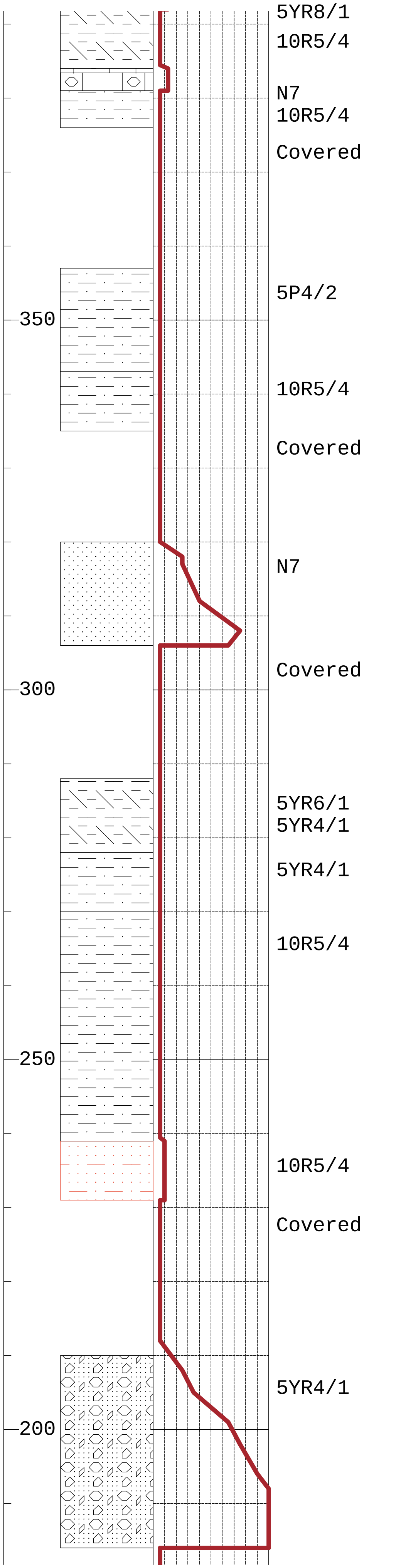

150
100
50
0
10YR7/4
5YR4/1
10R5/4
5GY7/2
Covered
5Y6/1
10Y6/2
Jm
Js
Sandstone: fine grained, quartzose, trough cross bedded, rippled, parallel laminated at top, rip up clasts along scour bases, limonitic, grayish orange
Mudstone: mostly brownish gray, but partly mottled grayish green and pale reddish brown
Mudstone: pale reddish brown, poorly exposed
Mudstone: pale green
Covered
Fossiliferous Limestone: coquina at top, light brownish gray, otherwise sandy limestone, medium to coarse grained, light brownish gray to pale olive

ROTTEN GRASS CREEK, NORTH SECTION

Location: Sec. 1-T8S-R32E

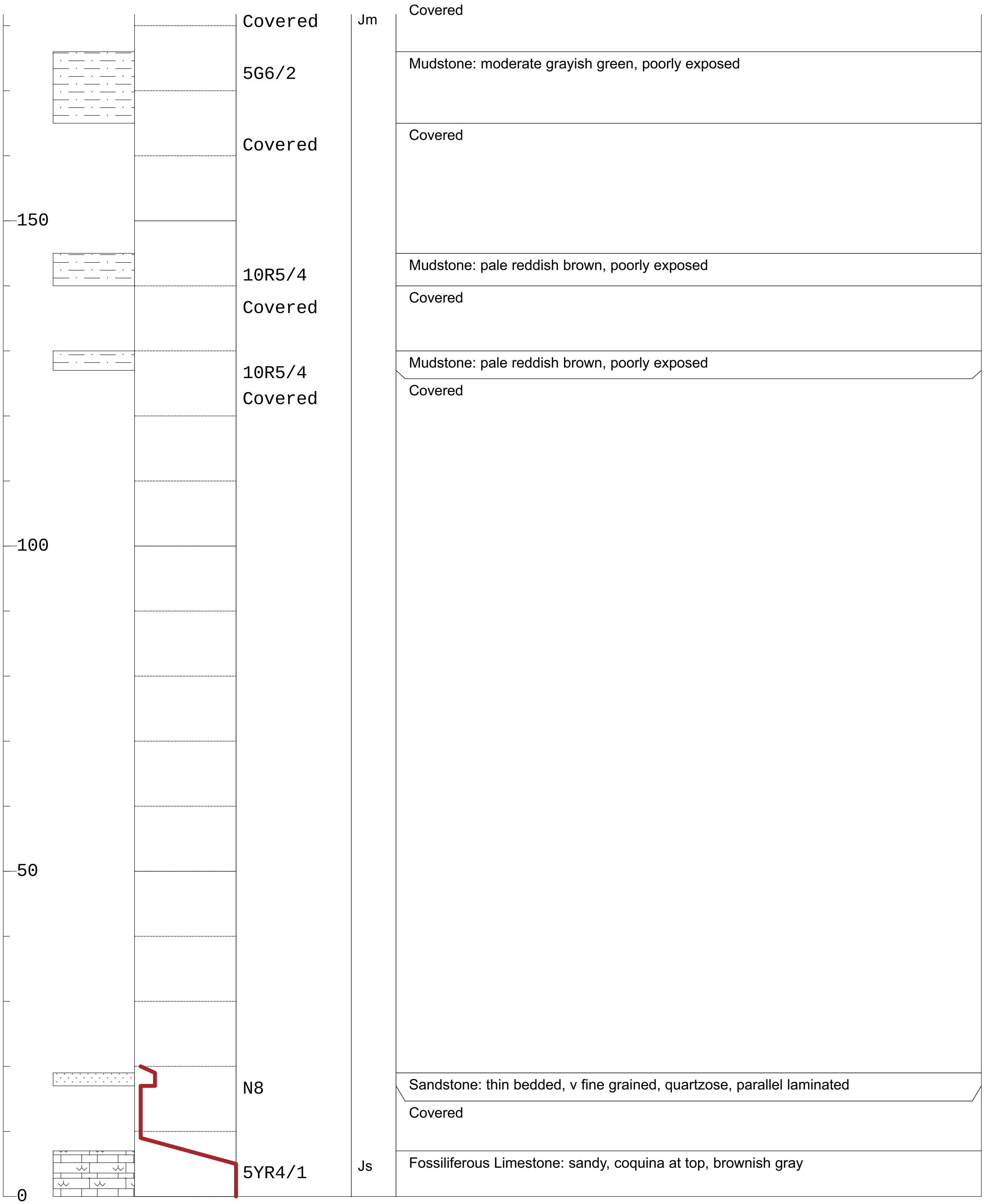


COLOR	AGE & FORMATION	LITHOLOGIC DESCRIPTION
Covered		Covered: probably medium dark gray fissile shale
5YR6/1		Argillaceous Sandstone: interbedded with thin beds medium dark gray shale, brownish gray, burrowed and bioturbated
5YR6/1		Sandstone & Shale, interbedded: brownish gray argillaceous sandstone, shale medium dark gray, thin bedded, burrowed and bioturbated
10YR6/6		Sandstone: hematitic, resistant
5YR6/1		Sandstone & Shale, interbedded: brownish gray argillaceous sandstone, shale medium dark gray, thin bedded, burrowed and bioturbated, sandstone beds thicker and less argillaceous upward
N4		Shale: medium dark gray, fissile
10R5/4 & N7	Kfr Kk	Bentonitic Mudstone: mottled pale reddish brown and light gray
5RP4/2		Bentonitic Mudstone: grayish red purple
10R5/4		Mudstone: pale reddish brown
5YR4/1		Argillaceous Sandstone: bentonitic, brownish gray, poorly exposed
5PB5/2		Bentonitic Mudstone: grayish blue
5P4/2		Bentonitic Mudstone: grayish purple to grayish blue
10R5/4 5YR8/1		Mudstone: pale reddish brown



Kpc

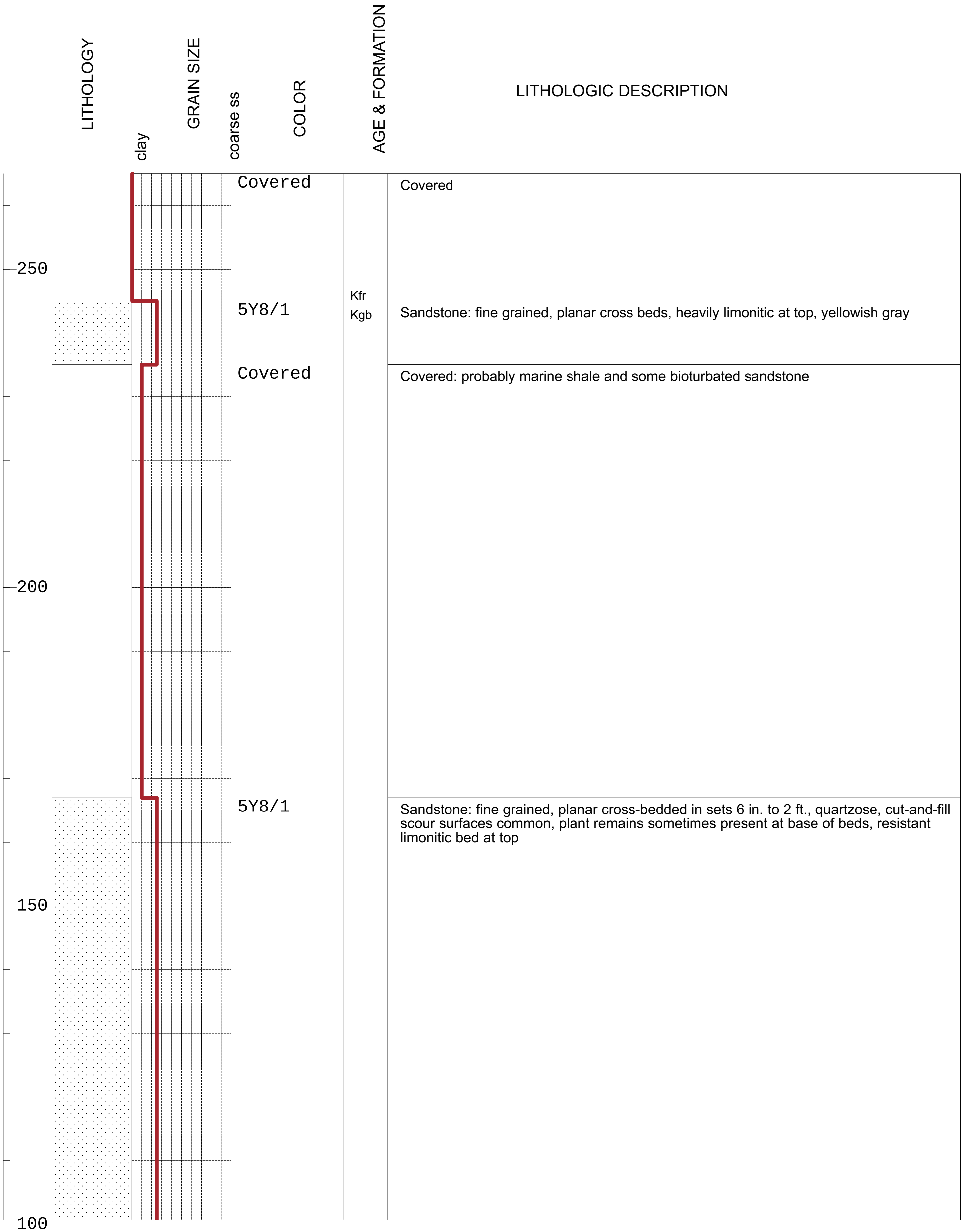
- Nodular Limestone: pinkish gray
- Bentonitic Mudstone: pale reddish brown, contains "gastroliths"
- Nodular Limestone: hard, light gray, highly fractured
- Mudstone: pale reddish brown
- Covered: probably reddish brown mudstone (soils reddish brown)
- Mudstone: grayish purple, contains light gray calcareous concretions 1 to 2 inches in diameter
- Mudstone: pale reddish brown
- Covered
- Sandstone: light gray, quartzose, argillaceous, oxidized at top (soil zone?)
- Covered
- Bentonitic Mudstone: brownish gray but paleo-soil zone at top is light brownish gray
- Mudstone: brownish gray, poorly exposed
- Mudstone: pale reddish brown, poorly exposed
- Argillaceous Sandstone: brownish gray, interbedded with mudstone, poorly exposed
- Covered
- Sandstone Coarse: fine to coarse grained, coarse grained ss at base, salt and pepper, chert, feldspar, contains clay rip-up clasts especially at the base,brownish gray, weathering light brown
- Covered

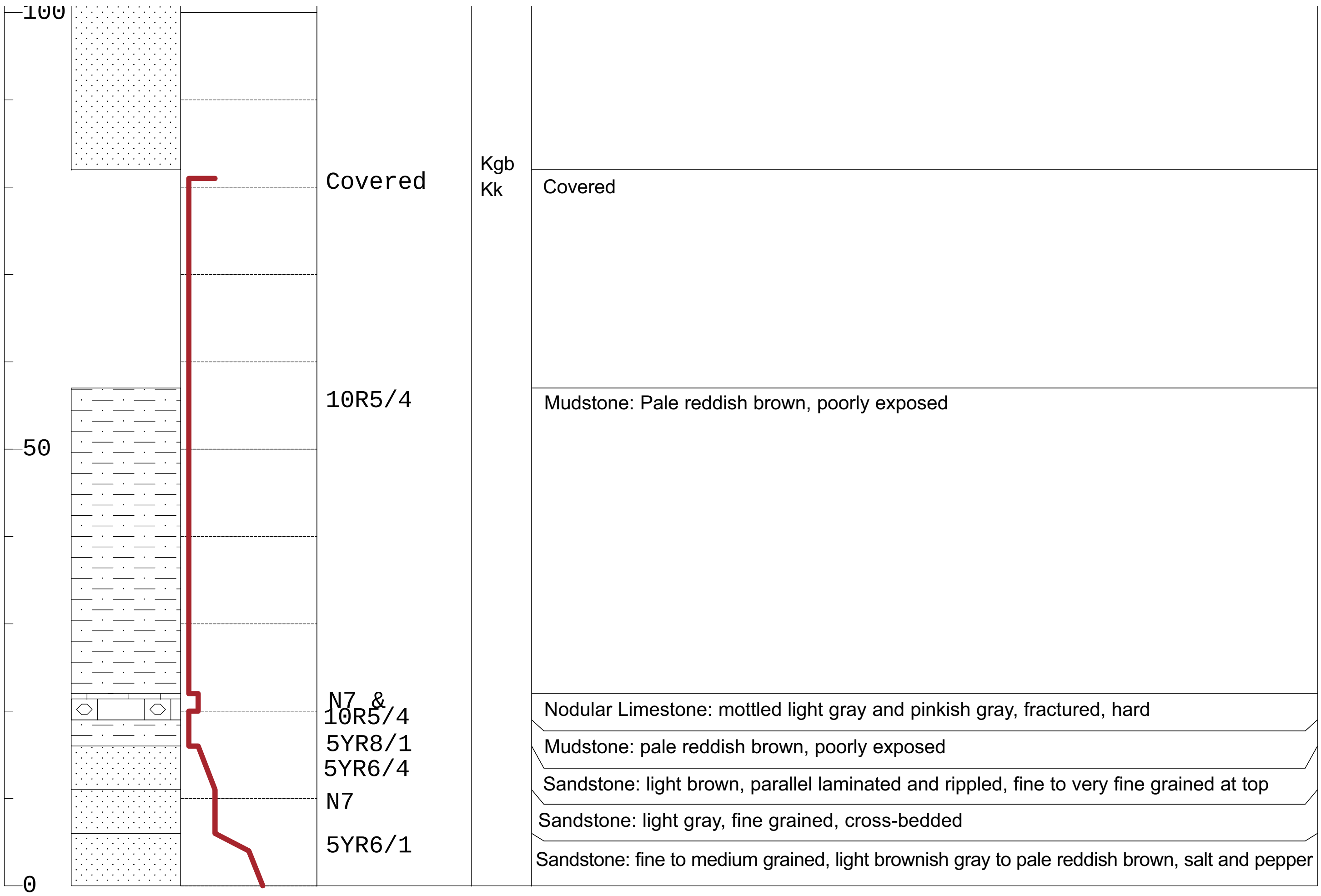


Covered
Jm
Covered
5G6/2
Mudstone: moderate grayish green, poorly exposed
Covered
Covered
150
10R5/4
Mudstone: pale reddish brown, poorly exposed
Covered
Covered
10R5/4
Mudstone: pale reddish brown, poorly exposed
Covered
Covered
100
50
N8
Sandstone: thin bedded, v fine grained, quartzose, parallel laminated
Covered
5YR4/1
Js
Fossiliferous Limestone: sandy, coquina at top, brownish gray
0

ROTTEN GRASS CREEK, SOUTH SECTION

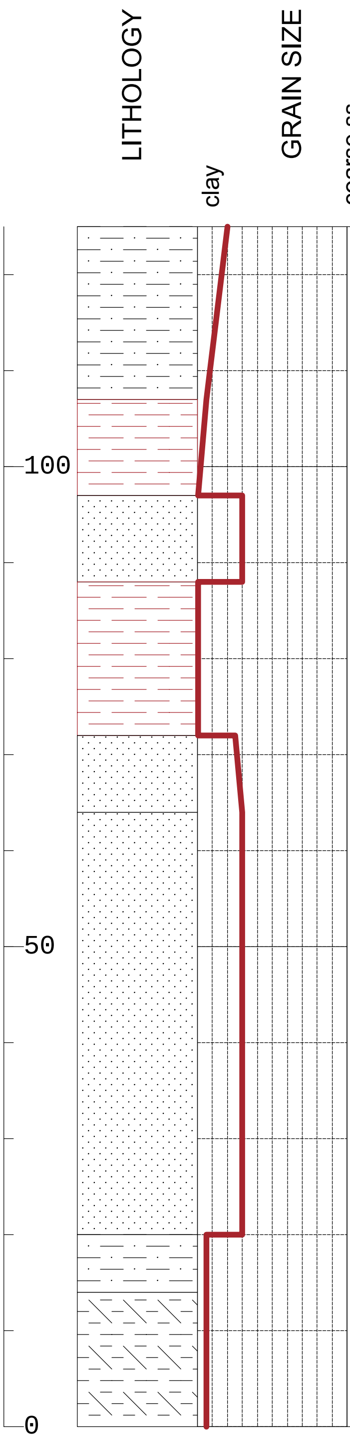
Location: Sec. 7-T8S-R33E




100
50
0
Covered
10R5/4
N7 &
10R5/4
5YR8/1
5YR6/4
N7
5YR6/1
Kgb
Kk
Covered
Mudstone: Pale reddish brown, poorly exposed
Nodular Limestone: mottled light gray and pinkish gray, fractured, hard
Mudstone: pale reddish brown, poorly exposed
Sandstone: light brown, parallel laminated and rippled, fine to very fine grained at top
Sandstone: light gray, fine grained, cross-bedded
Sandstone: fine to medium grained, light brownish gray to pale reddish brown, salt and pepper

SOAP CREEK OIL FIELD SECTION

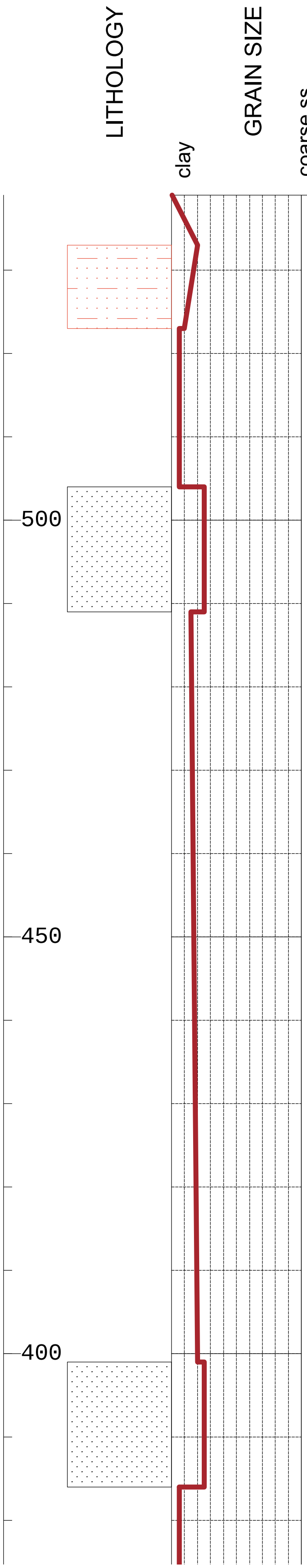
Location: W-C Sec. 27-T6S-R32E



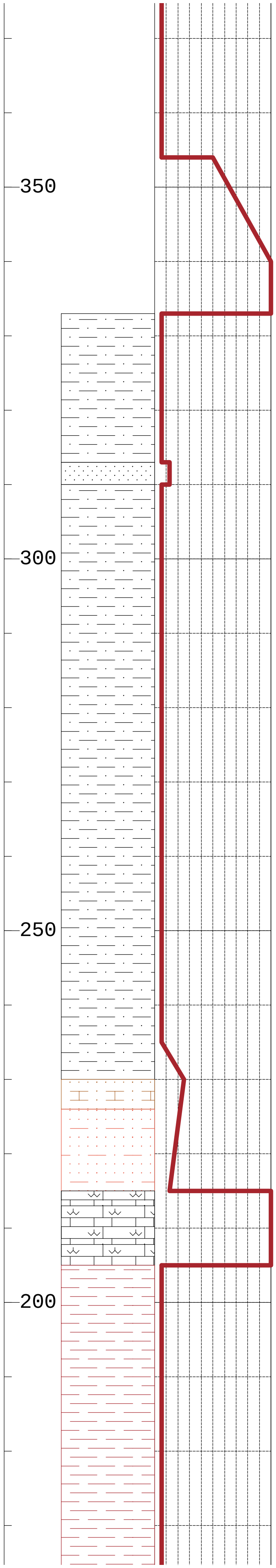
COLOR	AGE & FORMATION	LITHOLOGIC DESCRIPTION
5YR6/1 to 5YR4/1	Kfr	Sandstone & Shale, interbedded: light brownish gray to brownish gray, hematitic and limonitic stain especially at top, burrowed and bioturbated
N4		Shale: medium dark gray, fissile
5Y7/2	Kgb	Sandstone: fine grained, yellowish gray, sharp base, planar cross bedded, parallel laminated at top, base oxidized (limonite stained)
N5 N7		Shale: medium gray at top light gray and sandy toward base, bioturbated
10YR7/4 & 5YR6/1		Sandstone: bioturbated, mottled grayish orange and light brownish gray, fine grained
10YR6/6 10YR7/4 to 5YR6/1 10YR6/6	Kgb	Sandstone: fine grained, well sorted, well rounded, quartzose, sharp scoured base, planar cross bedded in sets 6 in to 3ft, grayish orange to light brownish gray, top and base highly limonitic and dark yellowish orange, resistant at top, otherwise soft to friable
N8	Kk	Mudstone: oxidized, very light gray with yellow veinlets
10R5/4, 10R4/6, & 10R6/2		Bentonitic Mudstone: variegated, pale reddish brown, moderate reddish brown, pale red, and light gray contains small iron stone concretions

