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Eocene Fluvial Drainage Patterns and Their Implications for Uranium and Hydrocarbon Exploration in the Wind River Basin, Wyoming

By DAVID A. SEELAND

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A paleocurrent study that defines the Eocene paleogeography of the basin and the course of the paleo-Wind River

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By DAVID A. SEELAND

ABSTRACT

Paleocurrent maps of the fluvial lower Eocene Wind River Formation in the Wind River Basin of central Wyoming define promising uranium- and hydrocarbon-exploration target areas. The Wind River Formation is thought to have the greatest potential for uranium mineralization in areas where it includes arkosic channel sandstones derived from the granitic core of the Granite Mountains, as in the channel-sandstone bodies deposited in Eocene time by a 40-kilometer segment of the eastward-flowing paleo-Wind River that extended westward from near the town of Powder River on the east edge of the basin. Channel-sandstone bodies with a Granite Mountains source occur south of this segment of the paleo-Wind River and north of the Granite Mountains. The southwestern part of this area includes the Gas Hills uranium district, but the channel-sandstone bodies between the Gas Hills district and the 40-kilometer segment of the paleo-Wind River may also be mineralized. This area includes the southeasternmost part of the Wind River Basin southeast of Powder River and contains northeasterly trending channel-sandstone bodies derived from the Granite Mountains.

Limited paleocurrent information from the margins of the Wind River Basin suggests that the paleo-Wind River in Paleocene time flowed eastward and had approximately the same location as the eastward-flowing paleo-Wind River of Eocene time.

The channel-sandstone bodies of the paleo-Wind Rivers are potential hydrocarbon reservoirs, particularly where they are underlain or overlain by the organic-rich shale and siltstone of the Waltman Shale Member of the Fort Union Formation.

If leaks of sulfur-containing gas have created a reducing environment in the Eocene paleo-Wind River channel-sandstone bodies, then I speculate that the areas of overlap of the channel-sandstone bodies and natural-gas fields in the underlying rocks may be particularly favorable areas in which to search for uranium deposits.

INTRODUCTION

The Tertiary basins of Wyoming contain 42 percent of the nation's \$10 per pound U_3O_8 uranium ore (Patterson, 1970, p. 119). In the sedimentary models of the basins now being developed, the paleocurrent systems provide an integrating framework that systematizes the distribution, orientation, and composition of the sedimentary rocks that constitute the basin fill. Preliminary results define two promising exploration target areas in the eastern Wind River Basin (fig. 1).

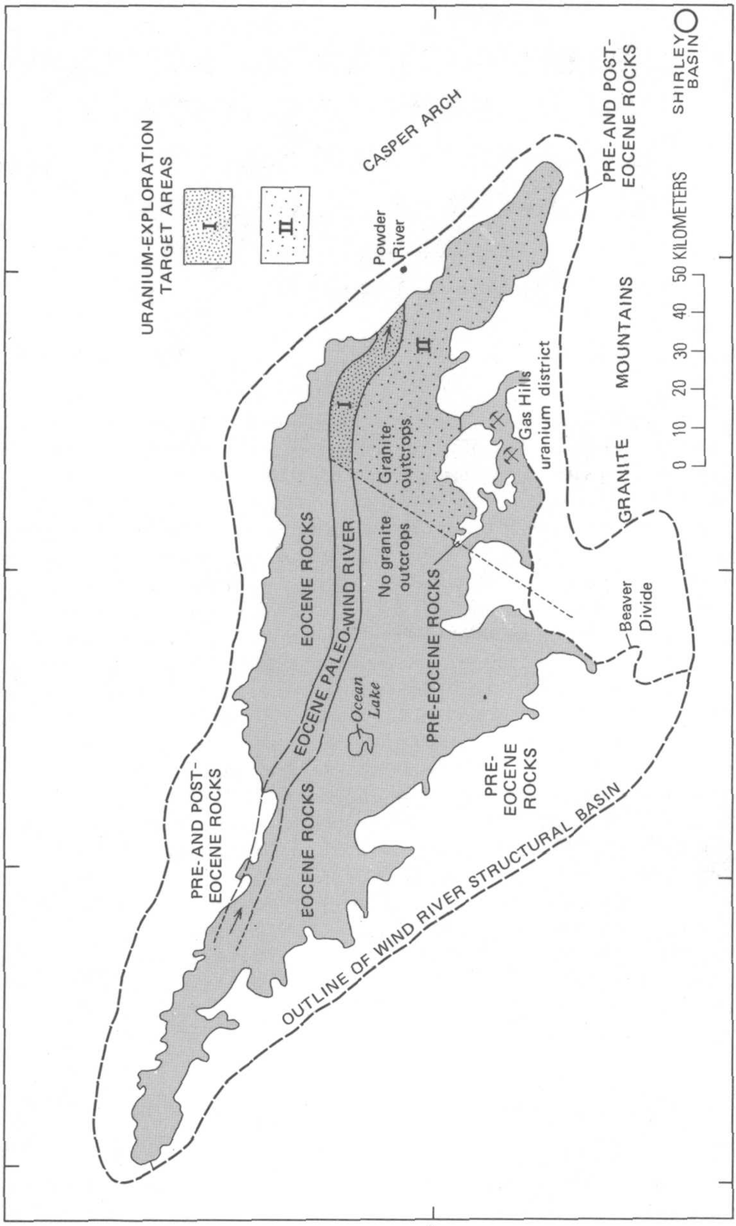

FIGURE 1. — Uranium-exploration target areas in eastern Wind River Basin, Wyo.

Recent comprehensive work on the Wind River Basin has been by Keefer (1965; 1970). Zeller (1957), Soister (1968), and Armstrong (1970) have studied the Gas Hills uranium mining district in the southern Wind River Basin; Harshman (1968; 1972) has studied the nearby Shirley Basin district; and Stephens (1964) has studied the Crooks Gap district on the northern margin of the Great Divide Basin. The locations of these three uranium mining districts are shown in figure 2.

