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GENERAL STRATIGRAPHY AND DEPOSITIONAL HISTORY OF THE FORT UNION, INDIAN MEADOWS, AND WIND RIVER FORMATIONS, WIND RIVER BASIN, WYOMING

by
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INTRODUCTION

The Fort Union, Indian Meadows, and Wind River Formations comprise a great wedge of fluviatile and lacustrine sediments, which accumulated in the Wind River Basin during Laramide deformation in Paleocene and early Eocene times. A detailed knowledge of the stratigraphy, structure, and depositional history of these strata is fundamental to an understanding of the tectonic evolution of the basin and its surrounding uplifts. Such knowledge is also pertinent to many matters of economic interest, particularly exploration and development of oil and gas fields and uranium deposits.

The Wind River Formation lies at the surface throughout much of the basin area, whereas the Indian Meadows and Fort Union Formations crop out here and there along the margins (Fig. 1). All are widespread in the subsurface and have been penetrated by numerous deep wells in the basin interior. Abundant basic data are therefore available on the Paleocene and lower Eocene strata throughout the region. As part of a program of regional geological investigations in the Wind River Basin by the U. S. Geological Survey, the writer synthesized and presented many of these data in two published reports (Keefer, 1961; 1965). This report is chiefly a summary of that material, and the reader is referred to the 1961 and 1965 publications for more complete discussions and documentation.

STRATIGRAPHY

Because the deposition of the Paleocene and lower Eocene strata coincided with the period of active subsidence of the Wind River Basin and pronounced uplift and rapid erosion of the surrounding uplifts, the sedimentary sequences vary greatly in thickness and lithology from one place to another. Individual stratigraphic units are thin, unconformable, and conglomeratic (mountainward facies) in most surface sections along the basin margins, whereas they are much thicker, virtually conformable, and predominantly fine grained (the basinward facies) in subsurface sections a few miles downdip from the outcrops (Fig. 2). As might be expected under these conditions, there is a complete gradation of the two major facies in areas which overlap both the mountain and the basin structural provinces. Depending upon the gradient and transport power of the ancient streams, the coarse mountainward facies may extend many miles into the basin proper, or it may be confined to the narrow mountain slopes. A precise correlation of beds is therefore difficult to establish in many areas along the basin margins.

In the central and northeastern parts of the Wind River Basin, the distinctive Waltman Shale Member of the Fort Union Formation affords an excellent datum for correlation of the Paleocene rocks. Other major stratigraphic units in the structurally deeper parts of the basin, however, are more difficult to define, because they represent a continuous depositional sequence in which lithologic changes are very gradual. For some wells the formation contacts are best defined on electric logs, but, owing to the similarities in electrical properties shown by many of these units, correlations based solely on electric logs are apt to be misleading unless they are supplemented by a general knowledge of the lithologies penetrated. Correlations based particularly on gross lithologic aspects, structural relations, and similar environments of deposition, however, can be made with some degree of assurance over fairly wide areas.

Fort Union Formation

The Fort Union Formation is divided regionally into three units: a lower unnamed part, the Waltman Shale Member in the middle, and the Shotgun Member at the top. The lower part of the formation and the Shotgun Member are chiefly of fluviatile origin, whereas the Waltman is of lacustrine origin.

The Waltman Shale Member is thickest along the north and northeast margins of the basin, but thins progressively southward and westward and wedges out within a few miles of the exposures of Fort Union rocks along the south and west margins (Fig. 2). Beyond the zero edge of the Waltman, strata of the overlying Shotgun Member merge with lithologically similar strata of the lower part of the Fort Union Formation, and the two members lose their identities. It is not feasible, therefore, to subdivide the Paleocene sequence in the surface

Fig. 1.—Index map showing major outcrop areas of Fort Union, Indian Meadows, and Wind River Formations in the Wind River Basin. (Outline of structural basin shown by dashed line.) See fold-out map following.

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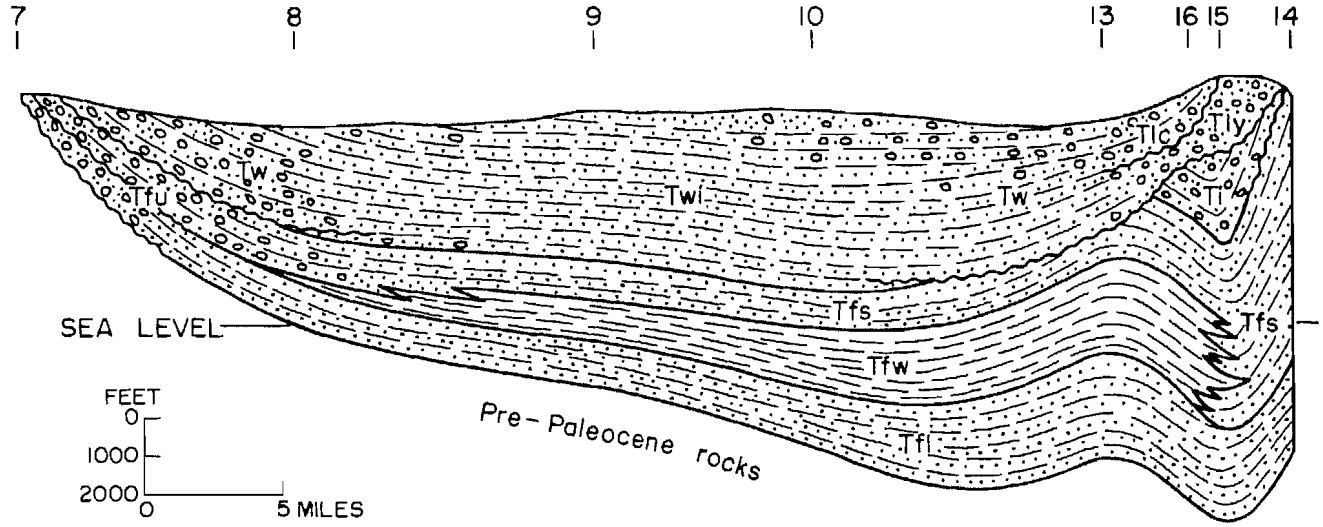


Fig. 2—Diagrammatic cross section showing stratigraphic and structural relations of Paleocene and lower Eocene rocks across central part of Wind River Basin. Line of section and numbered localities shown on Figure 1. Geologic symbols: Tw, Wind River Formation; Tlc, Lost Cabin Member; Tly, Lysite Member; Ti, Indian Meadows Formation; Twi, Wind River and Indian Meadows Formations undivided; Tfu, Fort Union Formation; Tfs, Shotgun Member; Tfw, Waltman Shale Member; Tfl, lower part.

sections and the nearby subsurface sections along the south and west sides of the Wind River Basin. In extensive exposures in the Shotgun Butte area at the north edge of the basin (Fig. 1, loc. 2), however, the Shotgun Member is easily distinguished from the lower part of the Fort Union, although the Waltman Shale Member is absent.

The thickness of the Fort Union Formation varies considerably from place to place. In exposures at the west and south margins of the basin, the thicknesses range from 200 to 1,000 feet; but to the north and east, toward the deep basin interior, they increase to as much as 8,000 feet (Fig. 3). The surface sections at Shotgun Butte and Waltman (locs. 2 and 19), with thicknesses of 3,925 and 2,970 feet, respectively, are in the main Wind River Basin trough area.