UPPER SOAP CREEK SECTION

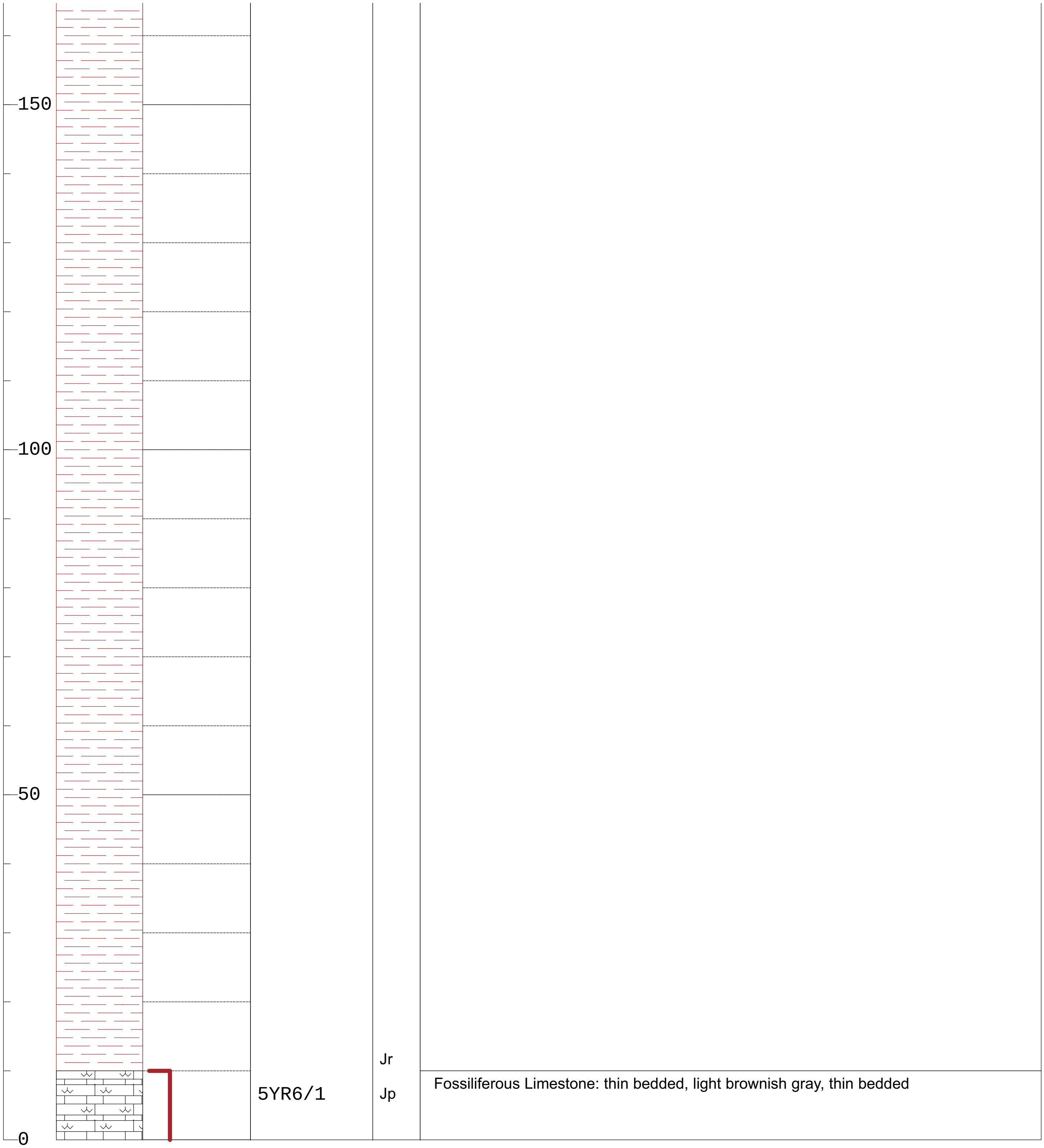
Location: SW1/4 Sec. 22-T7S-R32 E



COLOR	AGE & FORMATION	LITHOLOGIC DESCRIPTION
Covered		Covered: probably shale
10YR5/4 to 5YR6/1		Argillaceous Sandstone: very fine to fine grained, parallel laminated, burrowed and bioturbated in part, hematitic and limonitic especially at top moderate yellowish brown to light brownish gray
Covered	Kfr	Covered: probably shale
5Y8/1	Kgb	Sandstone: fine grained, limonite speckled, quartzose, planar cross beds, yellowish gray, resistant hematitic bed at top
Covered		Covered
5Y8/1	Kgb	Sandstone: friable, poorly exposed, fine grained, yellowish gray, planar cross bedded, parallel laminated upper 2 ft
Covered	Kk	Covered

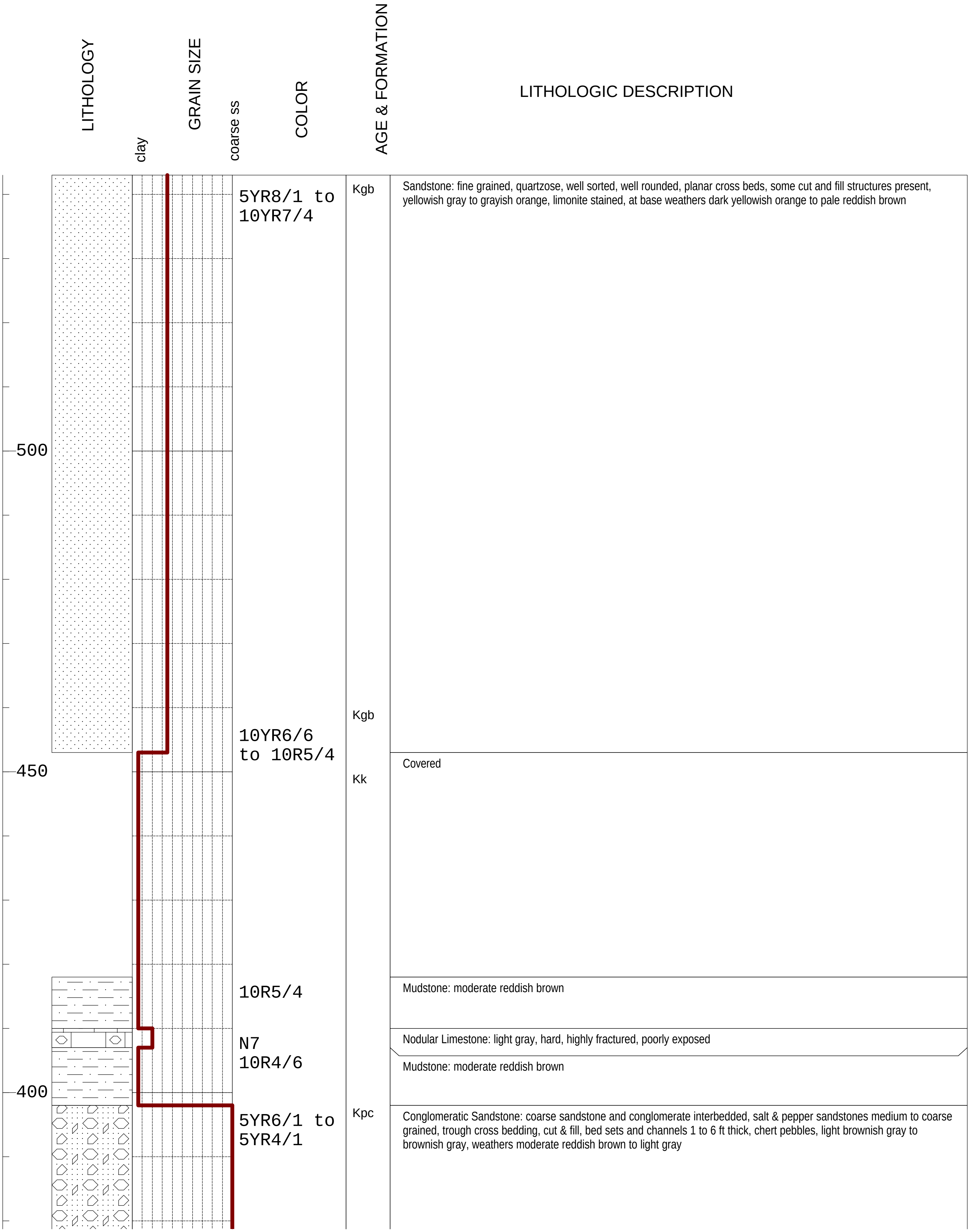


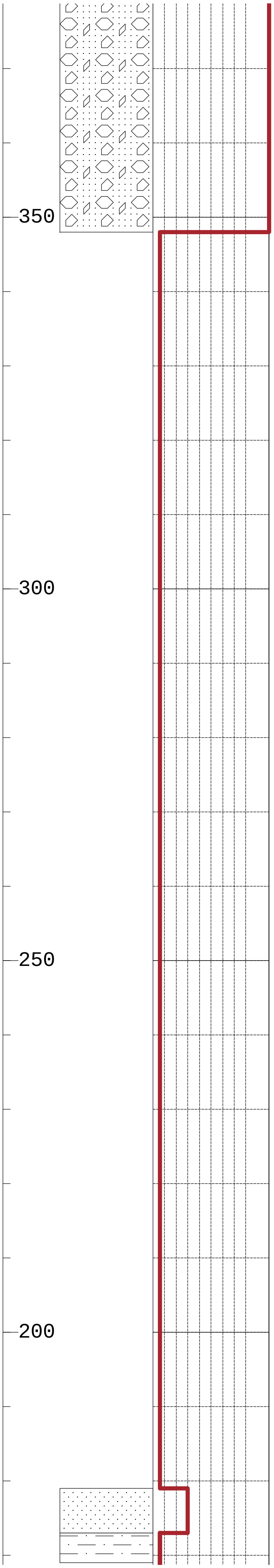
10YR7/4 to 10YR5/4	Kpc	Sandstone, coarse: fine to coarse grained, trough cross beds, rippled at base, parallel laminated at top, light brownish gray, salt and pepper, calcareous
5R6/2 & 10GY5/2	Jm	Mudstone: variegated, pale reddish brown and grayish green, dinosaur bone fragments
N7		Sandstone: very fine grained, light gray, calcareous, quartzose, cross bedded
5R6/2 & 10GY5/2	Jm	Mudstone: variegated, pale reddish brown and grayish green, poorly exposed, mostly covered
5YR6/1	Js	Calcareous Sandstone: fine to medium grained, light brownish gray, ripple cross laminated
5YR6/1		Argillaceous Sandstone: fine grained, very calcareous, light brownish gray
5Y5/2 to 10YR6/2		Fossiliferous Limestone: sandy, fine to coarse grained, partly coquina, light brownish gray, grades to very sandy limestone, ripple cross laminated, parallel laminated at top
10Y7/2	Jr	Shale: mostly covered, forms pale olive soil, fossiliferous, gryphaea and belemnites abundant


150
100
50
0
5YR6/1
Jr
Jp
Fossiliferous Limestone: thin bedded, light brownish gray, thin bedded

WEST LITTLE MOUNTAIN SECTION

Location: NE 1/4 Sec. 20-T6S-R28E



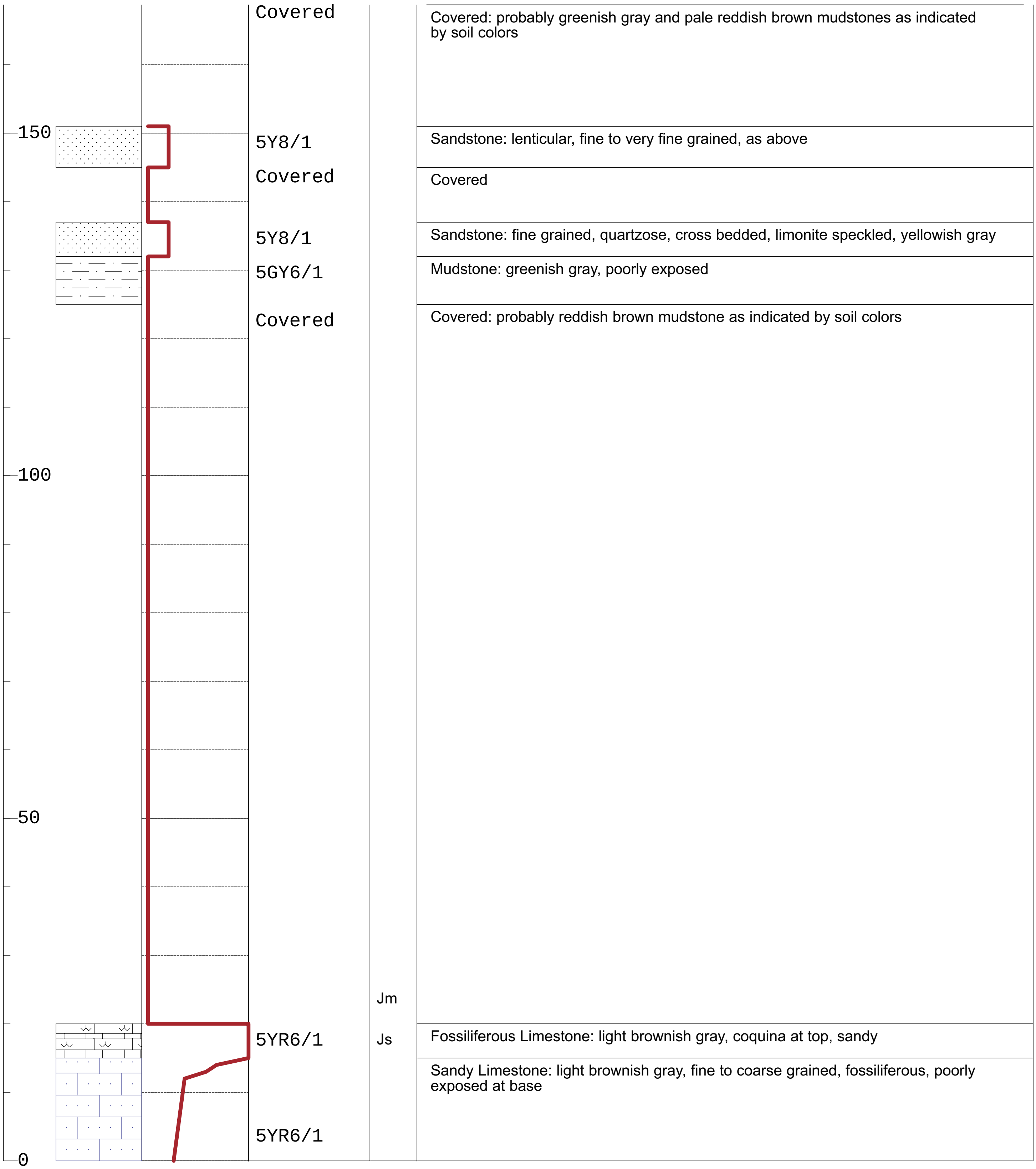


Kpc

Covered | Jm | Covered: apparently interbedded pale reddish brown and grayish green mudstones as indicated by soil colors

5Y8/1 | Sandstone: lenticular, fine grained, yellowish gray, quartzose, calcareous, cross bedded

5GY6/1 | Mudstone: greenish gray



150
100
50
0
Covered
Covered: probably greenish gray and pale reddish brown mudstones as indicated by soil colors
5Y8/1
Sandstone: lenticular, fine to very fine grained, as above
Covered
Covered
5Y8/1
Sandstone: fine grained, quartzose, cross bedded, limonite speckled, yellowish gray
5GY6/1
Mudstone: greenish gray, poorly exposed
Covered
Covered: probably reddish brown mudstone as indicated by soil colors
Jm
Js
5YR6/1
Fossiliferous Limestone: light brownish gray, coquina at top, sandy
Sandy Limestone: light brownish gray, fine to coarse grained, fossiliferous, poorly exposed at base
5YR6/1

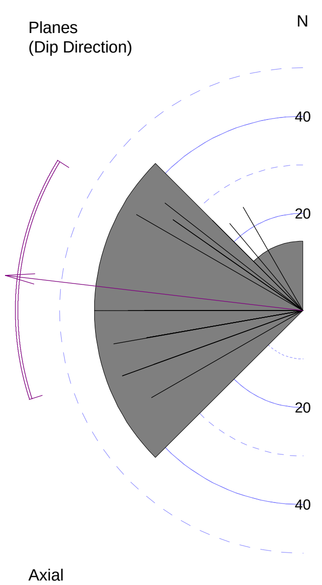
Appendix B

Paleocurrent Data for Surface Exposures of the Greybull Sandstone

Locations of surface Greybull Sandstone exposures where paleocurrent data were collected are listed in table B1. Data are from attitude measurements of planar cross-beds. The paleocurrent data are presented as rose diagrams, each of which is identified by location number in table B1. On the rose diagram plots, “n” refers to the number of measurements at that site. Rose diagrams were constructed using *Spheristat 2* software by Pangaea Scientific. Locations on the eastern side of the Bighorn Mountains (Deer, Upper Soap, Rotten Grass, and Lodge Grass creeks) are along a steeply dipping hogback. The data at these localities had to be rotated back to horizontal and was accomplished with the *Spheristat 2* software.

Table B1. Paleocurrent Data

ID Number	UTM E. Loc		UTM N. Loc	T&R Location	Measured Section Name	Comments
97LG-19	13	286740	5002400	S-C-7-8S-33E	Rotten Crass Creek	
97LG-21	13	279528	5010325	NE-20-7S-32E	Deer Creek Section	
97LG-22	13	282360	5017040	N-C-34-6S-32E	Soap Creek Oil Field	
97LG-48	12	711840	5019880	SE-17-6S-28E	West Little Mountain	
97LG-28	12	687690	5028160	W/2-23-5S-25E		Duffield Ranch
97LG-29	12	687530	5028690	NW-23-5S-25E		Duffield Ranch
97LG-31	12	689344	5030570	NW-13-5S-25E		Butte west of Mission
97LG-32	12	688400	5026770	SW-NE-26-5S-25E		South Butte west of Pryor
97LG-33	12	688510	5025350	NE-35-5S-25E		Railroad grade site
97LG-34	12	683970	5026430	NE-NW-29-5S-25E		
97LG-36	12	682250	5031520	W/2-NW-8-5S-25E		Near north edge channel
97LG-38	12	681260	5029570	W/2-18-5S-25E		Location of Hoodoos
97LG-39	12	681620	5028225	NE-19-5S-25E		Head of Willow Creek
97LG-40	12	681000	5025770	SE-SW-30-5S-25E		Reservation Boundary
97LG-41	12	677710	5027705	C-23-5S-24E		Middle Fork 5-Mile Creek
97LG-42	12	679540	5027620	W/2-SE-24-5S-24E		North Fork 5-Mile Creek
97LG-44	12	677020	5033425	SW-SW-35-4S-24E		5-Mile Creek
97LG-45	12	680075	5034550	SW-31-4S-25E		Arden Blair Ranch
97LG-47	12	681155	5039680	NE-18-4S-25E		Cottonwood Creek
97LG-48	13	292850	4995360	NE-NW-11-9S-33E	Lodge Grass Creek Section	



96LG-48

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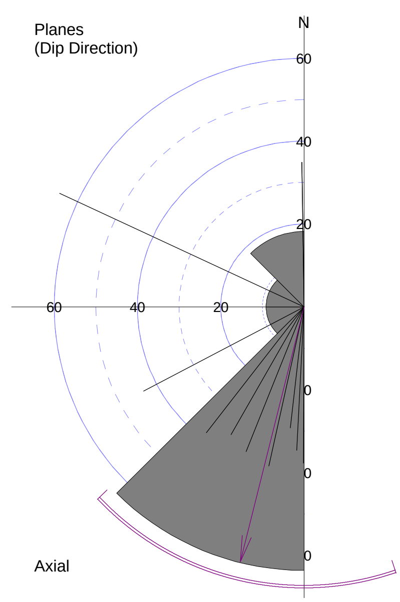