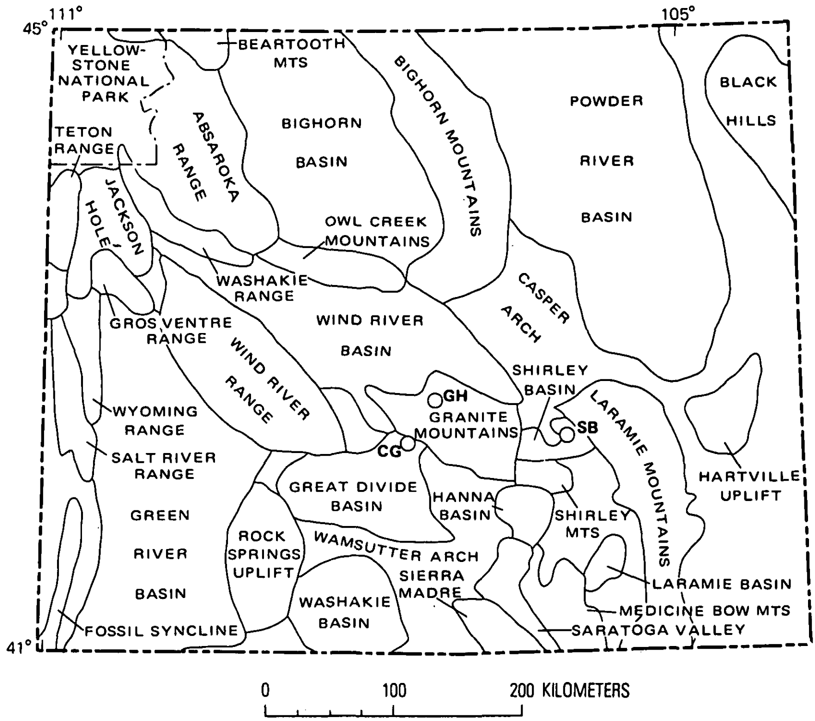

FIGURE 2. — Wyoming basins and ranges (modified from Love, 1961). Uranium mining districts: Crooks Gap (CG), Gas Hills (GH), and Shirley Basin (SB).

GEOLOGIC SETTING

The western topographic margin of the Wind River Basin is the Wind River Range. Its northern margin is formed by the Washakie and Absaroka Ranges and the Owl Creek and southern Bighorn Mountains. Topographically its southern margin is formed by the Beaver Divide, an erosional escarpment in rocks of Eocene, Oligocene, and Miocene age. The eastern margin is topographically undefined and merges into the high plains surface of the Powder River Basin.

The Wind River Basin is well defined structurally. Paleozoic rocks dip 12° to 15° NE. into the basin along the Wind River Range. Dips along the Washakie Range and the Owl Creek and Bighorn Mountains are into the basin in most places, but are much less regular, varying from flat to overturned. Structurally the east margin of the basin is well defined by the Casper arch, an anticline whose west limb is steep to overturned. The south Owl Creek Mountains thrust fault, with as much as 6 km (kilometers) of stratigraphic displacement, extends the length of the west side of the Casper arch. The southern structural margin of the basin is formed by the Granite Mountains, a unique collapsed Laramide uplift. Paleozoic and Mesozoic rocks dip 10° to 15° off the north flank of the mountains and are broken by east-west normal faults. Post-Wind River Tertiary rocks conceal most of the granitic core of the Granite Mountains, with the exception of a series of granite knobs. Generally flat-lying strata of the Wind River Formation floor the central part of the Wind River Basin and are the host rocks for the uranium in the Gas Hills district. The structural relief between the mountains and the basin, on the upper surface of the Precambrian, exceeds 9 km on the north side of the basin close to the Owl Creek Mountains (Keefer, 1970, p. D1).

TERTIARY STRATIGRAPHY

FORT UNION FORMATION

The lower part of the Paleocene Fort Union Formation was deposited by streams carrying clastic debris from the highlands that had begun to define the Wind River Basin into the subsiding trough area along the north edge of the basin. The upper part of the Fort Union consists of shale, siltstone, claystone, and sandstone (the Waltman Shale Member) deposited in a large lake which had at least a limited connection with an open sea to the east (Keefer, 1961, p. 1323). Along the north edge of the basin the Fort Union is as thick as 2,500 m (meters); on the west and south sides it ranges from 50 to 350 m in thickness (Keefer, 1965, p. A22).

INDIAN MEADOWS FORMATION

The Indian Meadows Formation, named by Love (1939, p. 58–59), is of earliest Eocene age and crops out on the northern margin of the Wind River Basin. It is impossible to distinguish it from the overlying Wind River Formation in drill-hole data. The Indian Meadows is commonly banded in shades of red, gray, and tan. Coarse conglomerates originated as stream-channel and alluvial-fan deposits. Clays and silts were deposited as overbank deposits on flood plains. Masses of Paleozoic rock, as much as 400 m long, are found within the formation and may be landslide deposits or may be remnants of thrust sheets formed during uplift of the Owl Creek Mountains and Washakie Range (Keefer, 1965, p. A42). The Indian Meadows is absent along the southwest side of the basin and may be a thousand or more meters thick in the subsurface along the north side of the basin.

WIND RIVER FORMATION

The Wind River Formation of early Eocene age is exposed over much of the central area of the basin. The Wind River Formation was deposited during the period following uplift of the Wind River and Washakie Ranges and the Owl Creek Mountains in earliest Eocene and is composed of debris eroded from these areas that was deposited in alluvial fans near the mountains, and in stream channels, flood plains, lakes, and swamps farther out in the basin.

Clast lithology in the conglomerates of the Wind River and the underlying Indian Meadows and Fort Union reflects areal variations of the rock types exposed in the mountain ranges bordering the basin. Clast lithology also strongly reflects progressive unroofing of the bordering mountain ranges. The lower part of the Indian Meadows and the Fort Union contain conglomerate derived from Mesozoic rocks. Conglomerate in the upper part of the Indian Meadows is coarser than conglomerate in the Fort Union and consists of fragments of Paleozoic rocks. The Wind River conglomerates contain abundant Precambrian rock fragments that record exposure of the igneous and metamorphic cores of the ranges bordering the basin.

Alternating red and grayish-green banded siltstones and claystones and light-brown sandstones make up most of the Wind River Formation. The thickness of the Wind River ranges from a few meters at the basin margin to several thousand meters in the trough in the northern part of the area.

OVERLYING TERTIARY ROCKS

Rocks overlying the Wind River Formation are present in depositional contact only in the northwest, south, and southeast parts of the basin. The most characteristic difference between the Wind River and the overlying rocks is that the younger rocks contain substantially more volcanic debris. The middle Eocene Aycross Formation has been described by Love (1939), and the overlying middle and upper Eocene Tepee Trail Formation of the northwest part of the basin has been described by Keefer (1957). The Aycross consists of tuffaceous claystone, shale, sandstone, and conglomerate with hornblende- and biotite-rich volcanic rocks in the upper part of the formation. The

Tepee Trail consists of greenish andesitic conglomerates, sandstone, shale, and tuff. The overlying Eocene Wiggins Formation is composed of volcanic conglomerate and breccia, both interbedded with tuffs.