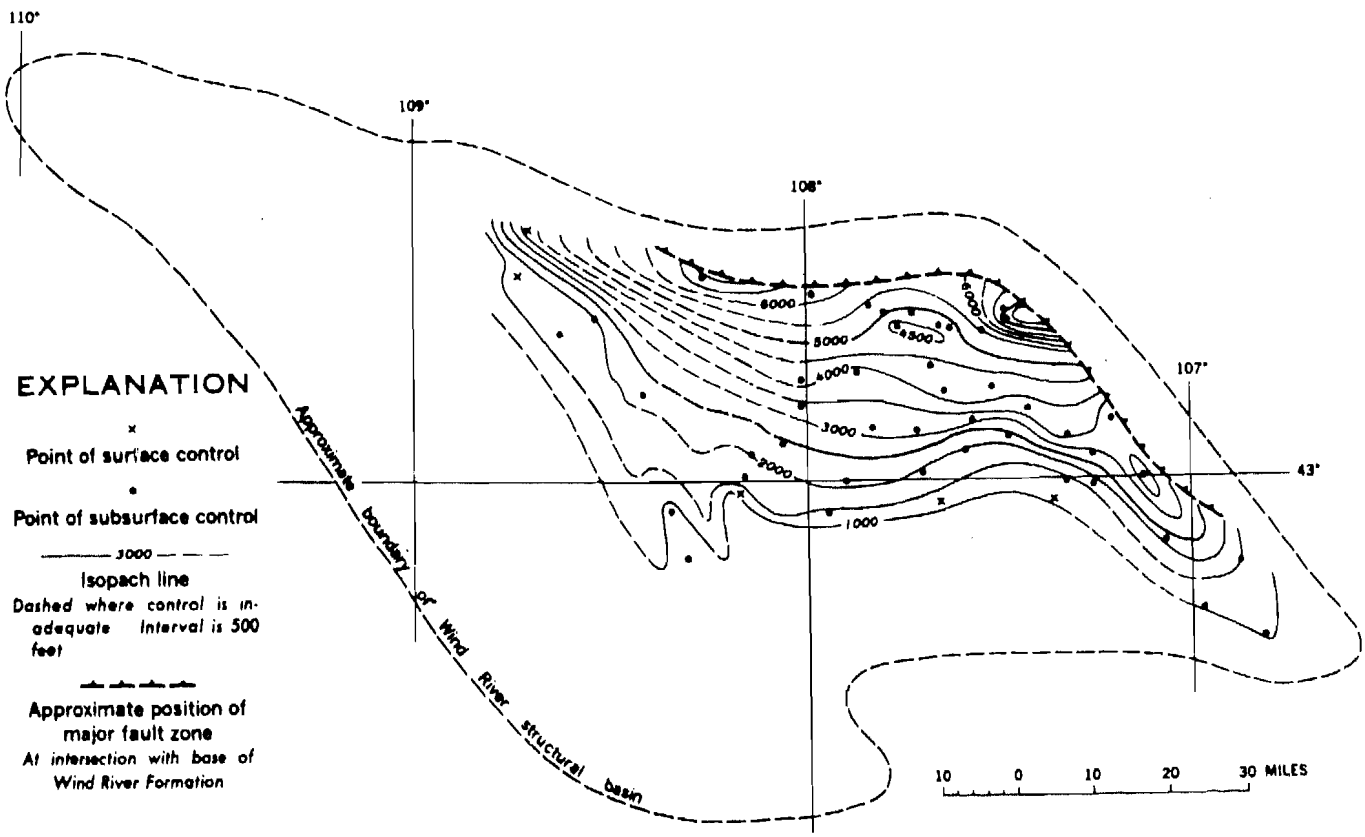
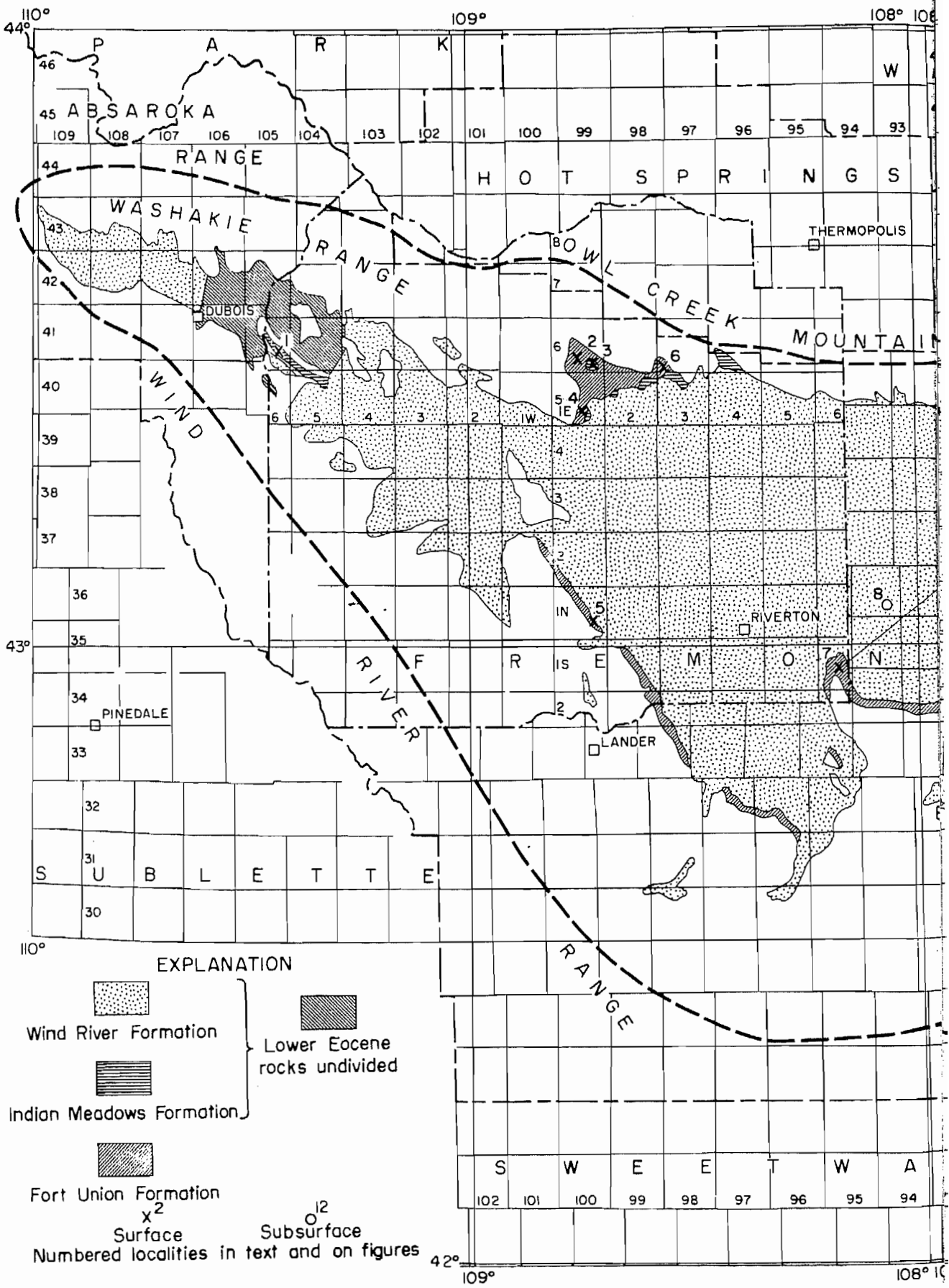