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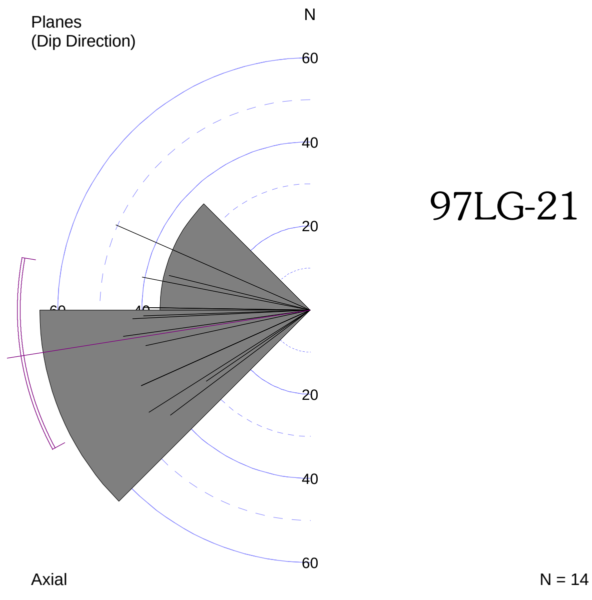
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20
20
40
60
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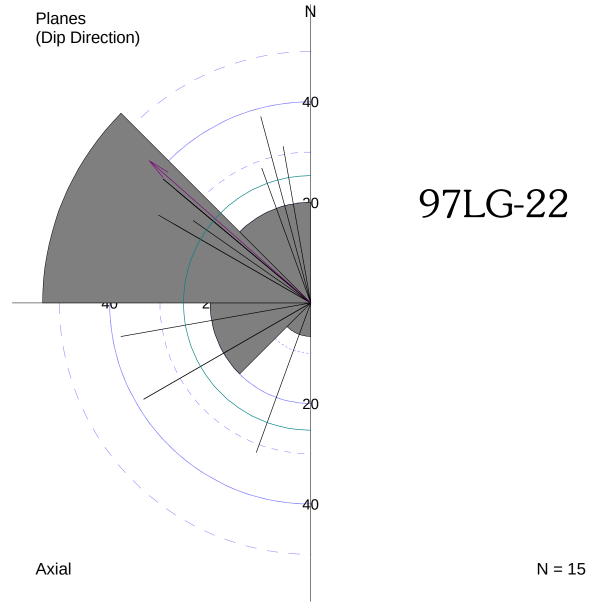
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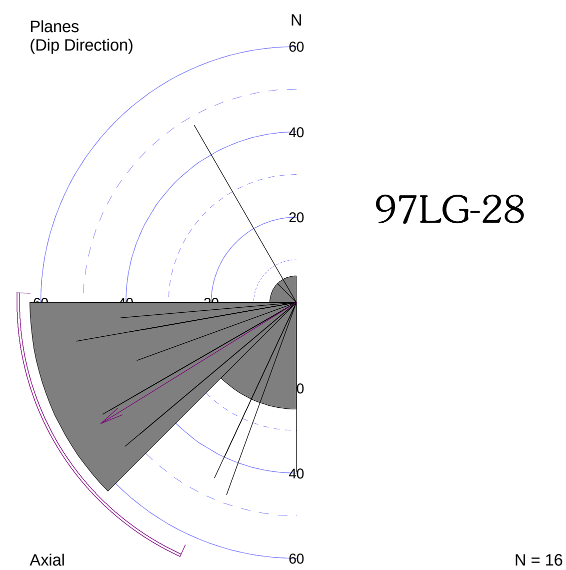
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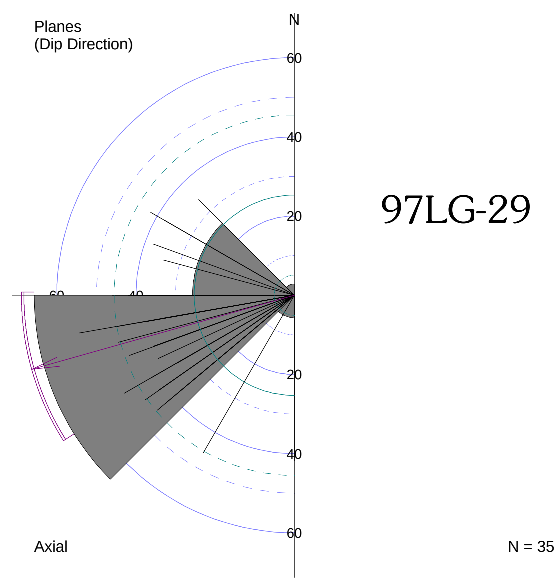
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97LG-29
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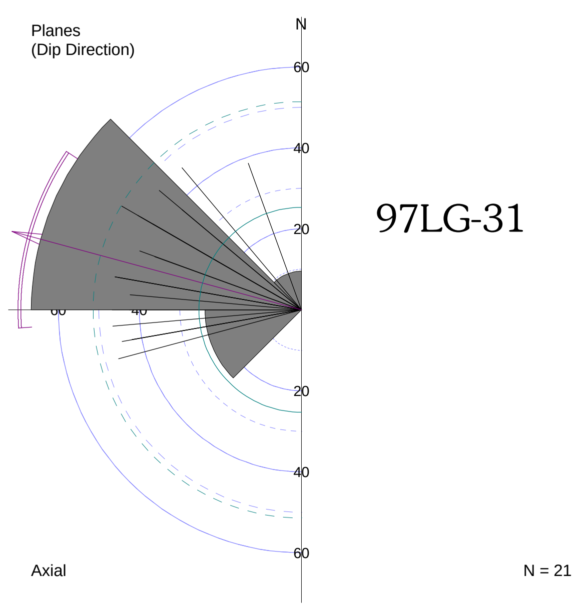
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Axial
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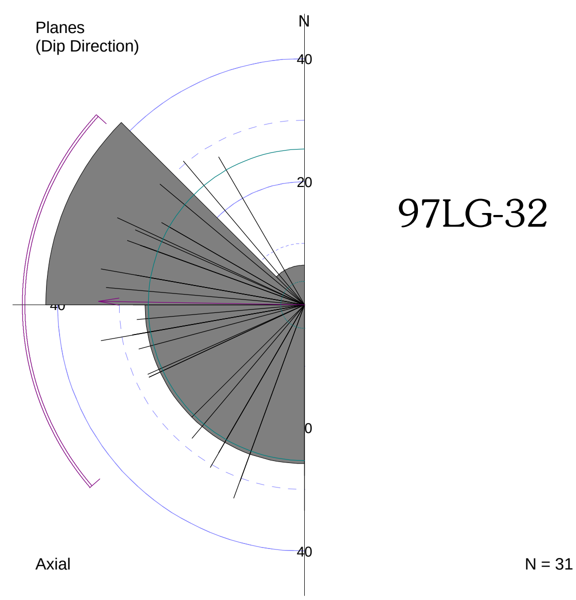
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40
Axial
97LG-32
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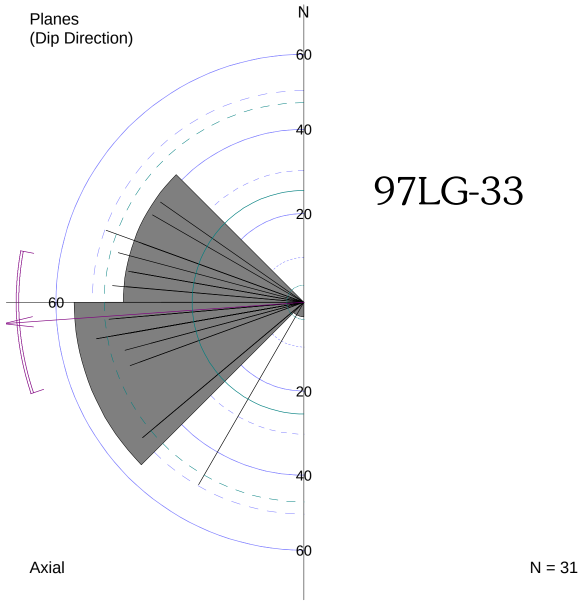

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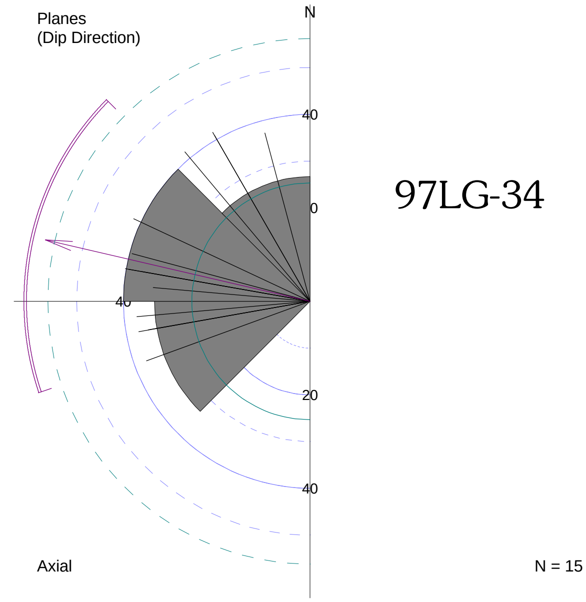

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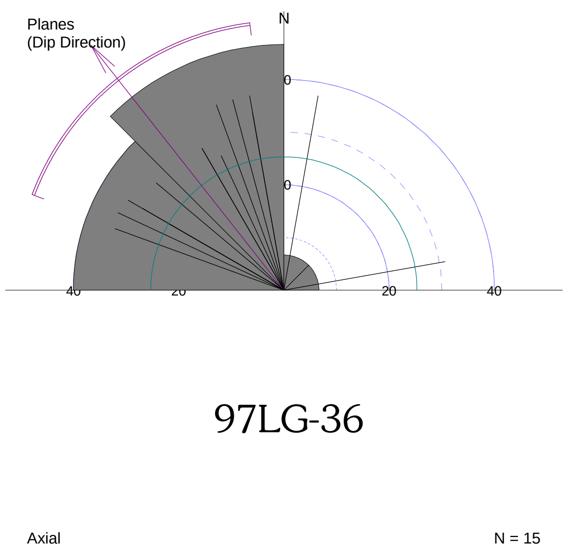

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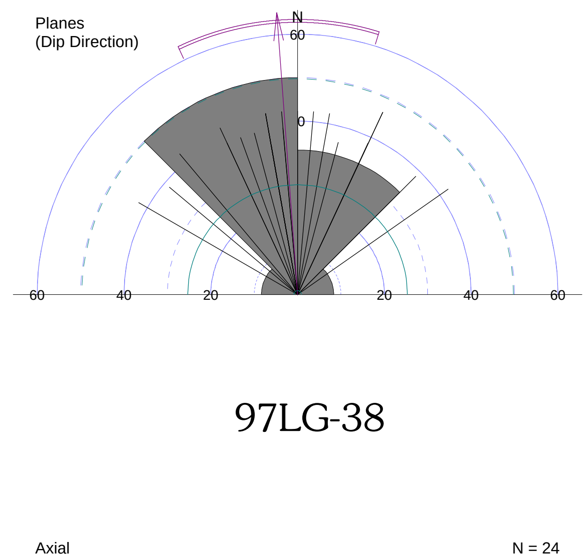

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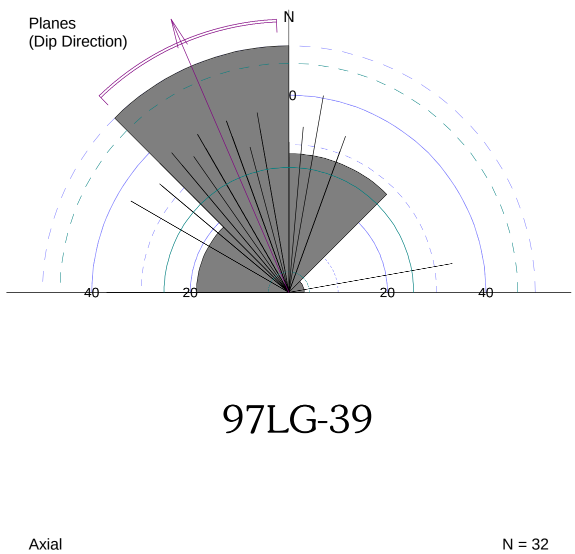

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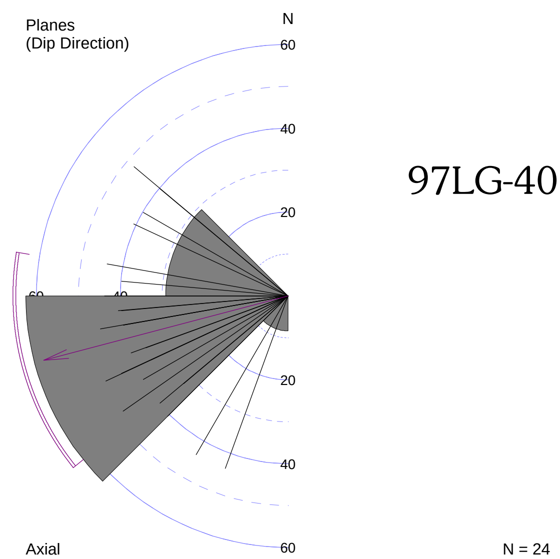

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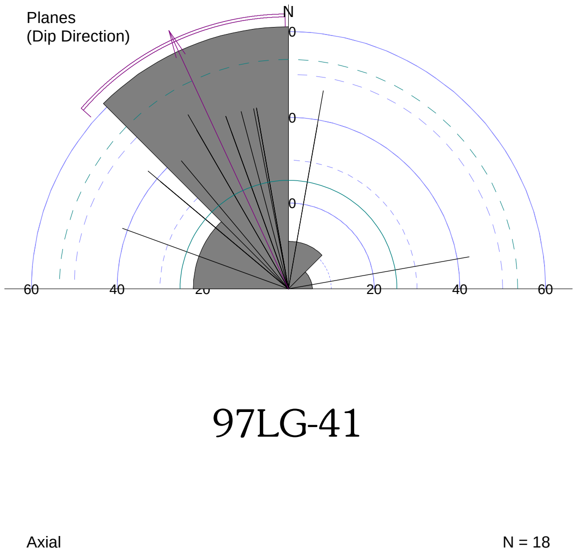

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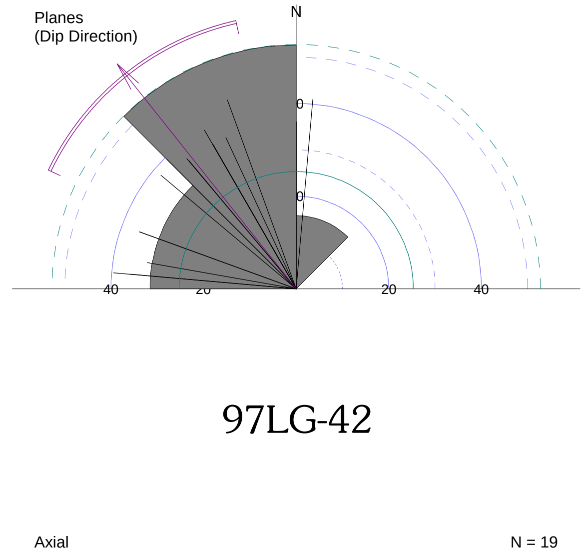

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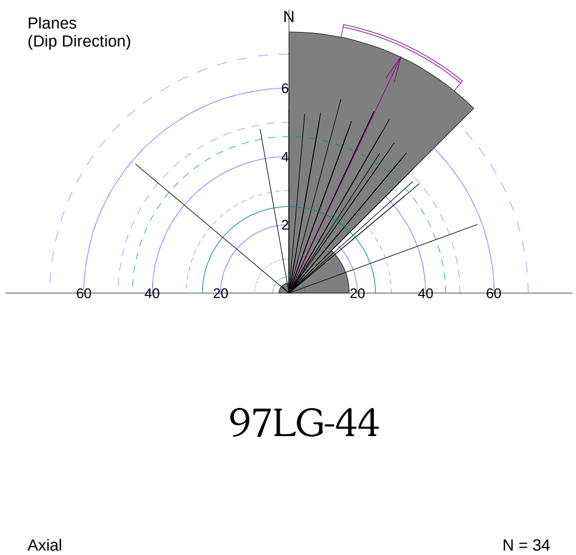

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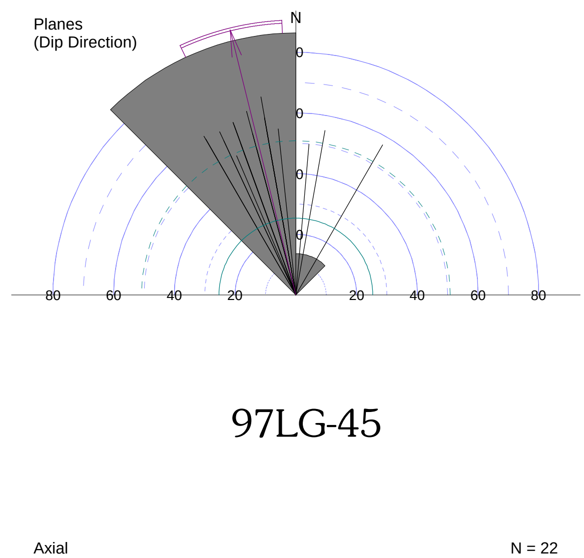
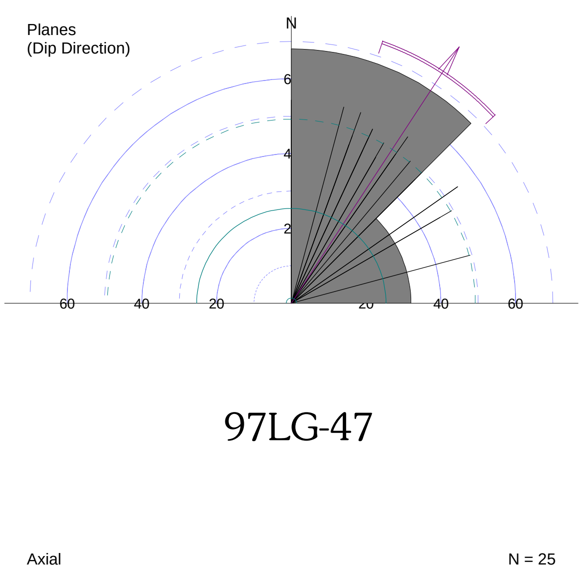
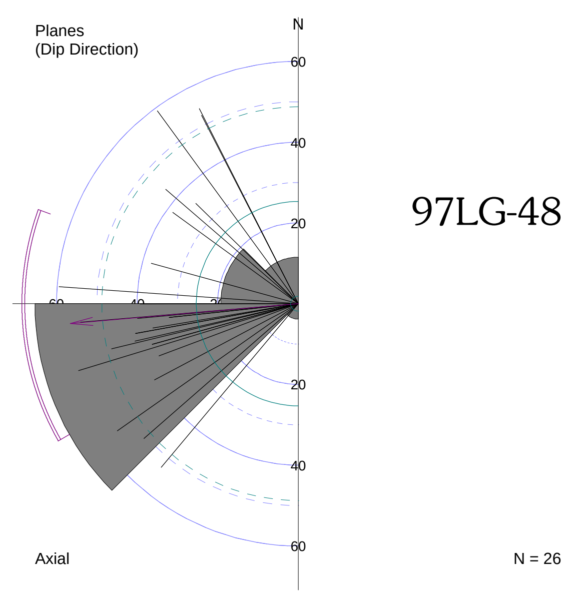


97LG-45



97LG-47



97LG-48

Appendix C

Soil Hydrocarbon Analytical Data and Statistical Analysis

Statistical Comparison of Propane Data, Crow Agency Line-F

Field data and soil-gas analyses are presented in the tables that follow this discussion. The sample line locations and soil-gas values at sample sites are shown in figures 17–20 and plate 5.

A t-test was used to compare propane data from two segments of the Crow Agency line (Samples F1–F43, F44–F88) to determine if the propane data from these two segments came from the same population.

A two-sample t-test, with a 95.0% confidence level was used. The line segment, samples F1–F43 (Minitab software, column C6), was compared with the line segment, F44–F88 (Minitab software, column C8). No alternative was specified. The statistical results were as follows:

	N	Mean	Standard Deviation	Standard Error of the Mean
Propane, Line segment 1	42	0.262	0.445	0.069
Propane, Line Segment 2	45	33.0	26.9	4.0

Confidence Interval

The 95% confidence interval for comparing column C6 to column C8 is -40.789– -24.6. Because this confidence interval does not include zero, the results are statistically significant.

T-Test

The t-value for propane column C6 versus propane column C8 is T=-8.17, with DF=44. The probability that these two data sets are part of the same population is zero. The T-test indicates that the two segments of line F are significantly different. This difference and the elevated propane levels in the segment from F44–F88 indicate that this entire segment is anomalous.

Statistical Comparison of Butane Data, Crow Agency Line F

A t-test was used to compare the two segments of the line that have different levels of butane (samples F1–F43, F44–F88), to determine if their data belong to the same population. A two-sample t-test, with a 95.0% confidence level, was used. Line segment F1–F43 was compared with line segment F44–F88 (columns C23 and C25, respectively, in Minitab software). No alternative was specified. The statistical results were as follows:

	N	Mean	Standard Deviation	Standard Error of the Mean
Butane, Line segment 1	42	19.7	21.8	3.4
Butane, Line segment 2	45	134	157	23.0

Confidence Interval

The 95% confidence interval for column 23 versus column 25 is -162.3– -67.0. Because this confidence interval does not include zero, it is statistically significant.

T-Test

The t-test for Butane column 23 versus Butane column 25 is T=-4.85, with DF=45. The probability that the butane data from these two line segments belongs to the same population is zero. This t-test result supports the statistical analysis of the propane data and indicates that the anomaly in the Crow Agency line is valid.

Crow Agency Line F Regression Analysis

Propane Analysis

A regression statistical procedure was used to determine if propane soil-gas values were affected by soil moisture or collection date. Propane data was regressed on soil moisture and sample collection date (sample collection date was nearly constant).

The regression equation is:

Propane = -24397 + 3.10 (%Moisture) + 0.341 (Sample date)

Results:

Predictor	Coefficient	Standard Deviation	t-ratio	p
Constant	-24397	2973	-8.21	0.000
%Moisture	3.099	1.473	2.10*	0.038
Sample Date	0.34092	0.04152	8.21*	0.000

s = 19.00 R-sq = 44.6% R-sq(adj) = 43.3%

* Statistically significant at the 95% level.
The p-value represents probability of occurrence.
%Moisture refers to the amount of soil moisture determined, using weight loss procedure.
Sample Date refers to the date the sample was collected.

This regression calculation indicates is a partial correlation between the propane concentration and soil moisture, which suggests that soil moisture does affect propane concentrations. The correlation between the propane concentrations and the sample date suggests some difference between the two dates during which samples along the F line were collected. This sample date difference implies a difference in sampling procedure, storage, or analysis effected the propane concentrations.

Analysis of Variance

Source	DF	Sum of Squares	Mean Squares	F	P
Regression	2	24,441	12,221	33.86*	0.000
Error	84	30,321	361		
Total	86	54,763			

* Statistically significant at 95% level.

Source	DF	SEQ SS
% Moisture	1	109
Sample Date	1	24332

Dividing the regression sum of squares (24,441) by the total sum of squares (54,763) results in a value of 0.446. This value indicates that this regression equation explains approximately 45% of the propane data variation. The regression calculations indicate that part of the variation in the propane data can be explained by a combination of soil moisture and sample collection date. The remainder of the variation is probably due to error (the variation in individual samples due to the sum of all other reasons). Some portion of the variation is caused by a subsurface hydrocarbon accumulation. Because other surface factors are generally constant, the anomaly appears to be valid. In other words, the anomaly probably represents a subsurface hydrocarbon accumulation because only a portion of the propane sample data variability can be explained by surface factors and sampling procedure.

Butane Analysis

The basic statistics for Crow Agency line F are as follows:

	N	Mean	Standard Deviation	Minimum	Maximum
Butane	87	79.0	127.1	6.0	886.0

Regression analysis similar to the procedure for the propane analysis was used to evaluate the variability in Butane data.

The regression equation is:

Butane = -876664 + 14.7 (%Soil Moisture) + 1.22 (Sample Date)

Results:

Predictor	Coefficient	Standard Deviation	t-ratio	p
Constant	-87664	17646	-4.97	0
%Moisture	14.659	8.742	1.68+	0.097
Sample Date	1.2249	0.2465	4.97*	0

s = 112.8 R-sq = 23.1% R-sq(adj) = 21.3%

+ Statistically significant at the 90% level.

* Statistically significant at the 95% level.
The p-value represents probability of occurrence.
%Moisture refers to the amount of soil moisture determined, using weight loss procedure.
Sample Date refers to the date the sample was collected.

This calculation indicates a correlation exists between butane concentrations and soil moisture, which suggests that soil moisture affects butane concentrations in the soil samples. The correlation between butane concentrations and sample date suggests some difference in the sampling technique, sample storage, or analysis between the two samplings.

Analysis of Variance

Source	DF	Sum of Squares	Mean Squares	F	P
Regression	2	321,157	160,579	12.63*	0
Error	84	1,068,251	12,717		
Total	86	1,389,408			

* Statistically significant at 95% level.

Source	DF	SEQ SS
% Moisture	1	7,029
Sample Date	1	314,128

Division of the regression sum of squares (321,157) by the total sum of squares (1,389,408) results in a value of 0.231, which indicates that this regression equation only explains about 23% in the butane data variation. In other words, approximately 77% of the butane data variation can not be explained by surface conditions or sampling procedures. Therefore, the anomaly is most likely caused by a hydrocarbon subsurface accumulation.

Statistical Analysis of the Crow Agency, Line F Extension

A two-sample t-test was conducted, comparing the butane data from the F-line extension (Minitab column C18) with the butane data from the anomalous segment of the F-line (samples F44–F88, Minitab column C25), to determine if the butane data from the F-line extension is part of the same population as the anomalous segment of the F-line.

The basic statistics for Crow Agency line F-extension are as follows:

	N	Mean	Standard Deviation	Standard Error of the mean
C18	47	17.3	11.8	1.7
C25	45	134	157	23

Confidence Interval

The 95% confidence interval for comparing column 18 and column 25 is -164.3 – -70. Because this interval does not include zero, it is statistically significant.