On the southeastern and southern margins of the Wind River Basin the Wind River Formation is conformably overlain by the Wagon Bed Formation of middle and late Eocene age. The Wagon Bed is made up of a series of laterally persistent beds of sandstone, siltstone, and mudstone, which contain volcanic debris and bentonitic clay, and which range from 40 to 200 m in thickness (Van Houten, 1964, p. 36).

The Oligocene White River Formation along the Beaver Divide on the south side of the basin is a calcareous tuffaceous mudstone and a fine-grained muddy sandstone, although sandstone and conglomerate are also present (Van Houten, 1964, p. 56–57). The White River has a maximum exposed thickness of 200 m along the Beaver Divide (Van Houten, 1964, p. 55). To the east, in the Shirley Basin, the White River is divided into a lower fine-grained siltstone member and an upper member, which is about one-third of the unit, of conglomerate, sandstone, and siltstone (Harshman, 1972, p. 26).

METHODS OF STUDY

The orientations of 815, mostly trough, crossbeds were determined at 72 localities in the Eocene Wind River Formation[1] in the Wind River Basin. A total of 19 crossbedding orientations were determined at 2 localities in the Paleocene Fort Union Formation. Courdin and Hubert (1969, p. 29) measured 203 Fort Union crossbeds at 5 localities in the Wind River Basin. The locations of these field stations are shown in figure 3.

True, not apparent, crossbed dips and dip directions (azimuths) were determined with a compass-and-level crossbed-measuring device. The thickness of crossbed sets was usually measured for each set whose orientation was determined. The number of crossbed sets measured at each locality was determined either by availability or by a rough plot of dip azimuths made after 10 crossbeds had been measured. If the azimuths were strongly grouped, no further measurements were made; if they were strongly dispersed, about 10 additional randomly selected measurements were made, if possible. Sedimentation-unit samples of conglomerate, sandstone, and siltstone-shale were also collected at each outcrop.

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[1] Some of the crossbed localities in the western part of the basin were in strata mapped by Keefer (1970, pl. 1) as "lower Eocene rocks undivided," and therefore a few localities may have actually been in the Indian Meadows Formation, which underlies the Wind River Formation.

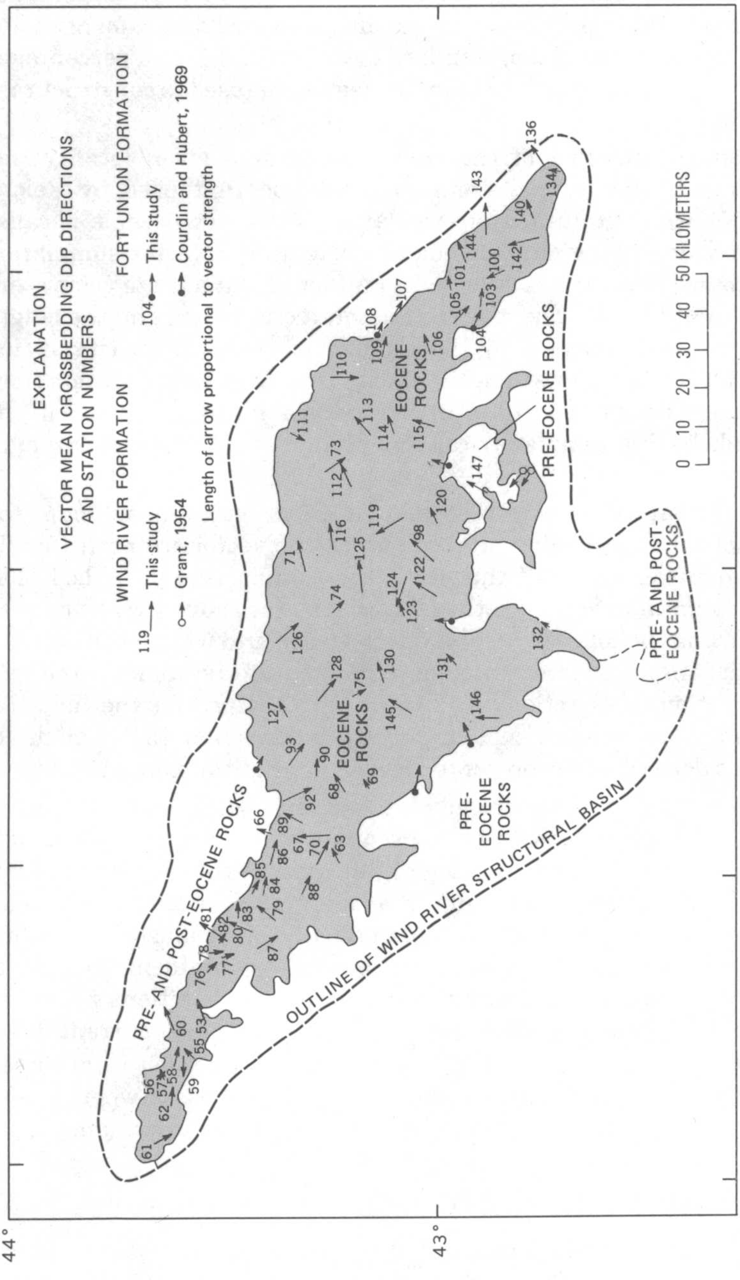

FIGURE 3. — Vector-mean crossbedding map, Wind River and Fort Union Formations, Wind River Basin, Wyo.

A computer program written by E. S. Robinson of Virginia Polytechnic Institute and State University and George Van Trump of the U.S. Geological Survey was used to correct for post-depositional tectonic tilt and to provide vector means, standard deviation of vector means, mean vector of dip, standard deviation of dip, and percentages of corrected crossbed azimuths in 30° segments (used to construct rose diagrams).

The mean direction of the crossbedding at a given locality was calculated by the vector summation method first used by Reiche (1938). Arithmetic means of circular data are not useable because they vary depending on the choice of origin. In a vector summation each crossbed azimuth is assigned a unit length, and these vectors are added "tail to head." The resultant is the vector mean, and the length of this resultant divided by the number of crossbed measurements times 100 is the vector strength. If all crossbeds at a field station have the same orientation, the vector strength is 100 percent; if the crossbeds have a completely random orientation, the vector strength will approach zero.

Locality vector means were plotted on a vector-mean map, the length of the arrow being proportional to the vector strength (fig. 3). The numerical results of this study are summarized in table 1. The vector-mean map was smoothed to produce the moving average map (fig. 4) using the following technique: a 10-km grid was placed over the vector-mean paleocurrent map, and at each intersection on the grid the vector-mean direction was graphically obtained for the field stations in the four squares surrounding the intersection; the mean direction thus derived was represented by an arrow at the grid intersection.