Fig. 3.—Isopach map of Fort Union Formation. (From Keefer, 1965, Fig. 12).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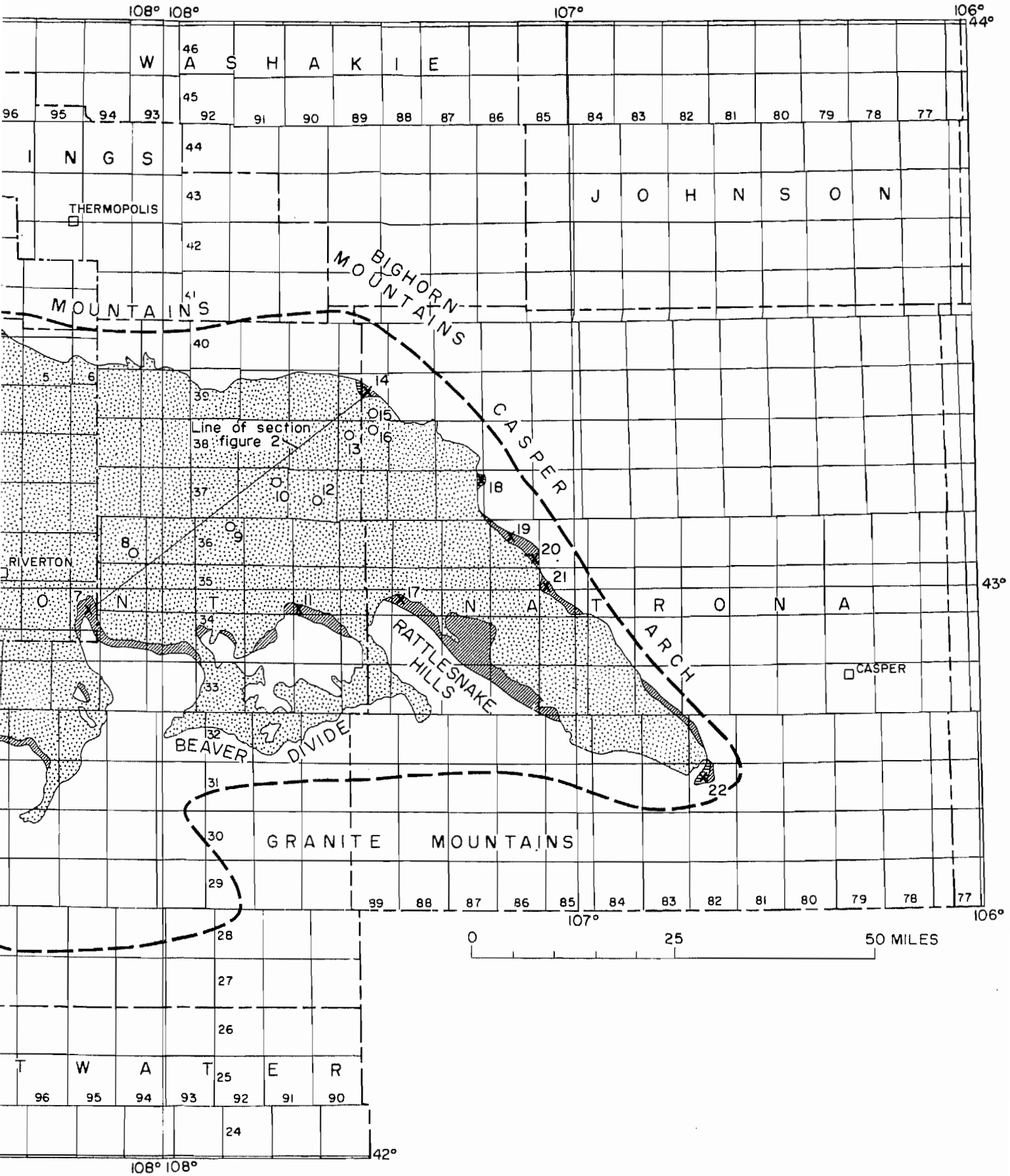
WIND RIVER RANGE
BOWL CREEK MOUNTAIN
HOT SPRINGS
FREMONT
SUBLETTE
SWEETWATER
DUBOIS
THERMOPOLIS
RIVERTON
PINEDALE
LANDER
EXPLANATION
Wind River Formation
Indian Meadows Formation
Fort Union Formation
Lower Eocene rocks undivided
Surface
Subsurface
Numbered localities in text and on figures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Lower part of Fort Union Formation.–The lower part of the Fort Union Formation is characterized by white to gray, fine- to coarse-grained, massive to crossbedded sandstone, interbedded with dark-gray to black shale, claystone, and siltstone and brown carbonaceous shale. Abundant thin brown-weathering ironstone beds are present in most places, and lenticular coal beds occur locally. The sequence generally forms resistant ridges in outcrops, and on electric logs it produces a more expanded series of resistivity and self-potential curves than either the overlying Waltman Shale Member or the underlying Cretaceous rocks (Fig. 4). Thicknesses range from 575 to 1,500 feet in wells near the south basin margin to a max mum of 3,500 feet farther north along the major trough line (Fig. 2).

In the Shotgun Butte area (loc. 2), as well as in some sections near the south edge of the basin, the lower part of the Fort Union locally contains much coarse-grained sandstone and conglomerate (Fig. 2). These beds contain abundant chert, quartz, porcelanite, and siliceous shale fragments, which range in size from coarse sand to cobbles as much as six inches across. The sequence penetrated by several deep wells near the north and northeast margins, however, appears to contain little, if any, coarse debris despite a close proximity to the Owl Creek and Bighorn Mountains.

The contact between the lower part of the Fort Union and the overlying Waltman Shale Member is shown to be sharp and well defined on electric logs (Fig. 4). Lithologically, however, most subsurface sections show a thin transitional zone of interbedded sandstone, black micaceous shale, carbonaceous shale, and thin coal beds near the contact.

Waltman Shale Member–The Waltman Shale Member of the Fort Union Formation is the most easily recognized unit within the lower Tertiary sequence of the Wind River Basin. At the type section near the town of Waltman (loc. 19), where it is part of a series of vertical to overturned beds along the west flank of the Casper arch, the member is 643 feet thick and consists of chocolate-brown and gray silty and shaly claystone and a few thin beds of ledge-forming sandstone. One of the most distinctive features is the abundance of uniformly disseminated minute white mica flakes. Southeast of the type section the sandstone beds become progressively thicker, so that at the southeasternmost exposures (loc. 21), about 1½ miles south of Hells Half Acre, only about 50 feet of claystone and shale remains. Some of the sandstone beds become conglomeratic southward, containing abundant pebbles of black chert and scattered cobbles of white Precambrian granite as much as six inches across in a coarse-grained arkosic sandstone matrix. At the type section, and elsewhere along the Casper arch, the Waltman Shale Member is overlain with conspicuous angular unconformity by lower Eocene strata.

In all other exposures of Paleocene rocks around the margins of the Wind River Basin, the Waltman Shale Member is

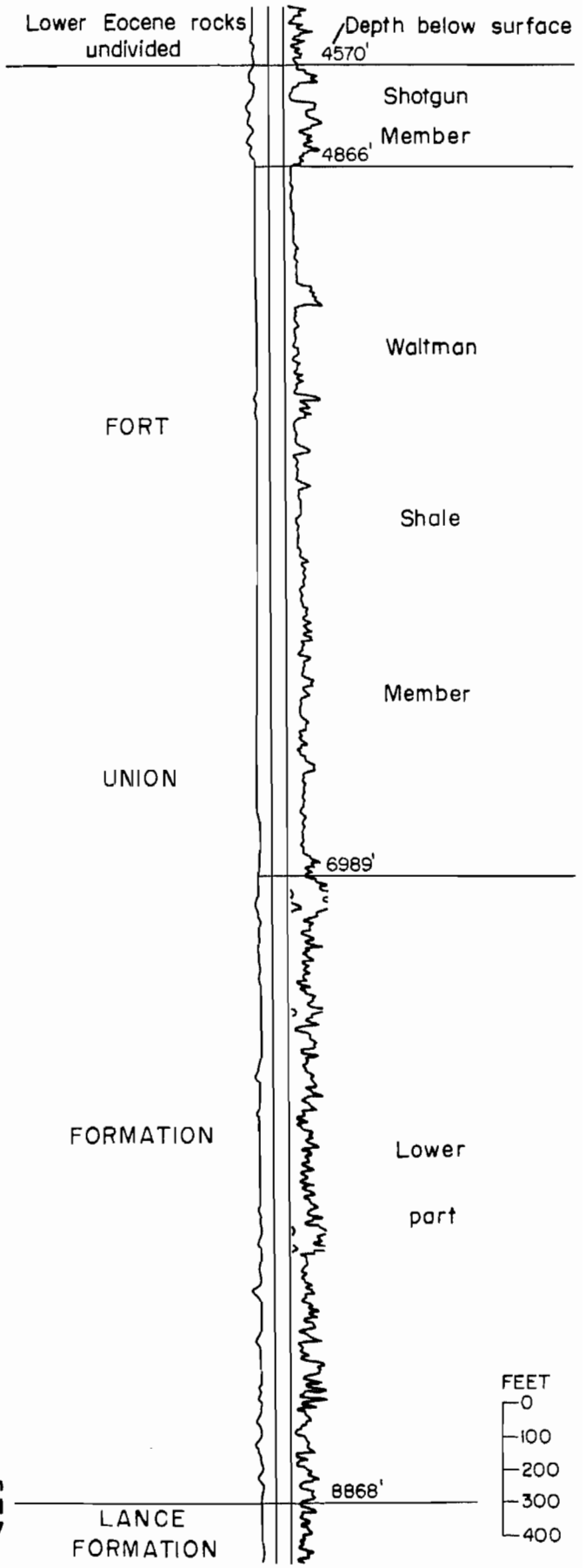

Fig. 4–Electric log characteristics of Fort Union Formation and adjacent strata in central Wind River Basin. (Humble Oil and Refining Company Frenchie Draw No. 2-B; sec. 21, T. 37 N., R. 90 W.; loc. 12, Fig. 1.)

absent; either it has been entirely truncated by the overlying lower Eocene rocks, or it has changed laterally into a different lithologic facies. Possibly some thin beds of the shale and claystone extend into outcrops in a few places along the south margin of the basin, such as at the north end of the Rattlesnake Hills (loc. 17), but if so, they have not been recognized.