T-Test

The t-test for butane, column 18 versus butane, column 25 is T=-4.99, with DF=44. The probability that these two data sets are part of the same population is zero. This t-test indicates that butane from the F-line extension is not part of the same population as that from the anomalous segment of line F.

Statistical Analysis of the Crow Agency, Line F Extension

A two-sample t-test was conducted for butane, Crow Agency line G (Minitab, column 27) versus butane from the anomalous segment of line F (Minitab, column 25).

The basic statistics for Crow Agency line G are as follows:

	N	Mean	Standard Deviation	Standard Error of the mean
C27	24	97	281	57
C25	45	134	157	23

Confidence Interval

The 95% confidence interval for comparing butane from line G (C27) to butane in the anomalous portion of line F (C25) is -89 – 164. Because this interval includes zero, it is not statistically significant.

T-Test

The t-test comparing butane C25 with butane C27 is T = 0.61; P = 0.55; DF = 30.

The data from line G included one extremely high value (1,405 p.m., butane) that indicates a probable analysis or sampling error. Therefore, the statistical analysis was repeated without this high value. The basic statistics for Crow Agency line G (revised) are as follows:

	N	Mean	Standard Deviation	Standard Error of the Mean
C29	23	39.7	36.5	7.6
C25	45	134	157	23

Confidence Interval (revised)

The 95% confidence interval comparing Butane C25 to butane C29 is 45–144.1. This interval does not include zero; therefore, it is statistically significant.

T-test (revised)

The t-test comparing butane C25 to butane C29 is: T = 3.85*; P = 0.0003; DF = 52. (* statistically significant at 95% level). These calculations indicate there is a very low probability that butane concentrations from line G belong to the same population as the butane concentrations from the anomalous portion of line F.

Soil Survey Line A

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
A1	Silty Clay	1	1	3	Upper 6" More Organic & Moist	06/10/1999	99-54326- 1	4	0	1	40	35.8836	32.9114	8.3
A2	Silty Clay	1	1	2		06/10/1999	99-54326- 2	2	0	0	19	44.2298	38.7676	12.3
A3	Silty Clay	1	1	3		06/10/1999	99-54326- 3	4	0	0	23	34.4426	30.7819	10.6
A4	Silty Clay	1	1	3	Trace of Iron Oxide	06/10/1999	99-54326- 4	3	1	0	35	36.8138	33.6970	8.5
A5	Silty Clay	1	1	2	Slightly More Organic than A2 & A3	06/10/1999	99-54326- 5	3	1	5	66	54.4298	47.3178	13.1
A6	Silty Clay	1	1	3		06/10/1999	99-54326- 6	4	1	1	62	35.7486	31.4301	12.1
A7	Silty Clay	1	1	2		06/10/1999	99-54326- 7	3	1	1	97	42.0894	35.7972	14.9
A8	Silty Clay	1	1	2	Organic Matter	06/10/1999	99-54326- 8	3	0	1	50	50.1895	43.2343	13.9
A9	Silty Clay	1	1	2	Organic Matter	06/10/1999	99-54326- 9	3	1	0	33	45.8577	38.5172	16.0
A10B	Silty Clay	1	1	3	Slightly Sandier	06/10/1999	99-54326-10	5	1	0	103	39.9709	37.2905	6.7
A11	Silty Clay	1	1	3		06/10/1999	99-54326-12	3	0	0	21	37.9483	34.4405	9.2
A12	Silty Clay	1	1	3		06/10/1999	99-54326-13	3	0	0	52	37.9076	34.5858	8.8
A13	Silty Clay	1	1	3		06/10/1999	99-54326-14	5	9	3	97	37.8038	34.4989	8.7
A14	Silty Clay	1	1	3		06/10/1999	99-54326-15	4	1	1	98	38.0063	34.9272	8.1
A15	Silty Clay	1	1	3		06/10/1999	99-54326-16	2	0	0	32	39.8909	36.6735	8.1
A16	Silty Clay	1	1	3		06/10/1999	99-54326-17	3	0	0	32	46.7208	41.4838	11.2
A17	Silty Clay	1	1	3	More Clay	06/10/1999	99-54326-18	5	2	1	50	40.1175	36.3218	9.5
A18	Silty Clay	1	1	3	By Drainage, More Silty	06/10/1999	99-54326-19	3	1	2	71	44.3808	41.4614	6.6
A19	Silty Clay	1	1	3	Near Little Woody Creek, More Silty	06/10/1999	99-54326-20	3	2	1	71	46.4328	43.5217	6.3
A20B	Silty Clay	1	1	3	Near Little Woody Creek	06/10/1999	99-54326-21	5	6	2	105	40.4048	37.1408	8.1
A21	Silty Clay	1	1	3	Very Slightly Moist, More Clay	06/10/1999	99-54326-23	3	9	2	66	42.7957	39.0514	8.7
A22	Silty Clay	1	1	4	Silt Stone Granules	06/10/1999	99-54326-24	3	0	0	24	38.6423	34.8757	9.7
A23	Silty Clay	1	1	3	Near Drainage	06/10/1999	99-54326-25	4	1	1	55	39.9505	37.3209	6.6
A24	Silty Clay	1	1	3		06/10/1999	99-54326-26	3	1	0	22	41.3144	38.0107	8.0
A25	Silty Clay	2	1	4	Only Sampled First 6"	06/10/1999	99-54326-27	7	29	2	190	41.1368	38.2307	7.1
A26	Silty Clay	2	1	3	Very Slightly Moist, Mowry Shale channel	06/10/1999	99-54326-28	3	4	1	72	40.4580	36.8170	9.0
A28	Silty Clay	2	1	4	Organic Material Present	06/10/1999	99-54326-29	3	1	0	34	37.7151	34.0810	9.6
A29	Silty Clay	1	1	3		06/10/1999	99-54326-30	4	3	1	88	37.7116	33.6667	10.7
A30B	Silty Clay	1	1	3		06/10/1999	99-54326-31	3	0	0	15	33.4319	29.9262	10.5
A31	Silty Clay	1	1	3		06/10/1999	99-54326-33	3	0	0	7	40.0603	34.6578	13.5
A32	Silty Clay	2	1	3		06/10/1999	99-54326-34	2	0	0	5	45.8220	41.8974	8.6
A33	Silty Clay	2	1	3	Near Drainage, More Clayey	06/11/1999	99-54326-35	4	1	1	21	44.4409	39.9889	10.0
A34	Silty Clay	2	1	3	Organic Material, Mowry Shale Chips	06/11/1999	99-54326-36	2	0	0	3	40.9057	36.2753	11.3
A35	Silty Clay	2	1	3	Silty	06/11/1999	99-54326-37	2	1	0	13	43.9385	40.5581	7.7
A36	Silty Clay	2	1	3		06/11/1999	99-54326-38	5	1	0	11	39.3686	34.5616	12.2
A37	Silty Clay	2	1	3	Some Organic Material Present	06/11/1999/	99-54326-39	3	0	0	12	43.4312	39.3376	9.4
A38	Silty Clay	2	1	3	Near Drainage	06/11/1999	99-54326-40	4	0	0	12	40.2170	36.4639	9.3
A39	Silty Clay	2	1	3	Side of Drainage	06/11/1999	99-54326-41	3	2	1	37	42.3711	38.4086	9.4

Soil Survey Line A

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
A40B	Silty Clay	2	1	4		06/11/1999	99-54326-42	4	0	0	15	36.2586	31.5675	12.9
A41	Silty Clay	2	1	3		06/11/1999	99-54326-44	1	0	0	19	42.4743	38.0731	10.4
A42	Silty Clay	2	1	3		06/11/1999	99-54326-45	2	0	0	8	41.8031	37.7628	9.7
A43	Silty Clay	2	1	3		06/11/1999	99-54326-46	2	0	0	6	39.0471	35.0060	10.3
A44	Silty Clay	2	1	3		06/11/1999	99-54326-47	2	0	0	4	38.4894	35.0027	9.1
A45	Silty Clay	2	1	3	On Side of Drainage	06/11/1999	99-54326-48	4	2	0	9	41.4686	36.6657	11.6
A46	Silty Clay	2	1	3	Clayey	06/11/1999	99-54326-49	2	0	0	4	42.0408	37.5102	10.8
A47	Silty Clay	2	1	3		06/11/1999	99-54326-50	4	0	0	9	43.6171	39.7705	8.8
A48	Silty Clay	2	1	3	Lot of Clay	06/11/1999	99-54326-51	2	1	0	13	37.3617	33.1556	11.3
A49	Silty Clay	2	1	3	Near Drainage	06/11/1999	99-54326-52	1	1	0	11	46.4449	42.1930	9.2
A50B	Silty Clay	2	1	3	Clayey, Silty	06/11/1999	99-54326-53	3	1	0	12	43.1815	38.4270	11.0
A51	Silty Clay	3	1	3	Near Drainage	06/11/1999	99-54326-55	2	0	0	2	44.5142	40.3117	9.4
A52	Silty Clay	2	1	3	Iron Oxide Prsnt, Organic Material	06/11/1999	99-54326-56	2	1	0	12	48.1943	44.7296	7.2
A53	Shale Bedrock	2	1	3	Bedrock Is Slightly Weathered	06/11/1999	99-54326-57	5	2	0	14	49.5434	45.9545	7.2
A54	Shale Bedrock	3	1	3	Bedrock Is Slightly Weathered	06/11/1999	99-54326-58	3	1	0	4	47.2775	42.7034	9.7
A55	Shale Bedrock	3	1	3	Bedrock Is Slightly Weathered	06/11/1999	99-54326-59	5	1	0	7	50.0462	45.9474	8.2
A56	Silty Clay	2	2	3		06/11/1999	99-54326-60	2	0	0	10	46.5496	42.0104	9.8
A57	Silty Clay	2	2	3	Very Slightly Moist	06/11/1999	99-54326-61	2	0	0	12	50.4206	46.4501	7.9
A58	Silty Clay	2	2	3		06/11/1999	99-54326-62	2	0	0	8	42.5907	38.2942	10.1
A59	Silty Clay	2	1	3	Clayey	EY/	99-54326-63	2	1	1	35	45.9724	42.1003	8.4
A60B	Silty Clay	2	1	3		06/11/1999	99-54326-64	3	0	0	25	42.7530	39.4634	7.7
A61	Shale Bedrock	3	1	3	Bedrock Is Slightly Weathered	06/11/1999	99-54326-66	3	1	0	16	45.8077	41.5229	9.4
A62	Silty Clay	2	2	3	Very Slightly Moist	06/11/1999	99-54326-67	1	1	0	12	43.7710	39.3979	10.0
A63	Silty Clay	2	2	3		06/11/1999	99-54326-68	3	1	0	23	43.6803	39.5480	9.5
A64	Silty Clay	2	2	3		06/11/1999	99-54326-69	3	1	1	30	38.3268	34.2108	10.7
A65	Silty Clay	2	2	3		06/11/1999	99-54326-70	4	0	0	23	39.0158	34.9995	10.3
A66	Silty Clay	1	1	3		06/11/1999	99-54326-71	1	0	0	11	38.7093	34.4106	11.1
A67	Weathered Shale	2	1	3		06/11/1999	99-54326-72	2	0	0	12	41.8275	38.0196	9.1
A68	Silty Clay	3	1	3		06/11/1999	99-54326-73	3	0	0	13	45.1317	40.5385	10.2
A69	Weathered Shale	3	1	3		06/11/1999	99-54326-74	4	2	0	19	47.8007	41.6297	12.9
A70B	Silty Clay	2	1	3		06/11/1999	99-54326-75	3	1	0	13	42.2398	38.1314	9.7
A71	Silty Clay	3	1	3		06/11/1999	99-54326-77	1	0	0	4	40.1975	35.1033	12.7
A72	Silty Clay	2	1	3		06/11/1999	99-54326-78	4	1	0	4	43.3142	36.9395	14.7
A73	Silty Clay	1	2	4		06/11/1999	99-54326-79	5	9	1	41	46.9202	44.7106	4.7

Soil Survey Line A

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
A74	Silty Clay	1	2	4	Sampled First 6"	06/11/1999	99-54326-80	6	11	2	46	27.2307	25.6255	5.9
A75	Silty Clay	1	2	4	Sampled First 6"	06/15/1999	99-54326-81	4	1	0	11	45.3283	43.2000	4.7
A76	Silty Clay	1	1	3	Sampled 10"	06/15/1999	99-54326-82	2	1	0	15	42.5538	38.8968	8.6
A77	Silty Clay	2	1	3	Sampled 10"	06/15/1999	99-54326-83	4	2	0	7	47.2777	42.4240	10.3
A78	Weathered Shale	2	1	3		06/15/1999	99-54326-84	5	4	1	21	45.8320	41.0524	10.4
A79	Clay	2	1	3	Decomposed Shale	06/15/1999	99-54326-85	3	2	0	8	43.9803	39.1837	10.9
A80B	Silty Clay	2	1	2		06/15/1999	99-54326-86	4	1	0	4	45.6934	38.5368	15.7
A81	Silty Clay	2	1	3		06/15/1999	99-54326-88	2	0	0	3	46.2878	41.7835	9.7
A82	Silty Clay	2	1	3		06/15/1999	99-54326-89	4	0	0	5	44.7818	37.4671	16.3
A83	Silty Clay	2	1	3		06/15/1999/	99-54326-90	3	0	0	5	43.9126	37.3342	15.0
A84	Silty Clay	2	1	3		06/15/1999	99-54326-91	2	0	0	8	40.0015	35.6810	10.8
A85	Silty Clay	2	1	3		06/15/1999	99-54326-92	2	0	0	4	38.9299	33.9748	12.7
A86	Silty Clay	2	1	3		06/15/1999	99-54326-93	2	1	0	18	40.6812	36.2862	10.8
A87	Silty Clay	1	1	3		06/15/1999	99-54326-94	3	1	0	12	41.0757	36.6031	10.9
A88	Silty Clay	1	1	3		06/15/1999	99-54326-95	2	0	0	6	44.3684	39.4253	11.1
A89	Silty Clay	3	1	3		06/15/1999	99-54326-96	2	0	0	6	44.0558	39.2668	10.9
A90B	Silty Clay	4	1	3		06/15/1999	99-54326-97	2	0	0	4	43.1276	38.3273	11.1
A91	Weathered Shale	4	1	3		06/15/1999	99-54326-99	5	6	1	22	46.2745	42.4310	8.3
A92	Silty Clay	1	1	3		06/15/1999	99-54326- 100	4	4	0	13	38.0973	35.3673	7.2
A93	Silty Clay	2	1	3		06/15/1999	99-54326- 101	4	1	0	3	43.1598	37.8485	12.3
A94	Silty Clay	2	1	3		06/15/1999	99-54326- 102	2	1	0	9	47.9109	42.6971	10.9
A95	Silty Clay	2	1	3		06/15/1999	99-54326- 103	4	3	1	18	48.0904	44.3272	7.8
A96	Silty Clay	2	1	3	Sampled First 10"	06/15/1999	99-54326- 104	2	0	0	4	43.0278	38.7420	10.0
A97	Silty Clay	2	1	3		06/15/1999	99-54326- 105	2	2	1	11	45.5303	41.2172	9.5
A98	Silty Clay	2	1	3		06/15/1999	99-54326- 106	2	0	0	7	44.3357	39.7903	10.3
A99	Silty Clay	2	1	3		06/15/1999	99-54326- 107	2	0	0	4	43.9809	39.0048	11.3
A100B	Silty Clay	2	1	3		06/15/1999	99-54326- 108	4	1	0	6	43.5501	38.7186	11.1
A101	Silty Clay	1	1	3	More Clay	06/15/1999	99-54326- 110	4	0	0	11	52.0329	45.3380	12.9
A102	Silty Clay	2	1	3		06/15/1999	99-54326- 111	4	1	1	11	52.4966	46.0533	12.3
A10C	Silty Clay	1	1	3	Slightly Sandier	06/10/1999	99-54326-11	5	1	1	147	38.1236	34.5547	9.4
A20C	Silty Clay	1	1	3	Near Little Woody Creek	06/10/1999	99-54326-22	5	4	1	91	40.2691	37.4847	6.9
A30C	Silty Clay	1	1	3		06/10/1999	99-54326-32	3	1	0	12	40.6689	36.3848	10.5
A40C	Silty Clay	2	1	4		06/11/1999	99-54326-43	3	0	0	16	38.4956	33.7718	12.3
A50C	Silty Clay	2	1	3	Clayey, Silty	06/11/1999	99-54326-54	2	2	0	13	43.2199	38.7245	10.4
A60C	Silty Clay	2	1	3		06/11/1999	99-54326-65	4	1	1	31	45.8758	42.5252	7.3
A70C	Silty Clay	2	1	3		06/11/1999	99-54326-76	2	0	0	9	39.9537	36.0765	9.7
A80C	Silty Clay	2	1	2		06/15/1999	99-54326-87	4	1	0	3	46.9272	39.5706	15.7
A90C	Silty Clay	4	1	3		06/15/1999	99-54326-98	2	0	0	5	42.8206	37.8974	11.5
A100C	Silty Clay	2	1	3		06/15/1999	99-54326- 109	4	1	0	5	42.7455	37.8215	11.5

Soil Survey Line B

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2	N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
B1	Silty	1	1	3		6/16/1999	99-54326-	112	2	1	0	18	40.5746	37.8269	6.8
B2	Silty	1	1	3	Sampled 10", Clayey	6/16/1999	99-54326-	113	2	1	0	12	42.4743	40.3146	5.1
B3	Silty	1	1	3		6/16/1999	99-54326-	114	3	0	0	27	48.0925	42.2407	12.2
B4	Silty Clay	1	1	3		6/16/1999	99-54326-	115	4	0	0	24	44.6857	40.5454	9.3
B5	Silty Clay	1	1	3		6/16/1999	99-54326-	116	4	1	0	23	40.7954	37.5723	7.9
B6	Silty Clay	1	1	3	Very Slightly Moist, Almost Dry	6/16/1999	99-54326-	117	3	1	0	12	42.6019	39.4672	7.4
B7	Silty Clay	1	1	3		6/16/1999	99-54326-	118	4	0	0	22	40.1793	36.8163	8.4
B8	Silty Clay	1	1	3	In Creek Channel, Sampled 20"	6/16/1999	99-54326-	119	4	2	1	64	38.6250	35.2371	8.8
B9	Silty Clay	1	1	3	In Creek Channel	6/16/1999	99-54326-	120	3	0	0	22	48.0457	44.1173	8.2
B10	Silty Clay	1	1	3	In Creek Channel	6/16/1999	99-54326-	121	3	1	1	64	38.7025	35.7658	7.6
B11B	Silty Clay	1	1	3	In Creek Channel	6/16/1999	99-54326-	122	2	3	2	24	44.1314	39.6806	10.1
B12	Silty Clay	1	1	3	In Creek Channel	6/16/1999	99-54326-	124	4	1	1	30	58.0804	52.9709	8.8
B13	Silty Clay	1	1	3	In Creek Channel, Silty	6/16/1999	99-54326-	125	5	1	1	130	44.6296	41.6072	6.8
B14	Silty Clay	1	1	4	In Creek Channel, Very Silty	6/16/1999	99-54326-	126	2	1	1	35	36.7462	34.2457	6.8
B15	Silty Clay	1	1	3	In Floodplain	6/16/1999	99-54326-	127	4	0	0	45	40.0326	37.1190	7.3
B16	Silty Clay	1	1	3	In Floodplain, Sampled 11"	6/16/1999	99-54326-	128	3	1	0	16	40.8325	38.3152	6.2
B17	Silty Clay	1	1	3	In Floodplain	6/16/1999	99-54326-	129	4	2	1	38	43.1011	39.7936	7.7
B18	Silty Clay	1	1	3		6/16/1999	99-54326-	130	4	1	1	48	44.2080	41.4595	6.2
B19	Silty Clay	1	1	3	Very Slightly Moist, in Floodplain	6/16/1999	99-54326-	131	2	0	0	19	46.1566	43.6523	5.4
B20B	Silty Clay	1	1	3		6/16/1999	99-54326-	132	2	1	0	22	43.6640	41.0546	6.0
B21	Silty Clay	1	1	3		6/16/1999	99-54326-	134	4	4	2	56	42.2563	39.8331	5.7
B22	Silty Clay	1	1	3		6/16/1999	99-54326-	135	3	2	1	25	41.8320	38.6206	7.7
B23	Silty Clay	1	1	3	In Floodplain, Silty	6/16/1999	99-54326-	136	3	1	1	43	49.0955	46.1212	6.1
B24	Silty Clay	1	1	3	On Creek Bank	6/16/1999	99-54326-	137	4	2	1	38	43.9841	41.0305	6.7
B25	Silty Clay	1	1	3	More Clay, Shale Granules	6/16/1999	99-54326-	138	4	0	0	23	46.9490	43.3903	7.6
B26	Silty Clay	1	1	3		6/16/1999	99-54326-	139	2	0	0	4	43.3355	39.5203	8.8
B27	Silty Clay	1	1	3		6/16/1999	99-54326-	140	4	1	0	19	47.3800	44.1847	6.7
B28	Silty Clay	1	1	3	Almost Dry	6/16/1999	99-54326-	141	3	1	1	18	43.9732	40.3642	8.2
B29	Silty Clay	1	1	3		6/16/1999	99-54326-	142	2	0	0	15	43.5110	40.8485	6.1
B30B	Silty Clay	1	1	3		6/16/1999	99-54326-	143	4	1	1	47	42.7359	39.9751	6.5
B31	Silty Clay	1	1	2	Clayey	6/16/1999	99-54326-	145	2	0	0	5	43.0075	37.5292	12.7
B32	Silty Clay	1	1	3	Very Silty, Nearly Dry	6/16/1999	99-54326-	146	3	0	0	5	44.2785	41.7029	5.8
B33	Silty Clay	1	1	4	Silty	6/16/1999	99-54326-	147	2	6	1	37	43.5721	41.2734	5.3
B34	Silty Clay	1	1	3	Very Slightly Moist	6/16/1999	99-54326-	148	2	0	0	18	45.7746	42.9301	6.2
B35	Silty Clay	1	1	4		6/16/1999	99-54326-	149	4	2	0	44	39.6069	36.8328	7.0
B36	Silty Clay	1	1	4		6/16/1999	99-54326-	150	4	1	0	27	44.1083	41.6688	5.5
B37	Silty Clay	1	1	4		6/16/1999	99-54326-	151	4	1	1	25	44.2126	41.6198	5.9

