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LARAMIDE STRUCTURAL HISTORY OF THE POWDER RIVER BASIN, WYOMING

By

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INTRODUCTION

The Powder River Basin in northeastern Wyoming is asymmetric, with its deepest axis along the southwestern side (Fig. 1). It is flanked by the Bighorn Mountains, Casper Arch, Laramie Range, Hartville Uplift, and Black Hills, all formed during the Laramide Orogeny.

It is known that structural movements were post Lewis (early Maestrichtian), because Lewis marine shales thicken southward in the basin and that strong deformation ended before deposition of the Oligocene White River Formation.

Non-marine late Cretaceous and early Tertiary sedimentary rocks were deposited in the basin during the Laramide Orogeny. They thicken to nearly 8,000' along the basin axis. On outcrops, most of these non-marine sedimentary rocks have been mapped as Wasatch, Ft. Union, and Lance Formations with a thin, basal, marine Fox Hills sandstone. Most efforts to further subdivide this thick, highly variable complex of non-marine sedimentary rocks on outcrops or in the subsurface have not been successful.

SUBSURFACE MAPPING

Since electric logs are the most abundant source of data on the subsurface distribution of these Lance and Ft. Union sedimentary rocks, accessory curves were constructed to show the generalized electrical responses of the different rock types. The specific design of these accessory curves has been described previously (Curry, 1969, p. 93). In general, the accessory curves show the variation in per cent of sandstone (SP) and low resistivity mudstone as a function of depth. These accessory curves were used to zone and correlate physically the non-marine deposits of the Powder River Basin on four cross-sections (Figs. 2-5).

LATE MAESTRICHTIAN LANCE AND FOX HILLS FORMATIONS

No consistent difference between marine Fox Hills sandstone and non-marine Lance Formation can be recognized on the accessory curves, therefore, the Fox Hills is included in the Lance Formation for subsurface mapping. The well in T38N R66W (Fig. 4) is near the type Lance section, defined by J. B. Hatcher in 1903 (Dunlap, 1958, p. 110). The upper contact of the Lance on outcrops is above the highest dinosaur fossils and below the lowest coal (Brown, 1958, p. 112). In the subsurface, the top of the Lance is picked at the top of the low resistivity mudstones of the upper Lance and below the high resistivity basal Ft. Union Tullock sandstones, thin coals, and lignites. This is the most distinctive formation boundary in the non-marine rock sequence.

An isopach map of the Lance Formation (Fig. 6) shows thickening southward, reflecting greater subsidence to the south. It is surprising that there is *no convincing evidence of the Laramide Orogeny during late Maestrichtian Lance deposition in the Powder River Basin* because Laramide deformation in other areas of Wyoming apparently started in late Maestrichtian.

The occurrence of some gas and oil in the Lance in the southern part of the Powder River Basin (Flat Top) is similar to that of the Wind River Basin and additional gas may be present in sandstones of the upper and middle members of the Lance Formation in the southern part of the basin.

EARLY PALEOCENE TULLOCK FORMATION

Accessory curves show the Tullock, basal formation of the Ft. Union Group, to be one of the most distinctive and widespread formations in the Powder River Basin. The most distinctive aspect of this formation is the increase of resistivity which is caused by the abundance of sandstone, thin coals, and lignite. Isopach map of the entire Ft. Union and Wasatch (Fig. 7) shows prominent thickening into the axis of the Powder River Basin; however, the Tullock isopach (Fig. 8) shows only moderate thickening and increased subsidence in the southwest and south parts of the basin. *Tullock deposition, at the start of the Paleocene, marks the first evidence of the Laramide deformation in the Powder River Basin; however, the prominent subsidence along the axis of the basin had not started.* The distribution of percentage of sandstone in the Tullock does not show an increase toward any of the margins of the basin and it seems likely that slight initial subsidence along the southwest side of the basin trapped sediments transported across the Casper Arch into the embryonic basin.

MIDDLE PALEOCENE LEBO FORMATION

The Lebo Formation, in the middle of the Ft. Union Group, is composed mainly of low resistivity mudstones. Sandstone content decreases upward, reaching a minimum near the top of the formation. The lower Lebo is a fine grained facies of the Tullock. The Lebo mudstones may have been co-extensive with the Waltman shales of the Wind River Basin before the uplift and erosion of the Casper Arch.