The Waltman Shale Member is widespread in the subsurface, underlying more than a thousand square miles of the basin interior. Thicknesses range from a few tens of feet in wells near the south and west margins to more than 2,500 feet in wells near the north and northwest margins (Figs. 2 and 5). The dark-brown to black color and the almost lustrous uniformly silty and micaceous character of the Waltman are particularly diagnostic features in well cuttings and cores. Common constituents of the shale, in addition to mica, are quartz, feldspar, pyrite, and glauconite. Calcite and dolomite occur in only minor amounts, and no evaporites are known to be present anywhere in the sequence. The shale is generally fissile in the subsurface, although some cores break into small blocky fragments as does the rock in the exposures near Waltman.

Strata of the Waltman Shale Member contain appreciable amounts of organic material, chiefly in the form of minute, thoroughly disseminated particles of coal. Scattered, thread-like laminae of black shiny coal are also distinctive features near the top and base of the unit.

On electric logs the interval of the Waltman Shale Member is characterized by low self-potential and resistivity curves, which are in sharp contrast to the more expanded curves of underlying and overlying strata (Fig. 4). Both the upper and the lower contacts are transitional, however, with thin beds of black shale alternating with fine-grained sandstone, carbonaceous shale, and coal. Toward the margins of the basin the interfingering, particularly with the basal beds of the overlying Shotgun Member, becomes more pronounced, and the black shale grades entirely into a coarser grained and lighter colored facies (Fig. 2) that is more appropriately assigned to other members of the Fort Union.

Shotgun Member—The Shotgun Member is 2,830 feet thick at the type section near Shotgun Butte (loc. 2), where it rests directly on the lower part of the Fort Union Formation with no intervening strata of the Waltman Shale Member. In these and adjacent outcrops, the member consists of remarkably even bedded soft claystone, siltstone, shale, and sandstone. In one section (loc. 4), the uppermost part contains some thick conglomerate beds, with granules and pebbles of quartzite, siliceous shale, and chert. The rocks are mostly gray, olive green, buff, tan, and brown, but locally a few zones are pale red and purple.

The only other known exposures of beds typical of the Shotgun Member are in an isolated outcrop on the south side of Badwater Creek in the northeastern part of the Wind River Basin (loc. 14). The section in that area is about 1,600 feet thick and is overlain unconformably by massive coarse conglomerate of early Eocene age.

In subsurface sections the Shotgun Member forms the series of fine grained sandstone, shale, and carbonaceous beds that overlie the Waltman Shale Member (Fig. 2). Thicknesses range from 0 to as much as 1,100 feet in wells near the south

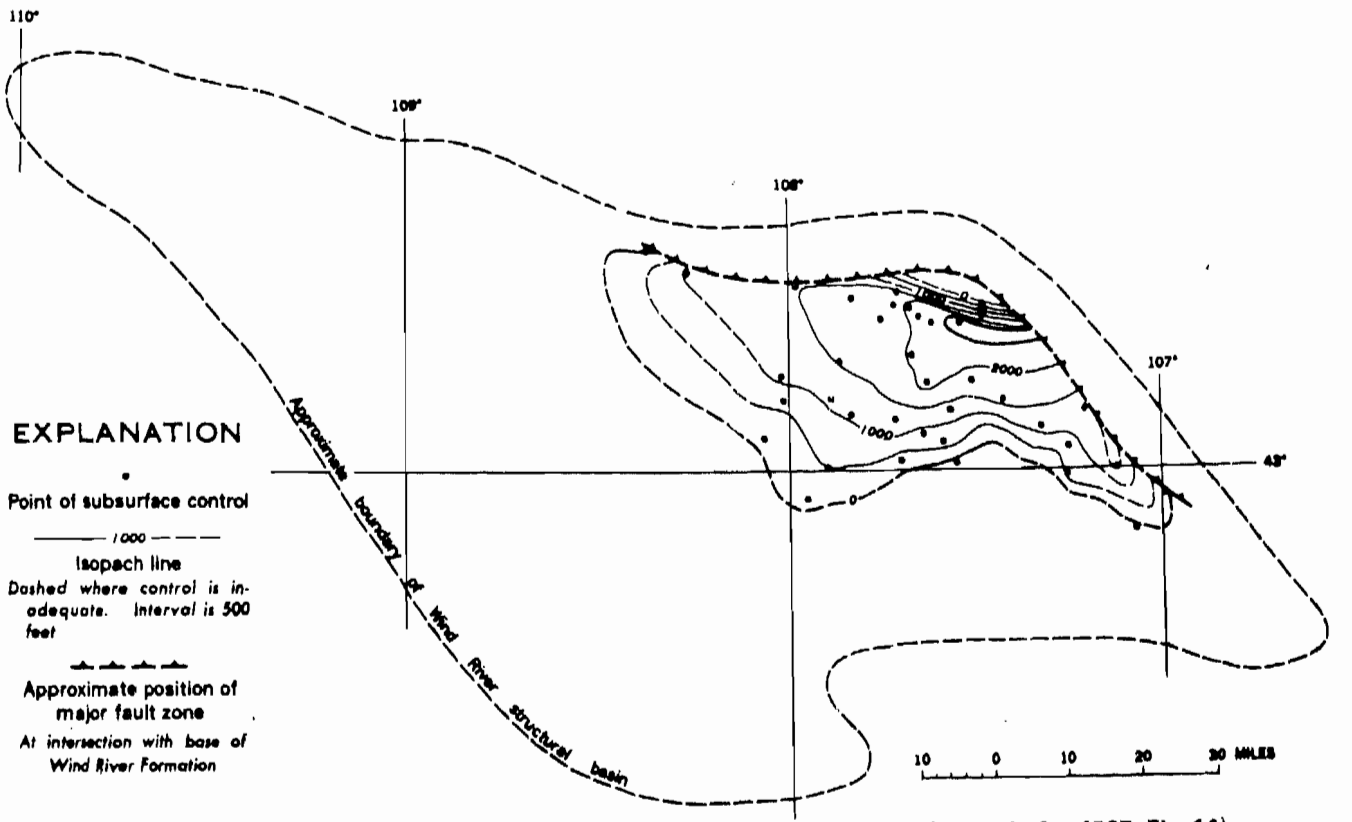

Fig. 5—Isopach map of Waltman Shale Member of Fort Union Formation. (From Keefer, 1965, Fig. 14).

margin of the basin and from 150 to more than 2,200 feet in wells along the north margins. The pronounced variations in thickness are the result of: (1) gradual increase in the amount of sediments deposited toward the basin interior; (2) interfingering at the base, particularly toward the basin margins, with strata of the Waltman Shale Member; and (3) erosion off the crest of rising anticlines before the beginning of deposition of the Wind River Formation (Fig. 2).

In places, the lateral change of facies from shale and claystone of the Waltman Shale Member to sandstone and siltstone of the Shotgun Member is abrupt. Ir the Badwater area (locs. 13-16), along the north edge of the basin, for example, a nearly complete transition appears to take place within about five miles (Fig. 2), owing probably to uplift and erosion of the nearby Bighorn Mountains during the depositional period. Similar relations can also be observed, as already mentioned, in outcrops in the Waltman-Hells Half Acre area (locs. 19-21), where strata of the Waltman grade southward within approximately six miles into coarse sandstone of the Shotgun Member.

The Shotgun Member becomes progressively coarser grained and more conglomeratic toward the west and south margins of the Wind River Basin (Fig. 2), and hence is difficult to distinguish from the lower part of the Fort Union in those areas where the Waltman Shale Member is absent.

Fort Union Formation (undivided) in western and southern Wind River Basin—In outcrops and nearby subsurface sections in the western, southern, and southeastern parts of the Wind River Basin, the Fort Union Formation is largely a series of interbedded white, gray, tan, buff, and brown sandstone, conglomerate, shale, and siltstone. Thicknesses range from 210 feet in exposures near Ethete (loc. 5) to about 1,000 feet at the north end of Alkali Butte anticline (loc. 7).