Soil Survey Line B

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
B38	Silty Clay	1	1	4		6/16/1999	99-54326-152	4	0	1	30	43.5802	41.4394	4.9
B39	Silty Clay	1	1	4	More Clay	6/16/1999	99-54326-153	2	2	1	12	47.6815	44.3322	7.0
B40B	Silty Clay	1	1	4	Dug Hole & Took out Sample	6/16/1999	99-54326-154	3	13	2	54	28.6787	26.2676	8.4
B41	Silty Clay	1	1	3	Sampled 10", Very Slightly Moist	6/16/1999	99-54326-156	3	0	0	12	39.6112	36.5880	7.6
B42	Silty Clay	1	1	4		6/16/1999	99-54326-157	2	1	0	3	47.5104	44.7335	5.8
B43	Silty Clay	1	1	4	Sampled 10"	6/16/1999	99-54326-158	2	1	0	10	46.7121	43.9335	5.9
B44	Silty Clay	1	1	4	Sampled 10"	6/16/1999	99-54326-159	2	0	0	11	46.2022	43.0287	6.9
B45	Silty Clay	1	1	3	Very Slighlty Moist, past Pipeline	6/17/1999	99-54326-160	4	0	0	8	36.9836	34.5349	6.6
B46	Silty Clay	1	1	4	Organic Material	6/17/1999	99-54326-161	2	1	0	8	44.0855	41.3588	6.2
B47	Silty Clay	1	1	4		6/17/1999	99-54326-162	2	0	0	4	43.5471	40.3010	7.5
B48	Silty Clay	1	1	4	Silty	6/17/1999	99-54326-163	2	0	0	7	47.3298	45.0359	4.8
B49	Silty Clay	1	1	3	Clay, Sampled 10", Almost Dry	6/17/1999	99-54326-164	2	0	0	6	41.5796	38.3317	7.8
B50B	Silty Clay	1	1	4		6/17/1999	99-54326-165	2	0	0	10	38.5519	35.8919	6.9
B51	Silty Clay	1	1	4		6/17/1999	99-54326-167	2	0	0	4	44.0410	41.2465	6.3
B52	Silty Clay	1	1	4		6/17/1999	99-54326-168	3	0	0	13	39.8903	37.0026	7.2
B53	Silty Clay	1	1	3	Creek Bed, Clayey	6/17/1999	99-54326-169	4	1	1	69	43.3908	38.0380	12.3
B54	Silty Clay	1	1	4	Sampled 10"	6/17/1999	99-54326-170	3	0	0	9	37.7414	34.9212	7.5
B55	Silty Clay	1	1	4		6/17/1999	99-54326-171	3	1	0	14	43.2030	40.5357	6.2
B56	Silty Clay	1	1	4		6/17/1999	99-54326-172	2	1	0	9	44.5303	42.2225	5.2
B57	Silty Clay	1	1	4		6/17/1999	99-54326-173	3	0	0	4	39.2048	36.5412	6.8
B58	Silty Clay	1	1	4		6/17/1999	99-54326-174	3	0	0	14	43.9218	41.2457	6.1
B59	Silty Clay	1	1	4		6/17/1999	99-54326-175	5	0	0	27	44.4446	40.8912	8.0
B60B	Silty Clay	1	1	4		6/17/1999	99-54326-176	2	1	0	15	42.1528	39.5243	6.2
B61	Silty Clay	1	1	4		6/17/1999	99-54326-178	2	0	0	13	41.9955	39.1575	6.8
B62	Silty Clay	1	1	4		6/17/1999	99-54326-179	3	0	0	22	45.9816	42.7685	7.0
B63	Silty Clay	1	1	4		6/17/1999	99-54326-180	4	1	1	75	39.4840	36.0128	8.8
B64	Silty Clay	1	1	4		6/17/1999	99-54326-181	2	0	0	11	41.2287	38.6603	6.2
B65	Silty Clay	1	1	4		6/17/1999	99-54326-182	3	1	0	18	42.5449	39.7820	6.5
B66	Silty Clay	1	1	3		6/17/1999	99-54326-183	2	1	0	13	43.9763	40.2433	8.5
B67	Silty Clay	1	1	3		6/17/1999	99-54326-184	2	1	1	14	46.3750	42.9665	7.3
B68	Silty Clay	2	1	3		6/17/1999	99-54326-185	3	0	0	13	38.4269	35.1179	8.6
B69	Silty Clay	1	1	3	Organic Matter	6/17/1999	99-54326-186	3	0	0	16	37.7154	35.0490	7.1
B70B	Silty Clay	1	1	3	Clayey	6/17/1999	99-54326-187	4	1	0	11	44.1641	38.4916	12.8
B71	Silty Clay	1	1	2	Near Salt Marsh	6/17/1999	99-54326-189	3	1	0	8	38.9192	33.7708	13.2
B72	Silty Clay	1	1	4		6/17/1999	99-54326-190	2	0	0	8	39.7689	36.6868	7.8
B73	Silty Clay	1	1	4		6/17/1999	99-54326-191	2	0	0	3	42.2574	39.2111	7.2
B74	Silty Clay	1	2	3	Very Slightly Moist	6/17/1999	99-54326-192	1	0	0	9	39.5814	36.1985	8.5

Soil Survey Line B

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2	Laboratory N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
B75	Silty Clay	1	2	3	Very Slightly Moist	6/17/1999	99-54326-	193	2	0	0	6	41.1723	36.8735	10.4
B76	Silty Clay	1	2	4		6/17/1999	99-54326-	194	2	0	0	2	48.8219	45.8243	6.1
B77	Silty Clay	1	2	3	Very Slightly Moist @ Bottom	6/17/1999	99-54326-	195	2	0	0	4	42.4586	38.6963	8.9
B78	Silty Clay	1	2	3	Bottom 2" Is Slightly Moist	6/17/1999	99-54326-	196	2	0	0	7	40.9947	37.5170	8.5
B79	Silty Clay	2	2	3	More Clayey	6/17/1999	99-54326-	197	2	0	0	3	42.5252	38.9058	8.5
B80B	Silty Clay	2	2	3		6/17/1999	99-54326-	198	2	0	0	2	40.5508	36.8349	9.2
B81	Silty Clay	1	2	3		6/17/1999	99-54326-	200	2	0	0	4	40.0801	35.0497	12.6
B82	Silty Clay	1	2	3		6/17/1999	99-54326-	201	2	0	0	4	41.6462	37.2821	10.5
B83	Silty Clay	2	1	3	Almost Dry	6/17/1999	99-54326-	202	2	0	0	8	41.3893	38.1743	7.8
B84	Clay	2	1	2	Near Salt Seep	6/17/1999	99-54326-	203	4	1	0	6	50.1490	45.3638	9.5
B85	Silty Clay	2	1	4	Bottom 1" Is Slightly Moist	6/17/1999	99-54326-	204	2	0	0	4	43.3312	39.9768	7.7
B86	Silty Clay	2	1	4		6/17/1999	99-54326-	205	2	1	0	19	40.2089	36.1761	10.0
B87	Silty Clay	1	1	4		6/17/1999	99-54326-	206	2	0	0	5	40.2639	36.4572	9.5
B88	Silty Clay	2	1	3	Very Slightly Moist	6/22/1999	99-54326-	207	1	0	0	5	41.4998	37.8555	8.8
B89	Silty Clay	1	1	3		6/22/1999	99-54326-	208	2	1	0	5	45.1142	41.8154	7.3
B90B	Silty Clay	1	1	4		6/22/1999	99-54326-	209	3	0	0	17	41.0095	37.8364	7.7
B91	Silty Clay	1	1	3	In Floodplain	6/22/1999	99-54326-	211	3	1	1	23	43.6933	40.2376	7.9
B92	Silty Clay	2	1	4		6/22/1999	99-54326-	212	3	0	0	16	45.5026	42.0262	7.6
B93	Silty Clay	2	1	3		6/22/1999	99-54326-	213	3	0	0	10	39.2103	35.4447	9.6
B94	Silty Clay	2	1	4		6/22/1999	99-54326-	214	2	0	0	6	40.8085	37.7885	7.4
B95	Silty Clay	1	1	2	Clayey	6/22/1999	99-54326-	215	2	0	0	5	42.7714	38.3125	10.4
B96	Silty Clay	1	1	3	Almost Dry, Some Caliche	6/22/1999	99-54326-	216	2	0	0	4	42.0525	39.0995	7.0
B97	Silty Clay	1	1	4	Silty	6/22/1999	99-54326-	217	2	0	0	5	41.7038	37.1026	11.0
B98	Silty Clay	1	1	3		6/22/1999	99-54326-	218	2	0	0	8	42.4139	36.9528	12.9
B99	Silty Clay	2	1	4		6/22/1999	99-54326-	219	2	0	0	7	37.8486	33.2028	12.3
B100B	Silty Clay	2	1	4		6/22/1999	99-54326-	220	2	1	0	7	39.5766	33.8129	14.6
B101	Silty Clay	2	1	4		6/22/1999	99-54326-	222	2	0	0	7	42.9528	38.3296	10.8
B102	Silty Clay	1	1	4		6/22/1999	99-54326-	223	3	0	0	9	38.6702	34.1708	11.6
B103	Silty Clay	2	1	4		6/22/1999	99-54326-	224	4	4	0	20	39.8202	35.4824	10.9
B104	Silty Clay	1	1	4	Two Samples	6/22/1999	99-54326-	225	3	0	0	11	41.7725	38.2684	8.4
B105	Silty Clay	2	1	3		6/22/1999	99-54326-	226	2	0	0	8	44.0553	40.0948	9.0
B106	Silty Clay	2	1	4		6/22/1999	99-54326-	227	3	0	0	11	36.6612	34.0980	7.0
B107	Silty Clay	2	1	4	Shale Chips	6/22/1999	99-54326-	228	3	0	0	9	47.1086	43.8424	6.9
B108	Silty Clay	2	1	4		6/22/1999	99-54326-	229	3	0	0	11	40.3875	36.5378	9.5
B109	Silty Clay	2	1	4		6/22/1999	99-54326-	230	2	0	0	6	37.1283	34.0778	8.2
B110B	Silty Clay	1	1	3	In Drainage	6/22/1999	99-54326-	231	4	1	0	31	44.6570	40.5091	9.3

Soil Survey Line B

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
B111	Weathered Shale	2	1	4		6/22/1999	99-54326-233	4	2	0	8	54.6989	50.6209	7.5
B112	Silty Clay	1	1	4		6/22/1999	99-54326-234	3	1	0	13	39.4916	35.0924	11.1
B113	Silty Clay	1	1	4		6/22/1999	99-54326-235	2	0	0	10	43.6881	39.2491	10.2
B114	Silty Clay	2	1	4		6/22/1999	99-54326-236	2	0	0	8	41.6164	37.2119	10.6
B115	Silty Clay	2	1	3		6/22/1999	99-54326-237	2	0	0	2	49.3394	43.3649	12.1
B116	Silty Clay	2	1	4		6/22/1999	99-54326-238	2	0	0	5	41.9850	38.9286	7.3
B117	Silty Clay	2	1	4		6/22/1999	99-54326-239	4	0	0	28	43.7735	41.1162	6.1
B118	Silty Clay	1	5	3		6/22/1999	99-54326-240	1	0	0	5	45.2090	40.2644	10.9
B119	Silty Clay	1	5	3	Very Slightly Moist	6/22/1999	99-54326-241	2	0	0	2	43.4034	38.2227	11.9
B120B	Silty Clay	2	5	4	Silty, Some Caliche	6/22/1999	99-54326-242	2	0	0	11	41.5287	38.2676	7.9
B121	Silty Clay	1	5	3		6/22/1999	99-54326-244	2	0	0	1	39.0495	34.3021	12.2
B122	Silty Clay	1	5	4		6/22/1999	99-54326-245	2	0	0	5	43.0191	39.4554	8.3
B123	Silty Clay	2	5	3		6/22/1999	99-54326-246	2	0	0	5	46.9040	41.7099	11.1
B124	Silty Clay	2	5	3		6/22/1999	99-54326-247	1	0	0	2	43.0146	38.1027	11.4
B125	Silty Clay	1	5	3		6/22/1999	99-54326-248	2	0	0	5	42.3964	37.7141	11.0
B126	Silty Clay	1	5	4		6/22/1999	99-54326-249	2	0	0	10	41.3610	36.3664	12.1
B127	Silty Clay	1	5	3		6/22/1999	99-54326-250	2	0	0	4	42.7667	37.6204	12.0
B128	Silty Clay	1	5	4		6/22/1999	99-54326-251	2	0	0	4	44.2086	39.3547	11.0
B11C	Silty Clay	1	1	3	In Creek Channel	6/22/1999	99-54326-123	2	1	1	16	43.2535	38.8406	10.2
B20C	Silty Clay	1	1	3		6/22/1999	99-54326-133	4	1	0	32	44.2142	41.6794	5.7
B30C	Silty Clay	1	1	3		6/22/1999	99-54326-144	4	1	1	52	44.2306	41.2262	6.8
B40C	Silty Clay	1	1	4	Sampled 10"	6/22/1999	99-54326-155	3	1	0	24	43.5825	40.4473	7.2
B50C	Silty Clay	1	1	4		6/22/1999	99-54326-166	2	0	0	3	47.0874	44.4017	5.7
B60C	Silty Clay	1	1	4		6/22/1999	99-54326-177	2	0	0	13	43.1582	40.8394	5.4
B70C	Silty Clay	1	1	3	Clayey	6/22/1999	99-54326-188	2	1	0	10	42.8291	38.0667	11.1
B80C	Silty Clay	2	2	3		6/22/1999	99-54326-199	2	0	0	2	39.3849	34.4077	12.6
B90C	Silty Clay	1	1	4		6/22/1999	99-54326-210	3	0	0	2	41.4341	38.2474	7.7
B100C	Silty Clay	2	1	4		6/22/1999	99-54326-221	2	1	0	7	44.8993	39.8313	11.3
B110C	Silty Clay	1	1	3	In Drainage	6/22/1999	99-54326-232	2	0	0	27	43.8530	39.6266	9.6
B120C	Silty Clay	2	5	4	Silty, Some Caliche	6/22/1999	99-54326-243	2	0	0	4	45.3607	41.5436	8.4

Soil Survey Line C

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
C1	Clay	1	2	2		6/23/1999	99-54326-252	2	3	1	9	48.3884	42.5229	12.1
C2	Silty Clay	1	2	2		6/23/1999	99-54326-253	2	1	0	15	54.9349	49.4260	10.0
C3	Silty Clay	1	2	2		6/23/1999	99-54326-254	2	0	0	3	47.4277	38.4428	18.9
C4	Silty Clay	1	2	2		6/23/1999	99-54326-255	1	0	0	2	44.9631	37.0529	17.6
C5	Clay	1	1	4		6/23/1999	99-54326-256	3	0	0	13	50.0679	45.0763	10.0
C6	Clay	1	1	4	Some Caliche Present	6/23/1999	99-54326-257	2	0	0	3	45.0784	40.9912	9.1
C7	Silty Clay	1	5	4	Some Caliche	6/23/1999	99-54326-258	2	0	0	4	47.5423	43.4556	8.6
C8	Weathered Shale	2	1	3		6/23/1999	99-54326-259	2	1	0	15	44.4535	40.0649	9.9
C9	Silty Clay	3	1	3		6/23/1999	99-54326-260	2	1	0	9	44.7900	40.2072	10.2
C10B	Silty Clay	1	2	3	Some Caliche	6/23/1999	99-54326-261	3	1	0	10	47.2297	42.2983	10.4
C11	Silty Clay	1	2	3	Very Silty	6/23/1999	99-54326-263	3	0	0	11	42.2557	36.4923	13.6
C12	Silty Clay	1	2	3	Very Slightly Moist	6/23/1999	99-54326-264	3	0	0	1	42.8362	38.0405	11.2
C13	Silty Clay	3	1	3		6/23/1999	99-54326-265	2	1	0	16	44.8463	40.6569	9.3
C14	Silty Clay	1	2	3		6/23/1999	99-54326-266	3	0	0	3	45.3451	39.6292	12.6
C15	Silty Clay	1	2	3		6/23/1999	99-54326-267	3	1	0	4	43.8922	38.7636	11.7
C16	Pbly Silty Clay	3	1	4		6/23/1999	99-54326-268	2	2	1	18	43.2992	41.2945	4.6
C17	Pbly Silty Clay	1	1	4		6/23/1999	99-54326-269	2	0	0	7	45.6274	41.9926	8.0
C18	Pbly Silty Clay	3	1	4		6/23/1999	99-54326-270	6	1	0	26	59.8523	58.9744	1.5
C19	Silty Clay	3	1	4		6/23/1999	99-54326-271	4	0	0	5	44.0042	40.3244	8.4
C20A	Pbly Silty Clay	3	1	4		6/24/1999	99-54326-272	5	1	0	26	46.9332	44.0856	6.1
C21	Silty Clay	2	1	3	Very Slightly Moist	6/24/1999	99-54326-274	3	1	0	17	42.0578	37.4590	10.9
C22	Silty Clay	3	1	3	Slightly Pebbly	6/24/1999	99-54326-275	2	1	0	25	40.0682	36.1137	9.9
C23	Silty Clay	2	1	3	Some Caliche	6/24/1999	99-54326-276	3	0	0	8	42.9576	38.6097	10.1
C24	Silty Clay	3	1	3	Caliche	6/24/1999	99-54326-277	3	0	0	5	40.9789	36.5327	10.8
C25	Weathered Shale	3	1	4		6/24/1999	99-54326-278	4	0	0	8	55.8301	51.4037	7.9
C26	Silty Clay	3	1	4		6/24/1999	99-54326-279	2	0	0	5	45.8452	42.3574	7.6
C27	Silty Clay	2	1	3	Clayey	6/24/1999	99-54326-280	3	0	0	13	35.1433	31.2256	11.1

Soil Survey Line C

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
C28	Silty Clay	2	1	3	Clayey	6/24/1999	99-54326-281	4	0	0	5	41.8258	37.8562	9.5
C29	Silty Clay	2	1	3	Silty	6/24/1999	99-54326-282	3	0	0	16	39.9426	36.7324	8.0
C30B	Silty Clay	2	1	3		6/24/1999	99-54326-283	4	0	0	16	42.5408	38.8627	8.6
C31	Silty Clay	2	1	3		6/24/1999	99-54326-285	2	0	0	6	44.2922	40.2754	9.1
C32	Silty Clay	2	1	3	Clayey	6/24/1999	99-54326-286	2	0	0	5	34.2466	30.0768	12.2
C33	Silty Clay	2	1	3		6/24/1999	99-54326-287	3	0	0	4	39.5276	35.4539	10.3
C34	Silty Clay	1	1	4		6/24/1999	99-54326-288	2	0	0	4	44.9105	40.3118	10.2
C35	Silty Clay	2	1	4		6/24/1999	99-54326-289	2	0	0	6	47.3305	42.3413	10.5
C36	Silty Clay	1	1	4		6/24/1999	99-54326-290	3	0	0	5	44.2382	39.4590	10.8
C37	Weathered Shale	1	1	4		6/24/1999	99-54326-291	2	0	0	1	49.7455	45.6436	8.2
C38	Weathered Shale	2	1	4		6/24/1999	99-54326-292	4	3	0	10	47.7261	43.9281	8.0
C39	Silty Clay	2	1	3	Lot of Caliche	6/24/1999	99-54326-293	2	0	0	6	45.1254	40.5162	10.2
C40B	Silty Clay	1	1	3		6/24/1999	99-54326-294	4	0	0	5	44.3911	40.1217	9.6
C41	Silty Clay	1	1	2	In Drainage	6/24/1999	99-54326-296	3	1	0	12	45.6959	40.3040	11.8
C42	Silty Clay	1	1	4	In Drainage	6/24/1999	99-54326-297	4	0	0	9	45.7387	41.7948	8.6
C43	Silty Clay	1	1	4	Very Silty	6/28/1999	99-54315-1	4	1	1	40	40.8274	38.1890	6.5
C44	Silty Clay	1	1	4	Very Silty	6/28/1999	99-54315-2	4	0	0	11	44.6667	42.2165	6.0
C45	Silty Clay	1	1	4		6/28/1999	99-54315-3	4	0	0	17	41.1515	38.0807	7.5
C46	Silty Clay	1	1	4		6/28/1999	99-54315-4	3	0	0	20	45.6305	42.8718	6.0
C47	Silty Clay	1	1	4		6/28/1999	99-54315-5	4	2	0	26	44.7653	42.2931	5.5
C48	Silty Clay	1	1	4		6/28/1999	99-54315-6	4	1	0	12	38.4495	35.3627	8.0
C49	Silty Clay	1	1	4		6/28/1999	99-54315-7	4	2	0	19	41.8156	38.4335	8.1
C50A	Silty Clay	1	1	4		6/28/1999	99-54315-8	3	0	0	14	41.6467	38.4678	7.6
C51	Silty Clay	1	1	4	Pebbly, Silty	6/28/1999	99-54315-10	5	3	2	77	43.9214	41.1818	6.2
C52	Silty Clay	2	1	4		6/28/1999	99-54315-11	4	1	0	29	43.2077	39.8367	7.8
C53	Silty Clay	2	1	4		6/28/1999	99-54315-12	4	2	1	21	46.4622	43.4512	6.5
C54	Silty Clay	2	1	4		6/28/1999	99-54315-13	4	5	1	43	45.1890	42.4796	6.0
C55	Silty Clay	2	1	4		6/28/1999	99-54315-14	4	1	0	35	39.5390	36.5213	7.6
C56	Silty Clay	1	1	4		6/28/1999	99-54315-15	4	1	0	23	38.9356	35.6297	8.5
C57	Silty Clay	2	1	4		6/28/1999	99-54315-16	3	1	0	20	39.2972	36.0254	8.3

Soil Survey Line C

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
C58	Silty Clay	1	1	4	Top of Sample Is Barely Moist	6/28/1999	99-54315-17	3	0	0	17	43.7622	40.2367	8.1
C59	Silty Clay	2	1	4		6/28/1999	99-54315-18	3	1	0	22	47.7130	44.5906	6.5
C60A	Silty Clay	1	1	4	Drainage	6/28/1999	99-54315-19	5	3	2	101	47.4678	44.6832	5.9
C61	Silty Clay	2	1	3		6/28/1999	99-54315-21	4	1	1	96	41.4171	38.5973	6.8
C62	Silty Clay	2	1	4		6/28/1999	99-54315-22	3	1	1	47	46.6428	43.4456	6.9
C63	Silty Clay	2	1	4		6/28/1999	99-54315-23	3	1	0	38	47.5996	44.3721	6.8
C64	Silty Clay	1	1	4		6/28/1999	99-54315-24	3	2	1	72	44.4024	41.1331	7.4
C65	Silty Clay	1	1	4	Some Caliche Present	6/28/1999	99-54315-25	3	1	1	41	43.8384	40.3552	7.9
C66	Silty Clay	1	1	4		6/28/1999	99-54315-26	3	1	0	28	43.9549	40.6511	7.5
C67	Silty Clay	2	1	4		6/28/1999	99-54315-27	3	0	0	15	44.4012	40.9168	7.8
C68	Silty Clay	1	1	4		6/28/1999	99-54315-28	4	2	1	40	38.9631	34.8536	10.5
C69	Silty Clay	1	1	4		6/28/1999	99-54315-29	4	3	1	53	41.5323	38.1640	8.1
C70A	Silty Clay	1	1	4		6/28/1999	99-54315-30	4	2	1	37	43.3985	38.6931	10.8
C71	Silty Clay	2	1	4		6/28/1999	99-54315-32	3	2	1	38	39.3940	35.5351	9.8
C72	Silty Clay	2	1	4		6/28/1999	99-54315-33	4	1	1	48	41.4564	38.1493	8.0
C73	Silty Clay	2	1	4	Pebbly	6/28/1999	99-54315-34	3	1	1	49	44.7078	41.9469	6.2
C74	Silty Clay	2	1	4		6/28/1999	99-54315-35	4	1	1	46	42.1292	38.2319	9.3
C75	Silty Clay	1	1	4	Clayey	6/28/1999	99-54315-36	4	1	1	38	37.4255	33.3435	10.9
C76	Silty Clay	1	1	4		6/28/1999	99-54315-37	4	1	1	48	44.5722	41.4236	7.1
C77	Silty Clay	1	1	4		6/28/1999	99-54315-38	3	0	0	16	42.2057	38.8460	8.0
C78	Silty Clay	2	1	3	Caliche	6/28/1999	99-54315-39	3	1	0	27	39.6785	35.5469	10.4
C79	Silty Clay	1	1	4		6/28/1999	99-54315-40	3	1	0	21	41.6658	38.1427	8.5
C80A	Weathered Shale	2	1	4	Near Drainage	6/28/1999	99-54315-41	2	0	0	9	50.9372	46.9320	7.9
C81	Silty Clay	1	1	4		6/28/1999	99-54315-43	3	0	0	23	43.5568	40.3408	7.4
C82	Silty Clay	1	1	4		6/28/1999	99-54315-44	2	1	1	54	44.8130	41.5023	7.4
C83	Silty Clay	2	1	4		6/28/1999	99-54315-45	2	0	0	17	49.1023	45.1980	8.0
C84	Silty Clay	1	1	4		6/28/1999	99-54315-46	2	1	1	36	42.1763	38.6958	8.3
C85	Silty Clay	2	1	4		6/28/1999	99-54315-47	3	1	1	72	42.6406	39.1148	8.3
C86	Silty Clay	1	1	4		6/28/1999	99-54315-48	4	2	1	77	42.7901	38.4677	10.1
C87	Silty Clay	1	1	4	Pebbly, Caliche, Sampled 10"	6/28/1999	99-54315-49	4	2	3	107	41.5183	37.2156	10.4