Because each grid square adjoins four intersections, each locality vector-mean current direction is used four times. Therefore, a single divergent current direction in a marginal area of the map, where sampling density is low, could result in as many as four moving averages that repeat the one direction. This effect is particularly misleading because vectors near the map edge are visually prominent. In order to minimize this effect, a minimum of three current directions were used in formulating each moving average; that is, the mean current directions from the three crossbed localities closest to each intersection were always used in the vector summation, regardless of whether one, two, or all three were in squares adjacent to the intersection.

INTERPRETATION OF PALEOCURRENT RESULTS

The fluvial-channel sandstones of the Wind River Formation in the Wind River Basin can be seen to cap linear ridges, as at station 128

TABLE 1. — *Crossbedding statistical summary*

[All stations are in the Eocene Wind River Formation (or in the "lower Eocene rocks undivided" of Keefer, 1970) unless otherwise noted]

Station No. (fig. 3)	Vector-mean azimuth (degrees)	Azimuth vector weight (percent)	Mean cross-bed dip (degrees)	Number of crossbeds measured
53	75.8	59	28.3	11
55	43.4	43	24.3	17
56	132.7	45	19.2	8
57	77.6	36	22.0	17
58	102.6	62	22.5	15
59	280.2	67	19.2	12
60	69.8	86	19.2	5
61	151.8	61	22.6	11
62	92.6	56	28.6	5
65	60.7	40	19.4	20
66	17.8	40	18.5	14
67	356.6	66	19.6	13
68	59.5	69	21.3	14
69	31.3	10	23.4	16
70	110.4	72	27.4	10
71	77.4	72	22.7	12
73	143.8	82	19.7	12
74	135.2	41	20.1	11
75	143.7	48	25.7	18
76	135.9	66	16.0	11
77	154.6	52	21.8	4
78	175.1	28	16.5	8
79	42.4	70	21.5	12
80	26.7	79	22.0	10
81[1]	36.6	94	54.2	9
82	120.5	37	18.9	14
83	86.5	44	19.2	15
84	98.5	59	15.8	13
85	114.6	50	20.1	6
86	105.8	69	15.9	11
87	148.5	70	20.9	9
88	113.4	54	21.5	11
89	29.5	59	19.9	17
90	94.1	50	19.9	15
92	157.1	85	24.4	11
93	120.6	66	19.9	14
98	45.1	88	21.3	12
100	333.5	58	19.2	14
101	66.8	27	27.6	19
103	90.4	75	26.0	6
104[2]	109.2	58	18.9	8
105	122.4	79	23.6	5
106	71.0	54	26.2	4
107	120.1	77	24.6	9
108[2]	107.1	22	32.6	11
109	100.0	74	25.5	14
110	183.9	83	24.0	6
111	205.1	77	20.9	8
112	64.7	80	21.0	11
113	48.5	71	21.3	11
114	69.1	54	22.6	18
115	15.3	55	18.0	4
116	83.0	83	21.9	11
119	330.0	89	22.5	6
120	64.0	35	18.4	20
122	30.1	71	17.2	12
123	83.8	44	20.3	12
124	289.3	93	22.2	6
125	86.5	75	18.2	12
126	134.6	71	24.6	15
127	62.5	35	19.3	20
128	129.8	84	23.7	14
130	70.0	46	19.4	11
131	43.7	52	19.4	10
132	22.1	27	22.3	17

TABLE 1. — *Crossbedding statistical summary* — Continued.

Station No. (fig. 3)	Vector-mean azimuth (degrees)	Azimuth vector weight (percent)	Mean cross-bed dip (degrees)	Number of crossbeds measured
134	354.9	43	15.8	11
136	58.8	72	14.7	3
140	64.4	57	19.9	7
142	345.0	95	29.0	2
143	91.2	85	21.0	9
144	71.4	58	21.4	12
145	34.1	78	22.1	18
146	2.8	67	18.8	10
147	22.2	82	23.0	7

[1] Pebble imbrication.

[2] In Paleocene Fort Union Formation.

(fig. 3) 11 km northeast of Ocean Lake, or extend from ridge to ridge in dissected topography, as at station 73 located 2.4 km south of Lysite. However, channel trends are generally difficult to ascertain visually, particularly in areas of poor outcrop. The average transport direction and thus the average channel azimuth in the Wind River Formation is N. 80° E. This direction was obtained by a vector summation of all 815 crossbed measurements. The corresponding overall vector strength is 36 percent. The degree of dispersion of transport directions can also be visually estimated from the crossbedding-dip-directions rose diagram for the Wind River Formation (fig. 5). The mean crossbed dip in the Wind River Basin is 22.1°. The mean exposed thickness of 632 crossbed sets was 43.1 cm; the range was 5–224 cm. Set thickness is presented in a histogram in figure 6.

The moving-average map (fig. 4) has been used to prepare the interpretative map of the Wind River Basin early Eocene stream pattern (fig. 7). The course of the paleoriver is obvious on both the moving-average map (fig. 4) and the interpretative map (fig. 7). The paleo-Wind River flowed east-southeast across the northern part of the basin, left the basin near the present town of Powder River, and flowed eastward across the Casper arch into the Powder River Basin. Northeasterly trending tributary streams carried coarse-grained arkosic sand, which formed the host sandstones in the Gas Hills uranium district. Eocene arkosic sandstones of the Shirley Basin uranium district were deposited by streams flowing eastward from the east end of the Granite Mountains. The Crooks Gap uranium district is on the south side of the Granite Mountains where deposits are in arkosic sandstones and conglomerates derived from the granitic core of the Granite Mountains and deposited by southerly flowing streams (Groth, 1970, p. 10).