Eastward from Alkali Butte to the north end of the Rattlesnake Hills (loc. 17), conglomerate beds in the lower part consist almost entirely of fragments of quartzite, chert, and siliceous shale in a nonarkosic sandstone matrix; however, there is a gradual change upward through arkosic sandstone into a conglomerate that contains abundant Precambrian granite cobbles in its upper part. This transition is especially well shown in sections at Alkali Butte (loc. 7) and Castle Gardens (loc. 11), although at the former locality an unconformity is present between the two types of beds. Along the west margin of the basin nearly all the Fort Union conglomerate is arkosic and contains granite cobbles, perhaps indicating that the strata in that area correlate only with beds which lie above the intraformational unconformity at Alkali Butte.

Contact with underlying strata—Throughout most of the Wind River Basin the Fort Union Formation conformably overlies strata of the uppermost Cretaceous Lance Formation. In many marginal exposures, however, such as south of Shotgun Butte (loc. 4) and at the north end of the Rattlesnake Hills (loc. 17), an angular and (or) erosional unconformity is present at the contact. In the Alkali Butte area (loc. 7), the Fort Union rests unconformably on strata that have previously been assigned to the Lance. However, recent paleontological studies of fresh-water mollusks from these beds suggest that the beds are Paleocene in age. If these beds are mapped with the lower part of the Fort Union then the Fort Union rests directly upon the Mesaverde Formation in that area. Farther north and northwest, in exposures along the west side of the Wind River Basin where the relationships are more clear-cut, the strata underlying the Fort Union are either in the Mesaverde Formation or in the next older Cody Shale.

In the central part of the basin, the Fort Union and Lance Formations represent a continuous depositional sequence, and the formation boundary can only be arbitrarily determined. As indicated by the thick, conformable sequences exposed in the Shotgun Butte (loc. 2) and Waltman (loc. 19) areas, however, the contact appears to coincide generally with a change from predominantly interbedded shale, claystone, and fine-grained sandstone below to predominantly sandstone above. Such change is also discernible on many electric logs (Fig. 4).

Contact with lower Eocene rocks—The contact relations between the Fort Union Formation and overlying lower Eocene rocks vary considerably from one place to another. In most outcrops the contact is easily recognized on the basis of angular unconformity, fossils, and a lithologic change from dull-colored strata below to bright red, purple, and gray strata above. The contact in many subsurface sections, however, is difficult to determine, because the rock units are thicker and more complete and lithologic changes are more gradual through the contact zone. In general, the contact is placed at the top of well-bedded sandstone, black silty shale, carbonaceous shale, and coal which characterize the Shotgun Member in many places, and (or) at the base of variegated beds that are typical of the lower Eocene rocks over wide areas. Where none of these features is well-developed, however, the contact is arbitrarily picked.

On some electric logs the upper strata of the Fort Union show more expanded resistivity and self-potential curves than the basal beds of the Eocene sequence (Fig. 4), but on other logs the difference in curve characteristics is minimal. The sandstone in the lower Eocene rocks is commonly coarse and unconsolidated in well cuttings, whereas the sandstone in the Fort Union is finer grained and consolidated and contains flakes of white mica and an abundance of green mineral grains. In the southeastern part of the basin, the base of the arkosic strata may mark the contact; but farther west, arkosic beds also occur in the upper part of the Fort Union Formation.

Age of the Fort Union Formation—Paleontological evidence, based on studies of fossil vertebrates, plants, spores, and pollen collected from numerous localities throughout the Wind River Basin, indicates that at least in the thicker sections the Fort Union Formation represents virtually all of Paleocene time. Fossils from the Waltman Shale and Shotgun Members show that these units range in age from probable late middle Paleocene at the base into Late Paleocene at the top. Possibly earliest Eocene beds may be locally present at the top of the Shotgun Member.

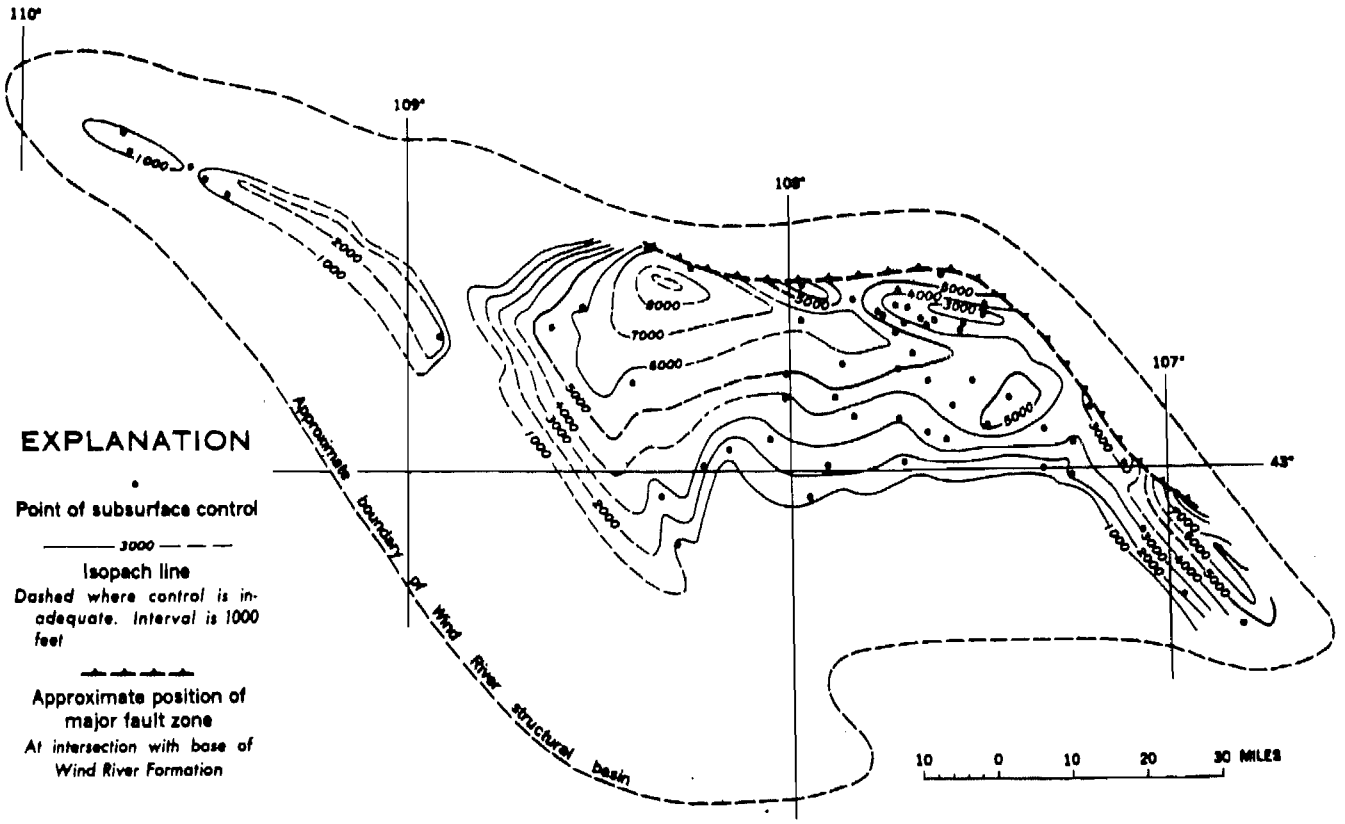

Fig. 6-- Generalized isopach map of lower Eocene rocks. (From Keefer, 1965, Fig. 29).

Indian Meadows Formation

The stratigraphic and structural relations exhibited by lower Eocene rocks in several areas around the north and east margins of the Wind River Basin indicate that the sequence is divisible into two formations separated by a major angular unconformity. Strata below the unconformity, which have been highly deformed in many places, are assigned to the Indian Meadows Formation; those above the unconformity, which have remained relatively undeformed, are included in the Wind River Formation (Fig. 2). The magnitude of the unconformity diminishes rapidly basinward, and in the deeper trough areas the formations merge into a continuous, virtually undisturbed stratigraphic sequence that cannot be readily subdivided. For this reason, all the lower Eocene rocks have been combined into a single unit for purposes of isopaching (Fig. 6). The following descriptions pertain only to outcrops and nearby subsurface sections in the northern and eastern parts of the basin in which the Indian Meadows Formation has been identified; so far as is known, rocks equivalent to the Indian Meadows do not extend into outcrops along the west and south margins. Discussions of the basal Eocene rocks in the basin interior are given in a later section of the text.