Soil Survey Line C

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
C88	Silty Clay	2	1	4		6/28/1999	99-54315-50	3	1	1	45	45.7979	41.9467	8.4
C89	Silty Clay	2	1	4		6/29/1999	99-54315-51	4	3	5	245	42.1441	38.6139	8.4
C90A	Silty Clay	2	1	4	Caliche	6/29/1999	99-54315-52	4	3	2	140	41.8814	38.2722	8.6
C91	Silty Clay	2	1	4		6/29/1999	99-54315-54	4	1	0	22	42.9372	39.9697	6.9
C92	Silty Clay	2	1	4		6/29/1999	99-54315-55	2	0	0	11	44.1016	40.7593	7.6
C93	Silty Clay	2	1	4		6/29/1999	99-54315-56	3	0	0	16	46.9131	44.3825	5.4
C94	Silty Clay	2	1	4		6/29/1999	99-54315-57	3	0	0	17	48.1434	45.2057	6.1
C95	Silty Clay	3	1	3		6/29/1999	99-54315-58	2	0	0	10	41.6008	36.1599	13.1
C96	Silty Clay	1	1	4		6/29/1999	99-54315-59	2	0	0	26	38.8780	34.3527	11.6
C97	Silty Clay	1	1	4		6/29/1999	99-54315-60	2	1	0	32	40.3094	36.4123	9.7
C98	Silty Clay	1	1	4	Lot of Caliche	6/29/1999	99-54315-61	2	0	0	13	44.8811	40.8461	9.0
C99	Silty Clay	1	1	4		6/29/1999	99-54315-62	3	1	0	15	40.2705	36.7419	8.8
C100A	Silty Clay	1	1	4		6/29/1999	99-54315-63	4	1	0	11	39.2004	35.0384	10.6
C101	Silty Clay	1	1	4		6/29/1999	99-54315-65	3	2	1	21	43.8693	40.1564	8.5
C102	Silty Clay	2	1	3	Almost Dry, Slightly Moist @ Bottom	6/29/1999	99-54315-66	2	0	0	5	44.9913	41.1392	8.6
C103	Silty Clay	1	1	3	Slightly Moist at Bottom	6/29/1999	99-54315-67	3	1	0	7	42.7210	39.0191	8.7
C104	Silty Clay	1	1	4	Caliche	6/29/1999	99-54315-68	2	0	0	7	41.0281	37.1928	9.3
C105	Silty Clay	1	1	4		6/29/1999	99-54315-69	2	1	0	9	44.0090	40.1678	8.7
C106	Silty Clay	1	1	4		6/29/1999	99-54315-70	2	0	0	8	46.5849	43.2912	7.1
C107	Silty Clay	3	1	4	Shale Chips, Iron Oxide Present	6/29/1999	99-54315-71	4	1	0	7	43.6554	39.7987	8.8
C108	Silty Clay	1	1	4	Pebbly	6/29/1999	99-54315-72	3	1	1	18	38.6430	35.0084	9.4
C109	Silty Clay	1	1	4		6/29/1999	99-54315-73	3	1	0	18	40.7778	37.2565	8.6
C110A	Silty Clay	1	1	3		6/29/1999	99-54315-74	3	1	0	9	38.8847	34.8478	10.4
C111	Silty Clay	1	1	3		6/29/1999	99-54315-76	2	0	0	9	38.8526	35.6498	8.2
C112	Silty Clay	2	1	4		6/29/1999	99-54315-77	2	0	0	7	43.8310	40.1207	8.5
C113	Silty Clay	2	1	4		6/29/1999	99-54315-78	2	0	0	4	44.1338	40.8984	7.3
C114	Silty Clay	2	1	4		6/29/1999	99-54315-79	2	0	0	8	43.1970	39.8796	7.7
C115	Silty Clay	3	1	3	Slightly Moist at Botton 1"	6/29/1999	99-54315-80	2	1	0	10	43.0919	39.7142	7.8
C116	Silty Clay	1	1	4		6/29/1999	99-54315-81	2	0	0	5	43.0361	40.1140	6.8

Soil Survey Line C

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
C117	Weathered Shale	2	1	4		6/29/1999	99-54315-82	2	0	0	5	41.6228	37.3224	10.3
C118	Silty Clay	3	1	4		6/29/1999	99-54315-83	2	0	0	15	45.9990	42.3348	8.0
C119	Silty Clay	2	1	4		6/29/1999	99-54315-84	4	2	1	10	42.1453	39.2141	7.0
C120A	Silty Clay	1	6	3		6/29/1999	99-54315-85	2	0	0	5	45.3972	38.2625	15.7
C121	Silty Clay	2	6	3		6/29/1999	99-54315-87	4	1	3	45	41.6659	37.5922	9.8
C122	Silty Clay	1	6	3		6/29/1999	99-54315-88	3	1	1	30	45.5389	39.9259	12.3
C123	Silty Clay	1	6	3		6/29/1999	99-54315-89	2	0	0	11	44.4893	39.8313	10.5
C124	Silty Clay	1	6	3		6/29/1999	99-54315-90	3	3	1	19	46.6362	42.2213	9.5
C125	Silty Clay	1	6	3		6/29/1999	99-54315-91	2	1	0	12	44.2159	39.8792	9.8
C126	Silty Clay	1	6	3		6/29/1999	99-54315-92	2	0	0	8	42.1577	37.2211	11.7
C127	Silty Clay	1	6	3		6/29/1999	99-54315-93	2	1	0	14	43.2575	38.9436	10.0
C128	Silty Clay	1	6	3		6/29/1999	99-54315-94	2	0	0	8	48.0811	43.2588	10.0
C129	Silty Clay	1	6	3		6/29/1999	99-54315-95	2	2	1	3	48.1367	44.0075	8.6
C130A	Silty Clay	1	6	3		6/29/1999	99-54315-96	2	1	1	10	50.4031	45.2186	10.3
C131	Silty Clay	1	6	3		6/29/1999	99-54315-98	2	0	1	12	44.2066	39.7842	10.0
C132	Silty Clay	1	1	3		6/29/1999	99-54315-99	3	1	0	13	47.3430	43.9407	7.2
C133	Silty Clay	1	1	3	Almost Dry	6/29/1999	99-54315-100	4	0	0	8	48.6333	45.1345	7.2
C10C	Silty Clay	1	2	3	Some Caliche	6/23/1999	99-54326-262	3	1	0	5	45.4930	40.1438	11.8
C20B	Silty Clay	3	1	4	Pebbly	6/24/1999	99-54326-273	5	1	0	31	46.8112	43.6868	6.7
C30C	Silty Clay	2	1	3		6/24/1999	99-54326-284	3	0	0	5	43.2370	39.3990	8.9
C40C	Silty Clay	1	1	3		6/24/1999	99-54326-295	3	0	0	6	45.7511	41.3384	9.6
C50B	Silty Clay	1	1	4		6/28/1999	99-54315-9	3	0	0	14	41.5508	38.4958	7.4
C60B	Silty Clay	1	1	4	Drainage	6/28/1999	99-54315-20	4	2	1	100	43.7252	40.8862	6.5
C70B	Silty Clay	1	1	4		6/28/1999	99-54315-31	4	1	1	41	42.3194	37.6266	11.1
C80B	Weathered Shale	2	1	4	Near Drainage	6/28/1999	99-54315-42	2	0	0	5	47.5957	43.6258	8.3
C90B	Silty Clay	2	1	4	Caliche	6/28/1999	99-54315-53	3	1	1	83	38.8168	34.9968	9.8
C100B	Silty Clay	1	1	4		6/28/1999	99-54315-64	2	1	0	9	43.3433	39.2039	9.6
C110B	Silty Clay	1	1	3		6/28/1999	99-54315-75	3	1	0	14	43.9377	40.2598	8.4
C120B	Silty Clay	1	6	3		6/28/1999	99-54315-86	2	0	1	20	42.2234	37.6212	10.9
C130B	Silty Clay	1	6	3		6/28/1999	99-54315-97	2	1	1	9	49.0008	42.9601	12.3

Soil Survey Line D

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
D1	Silty Clay	2	2	3		6/30/99	99-54315-101	3	0	0	10	49.2860	45.3390	8.0
D2	Silty Clay	2	2	3		6/30/99	99-54315-102	5	1	1	37	44.2227	40.0727	9.4
D3	Silty Clay	2	2	3		6/30/99	99-54315-103	3	0	0	16	44.0609	39.6773	9.9
D4	Silty Clay	2	2	3		6/30/99	99-54315-104	5	1	1	26	48.3372	44.2246	8.5
D5	Silty Clay	1	2	2		6/30/99	99-54315-105	2	0	0	22	53.3139	47.5699	10.8
D6	Silty Clay	2	1	2		6/30/99	99-54315-106	4	0	0	10	38.0255	34.4345	9.4
D7	Silty Clay	2	1	3	Clayey	7/11/99	99-54315-107	6	4	1	27	44.3304	40.9675	7.6
D8	Silty Clay	1	1	3		7/11/99	99-54315-108	2	0	0	15	40.2404	37.3185	7.3
D9	Silty Clay	1	6	2	Clayey	7/11/99	99-54315-109	4	0	0	24	42.2728	37.4322	11.5
D10A	Silty Clay	2	1	3		7/11/99	99-54315-110	4	1	1	46	46.4974	43.0488	7.4
D11	Silty Clay	2	1	3		7/11/99	99-54315-112	4	1	0	13	46.0526	42.3342	8.1
D12	Silty Clay	2	1	2		7/11/99	99-54315-113	3	1	1	41	44.8033	40.8185	8.9
D13	Silty Clay	2	1	3	Shale Chips	7/11/99	99-54315-114	6	4	1	27	47.4616	43.5550	8.2
D14	Silty Clay	2	1	3		7/11/99	99-54315-115	3	3	1	45	44.9666	40.7490	9.4
D15	Silty Clay	1	6	2	Clayey	7/11/99	99-54315-116	3	1	1	26	48.1910	41.9785	12.9
D16	Silty Clay	1	6	3		7/11/99	99-54315-117	4	3	2	51	45.1830	40.6050	10.1
D17	Silty Clay	1	6	2		7/11/99	99-54315-118	3	0	0	10	50.0996	44.1174	11.9
D18	Silty Clay	3	1	2		7/11/99	99-54315-119	4	1	1	10	47.2468	42.5962	9.8
D19	Silty Clay	3	1	4		7/11/99	99-54315-120	3	0	0	13	45.0573	41.4836	7.9
D20A	Silty Clay	2	6	3		7/11/99	99-54315-121	3	1	1	26	43.9691	38.7811	11.8
D21	Silty Clay	1	6	2		7/11/99	99-54315-123	4	2	2	31	46.8106	41.0818	12.2
D22	Weathered Shale	3	1	3		7/11/99	99-54315-124	5	1	0	12	45.9318	41.6383	9.3
D23	Weathered Shale	4	1	3		7/11/99	99-54315-125	5	11	2	42	47.0896	42.8273	9.1
D24	Weathered Shale	4	1	3	Almost Dry	7/11/99	99-54315-126	3	0	0	14	48.8080	45.2384	7.3
D25	Silty Clay	1	1	4		7/11/99	99-54315-127	4	2	1	89	45.4061	41.6238	8.3
D26	Silty Clay	3	1	4		7/11/99	99-54315-128	5	7	1	34	43.7193	39.2036	10.3
D27	Silty Clay	4	1	3		7/11/99	99-54315-129	5	3	1	14	41.8366	37.4728	10.4
D28	Silty Clay	1	1	2	In Drainage	7/11/99	99-54315-130	4	0	0	12	51.3732	46.1874	10.1

Soil Survey Line D

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
D29	Silty Clay	4	1	3		7/11/99	99-54315-131	5	10	1	23	41.2353	35.6823	13.5
D30A	Silty Clay	2	1	4		7/11/99	99-54315-132	3	1	0	11	44.8222	41.0404	8.4
D31	Silty Clay	2	1	3		7/11/99	99-54315-134	4	0	0	13	45.2986	40.5991	10.4
D32	Silty Clay	2	1	3	Very Clayey	7/11/99	99-54315-135	4	5	1	47	46.8997	42.1699	10.1
D33	Silty Clay	2	1	3		7/11/99	99-54315-136	3	1	0	15	47.4864	43.3653	8.7
D34	Silty Clay	1	1	3		7/11/99	99-54315-137	3	1	0	29	44.2330	40.2349	9.0
D35	Silty Clay	1	1	3		7/11/99	99-54315-138	4	2	1	29	46.4904	42.0626	9.5
D36	Silty Clay	1	1	3		7/11/99	99-54315-139	3	0	0	16	42.2990	37.5950	11.1
D37	Silty Clay	1	1	4		7/11/99	99-54315-140	3	2	1	53	49.5931	47.3536	4.5
D38	Silty Clay	1	1	3		7/11/99	99-54315-141	3	0	0	12	47.0719	42.0025	10.8
D39	Silty Clay	1	1	4		7/11/99	99-54315-142	4	11	2	110	47.1171	44.2945	6.0
D40A	Silty Clay	1	1	4		7/11/99	99-54315-143	4	2	1	52	46.4303	42.3053	8.9
D41	Silty Clay	1	1	4		7/11/99	99-54476-1	3	0	0	5	45.1494	40.3836	10.6
D42	Silty Clay	1	1	4		7/11/99	99-54476-2	4	0	0	8	47.1154	42.4570	9.9
D43	Silty Clay	1	1	4		7/11/99	99-54476-3	4	1	0	9	42.8019	38.2988	10.5
D44	Silty Clay	1	1	4		7/11/99	99-54476-4	5	1	0	12	45.3864	40.9682	9.7
D45	Silty Clay	1	1	4		7/11/99	99-54476-5	3	0	0	8	44.7362	40.2946	9.9
D46	Silty Clay	1	1	4		7/11/99	99-54476-6	4	0	0	5	43.6598	39.3810	9.8
D47	Silty Clay	1	1	4		7/11/99	99-54476-7	4	2	0	14	47.4044	42.8265	9.7
D48	Silty Clay	1	1	3	Clay Rich	7/11/99	99-54476-8	2	1	0	8	45.5205	40.3751	11.3
D49	Silty Clay	1	1	4		7/11/99	99-54476-9	5	1	0	13	42.2002	36.9199	12.5
D50A	Silty Clay	1	1	4		7/11/99	99-54476-10	3	1	0	6	44.0314	39.6499	10.0
D51	Silty Clay	1	1	4		7/6/99	99-54476-12	4	1	0	6	44.7220	39.5712	11.5
D52	Silty Clay	1	1	4		7/6/99	99-54476-13	2	1	0	10	44.5218	38.9708	12.5
D53	Silty Clay	1	1	4		7/6/99	99-54476-14	5	2	0	29	47.0049	42.6305	9.3
D54	Silty Clay	1	1	4		7/6/99	99-54476-15	2	0	0	8	43.2049	39.1266	9.4
D55	Silty Clay	1	1	4		7/6/99	99-54476-16	4	0	0	10	40.7417	36.8591	9.5
D56	Silty Clay	1	1	3		7/6/99	99-54476-17	2	1	0	9	43.0442	38.4484	10.7
D57	Silty Clay	1	1	4		7/6/99	99-54476-18	3	0	0	5	44.4374	40.3668	9.2
D58	Silty Clay	1	1	4	Some Caliche	7/6/99	99-54476-19	3	1	0	11	43.1283	38.3438	11.1

Soil Survey Line D

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
D59	Silty Clay	1	1	4		7/6/99	99-54476-20	3	0	0	5	43.4682	38.3827	11.7
D60A	Silty Clay	1	1	4		7/6/99	99-54476-21	3	0	0	9	44.1361	40.2701	8.8
D61	Silty Clay	1	1	4		7/6/99	99-54476-23	3	1	0	17	42.8574	38.6749	9.8
D62	Silty Clay	1	1	4		7/6/99	99-54476-24	3	0	0	6	45.1760	41.3972	8.4
D63	Silty Clay	1	1	4		7/6/99	99-54476-25	3	0	0	8	40.6420	36.6821	9.7
D64	Silty Clay	1	1	4		7/6/99	99-54476-26	3	0	0	7	42.7186	38.6224	9.6
D65	Silty Clay	1	1	4		7/6/99	99-54476-27	3	1	0	8	45.2389	40.6182	10.2
D66	Silty Clay	1	1	4		7/6/99	99-54476-28	3	1	1	23	41.2514	35.8864	13.0
D67	Silty Clay	1	1	4	Pebbly, Caliche	7/6/99	99-54476-29	3	1	1	19	42.4373	37.7709	11.0
D68	Silty Clay	2	1	4		7/6/99	99-54476-30	4	6	1	64	46.8357	44.1708	5.7
D69	Silty Clay	1	1	4		7/6/99	99-54476-31	4	1	0	18	42.3835	37.5690	11.4
D70A	Silty Clay	1	1	4		7/6/99	99-54476-32	3	1	0	18	42.8691	38.6683	9.8
D71	Silty Clay	1	1	4		7/6/99	99-54476-34	1	1	0	5	42.0568	38.0906	9.4
D72	Silty Clay	1	1	3		7/6/99	99-54476-35	3	1	0	12	43.7138	39.9734	8.6
D73	Silty Clay	1	1	4		7/6/99	99-54476-36	2	0	0	8	44.2127	40.8307	7.6
D74	Silty Clay	1	1	4		7/6/99	99-54476-37	3	0	0	5	43.8561	39.3403	10.3
D75	Silty Clay	1	1	4		7/6/99	99-54476-38	3	0	0	8	46.5728	42.2047	9.4
D76	Silty Clay	1	1	4		7/6/99	99-54476-39	3	1	0	9	45.9890	41.2784	10.2
D77	Silty Clay	1	1	4		7/6/99	99-54476-40	3	1	0	9	45.2885	41.4875	8.4
D78	Silty Clay	1	1	4		7/6/99	99-54476-41	2	1	1	10	47.0454	43.6291	7.3
D79	Silty Clay	1	1	4		7/6/99	99-54476-42	2	0	0	10	50.5497	46.8732	7.3
D80A	Silty Clay	1	1	4	On Section Corner, Caliche	7/6/99	99-54476-43	2	1	0	10	42.1243	37.5172	10.9
D81	Silty Clay	1	1	4		7/6/99	99-54476-45	3	0	0	16	44.9579	41.4976	7.7
D82	Silty Clay	1	1	4		7/6/99	99-54476-46	2	0	0	5	42.4584	38.8350	8.5
D83	Silty Clay	1	1	4		7/6/99	99-54476-47	2	1	0	15	41.8833	38.5031	8.1
D84	Silty Clay	1	1	4		7/6/99	99-54476-48	2	0	0	6	46.9847	42.7788	9.0
D85	Silty Clay	1	1	4		7/6/99	99-54476-49	3	0	0	10	45.9218	41.2945	10.1
D86	Silty Clay	2	1	4		7/6/99	99-54476-50	2	1	0	6	46.3904	43.1690	6.9
D87	Silty Clay	1	6	4		7/6/99	99-54476-51	2	0	0	6	45.1240	39.9435	11.5
D88	Silty Clay	1	6	3		7/6/99	99-54476-52	3	1	0	14	43.3768	38.0491	12.3

Soil Survey Line D

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
D89	Silty Clay	1	6	3		7/6/99	99-54476-53	2	0	0	5	40.9498	35.6892	12.8
D90A	Silty Clay	1	6	3		7/6/99	99-54476-54	2	1	0	10	39.5250	35.3399	10.6
D91	Silty Clay	1	6	4		7/6/99	99-54476-56	1	1	0	8	43.7176	39.3200	10.1
D92	Silty Clay	1	1	4		7/6/99	99-54476-57	3	1	0	17	47.7506	45.0001	5.8
D93	Silty Clay	1	6	4		7/6/99	99-54476-58	2	0	0	9	45.5688	41.9703	7.9
D94	Silty Clay	1	6	3		7/6/99	99-54476-59	2	0	0	7	43.9959	39.0915	11.1
D95	Silty Clay	1	6	4		7/6/99	99-54476-60	3	0	0	15	45.0906	41.6474	7.6
D96	Silty Clay	3	1	4		7/6/99	99-54476-61	2	0	0	10	45.6622	42.6060	6.7
D97	Silty Clay	1	6	4		7/6/99	99-54476-62	3	1	0	31	40.1070	33.6855	16.0
D98	Silty Clay	2	1	4		7/6/99	99-54537-1	2	0	0	9	44.9630	40.9993	8.8
D99	Silty Clay	2	1	4		7/6/99	99-54537-2	2	0	0	6	44.6856	40.9219	8.4
D100A	Silty Clay	1	1	4		7/6/99	99-54537-3	2	0	0	8	46.6356	43.4001	6.9
D101	Silty Clay	1	1	3		7/6/99	99-54537-5	3	2	1	25	46.1632	42.4921	8.0
D102	Silty Clay	1	1	4	Pebbly	7/6/99	99-54537-6	3	2	1	14	43.9120	41.6947	5.0
D103	Silty Clay	2	1	4		7/6/99	99-54537-7	4	0	0	10	45.7274	42.5837	6.9
D104	Silty Clay	3	1	4		7/6/99	99-54537-8	4	0	0	18	43.1780	41.0445	4.9
D105	Silty Clay	3	1	3	Pebbly	7/6/99	99-54537-9	2	1	0	8	47.5795	43.9282	7.7
D106	Silty Clay	3	1	4	Pebbly	7/6/99	99-54537-10	3	0	0	5	31.7057	29.0833	8.3
D107	Silty Clay	1	1	4		7/6/99	99-54537-11	3	1	0	11	47.9055	44.0637	8.0
D108	Silty Clay	1	1	4		7/6/99	99-54537-12	3	0	0	12	45.0047	41.2637	8.3
D109	Silty Clay	1	1	4	Power Line Btn. Samples	7/6/99	99-54537-13	4	1	1	32	42.8386	39.0891	8.8
D110A	Silty Clay	1	1	4		7/6/99	99-54537-14	5	1	1	29	45.8828	42.7900	6.7
D111	Silty Clay	1	1	4		7/6/99	99-54537-16	3	1	0	12	43.0233	39.6142	7.9
D112	Silty Clay	1	1	4		7/6/99	99-54537-17	4	1	1	18	48.5023	44.7513	7.7
D113	Silty Clay	1	1	4		7/6/99	99-54537-18	3	2	1	15	48.0731	44.0179	8.4
D114	Silty Clay	1	1	3		7/6/99	99-54537-19	2	0	0	9	42.4890	38.0301	10.5
D115	Silty Clay	1	1	4		7/6/99	99-54537-20	4	1	1	21	47.2480	43.3291	8.3
D116	Silty Clay	1	1	4		7/6/99	99-54537-21	4	3	1	19	41.8059	38.2192	8.6
D117	Silty Clay	1	1	3		7/6/99	99-54537-22	5	4	1	15	47.0312	43.5379	7.4
D118	Silty Clay	1	1	4		7/6/99	99-54537-23	3	2	1	13	46.8069	43.4144	7.2