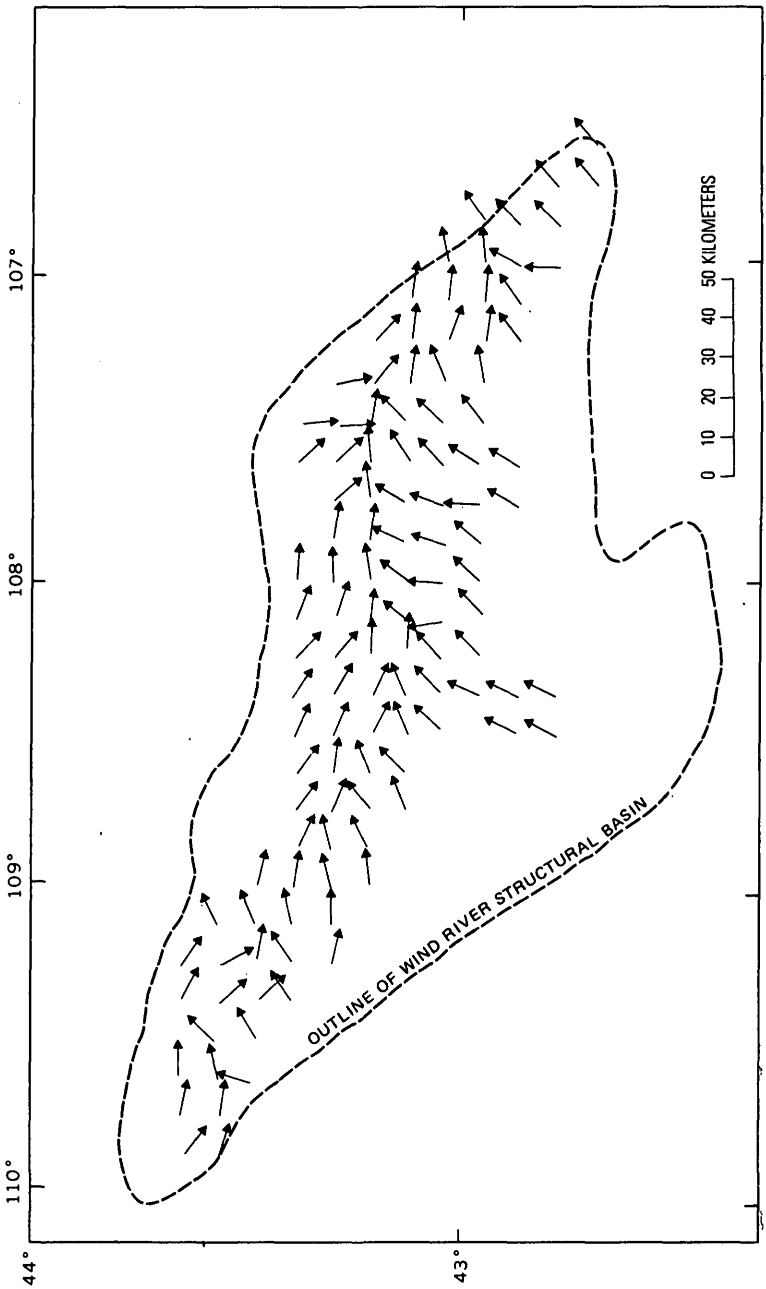

FIGURE 4. — Moving-average crossbedding map, Wind River Formation, Wind River Basin, Wyo.

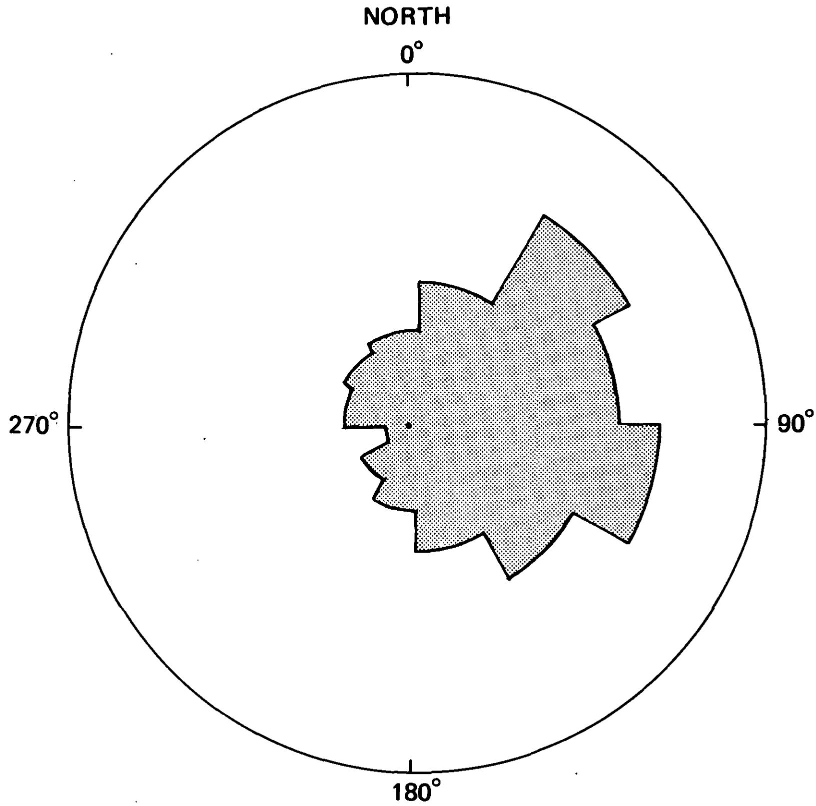

FIGURE 5. — Crossbedding-dip-directions rose diagram for 815 crossbed measurements in the Wind River Formation, Wind River Basin, Wyo.

The source of uranium in the ore-bearing solutions has been the subject of much discussion. Love (1970, p. C129) lists the following primary sources which have been proposed for the uranium deposits in the Granite Mountains area: (1) Precambrian granite of the Granite Mountains, (2) arkosic sandstones derived from the Precambrian granite of the Granite Mountains, (3) Precambrian vein deposits of hydrothermal origin (Guilinger, 1963), (4) Tertiary uraniferous tuff (Love, 1954; Pipiringos, 1961), and (5) hydrothermal solutions (Melbye, 1957; Gabelman and Krusiewski, 1964).

Harshman (1970, p. 227) favors a multiple source for the deposits: Precambrian granite in the cores of the flanking ranges, and Tertiary tuffaceous rocks that once were more widespread in the eastern two-thirds of Wyoming. Love (1970, p. C132) favors Tertiary tuffaceous rocks as the source of the uranium in the Gas Hills and Crooks Gap districts. Soister (1968, p. A48) believes that the arkose itself is the