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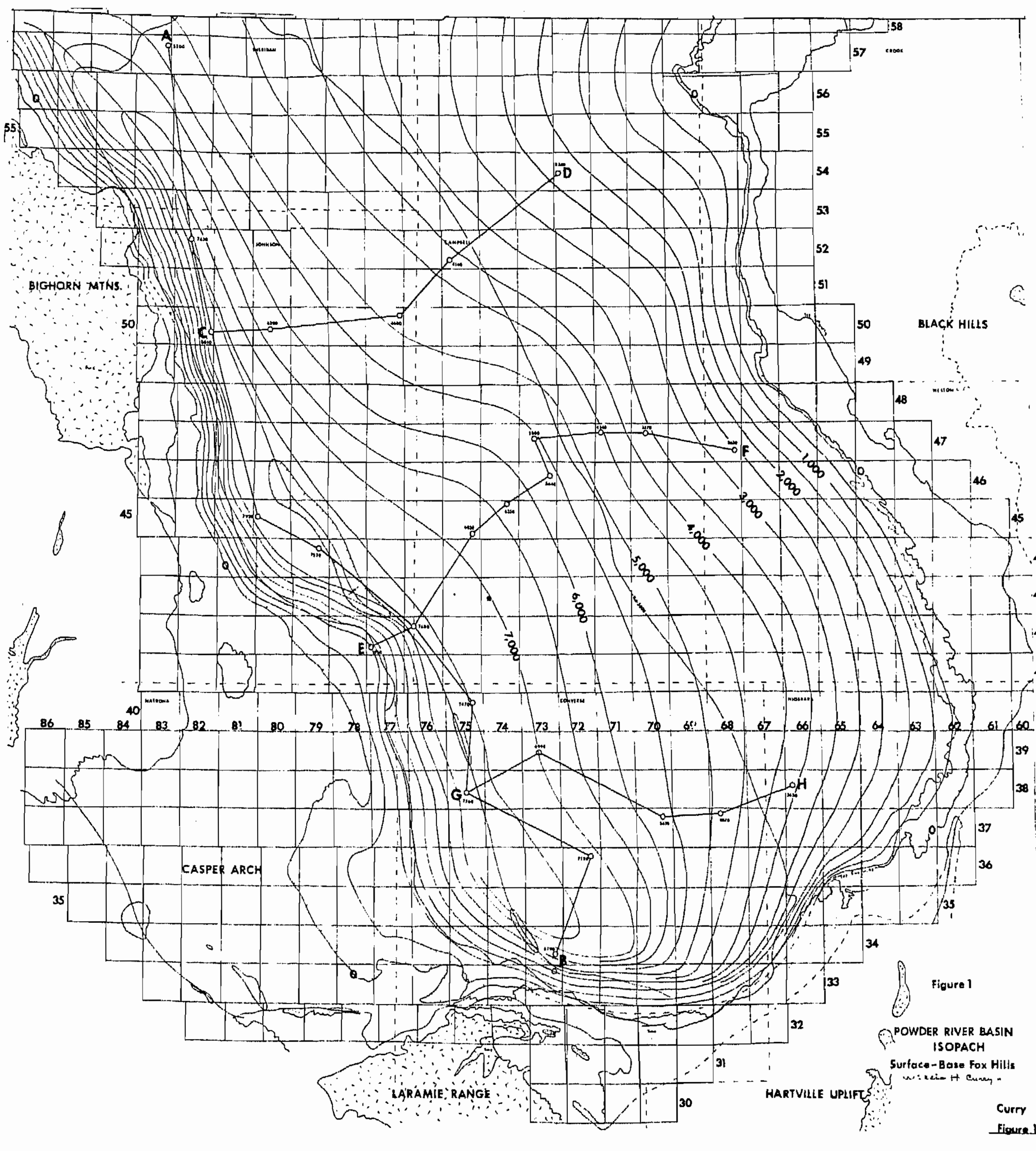

BIGHORN MTNS.
BLACK HILLS
CASPER ARCH
LARAMIE RANGE
HARTVILLE UPLIFT
1,000
2,000
3,000
4,000
5,000
6,000
7,000
A
B
C
D
E
F
G
H
Figure 1
POWDER RIVER BASIN
ISOPACH
Surface-Base Fox Hills
Curry
Figure 1