Soil Survey Line D

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
D119	Silty Clay	1	1	4		7/6/99	99-54537-24	4	2	1	17	47.0177	43.5674	7.3
D120A	Silty Clay	1	1	4		7/6/99	99-54537-25	4	1	0	6	45.0045	41.0001	8.9
D121	Silty Clay	1	1	4		7/6/99	99-54537-27	4	1	1	28	41.5653	38.2509	8.0
D122	Silty Clay	1	1	4		7/6/99	99-54537-28	3	1	1	25	46.0631	41.9493	8.9
D123	Silty Clay	1	1	3		7/6/99	99-54537-29	3	1	0	11	45.0283	39.9037	11.4
D124	Silty Clay	1	1	3		7/6/99	99-54537-30	4	1	1	21	46.0995	41.9371	9.0
D125	Silty Clay	1	1	3		7/6/99	99-54537-31	3	1	1	17	43.7077	39.5959	9.4
D126	Silty Clay	1	1	4		7/6/99	99-54537-32	3	1	1	16	49.0970	45.0677	8.2
D127	Silty Clay	1	1	4		7/6/99	99-54537-33	3	1	1	8	47.3864	43.6310	7.9
D128	Silty Clay	1	1	4		7/6/99	99-54537-34	3	1	1	12	41.6806	37.1761	10.8
D10B	Silty Clay	2	1	3		7/6/99	99-54315-111	3	1	1	61	47.4769	43.7801	7.8
D20B	Silty Clay	2	6	3		7/6/99	99-54315-122	1	1	1	11	47.2508	40.8559	13.5
D30B	Silty Clay	2	1	4		7/6/99	99-54315-133	4	1	0	17	44.6360	40.7802	8.6
D40B	Silty Clay	1	1	4		7/6/99	99-54315-144	2	1	0	12	41.4246	36.5926	11.7
D50B	Silty Clay	1	1	4		7/6/99	99-54476-11	2	1	1	6	44.5237	39.9786	10.2
D60B	Silty Clay	1	1	4		7/6/99	99-54476-22	3	0	0	6	44.4602	40.5995	8.7
D70B	Silty Clay	1	1	4		7/6/99	99-54476-33	3	1	0	10	43.5418	39.3750	9.6
D80B	Silty Clay	1	1	4	On Section Corner, Caliche	7/6/99	99-54476-44	1	0	0	10	42.4752	37.8907	10.8
D90B	Silty Clay	1	6	3		7/6/99	99-54476-55	2	0	0	6	45.6777	38.3662	16.0
D100B	Silty Clay	1	1	4		7/8/99	99-54537-4	3	0	0	10	44.6759	41.6757	6.7
D110B	Silty Clay	1	1	4		7/8/99	99-54537-15	4	1	1	19	47.6669	45.2369	5.1
D120B	Silty Clay	1	1	4		7/8/99	99-54537-26	6	4	1	36	44.1385	40.1185	9.1

Soil Survey Line E

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
E1	Silty Clay	1	5	4		7/09/1999	99-54590-1	3	0	0	14	50.2435	47.7195	5.0
E2	Silty Clay	1	5	4		7/09/1999	99-54590-2	3	0	0	7	48.4526	46.6404	3.7
E3	Silty Clay	1	5	4		7/09/1999	99-54590-3	2	0	0	9	48.9371	46.0830	5.8
E4	Silty Clay	1	5	3		7/09/1999	99-54590-4	2	0	0	9	46.4539	42.0265	9.5
E5	Silty Clay	1	5	4	Cemetery–400 ft to next Spot	7/09/1999	99-54590-5	2	1	1	18	47.0731	44.8801	4.7
E6	Silty Clay	1	5	4		7/09/1999	99-54590-6	3	0	0	7	44.8699	41.6205	7.2
E7	Silty Clay	1	5	4		7/09/1999	99-54590-7	2	0	0	5	45.2159	40.9646	9.4
E8	Silty Clay	3	5	4	Pebbly	7/09/1999	99-54590-8	2	2	1	34	40.2540	37.5933	6.6
E9	Silty Clay	1	5	4		7/09/1999	99-54590-9	1	0	0	8	48.4311	44.9716	7.1
E10a	Silty Clay	1	5	4		7/09/1999	99-54590-10	3	0	0	7	52.4519	48.9071	6.8
E11	Silty Clay	1	5	4		7/09/1999	99-54590-12	6	6	4	72	51.6024	48.2766	6.4
E12	Silty Clay	1	5	4		7/09/1999	99-54590-13	2	1	0	18	51.8713	49.9410	3.7
E13	Silty Clay	1	5	4		7/09/1999	99-54590-14	24	1	1	42	45.0379	40.9278	9.1
E14	Silty Clay	1	5	4		7/09/1999	99-54590-15	4	2	2	41	51.9879	49.0042	5.7
E15	Silty Clay	1	5	4	Few Pebbles, Caliche	7/09/1999	99-54590-16	2	1	1	10	51.3708	48.0353	6.5
E16	Silty Clay	1	2	4	On Benchmark	7/09/1999	99-54590-17	4	1	1	15	50.5771	48.2269	4.6
E17	Silty Clay	1	2	4		7/09/1999	99-54590-18	3	1	1	20	46.2671	43.3454	6.3
E18	Silty Clay	1	2	4		7/09/1999	99-54590-19	2	1	1	15	47.1680	43.2839	8.2
E19	Silty Clay	1	1	4		7/09/1999	99-54590-20	2	0	0	12	43.8013	40.5258	7.5
E20a	Silty Clay	2	1	4		7/09/1999	99-54590-21	3	1	1	10	47.3358	44.6692	5.6
E21	Silty Clay	1	1	4		7/09/1999	99-54590-23	5	0	0	5	48.9661	46.8847	4.3
E22	Silty Clay	1	1	4		7/09/1999	99-54590-24	3	1	0	15	46.0873	43.7659	5.0
E23	Silty Clay	3	1	4		7/09/1999	99-54590-25	2	0	0	6	50.0006	47.2100	5.6
E24	Silty Clay	1	1	3		7/09/1999	99-54590-26	3	0	0	2	42.6468	38.6444	9.4
E25	Silty Clay	1	6	3		7/09/1999	99-54590-27	3	3	1	7	46.9159	42.6232	9.1
E26	Silty Clay	1	6	3		7/09/1999	99-54590-28	3	1	1	9	42.7846	39.1768	8.4
E27	Silty Clay	1	6	4		7/09/1999	99-54590-29	3	4	1	16	48.2568	45.4497	5.8
E28	Silty Clay	1	6	3		7/09/1999	99-54590-30	3	1	0	7	46.1867	41.6325	9.9
E29	Silty Clay	1	6	3		7/09/1999	99-54590-31	2	0	0	11	44.9479	40.5104	9.9
E30a	Silty Clay	4	1	4	Pebbly	7/09/1999	99-54590-32	4	1	1	10	42.4752	39.6310	6.7
E31	Silty Clay	1	1	3		7/09/1999	99-54590-34	3	5	2	70	39.5142	35.1504	11.0
E32	Silty Clay	1	1	4	Pebbly	7/09/1999	99-54590-35	3	2	1	13	45.2596	42.7634	5.5
E33	Silty Clay	3	2	3		7/09/1999	99-54590-36	2	0	0	8	47.3239	43.8488	7.3

Soil Survey Line E

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
E34	Silty Clay	1	2	3		7/09/1999	99-54590-37	4	1	1	13	49.9192	46.8555	6.1
E35	Silty Clay	1	2	4		7/09/1999	99-54590-38	4	1	0	14	49.3775	46.2994	6.2
E36	Silty Clay	1	2	4		7/09/1999	99-54590-39	5	1	1	11	50.9915	48.1495	5.6
E37	Silty Clay	1	2	3		7/09/1999	99-54590-40	2	0	0	10	45.1787	41.7622	7.6
E38	Silty Clay	1	1	3		7/09/1999	99-54590-41	2	1	0	10	43.1007	39.9251	7.4
E39	Silty Clay	1	1	3		7/09/1999	99-54590-42	2	0	0	11	39.3398	36.3013	7.7
E40	Silty Clay	1	1	2	Pebbly, in Drainage	7/09/1999	99-54590-43	5	6	2	48	45.4449	39.4970	13.1
E41a	Silty Clay	1	1	4	Caliche	7/09/1999	99-54590-44	5	0	0	7	41.9655	38.0279	9.4
E42	Silty Clay	1	1	3		7/09/1999	99-54590-46	2	0	0	7	45.7205	41.6353	8.9
E43	Silty Clay	1	1	4	Sec. 12 & 13 Corner, Caliche	7/09/1999	99-54590-47	3	0	0	7	47.2726	43.6550	7.7
E44	Silty Clay	3	1	4		7/09/1999	99-54590-48	2	1	1	22	48.9113	46.5155	4.9
E45	Silty Clay	2	1	4		7/09/1999	99-54590-49	3	1	1	18	44.8669	41.8623	6.7
E46	Silty Clay	2	1	3		7/09/1999	99-54590-50	2	0	0	14	45.5121	42.6875	6.2
E47	Silty Clay	2	1	4		7/09/1999	99-54590-51	3	2	1	24	47.6527	43.7337	8.2
E48	Silty Clay	1	1	4		7/09/1999	99-54590-52	2	0	0	8	47.5663	44.8741	5.7
E49	Silty Clay	2	1	3		7/09/1999	99-54590-53	19	0	0	6	42.7636	38.7669	9.3
E50a	Silty Clay	1	1	3	Pebbly	7/09/1999	99-54590-54	3	4	1	65	47.9709	44.6082	7.0
E51	Silty Clay	1	1	4		7/09/1999	99-54590-56	2	1	0	12	50.2905	47.4358	5.7
E52	Silty Clay	1	1	4	Pebbly	7/09/1999	99-54590-57	3	1	0	7	54.9637	52.5445	4.4
E53	Silty Clay	1	1	4		7/12/1999	99-54633-1	2	0	0	9	49.4904	45.8867	7.3
E54	Silty Clay	1	1	4		7/12/1999	99-54633-2	2	0	0	10	43.1558	39.5629	8.3
E55	Silty Clay	1	1	4		7/12/1999	99-54633-3	4	0	0	9	49.7126	45.9617	7.5
E56	Silty Clay	1	1	4		7/12/1999	99-54633-4	2	0	0	3	45.2158	40.7654	9.8
E57	Silty Clay	1	1	4		7/12/1999	99-54633-5	4	1	0	9	44.9327	41.1674	8.4
E58	Silty Clay	1	1	3	In Drainage	7/12/1999	99-54633-6	2	2	1	56	45.4394	37.3568	17.8
E59	Silty Clay	1	1	4	Caliche	7/12/1999	99-54633-7	2	0	0	9	48.2694	44.5431	7.7
E60a	Silty Clay	3	1	4	Pebbly	7/12/1999	99-54633-8	3	3	2	32	40.7043	37.3571	8.2
E61	Silty Clay	1	1	4		7/12/1999	99-54633-10	3	1	0	9	48.2377	45.4558	5.8
E62	Silty Clay	3	1	4	Moved 325 ft for next Sample	7/12/1999	99-54633-11	3	2	1	1	42.2090	39.5738	6.2
E63	Silty Clay	1	1	3		7/12/1999	99-54633-12	3	0	1	42	49.7929	43.6292	12.4
E64	Silty Clay	3	1	4		7/12/1999	99-54633-13	2	0	0	5	44.2191	38.9657	11.9
E65	Silty Clay	1	1	4		7/12/1999	99-54633-14	4	1	0	9	46.8960	45.0359	4.0
E66	Silty Clay	1	1	4		7/12/1999	99-54633-15	4	1	0	8	51.6405	48.1219	6.8

Soil Survey Line E

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
E67	Silty Clay	1	1	4		7/12/1999	99-54633-16	3	1	0	9	43.3565	40.6557	6.2
E68	Silty Clay	1	6	4		7/12/1999	99-54633-17	2	2	1	13	51.9664	48.8351	6.0
E69	Silty Clay	1	6	3		7/12/1999	99-54633-18	2	1	0	7	50.1419	44.3929	11.5
E70a	Silty Clay	1	6	3		7/12/1999	99-54633-19	2	0	0	8	48.6558	43.8746	9.8
E71	Silty Clay	1	6	3		7/12/1999	99-54633-21	1	0	0	9	46.5705	41.2117	11.5
E72	Silty Clay	1	6	3		7/12/1999	99-54633-22	1	0	1	15	46.6892	41.3943	11.3
E73	Silty Clay	1	6	3		7/12/1999	99-54633-23	3	1	1	19	47.9938	43.4894	9.4
E74	Silty Clay	1	6	3		7/12/1999	99-54633-24	2	1	0	6	49.7553	44.5991	10.4
E75	Silty Clay	1	6	3		7/12/1999	99-54633-25	2	0	0	4	40.9981	35.5667	13.2
E76	Silty Clay	1	1	4		7/12/1999	99-54633-26	3	0	0	5	37.3728	34.5612	7.5
E77	Silty Clay	3	1	4		7/12/1999	99-54633-27	4	0	0	2	49.5999	46.7361	5.8
E78	Silty Clay	1	1	4		7/12/1999	99-54633-28	5	0	0	5	49.5912	47.5354	4.1
E79	Silty Clay	1	1	4		7/12/1999	99-54633-29	2	1	1	19	43.7613	40.8502	6.7
E80a	Silty Clay	1	1	4		7/12/1999	99-54633-30	4	0	0	7	42.1721	40.1534	4.8
E81	Silty Clay	1	1	4	Next to Road	7/12/1999	99-54633-32	2	1	0	9	45.0682	41.6962	7.5
E82	Silty Clay	1	1	4		7/12/1999	99-54633-33	2	0	0	9	46.5096	43.4493	6.6
E83	Silty Clay	1	1	4		7/12/1999	99-54633-34	3	1	0	8	46.3399	43.8376	5.4
E84	Silty Clay	1	1	4		7/12/1999	99-54633-35	3	1	0	8	46.7665	44.6141	4.6
E85	Silty Clay	1	1	4		7/12/1999	99-54633-36	5	3	1	17	43.9820	41.0215	6.7
E86	Silty Clay	1	1	4		7/12/1999	99-54633-37	4	3	1	20	47.6982	45.3969	4.8
E87	Silty Clay	1	1	4	Slightly Moist at Bottom	7/12/1999	99-54633-38	4	1	0	13	49.4384	45.2942	8.4
E88	Silty Clay	1	1	4		7/12/1999	99-54633-39	4	3	1	20	45.8744	43.5490	5.1
E89	Silty Clay	1	2	4		7/12/1999	99-54633-40	5	2	0	9	41.6739	39.9802	4.1
E90a	Silty Clay	1	2	4		7/12/1999	99-54633-41	3	0	0	5	45.3337	41.5407	8.4
E91	Silty Clay	1	2	4		7/12/1999	99-54633-43	4	1	1	6	51.8175	48.5404	6.3
E92	Silty Clay	1	2	4		7/12/1999	99-54633-44	4	3	1	15	45.4680	43.0294	5.4
E93	Silty Clay	1	1	4		7/12/1999	99-54633-45	2	1	1	9	49.9576	47.4114	5.1
E94	Silty Clay	1	1	4		7/12/1999	99-54633-46	2	0	0	8	45.0350	41.5197	7.8
E95	Silty Clay	2	6	4		7/12/1999	99-54633-47	2	1	1	7	43.9156	40.3109	8.2
E96	Silty Clay	2	6	2		7/12/1999	99-54633-48	1	0	0	4	47.2918	40.7928	13.7
E97	Silty Clay	2	6	3		7/12/1999	99-54633-49	3	0	0	13	44.3593	40.3146	9.1
E98	Silty Clay	2	6	3		7/12/1999	99-54633-50	2	1	1	15	48.8195	43.0777	11.8
E99	Silty Clay	1	6	3		7/12/1999	99-54633-51	4	1	1	38	47.0478	41.6986	11.4

Soil Survey Line E

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
E100a	Silty Clay	2	1	4		7/12/1999	99-54633-52	2	1	1	12	47.2177	43.5676	7.7
E101	Silty Clay	1	6	3		7/13/1999	99-54681-1	2	0	0	16	40.9905	34.8844	14.9
E102	Silty Clay	1	6	3		7/13/1999	99-54681-2	2	0	0	10	41.5212	35.0261	15.6
E103	Silty Clay	1	1	4		7/13/1999	99-54681-3	2	1	0	16	39.5348	36.8478	6.8
E104	Silty Clay	2	1	4		7/13/1999	99-54681-4	2	0	0	6	44.7125	41.1775	7.9
E105	Silty Clay	2	6	4		7/13/1999	99-54681-5	2	0	0	4	40.4053	37.6980	6.7
E106	Silty Clay	3	1	4		7/13/1999	99-54681-6	3	1	0	27	34.4429	31.8913	7.4
E107	Silty Clay	2	1	4		7/13/1999	99-54681-7	2	0	0	10	41.8304	38.1950	8.7
E108	Silty Clay	1	1	4		7/13/1999	99-54681-8	2	0	0	11	43.1272	40.0185	7.2
E109	Silty Clay	2	1	4		7/13/1999	99-54681-9	1	0	0	7	42.5420	38.8325	8.7
E110a	Silty Clay	1	1	4		7/13/1999	99-54681-10	3	0	0	14	48.5803	45.5020	6.3
E111	Silty Clay	2	1	4		7/13/1999	99-54681-12	2	0	0	11	49.5841	46.5951	6.0
E112	Silty Clay	3	1	4		7/13/1999	99-54681-13	4	0	0	17	51.7163	49.2672	4.7
E113	Silty Clay	2	1	4		7/13/1999	99-54681-14	0	1	1	22	45.2573	42.6251	5.8
E114	Silty Clay	2	1	4		7/13/1999	99-54681-15	2	0	0	12	41.5518	39.3436	5.3
E115	Silty Clay	1	1	4		7/13/1999	99-54681-16	3	1	0	13	40.8093	36.0755	11.6
E116	Silty Clay	2	1	4		7/13/1999	99-54681-17	3	0	0	10	44.6508	41.9916	6.0
E117	Silty Clay	1	1	4	Pebbly	7/13/1999	99-54681-18	3	3	1	31	41.5159	38.0684	8.3
E118	Silty Clay	1	1	4		7/13/1999	99-54681-19	4	1	1	15	47.2415	44.3263	6.2
E119	Silty Clay	1	1	4		7/13/1999	99-54681-20	3	1	0	8	45.1606	41.3521	8.4
E120a	Silty Clay	1	1	4		7/13/1999	99-54681-21	2	2	1	37	45.5154	42.4966	6.6
E121	Silty Clay	1	1	4		7/13/1999	99-54681-23	3	1	0	24	44.6952	42.0621	5.9
E122	Silty Clay	1	1	4		7/13/1999	99-54681-24	3	1	0	7	44.7874	42.4052	5.3
E123	Silty Clay	1	1	4		7/13/1999	99-54681-25	2	1	1	29	43.3040	40.6440	6.1
E124	Silty Clay	1	1	4		7/13/1999	99-54681-26	4	2	1	41	44.4509	41.7284	6.1
E125	Silty Clay	1	1	4		7/13/1999	99-54681-27	3	1	1	41	39.2276	36.1323	7.9
E126	Silty Clay	2	1	4		7/13/1999	99-54681-28	3	1	1	22	42.6104	39.6358	7.0
E127	Silty Clay	3	1	4		7/13/1999	99-54681-29	4	1	1	18	40.2285	38.3497	4.7
E128	Sandy	2	1	4		7/13/1999	99-54681-30	3	1	1	13	42.1361	40.2538	4.5
E129	Silty Clay	1	1	4	Pebbly	7/13/1999	99-54681-31	4	1	1	28	40.4441	38.9961	3.6
E130a	Silty Clay	1	1	4		7/13/1999	99-54681-32	4	2	0	15	39.3252	37.3777	5.0
E131	Sandy	2	1	4		7/13/1999	99-54681-34	4	2	1	8	45.8272	43.5679	4.9
E132	Silty Clay	3	1	4		7/13/1999	99-54681-35	2	1	0	17	41.0427	39.1427	4.6