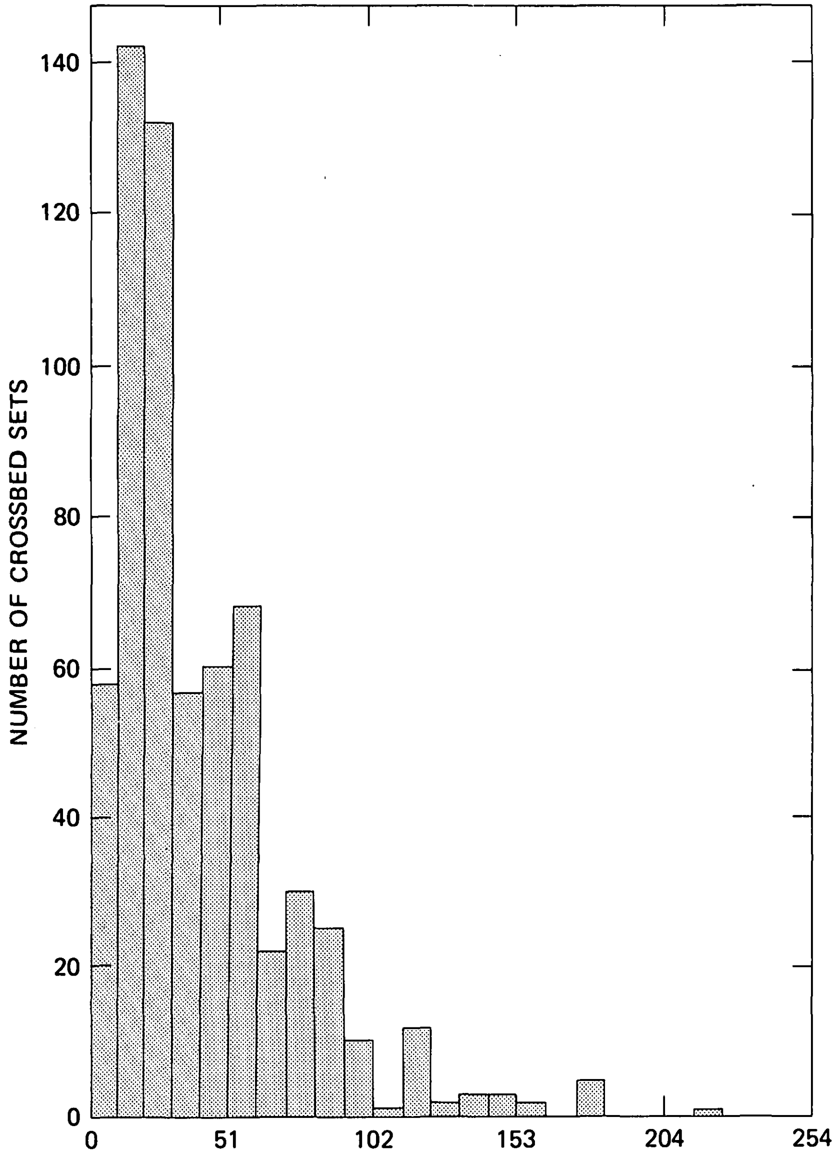

FIGURE 6. — Histogram of thickness of crossbed sets, Wind River Formation, Wind River Basin, Wyo.

most likely source. Because the altered sandstone contains slightly more uranium and 10 to 20 times more selenium than the unaltered sandstone, Harshman concludes that the altered arkose is not the source of the uranium.

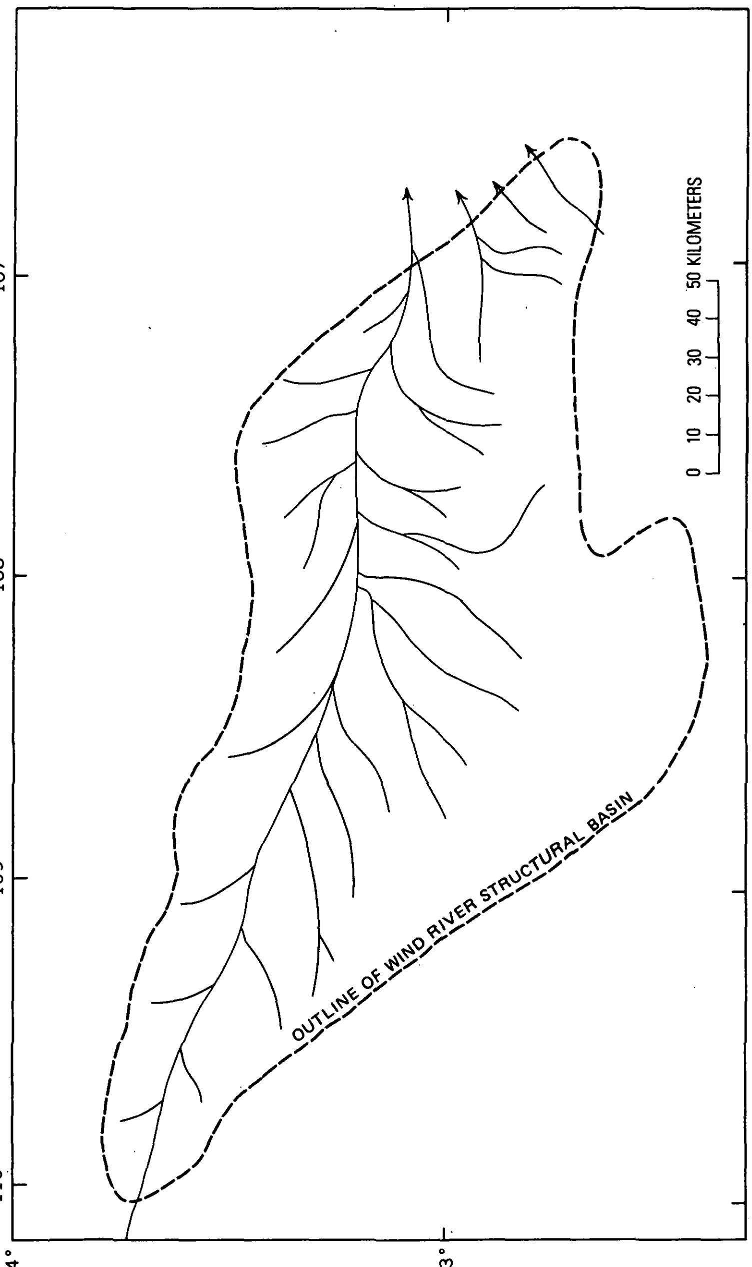

FIGURE 7. — Interpretative map of early Eocene stream pattern, Wind River Basin, Wyo.

But whatever the source of the uranium-bearing solutions, permeable clastic units — and particularly paleochannel sandstones — are favorable environments for uranium-ore formation (Harshman, 1961; Davis, 1970, p. 24; Armstrong, 1970, p. 35; Groth, 1970, p. 11; Grant, 1954; Hayashi, 1970, p. 233; Zeller, 1957, p. 158). Therefore, if a Granite Mountains sediment source and the existence of fluvial-channel sandstones are important parameters in the localization of uranium deposits in the Wind River Basin, then paleocurrent maps define two favorable target areas as shown in figure 1.

The western end of a 40-km segment of favorable channel-sandstone bodies of the paleo-Wind River was determined by projecting the westernmost extent of the granites of the Granite Mountains (fig. 1) northeast parallel to the stream directions represented on the moving-average paleocurrent map (fig. 4). The channel-sandstone bodies[2] of this 40-km-long segment of the Eocene Wind River Formation define one uranium-exploration target area (I in fig. 1). The second target area (II in fig. 1) includes channel-sandstone bodies with a Granite Mountains source found in the area south of this segment and north of the Granite Mountains. The southwestern part of this area includes the Gas Hills uranium district, but channel-sandstone bodies between the Gas Hills district and the 40-km segment of the paleo-Wind River may be mineralized. This area extends into the southeasternmost part of the Wind River Basin and contains northeasterly trending channel-sandstone bodies derived from the Granite Mountains.