In its type locality along the East Fork Wind River (loc. 1), in the northwestern part of the Wind River Basin, the Indian Meadows Formation is composed of variegated brick-red, purple, gray and white claystone, siltstone, sandstone, and conglomerate and thin beds of gray algal-ball limestone. The conglomerate consists chiefly of rounded pebbles and cobbles of granite of Precambrian age and limestone, dolomite, sandstone, quartzite, and chert of Paleozoic age. The formation, which generally weathers to prominent badlands, is highly folded and faulted. Elsewhere in this part of the basin, where the lower Eocene rocks are not so severely deformed, the Indian Meadows cannot be distinguished with certainty from the overlying Wind River Formation (Fig. 1).

One of the thickest and best exposed sections of the Indian Meadows Formation occurs along the slopes of Shotgun Butte (loc. 3), where 725 feet of bright-red, gray, and tan claystone, sandstone, and massive conglomerate has been preserved from erosion by being downfolded in a large syncline that underlies the butte. The conglomerate predominantly contains rock fragments of Mesozoic age in its lower part and rock fragments of Paleozoic age in its upper part. The absence of Precambrian crystalline rocks distinguishes these conglomerates from those in the overlying Wind River Formation, which in this area contain an abundance of the crystalline rocks.

Along Badwater Creek (loc. 14), in the northeastern part of the basin, beds assigned to the Indian Meadows include varicolored siltstone, sandstone, conglomerate, and algal-ball limestone; this sequence unconformably overlies the Shotgun Member of the Fort Union Formation and unconformably underlies the Lysite Member of the Wind River Formation. The conglomerate beds consist mostly of cobbles and boulders of sandstone, siliceous shale, and chert as much as 4 feet across, and they contain few or none of the limestone and

dolomite fragments that are common in the overlying Lysite Member of the Wind River Formation. Maximum thickness is about 2,500 feet in surface exposures in the Badwater area, but the thickness increases substantially in nearby subsurface sections where as much as 4,000-5,000 feet of strata occurs between the Fort Union and Wind River Formations (Fig. 2). This thick sequence of the Indian Meadows, as well as the underlying Fort Union Formation, is overriden by reverse fault blocks along the south flanks of the Owl Creek and Bighorn Mountains, but the Wind River strata are not.

Rocks also believed to be equivalent to the Indian Meadows Formation are present in limited exposures near the town of Arminto (loc. 18) at the east edge of the basin and at Clarkson Hill (loc. 22) in the extreme southeast corner. The composition of the conglomerate near Arminto is similar to that described for the Badwater area, but at Clarkson Hill the sequence contains much arkosic material. The stratigraphic and structural relations between these two isolated outcrops, as interpreted from subsurface sections all along the east margin of the basin, indicate, as they do in the Badwater area described above, that several hundred to as much as 6,000 feet of post-Fort Union pre-Wind River rocks is involved in the reverse faulting along the west flank of the Casper arch. These strata, particularly toward the southeast end of the basin, are largely arkosic and contain abundant grains of white feldspar that are easily recognized in well cuttings.

Collections of fossil mammals have been obtained from the Indian Meadows Formation only in the type locality (loc. 1) and in the Shotgun Butte area (loc. 3). The fossils are considered to be earliest Eocene (older than the Lysite Member of the Wind River Formation) in age.

Wind River Formation

The Wind River Formation forms the surface rock over nearly 4,000 square miles of the Wind River Basin (Fig. 1). Thicknesses range from a wedge-edge at the margins to several thousand feet in the major trough areas. Because the strata are flat-lying and easily weathered, however, only a few hundred feet at most can be observed in outcrops in any given area. Lithologies within the formation are extremely variable, both laterally and vertically; but in general, two facies predominate: (1) a coarse conglomeratic facies along the basin margins and nearby mountain slopes; and (2) a fine-grained facies toward the basin interior. Although there is no consistent pattern, the transition from one major facies to the other generally takes place within a 5- to 10-mile strip along the basin margins (Fig. 2).

The coarse mountainward facies of the Wind River Formation is characterized by massive conglomerate beds interbedded with coarse-grained sandstone and minor amounts of shale and siltstone; colors are usually gray, tan, red, and brown. The composition and texture of the conglomerates vary from place to place, depending upon the kinds of rock that were being eroded from the adjacent mountain masses and the amount of local topographic relief at the time of deposition. Because most of the uplifts, at least along the south, west, and north sides of the Wind River Basin, had been breached to the Precambrian basement by late early Eocene time, the most common constituents of the conglomerates were derived from Precambrian and lower Paleozoic rock terranes. Individual boulders are locally as much as 15 feet in diameter, particularly along the slopes of the Wind River Range. The interbedded coarse-grained sandstone beds and the matrices of the conglomerate beds are highly arkosic in most places.

The fine-grained basinward facies of the Wind River Formation, which weathers to prominent badlands, consists primarily of bright-red, purple, gray, and white claystone, shale, siltstone, and sandstone and only minor amounts of pebble and cobble conglomerate. Many of the sandstone beds are elongate, highly lenticular bodies which locally form conspicuous ledges, bluffs, and small buttes in the otherwise subdued topography of the basin surface. The uppermost strata are moderately bentonitic and tuffaceous over wide areas.

In the eastern and northeastern parts of the Wind River Basin, the Wind River Formation has been divided into the Lysite Member at the base and the Lost Cabin Member at the top. Regional relationships suggest that the two units are separated by an angular and (or) erosional unconformity along and near these basin margins (Fig. 2). In the Badwater area (locs. 14-16) the maximum thicknesses of the Lysite and Lost Cabin are 3,000 and 2,000 feet, respectively; both members are conglomeratic and both also contain much fine-grained, in part varicolored, strata. Rock fragments in the Lysite conglomerate beds are derived almost exclusively from Paleozoic formations, whereas those in the overlying Lost Cabin incorporate abundant Precambrian granite and gneiss.

In surface and nearby subsurface sections along the east margin of the basin, the Lysite Member is 1,000 to 3,000 feet thick and consists predominantly of red, purple, gray, greenish-gray, and white siltstone and claystone interbedded with white, gray, and buff lenticular, in part arkosic and conglomeratic, sandstone. The Lost Cabin Member, which has a maximum thickness of about 1,000 feet, is characterized by gray, greenish-gray, yellowish-gray, and tan arkosic sandstone and siltstone. The sandstone is commonly conglomeratic, with abundant boulders and cobbles of granite, quartz, and chert.

The unconformity between the Lysite and Lost Cabin Members of the Wind River Formation and the one between the Lysite Member and older rocks are best seen in the vicinity of Hells Half Acre (loc. 20). The spectacular badlands there are developed in varicolored strata of the Lysite Member that dip 20° to 30° westward. These strata overlie beds of the Fort Union and Lance Formations, which dip from 45° westward to nearly vertical along the east side of the badlands. Around the west rim of the badlands area, 20 to 30 feet of dull, gently dipping sandstone beds of the Lost Cabin Member, which form the upper part of the rim, bevel across the more steeply dipping red-banded strata of the Lysite.

Abundant fossils (mainly vertebrates) of early Eocene age have been collected in Wind River strata from all parts of the Wind River Basin.

Lower Eocene Rocks in Central Part of Wind River Basin

The Lost Cabin Member of the Wind River Formation is the surface rock throughout the central part of the Wind River Basin. In most wells, however, there are no criteria, either on the basis of sample or electric-log studies, for separating the Wind River into its individual members, or for distinguishing it from the underlying Indian Meadows Formation. The lower Eocene rocks are therefore treated as a single unit.

The lower Eocene sequence thickens appreciably toward the major trough areas in the north-central and southeastern parts of the basin, where it may consist of as much as 9,000 feet of strata (Fig. 6). The rocks also become fine grained, and the intraformational and interformational unconformities disappear. Most sections are characterized by red, gray, gray-green claystone and siltstone interbedded with white to gray, fine- to medium-grained sandstone. Over wide areas the upper few hundred feet is predominantly buff and gray sandstone that grades downward into the varicolored strata. Locally, the lowermost beds of the sequence are gray to black carbonaceous shale and claystone, which are transitional with strata of the underlying Fort Union Formation.