Soil Survey Line E

Sample	Soil Type	Slope	Land Use	Soil Moist	Comments	Date	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
E133	Sandy	1	1	4	On Grvl Trc, Shallow Sample	7/13/1999	99-54681-36	4	0	0	7	32.2848	30.9019	4.3
E134	Sandy	3	1	4	On Gravel Terrace	7/13/1999	99-54681-37	4	1	0	19	50.7082	49.0889	3.2
E135	Sandy	3	1	4	On Gravel Terrace	7/13/1999	99-54681-38	1	0	4	14	42.6749	40.6449	4.8
E136	Silty Clay	2	1	4		7/13/1999	99-54681-39	3	0	0	10	41.7582	38.9915	6.6
E137	Silty Clay	2	1	4		7/13/1999	99-54681-40	4	0	0	13	50.8270	49.1312	3.3
E138	Silty Clay	1	1	4		7/13/1999	99-54681-41	3	0	0	17	46.8917	44.7153	4.6
E139	Silty Clay	1	1	4	Calich, Pebbly	7/13/1999	99-54681-42	3	1	0	16	52.6168	50.8076	3.4
E140a	Silty Clay	2	1	4		7/13/1999	99-54681-43	4	1	1	11	28.2761	26.4418	6.5
E141	Silty Clay	1	2	3		7/13/1999	99-54681-45	3	0	0	14	38.5960	35.2170	8.8
E142	Silty Clay	1	2	3		7/13/1999	99-54681-46	2	0	0	11	44.3107	41.4436	6.5
E143	Silty Clay	1	2	3		7/13/1999	99-54681-47	3	2	0	16	44.7060	41.6060	6.9
E144	Silty Clay	1	2	3		7/13/1999	99-54681-48	2	1	0	11	45.2989	42.3068	6.6
E145	Silty Clay	1	2	3		7/13/1999	99-54681-49	1	0	0	7	42.1765	38.2393	9.3
E146	Silty Clay	1	2	3		7/13/1999	99-54681-50	2	0	0	10	42.4151	39.2010	7.6
E147	Silty Clay	1	2	3		7/13/1999	99-54681-51	3	1	0	16	42.1406	38.9079	7.7
E148	Silty Clay	1	1	3	Slightly Moist at Bottom	7/13/1999	99-54681-52	3	1	1	12	47.2518	44.4613	5.9
E149	Sandy	3	1	4	Pebbly	7/13/1999	99-54681-53	3	0	0	12	50.2197	48.9250	2.6
E10b	Silty Clay	1	5	4		7/09/1999	99-54590-11	3	0	0	7	50.2048	46.8811	6.6
E20b	Silty Clay	2	1	4		7/09/1999	99-54590-22	3	1	1	26	49.1504	46.2185	6.0
E30b	Silty Clay	4	1	4	Pebbly	7/09/1999	99-54590-33	4	0	0	8	44.6455	41.9681	6.0
E41b	Silty Clay	1	1	4	Caliche	7/09/1999	99-54590-45	2	0	0	16	46.6035	42.8572	8.0
E50b	Silty Clay	1	1	3	Pebbly	7/09/1999	99-54590-55	3	2	1	28	46.1518	43.0692	6.7
E60b	Silty Clay	3	1	4	Pebbly	7/12/1999	99-54633-9	3	3	1	24	42.0491	38.3745	8.7
E70b	Silty Clay	1	6	3		7/12/1999	99-54633-20	2	0	0	7	48.9985	43.6667	10.9
E80b	Silty Clay	1	1	4		7/12/1999	99-54633-31	3	0	0	8	47.8281	45.2484	5.4
E90b	Silty Clay	1	2	4		7/12/1999	99-54633-42	4	0	0	6	47.4622	43.6271	8.1
E100b	Silty Clay	2	1	4		7/12/1999	99-54633-53	2	0	1	24	46.5946	42.7860	8.2
E110b	Silty Clay	1	1	4		7/13/1999	99-54681-11	2	0	0	5	44.4782	38.1183	14.3
E120b	Silty Clay	1	1	4		7/13/1999	99-54681-22	2	1	0	23	49.6215	46.7898	5.7
E130b	Silty Clay	1	1	4		7/13/1999	99-54681-33	3	3	1	20	38.3613	36.4808	4.9
E140b	Silty Clay	2	1	4		7/13/1999	99-54681-44	2	1	1	38	40.3879	37.4306	7.3

Soil Survey Line F

Sample	Soil Type	Slope	Soil Moist	Comments	Date	Land Use	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
F1	Silty Clay	1	4	Base of steep slope	7/15/99	1	99-54733-1	4	0	1	10	42.0699	38.8185	7.7
F2	Silty Clay	1	4		7/15/99	1	99-54733-2	3	1	0	14	44.2922	41.3100	6.7
F3	Silty Clay	1	4		7/15/99	1	99-54733-3	3	1	1	23	41.8177	39.0472	6.6
F4	Silty Clay	1	4		7/15/99	1	99-54733-4	4	1	1	22	44.0794	41.2128	6.5
F5	Silty Clay	1	4		7/15/99	1	99-54733-5	3	1	1	23	38.1675	34.0280	10.8
F6	Silty Clay	1	4		7/15/99	1	99-54733-6	3	5	2	148	41.8469	39.3396	6.0
F7	Silty Clay	1	4		7/15/99	1	99-54733-7	3	1	0	19	46.4596	43.8973	5.5
F8	Silty Clay	1	4		7/15/99	1	99-54733-8	2	1	0	15	44.5113	41.2552	7.3
F9	Silty Clay	1	4		7/15/99	1	99-54733-9	3	1	0	9	39.5397	36.2306	8.4
F10	Silty Clay	1	4		7/15/99	1	99-54733-10	2	0	0	7	43.2039	39.9681	7.5
F11	Silty Clay	1	4		7/15/99	1	99-54733-12	2	1	0	16	43.9403	40.6881	7.4
F12	Silty Clay	1	4		7/15/99	1	99-54733-13	3	1	0	10	44.9811	40.9009	9.1
F13	Silty Clay	1	4		7/15/99	1	99-54733-14	3	1	0	12	42.5366	38.5945	9.3
F14	Silty Clay	1	4		7/15/99	1	99-54733-15	3	1	1	31	42.6179	40.2466	5.6
F15	Silty Clay	1	4		7/15/99	1	99-54733-16	3	1	0	24	46.0241	43.0402	6.5
F16	Silty Clay	1	4		7/15/99	1	99-54733-17	4	1	0	12	48.6372	46.1374	5.1
F17	Silty Clay	1	4		7/15/99	1	99-54733-18	3	2	0	23	45.9778	44.2221	3.8
F18	Silty Clay	1	4		7/15/99	1	99-54733-19	3	1	0	18	41.1814	37.0672	10.0
F19	Silty Clay	1	4		7/15/99	1	99-54733-20	2	1	0	14	42.3308	39.1104	7.6
F20	Silty Clay	1	4		7/15/99	1	99-54733-21	2	0	0	8	43.3929	39.2991	9.4
F21	Silty Clay	1	4		7/15/99	1	99-54733-23	2	0	0	10	40.4408	37.2510	7.9
F22	Silty Clay	1	4		7/15/99	1	99-54733-24	4	4	1	47	42.3206	39.2295	7.3
F23	Silty Clay	1	4		7/15/99	1	99-54733-25	2	1	0	24	45.4041	41.9482	7.6
F24	Silty Clay	1	4	Fence Line; cross line E	7/15/99	1	99-54733-26	3	2	1	25	44.2100	40.6072	8.1
F25	Silty Clay	1	4		7/15/99	1	99-54733-27	3	1	0	21	44.0498	40.8567	7.2
F26	Silty Clay	1	4		7/15/99	1	99-54733-28	3	1	0	15	41.0911	38.0353	7.4
F27	Silty Clay	1	4		7/15/99	1	99-54733-29	2	0	0	16	46.7950	43.5971	6.8
F28	Silty Clay	1	4		7/15/99	1	99-54733-30	3	1	0	19	46.9134	43.5581	7.2
F29	Silty Clay	1	4		7/15/99	1	99-54733-31	3	1	0	9	45.0400	41.6223	7.6
F30	Silty Clay	1	4		7/15/99	1	99-54733-32	4	1	0	14	43.6927	40.8113	6.6
F31	Silty Clay	1	4		7/15/99	1	99-54733-34	3	0	0	8	44.0230	40.4984	8.0
F32	Silty Clay	1	4		7/15/99	1	99-54733-35	4	1	0	7	46.8813	44.2231	5.7
F33	Silty Clay	1	4		7/15/99	1	99-54733-36	4	1	0	28	46.2449	43.1468	6.7
F34	Silty Clay	1	4		7/15/99	1	99-54733-37	2	0	0	14	45.0407	41.7687	7.3

Soil Survey Line F

Sample	Soil Type	Slope	Soil Moist	Comments	Date	Land Use	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
F35	Silty Clay	1	4		7/15/99	1	99-54733-38							
F36	Silty Clay	1	4	More silty than typical sample	7/15/99	1	99-54733-39	4	0	0	15	47.5557	44.6831	6.0
F37	Silty Clay	1	4		7/15/99	1	99-54733-40	4	0	0	6	45.2249	42.8750	5.2
F38	Silty Clay	1	4		7/15/99	1	99-54733-41	4	1	0	7	45.7757	44.5153	2.8
F39	Silty Clay	1	4		7/15/99	1	99-54733-42	4	0	0	12	44.8056	41.2607	7.9
F40	Silty Clay	1	4		7/15/99	1	99-54733-43	3	1	1	14	46.0960	43.6395	5.3
F41	Silty Clay	1	4		7/15/99	1	99-54733-44	4	1	0	22	48.3048	46.0081	4.8
F42	Silty Clay	1	4		7/15/99	1	99-54733-46	3	0	0	17	46.7567	44.0531	5.8
F43	Silty Clay	1	4		7/15/99	1	99-54733-47	3	1	1	21	50.3730	47.9178	4.9
F44	Silty Clay	1	4		7/15/99	1	99-54775-1	2	0	14	28	46.4458	46.4458	6.9
F45	Silty Clay	1	4	Fence Line	7/15/99	1	99-54775-2	2	0	20	160	44.2054	44.2054	7.4
F46	Silty Clay	1	4		7/15/99	1	99-54775-3	2	0	8	22	45.6171	45.6171	6.5
F47	Silty Clay	1	4		7/15/99	1	99-54775-4	2	0	48	43	46.0502	46.0502	6.4
F48	Silty Clay	1	4		7/15/99	1	99-54775-5	3	0	21	63	42.7483	42.7483	7.7
F49	Silty Clay	1	4		7/15/99	1	99-54775-6	3	0	16	44	48.6588	48.6588	4.8
F50	Silty Clay	1	4		7/15/99	1	99-54775-7	3	0	30	66	50.1936	50.1936	5.4
F51	Silty Clay	1	4		7/15/99	1	99-54775-9	3	1	34	59	46.3083	46.3083	5.9
F52	Silty Clay	1	4		7/15/99	1	99-54775-10	3	1	29	112	44.4484	44.4484	6.0
F53	Silty Clay	1	4		7/15/99	1	99-54775-11	4	0	32	190	42.8732	42.8732	6.4
F54	Silty Clay	1	4		7/15/99	1	99-54775-12	4	0	23	99	45.3892	45.3892	5.7
F55	Silty Clay	1	4		7/15/99	1	99-54775-13	3	0	22	73	45.7881	45.7881	5.6
F56	Silty Clay	1	4		7/15/99	1	99-54775-14	3	1	39	184	43.8724	43.8724	6.3
F57	Silty Clay	1	4		7/15/99	1	99-54775-15	4	0	35	69	49.3723	49.3723	4.7
F58	Silty Clay	1	4		7/15/99	1	99-54775-16	4	1	22	60	46.9894	46.9894	5.6
F59	Silty Clay	1	4		7/15/99	1	99-54775-17	3	0	17	38	47.4823	47.4823	5.3
F60	Silty Clay	1	4		7/15/99	1	99-54775-18	3	1	32	148	45.0528	45.0528	4.3
F61	Silty Clay	1	4		7/15/99	1	99-54775-20	3	0	21	62	45.6689	45.6689	5.9
F62	Silty Clay	1	4	Near Drainage	7/15/99	1	99-54775-21	3	1	35	138	44.3477	44.3477	5.6
F63	Silty Clay	1	4		7/15/99	1	99-54775-22	2	1	44	161	43.3924	43.3924	6.1
F64	Silty Clay	1	4		7/15/99	1	99-54775-23	3	2	89	607	37.9280	37.9280	7.3
F65	Silty Clay	1	4		7/15/99	1	99-54775-24	3	0	21	74	42.8007	42.8007	5.9
F66	Silty Clay	1	4		7/15/99	1	99-54775-25	4	1	42	205	45.5040	45.5040	5.2
F67	Silty Clay	1	4	Fence Line	7/15/99	1	99-54775-26	5	1	28	65	47.9501	47.9501	4.3
F68	Silty Clay	1	4		7/15/99	1	99-54775-27	4	1	15	50	36.8883	36.8883	7.4

Soil Survey Line F

Sample	Soil Type	Slope	Soil Moist	Comments	Date	Land Use	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
F69	Silty Clay	1	4		7/15/99	1	99-54775-28	4	0	12	33	45.7372	45.7372	4.1
F70	Silty Clay	1	4		7/15/99	1	99-54775-29	4	1	33	102	43.6325	43.6325	6.2
F71	Silty Clay	1	4		7/15/99	1	99-54775-31	3	0	0	34	46.3106	46.3106	5.2
F72	Silty Clay	1	4		7/15/99	1	99-54775-32	4	0	28	124	47.8288	47.8288	4.8
F73	Silty Clay	1	4		7/15/99	1	99-54775-33	1	0	6	41	42.1467	42.1467	7.1
F74	Silty Clay	1	4		7/15/99	1	99-54775-34	3	0	13	42	45.7882	45.7882	5.9
F75	Silty Clay	1	4		7/15/99	1	99-54775-35	3	0	15	40	44.4836	44.4836	7.2
F76	Silty Clay	1	4		7/15/99	1	99-54775-36	3	0	10	61	45.7533	45.7533	6.1
F77	Silty Clay	1	4		7/15/99	1	99-54775-37	1	2	100	292	40.3758	40.3758	9.0
F78	Silty Clay	1	4		7/15/99	1	99-54775-38	2	1	36	164	45.3678	45.3678	6.4
F79	Silty Clay	1	4		7/15/99	1	99-54775-39	3	3	105	416	38.4388	38.4388	8.2
F80	Silty Clay	1	4		7/15/99	1	99-54775-40	3	0	19	87	44.9762	44.9762	7.9
F81	Silty Clay	1	4		7/15/99	1	99-54775-42	2	1	35	119	39.7784	39.7784	7.2
F82	Silty Clay	1	4		7/15/99	1	99-54775-43	3	1	52	218	43.3109	43.3109	7.5
F83	Silty Clay	1	4		7/15/99	1	99-54775-44	3	3	136	886	43.9164	43.9164	7.3
F84	Silty Clay	1	4		7/15/99	1	99-54775-45	3	0	23	102	44.4884	44.4884	6.8
F85	Silty Clay	1	4		7/15/99	1	99-54775-46	2	1	45	192	39.5296	39.5296	7.9
F86	Silty Clay	1	4		7/15/99	1	99-54775-47	2	0	16	57	42.7454	42.7454	8.2
F87	Silty Clay	1	4		7/15/99	1	99-54775-48	3	1	18	66	41.6986	41.6986	8.6
F88	Silty Clay	1	4	Fence Line	11/30/99	1	99-54775-49	4	3	45	150	41.1709	41.1709	7.2
F89	Silty Clay	1	2	Repeat of F87	11/30/99	1	99-59454-1	7	3	1	38	43.7663	37.8136	13.6
F90	Silty Clay	1	2	Repeat of F88	11/30/99	1	99-59454-2	4	2	1	32	39.5125	35.0175	11.4
F91	Silty Clay	1	2		11/30/99	1	99-59454-3	3	1	1	40	36.9076	32.0741	13.1
F92	Silty Clay	1	2		11/30/99	1	99-59454-4	3	1	0	11	46.4066	40.0250	13.8
F93	Silty Clay	1	2	Under Power Line	11/30/99	1	99-59454-5	5	1	0	14	36.0008	32.2838	10.3
F94	Silty Clay	1	2		11/30/99	1	99-59454-6	5	1	0	10	39.9043	36.4615	8.6
F95	Silty Clay	1	2		11/30/99	1	99-59454-7	4	1	0	15	39.7388	32.9442	17.1
F96	Silty Clay	1	2		11/30/99	1	99-59454-8	4	0	0	4	42.8740	38.3712	10.5
F97	Silty Clay	1	2		11/30/99	1	99-59454-9	4	2	1	30	39.5575	34.2280	13.5
F98	Silty Clay	1	2		11/30/99	1	99-59454-10	4	1	0	13	39.6567	35.7342	9.9
F99	Silty Clay	1	2	Cross Line G	11/30/99	1	99-59454-11	4	0	0	10	38.5162	34.1791	11.3
F100	Silty Clay	1	2		11/30/99	1	99-59454-12	3	0	0	2	38.0093	32.4150	14.7
F101	Silty Clay	1	2		11/30/99	1	99-59454-13	3	0	0	9	38.8126	34.8095	10.3
F102	Silty Clay	1	2		11/30/99	1	99-59454-14	3	2	0	14	45.2345	39.0499	13.7

Soil Survey Line F

Sample	Soil Type	Slope	Soil Moist	Comments	Date	Land Use	Laboratory N2 N3	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Z Moist
F103	Silty Clay	1	2		11/30/99	1	99-59454-15	4	2	0	21	37.6311	33.0147	12.3
F104	Silty Clay	1	2		11/30/99	1	99-59454-16	4	1	0	20	35.9708	31.8641	11.4
F105	Silty Clay	1	2		11/30/99	1	99-59454-17	3	1	0	14	43.1476	38.4861	10.8
F106	Silty Clay	1	2		11/30/99	1	99-59454-18	4	1	0	18	42.6995	36.7961	13.8
F107	Silty Clay	1	2		11/30/99	1	99-59454-19	4	1	0	24	42.5165	37.5400	11.7
F108	Silty Clay	1	2		11/30/99	1	99-59454-20	3	1	0	15	42.8523	37.2841	13.0
F109	Silty Clay	1	2		11/30/99	1	99-59454-21	3	0	0	11	42.5669	37.7688	11.3
F110	Silty Clay	1	2	Fence Line	11/30/99	1	99-59454-22	4	1	1	29	41.3650	36.8331	11.0
F111	Silty Clay	1	2		11/30/99	1	99-59454-23	4	1	1	14	41.2110	36.2006	12.2
F112	Silty Clay	1	2		11/30/99	1	99-59454-24	3	1	0	11	44.5115	37.4714	15.8
F113	Silty Clay	1	2		11/30/99	1	99-59454-25	4	1	1	22	44.7273	39.8394	10.9
F114	Silty Clay	1	2		11/30/99	1	99-59454-26	4	1	0	16	40.1141	35.7057	11.0
F115	Silty Clay	1	2		11/30/99	1	99-59454-27	4	1	0	15	40.4990	36.1970	10.6
F116	Silty Clay	1	2		11/30/99	1	99-59454-28	2	0	0	11	45.3112	38.5185	15.0
F117	Silty Clay	1	2		11/30/99	1	99-59454-29	3	1	0	11	43.6466	37.5573	14.0
F118	Silty Clay	1	2		11/30/99	1	99-59454-30	2	1	1	18	44.0331	38.2602	13.1
F119	Silty Clay	1	2		11/30/99	1	99-59454-31	3	1	0	11	45.8605	39.1768	14.6
F120	Silty Clay	1	2		11/30/99	1	99-59454-32	5	19	3	69	38.1506	30.3708	20.4
F121	Silty Clay	1	2		11/30/99	1	99-59454-33	3	1	0	12	43.5515	38.4409	11.7
F122	Silty Clay	1	2		11/30/99	1	99-59454-34	2	1	1	19	48.4412	41.5624	14.2
F123	Silty Clay	1	2		11/30/99	1	99-59454-35	4	0	0	21	43.0383	37.3231	13.3
F124	Silty Clay	1	2		11/30/99	1	99-59454-36	3	1	0	16	46.8568	41.5162	11.4
F125	Silty Clay	1	2		11/30/99	1	99-59454-37	2	1	0	11	41.8270	36.7662	12.1
F125A	Silty Clay	1	2		11/30/99	1	99-59454-38	4	0	0	9	40.2155	35.1676	12.6
F126	Silty Clay	1	2		11/30/99	1	99-59454-39	3	0	0	8	39.5728	35.4748	10.4
F127	Silty Clay	1	2		11/30/99	1	99-59454-40	2	0	0	7	42.8039	36.8159	14.0
F128	Silty Clay	1	2		11/30/99	1	99-59454-41	3	1	0	16	43.5154	37.2047	14.5
F129	Silty Clay	1	2		11/30/99	1	99-59454-42	4	1	0	10	43.5914	38.9153	10.7
F130	Silty Clay	1	2	Fence Line	11/30/99	1	99-59454-43	2	1	0	26	38.5607	33.5394	13.0
F131	Silty Clay	1	2		11/30/99	1	99-59454-44	2	0	0	8	40.3747	35.6517	11.7
F132	Silty Clay	1	2		11/30/99	1	99-59454-45	4	0	0	11	38.0424	33.5896	11.7
F133	Silty Clay	1	2		11/30/99	1	99-59454-46	4	1	0	41	38.2838	32.8517	14.2
F134	Silty Clay	1	2		11/30/99	1	99-59454-47	4	0	0	8	44.0215	39.7126	9.8

Soil Survey Line G

Sample	Soil Type	Slope	Land Use	Soil Moist	Date	Comments	Laboratory	Methane	Ethane	Propane	Butane	Wet Weight	Dry Weight	Moisture
G1	gravel clay	0	1	2	11/99		99-59454-	4	1	0	40	38.7004	34.9714	9.6
G2	gravel clay	0	1	2	11/99		99-59454-	3	1	0	27	40.2798	36.0724	10.4
G3	gravel clay	0	1	2	11/99		99-59454-	2	1	0	11	40.2907	34.5174	14.3
G4	silty clay	0	1	2	11/99		99-59454-	3	5	2	60	35.4913	29.4993	16.9
G5	silty clay	0	1	2	11/99		99-59454-	3	9	2	63	26.1073	21.2215	18.7
G6	silty clay	0	1	2	11/99		99-59454-	3	1	0	13	41.8158	35.8982	14.2
G7	silty clay	0	1	2	11/99		99-59454-	3	3	1	63	33.9612	27.6683	18.5
G8	silty clay	0	1	2	11/99		99-59454-	4	11	2	66	38.3651	31.5794	17.7
G9	silty clay	0	1	2	11/99		99-59454-	3	1	1	23	45.3879	40.3128	11.2
G10	silty clay	0	1	2	11/99		99-59454-	3	1	1	23	45.4753	39.4675	13.2
G11	silty clay	0	1	2	11/99		99-59454-	4	0	0	11	43.1834	37.6774	12.8
G12	gravel clay	0	1	2	11/99		99-59454-	4	0	0	9	45.0114	40.7196	9.5
G13	gravel clay	0	1	2	11/99		99-59454-	2	0	0	9	43.0383	37.2536	13.4
G14	gravel clay	0	1	2	11/99		99-59454-	4	8	2	147	40.795	34.7119	14.9
G15	silty clay	0	1	2	11/99		99-59454-	4	4	2	113	38.2226	33	12.8
G16	silty clay	0	1	2	11/99	Near Creek & Cor	99-59454-	4	4	2	71	41.7795	36.4984	12.6
G17	silty clay	0	1	2	11/99		99-59454-	3	0	0	11	48.2753	42.157	12.7
G18	silty clay	0	1	2	11/99		99-59454-	5	5	5	1405	47.4321	41.3935	12.7
G19	silty clay	0	1	2	11/99		99-59454-	3	0	1	34	41.5884	36.686	11.8
G20	silty clay	0	1	2	11/99		99-59454-	3	0	0	11	46.4054	41.673	10.2
G21	silty clay	0	1	2	11/99		99-59454-	4	0	0	17	43.3397	38.4373	11.3
G22	silty clay	0	1	2	11/99		99-59454-	3	0	0	5	47.9031	44.2319	7.7
G23	gravel clay	0	1	2	11/99		99-59454-	3	2	1	22	43.873	38.0876	13.2
G24	gravel clay	0	1	2	11/99		99-59454-	3	3	1	63	39.3809	34.0836	14