Note that the position of the paleo-Wind River cannot be located more closely than the grid spacing of the moving-average map (10 km). More closely spaced moving-average grid lines would require more closely spaced field stations, which in some areas of the basin would be difficult to obtain because of the scarcity of outcrops. Furthermore, the position of the paleo-Wind River is based on stratigraphically uncontrolled crossbed measurements. If the stratigraphic position of the crossbed measurements were random, then the location of the paleo-Wind River would be the mean position during that portion of early Eocene time represented by the remaining beds of an originally thicker Wind River Formation. The stability of the current pattern and of the position of the paleo-Wind River is estimated to be fairly high, based on the similarity of Eocene and Paleocene current rose diagrams (fig. 5, 8).

The likelihood of uranium mineralization depends in part on the source of the uranium-bearing ground water and the relative volume of the channel-sandstone bodies. The channel sandstones of the paleo-

[2] "Channel sandstone" includes point-bar, channel-lag, channel-bar, and channel-fill deposits.

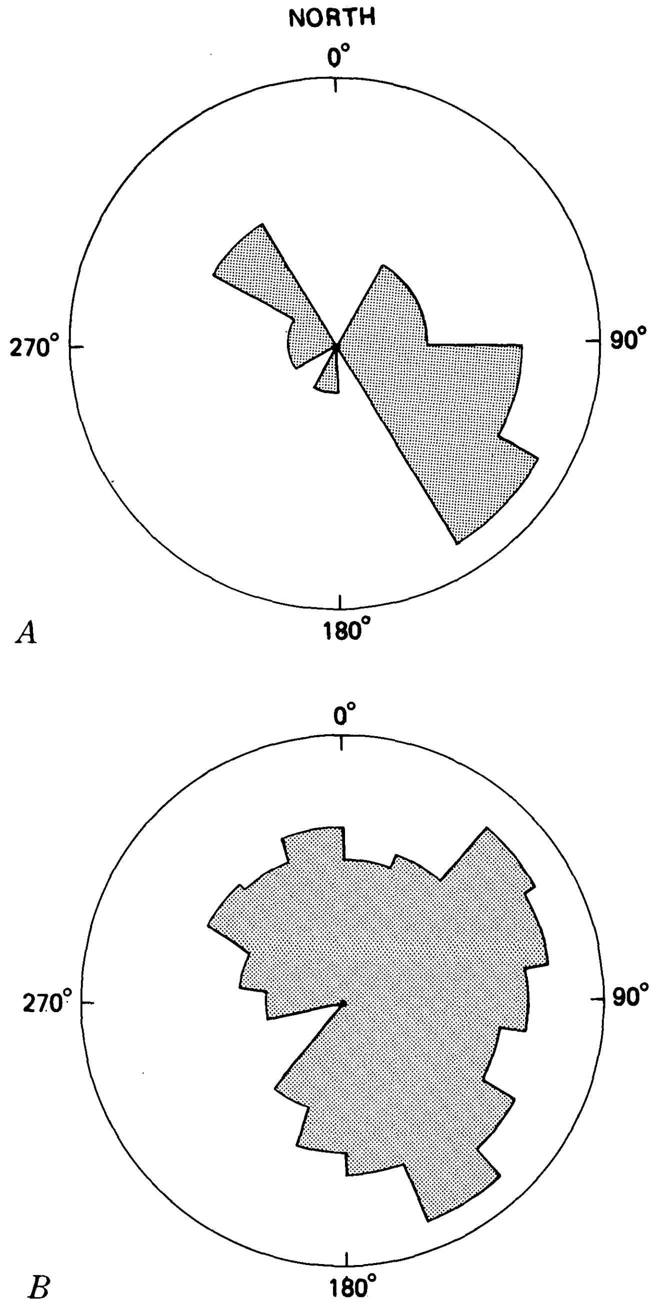

FIGURE 8. — Crossbedding-dip-directions rose diagrams for the Fort Union Formation. *A*, 19 crossbed orientations, this study. *B*, 208 crossbed orientations from Courdin and Hubert (1969, fig. 1).

Wind River (target area I, fig. 1) and the ground-water flow through them are only partially derived from the Granite mountains. So, in spite of the fact that the channel-sandstone bodies of the paleo-Wind River should be the largest of any in the two areas, dilution of the Granite Mountain sediment and ground water by sediment and ground water derived elsewhere should decrease the potential of this area. But if uraniferous tuffs are the source of the uranium, then the area with the largest channel-sandstone bodies, the area defined by channel-sandstone bodies of the paleo-Wind River, should be most favorable. It is necessary though, as Love (1970, p. C132) points out, that a hydraulic connection exist between the host rock and the source rock, and it is not known if such a connection existed in this area because the overlying tuffaceous rocks have been eroded away. The second area (target area II, fig. 1) should have smaller channel-sandstone bodies, but the arkose in these, and the ground water that has flowed through them, should have come exclusively from the Granite Mountains.

Channel-sandstone bodies should be larger and accumulations of plant debris more likely in the deposits of the lower velocity down-stream parts of the tributaries to the paleo-Wind River. These factors suggest that the northern part of the second area may be more favorable than the southern part (excepting, of course, the Gas Hills mining district).

Sulfur in the gas or in associated oil of the Waltman gas field (fig. 9) could have reacted with iron in the Tertiary sediments to form pyrite and to create a reducing environment that would precipitate uranium, as suggested by Love (1970, p. C132). This gas field seems to lie directly on the course of the paleo-Wind River near the east margin of the basin, where the amount of arkose and ground-water flow from a Granite Mountains source would be maximized, and where the channel-sandstone bodies should reach their greatest size. This area, therefore, seems to be an especially favorable target.