Post-Lower Eocene Rocks

The Wind River Formation is in direct contact with younger Tertiary rocks in a few places around the margins of the Wind River Basin. Along the north slopes of Beaver Divide, at the south margin, the formation is overlain by a transition zone of uncertain age which, in turn, grades upward into strata of known middle Eocene age. In the southeastern part of the basin a conglomerate sequence assigned to the upper part of the Wind River is overlain with conspicuous angular discordance by rocks younger than early Eocene. At the northeast edge, post-lower Eocene strata are faulted down against the Wind River Formation; therefore, depositional contacts cannot be observed. In the northwestern part of the basin, the Wind River Formation is overlain directly by middle and upper Eocene rocks throughout a considerable length of outcrop. The contact there is marked by an angular and erosional unconformity, although in some places the degree of discordance is slight.

DEPOSITIONAL HISTORY AND PALEOGEOGRAPHY

By the beginning of Paleocene time, a pronounced downwarp had already developed along the present north margin of the Wind River Basin, and it probably extended

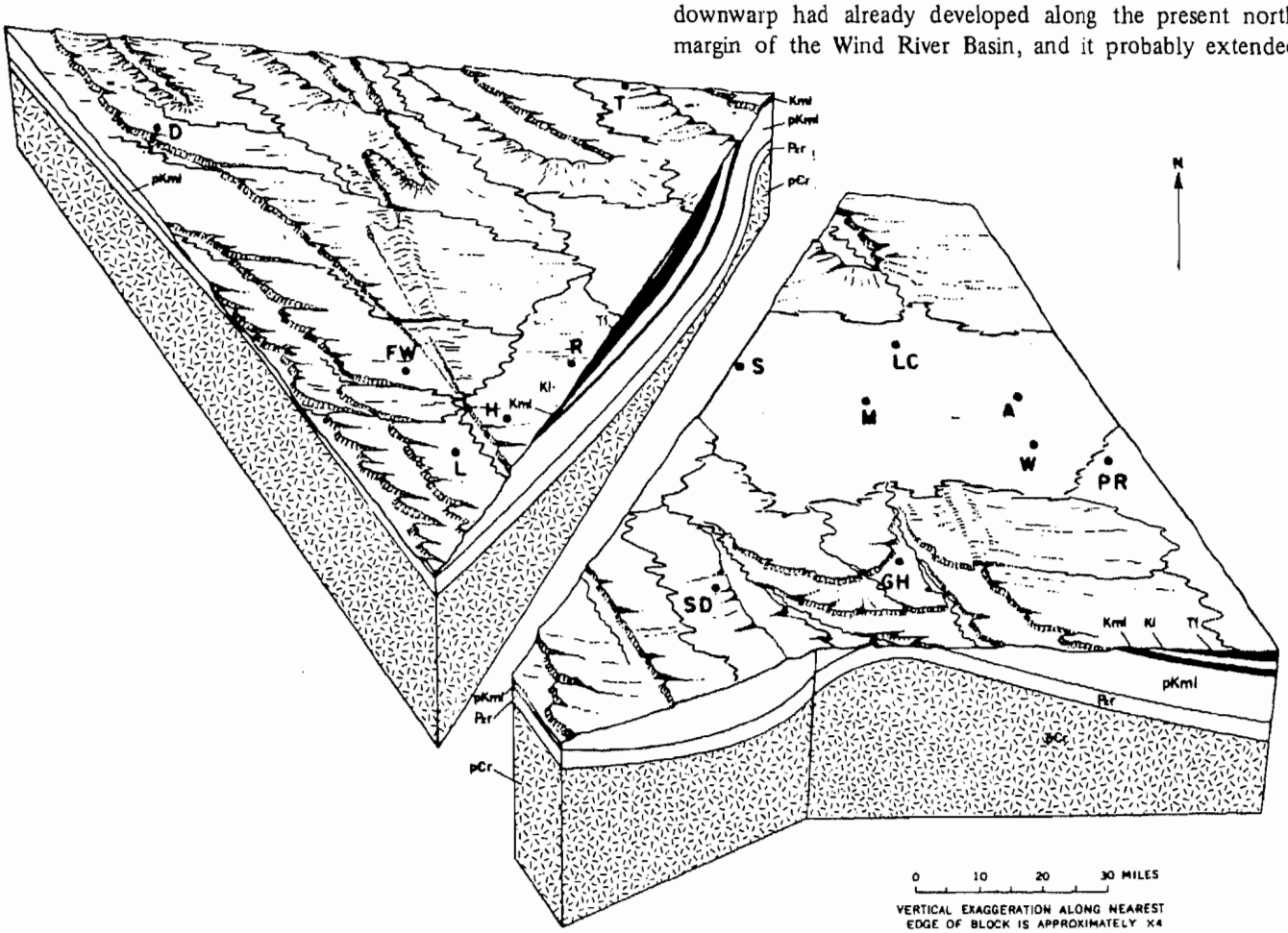

Fig. 7—Wind River Basin during deposition of Waltman Shale Member of Fort Union Formation. Geologic symbols: pCr, Precambrian rocks; Pzr, Paleozoic rocks; pKml, pre-Lewis Shale; Kml, Meeteetse and Lewis Formations; Kl, Lance Formation; Tf, Fort Union Formation. Localities: A, Arminto; D, Dubois; GH, Gas Hills; H, Hudson; L, Lander; LC, Lost Cabin; M, Moneta; PR, Powder River; R, Riverton; S, Shoshoni; SD, Sand Draw; T, Thermopolis; W, Waltman; FW, Fort Washakie. (From Keefer, 1965, Fig. 32).

eastward across the present site of the Casper arch into the Powder River Basin (Figs. 1 and 3). All the surrounding uplifts except the Casper arch had also risen to various heights, primarily by folding. By middle to late Paleocene time the Precambrian crystalline cores of the Wind River Range and Granite Mountains were breached locally by erosion; but in the southeastern part of the Washakie Range and in the Owl Creek Mountains, dissection had probably not yet yeached the Paleozoic rocks in most places. Locally derived clastic debris was spread basinward by streams flowing across broad surfaces which flanked the rising highlands. Continued downwarping of the major basin trough area resulted in the accumulation there of a thick sequence of fine-grained fluviatile sediments during early Paleocene time and of several thousand feet of lacustrine deposits in middle and late Paleocene time.

The landscape during the maximum expansion of Waltman Lake is reconstructed in Figure 7. The shoreline of the lake migrated from east to west across the basin area; apparently the main trough was flooded rapidly, but then it subsided slowly as it filled with fine-grained detritus at a rate commensurate with the rate of sinking. Sedimentation took place largely under quiet-water conditions, and this environment prevailed for a long time. The water body extended eastward, and perhaps northeastward for unknown distances beyond the present limits of the Wind River Basin, for the Casper arch had not yet begun to rise along the east margin. The presence of marine-type shark remains in strata of the Shotgun Member of the Fort Union Formation (loc. 6) suggests that there was a close connection with an open sea thay may have lain somewhere east of the present Wyoming State line at that time. Near the close of the Paleocene, the lake largely disappeared and fluviatile conditions returned to most of the central basin area; however, vestiges of small water bodies may have remained locally and may have persisted into Eocene time (Fig. 8).

In earliest Eocene time, uplift of the mountain masses accelerated and was accompanied in places by large-scale reverse faulting. The coarse conglomerates of the Indian Meadows Formation originated as a series of extensive alluvial fans and stream-channel deposits along the south flanks of the Washakie Range and Owl Creek Mountains. Powerful streams, with headwaters in the ancestral Granite Mountains to the south, flowed northeastward across the present site of the Casper arch and deposited thick sequences of coarse arkosic sand and gravel alternating with silt and clay. Fine-grained clastic debris and carbonaceous beds continued to accumulate in the major trough area, and it seems probable, as noted earlier, that lakes occupied parts of the trough almost continuously throughout Indian Meadows time.

By the beginning of deposition of the Wind River Formation, the Casper arch had been uplifted and faulted along the east margin of the Wind River Basin, and for at least

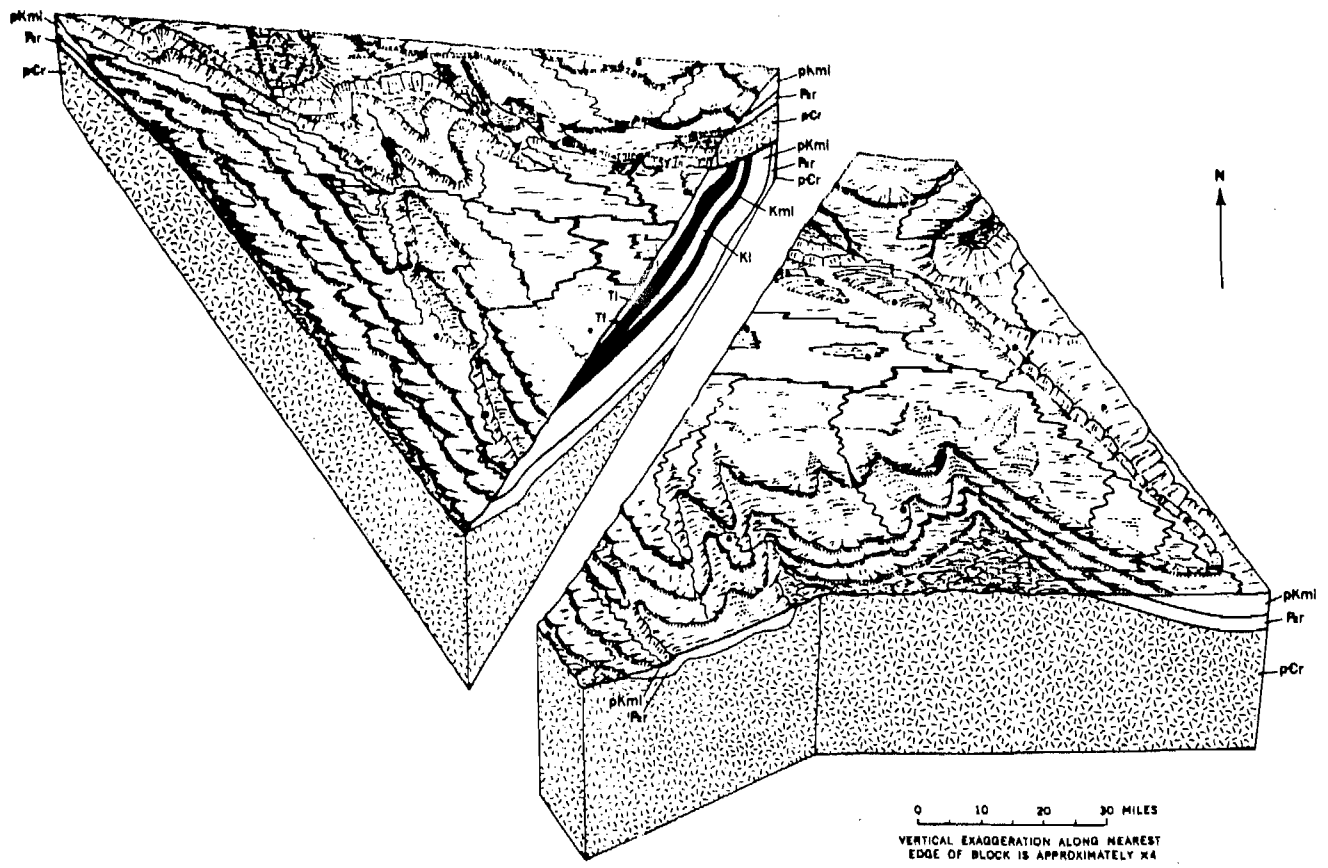

Fig. 8—Wind River Basin at beginning of Wind River deposition. Ti, Indian Meadows Formation. See Figure 7 for locality names and explanation of other geologic symbols. (From Keefer, 1965, Fig. 33).

a short period all drainage out of the basin may have been blocked. A reconstruction of the landscape at this stage is shown in Figure 8.

Extensive lowering of the highlands that surrounded the Wind River Basin continued throughout the period of deposition of the Wind River Formation. Large areas of Precambrian rocks in all the ranges around the south, west, and north sides were exposed to erosion. The arkosic detritus was spread into the basin and was supplemented during the latter part of early Eocene time by volcanic debris from the Absaroka-Yellowstone region to the northwest. By the close of the early Eocene, the accumulated basin-fill sediments lapped high onto the mountain flanks and probably buried the Casper arch, as well as parts of the Washakie Range and Owl Creek Mountains (Fig. 9); exterior drainage toward the east was reestablished. The major basin trough, which now swung southeastward along the west flank of the Casper arch (Fig. 6), continued to sink; but by the end of early Eocene time, or shortly thereafter, the downwarping movements had nearly ceased.

Renewed folding and faulting of existing structural features, such as the Casper arch, took place during and at the end of Wind River deposition. New folds and reverse faults were established in some areas, but with few exceptions these were relatively minor features which did not significantly modify the earlier structural trends.

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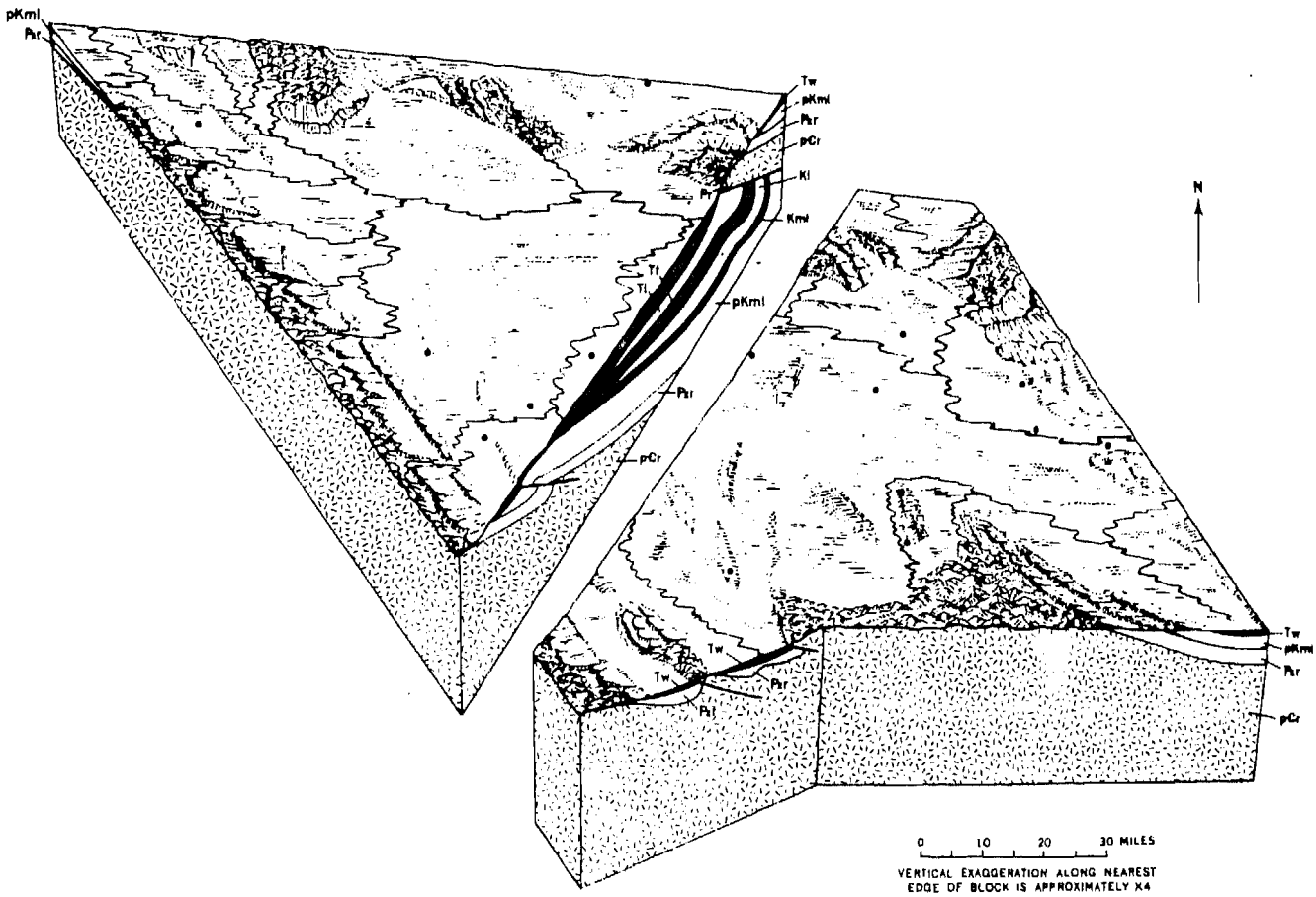

Fig. 9—Wind River Basin at end of Wind River deposition. Tw, Wind River Formation; Ti, Indian Meadows Formation. See Figure 7 for locality names and explanations of other geologic symbols. (From Keefer, 1965, Fig. 34).