The paleo-Wind River shown in figure 9 intersects or passes near several other gas fields located by Lane, Root, and Glass (1972). These fields are Frenchie Draw, Reservoir Creek, Pony Creek, Dinty Moore Reservoir, Shoshoni, Poison Creek, Muddy Ridge, and Pavillion. These fields, with the exception of Frenchie Draw, lie west of the area in which arkose and ground water derived from the Granite Mountains area occurs (or occurred), but the paleo-Wind River channel-sandstone bodies in the vicinity of these fields could be mineralized if other arkoses or uraniferous tuffs were the source of the mineralizing solutions. These fields produce gas mostly from the Paleocene Fort Union Formation, but the Muddy Ridge and Lost Cabin fields produce partly from the lower Eocene Wind River Formation, and the Lysite

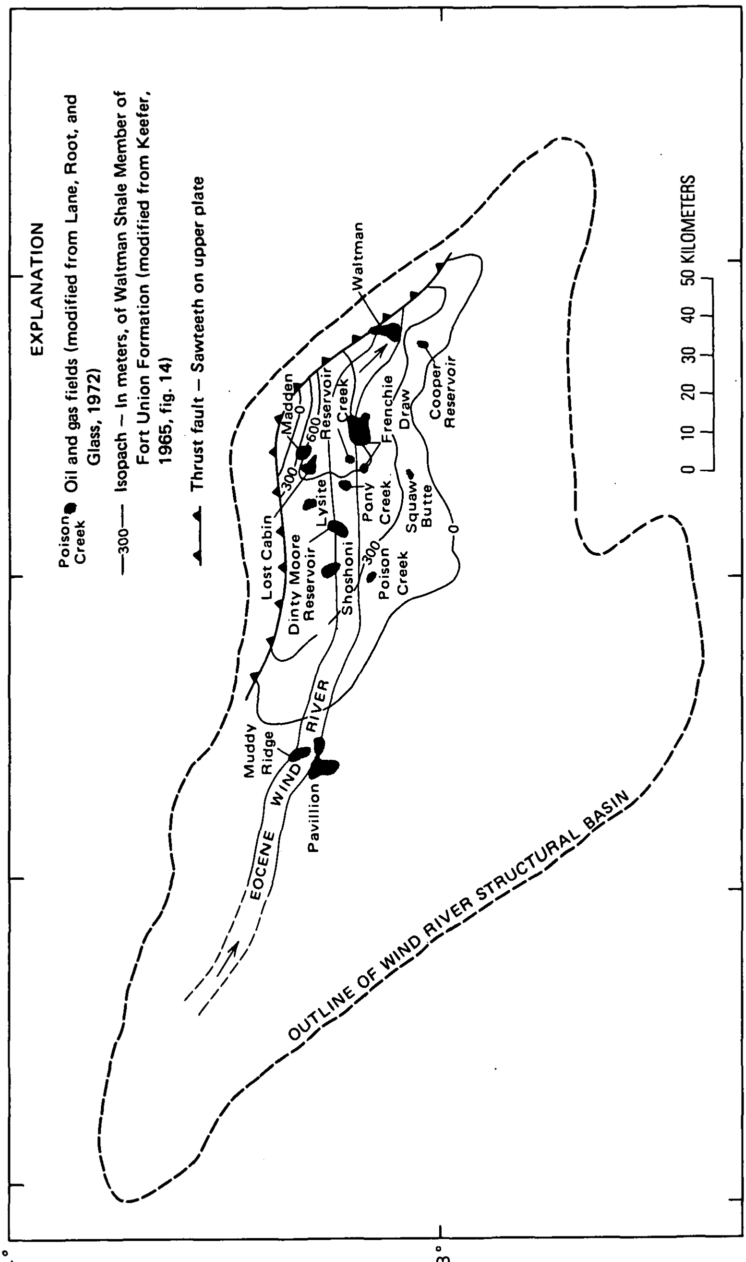

FIGURE 9. — Gas fields in northern Wind River Basin, Eocene paleo-Wind River location, and isopach map of Waltman Shale Member of Fort Union Formation.

field produces chiefly from the lower Eocene (Keefer, 1969, p. 1859). All these fields lie within 10 km of the approximate location of the paleo-Wind River. Since the location of the paleo-Wind River channel is approximate, gas leaks from these fields could also create a reducing environment in nearby channel-sandstone bodies of the paleo-Wind River.

It is possible that the fluvial channel sandstones of the paleo-Wind Rivers are potential natural gas or petroleum reservoir rocks. Comparison of crossbed-dip-direction rose diagrams of Courdin and Hubert (1969) and those obtained during this study from the lower fluvial part of the Paleocene Fort Union Formation (fig. 8) with the Wind River Formation rose diagram (fig. 5) suggests a similarity in current pattern, as do the vector-mean current directions (fig. 3). The overall vector means of N. 73° E. for the Fort Union (Courdin and Hubert, 1969, p. 29) and N. 80° E. for the Wind River Formation are very close. These facts may indicate the paleo-Wind River channel system occupied approximately the same position in Paleocene time as in Eocene time. Thus, the Eocene and Paleocene paleo-Wind River channel sandstones are potential hydrocarbon reservoirs and worthy exploration targets, particularly where the channel sandstones are underlain or overlain by the organic-rich shale and siltstone of the Waltman Shale Member of the Fort Union Formation. An isopach map of the Waltman Shale Member (from Keefer, 1965, fig. 14) is shown in figure 9 with the approximate position of the Eocene paleo-Wind River (which is also the inferred position of the Paleocene paleo-Wind River). This map, therefore, shows where the paleo-Wind River channel sandstones have maximum oil and gas potential. Keefer (1969, p. 1859) does state, however, that the amount of hydrocarbons found in sandstones adjacent to the Waltman Shale Member has been smaller than expected.

SUMMARY AND CONCLUSIONS

The source of the uranium-bearing solutions that formed the ore deposits near the Granite Mountains is not known but the uranium may have been leached from post-Wind River tuffaceous rocks of Oligocene and Miocene age, from granitic rocks of Precambrian age in the core of the Granite Mountains, or from arkosic sandstones of early Eocene age derived from the Granite Mountains. A Granite Mountains source for the host rock and the presence of fluvial-channel sandstone bodies of the Wind River Formation are apparently important factors in the localization of the Gas Hills, Shirley Basin, and Crooks Gap uranium deposits. Based on these two factors, paleocurrent maps derived from a study of fluvial crossbedding of the Wind River Formation in the Wind River Basin of central Wyoming were used to identify two areas having a maximum probability of uranium mineralization (fig. 1). An additional factor favoring uranium precipitation is the possibility that gas containing reductants leaked into the sandstone from adjacent gas fields, such as the Waltman field, which underlies the paleo-Wind River channel-sandstone bodies. The moving-average paleocurrent map of the Wind River Formation clearly shows the source areas for the lower Eocene rocks of the basin and locates the area in which channel-sandstone bodies of the paleo-Wind River are most likely to be found. The location of the paleo-Wind River in Paleocene time is quite probably similar to that of the river in Eocene time, based on limited paleocurrent data from the margin of the basin. Oil and gas accumulations in the channel sandstones of the Eocene and Paleocene paleo-Wind Rivers are more likely where they overlie or underlie the organic-rich Waltman Shale Member in the central and northeastern Wind River Basin.

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