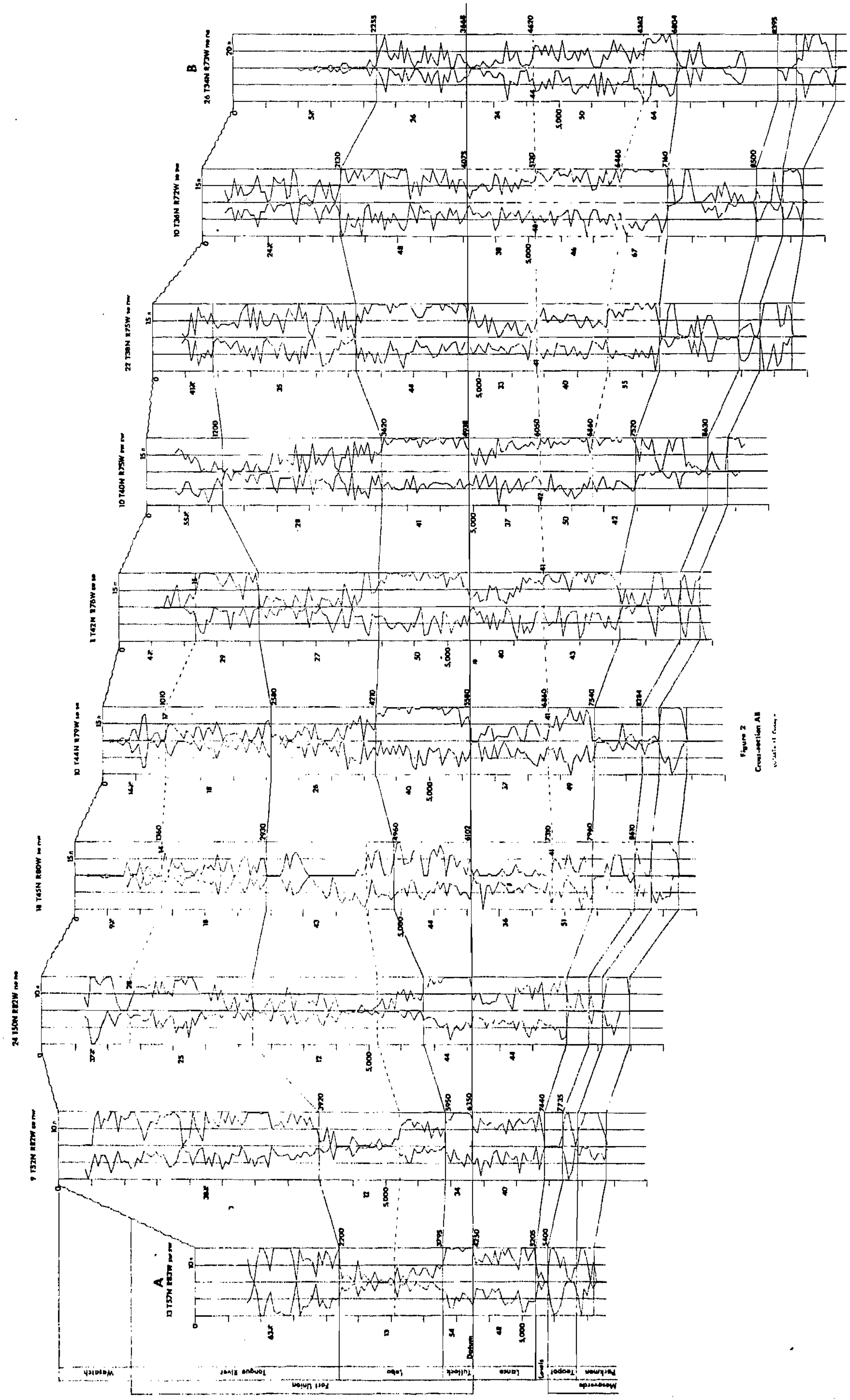


Figure 2
Cross-section AB

Isopach map of the Lebo (Fig. 9) shows prominent thickening and subsidence toward the axis of the Powder River Basin, particularly adjacent to the Bighorn Mountains. *Deposition of Lebo mudstones, during middle Paleocene, is the first time that typical Laramide structural movements are evidenced in the Powder River Basin.* It is probable that many of the other Laramide structural features along the margins of the basin were first formed during Lebo time. It is interesting to note that when the Laramide structural movements in this area were finally active, a thick, fine-grained mudstone unit, rather than coarse fans of clastics derived from mountain uplifts, filled the basin. In fact, sections near the Laramie Range (T34N R 73W) and Bighorn Mountains (T50N R 82W) have the lowest sandstone content in the whole basin, suggesting that subsidence of the basin rather than uplift of the adjacent mountains was the first stage of structural deformation.

LATE PALEOCENE TONGUE RIVER FORMATION

Accessory curves do not allow a uniform subdivision of the Wasatch from the Tongue River; therefore, they are combined for subsurface mapping. The Tongue River Formation, at the top of the Ft. Union Group, generally has abundant sandstones, particularly along the north end of the mapped area, and high resistivity caused by the abundant sandstone and thick coals.

An isopach of the Tongue River-Wasatch (Fig. 10) shows strong thickening into the western axis of the Powder River Basin and indicates that the Laramide Orogeny was near its peak of activity.

The percentage of sandstone is a minimum in the area of greatest subsidence, from T42N R76W to T52N R82W, (14–40%) and increases generally along the margins of the basin, but conglomerate fans similar to the Eocene

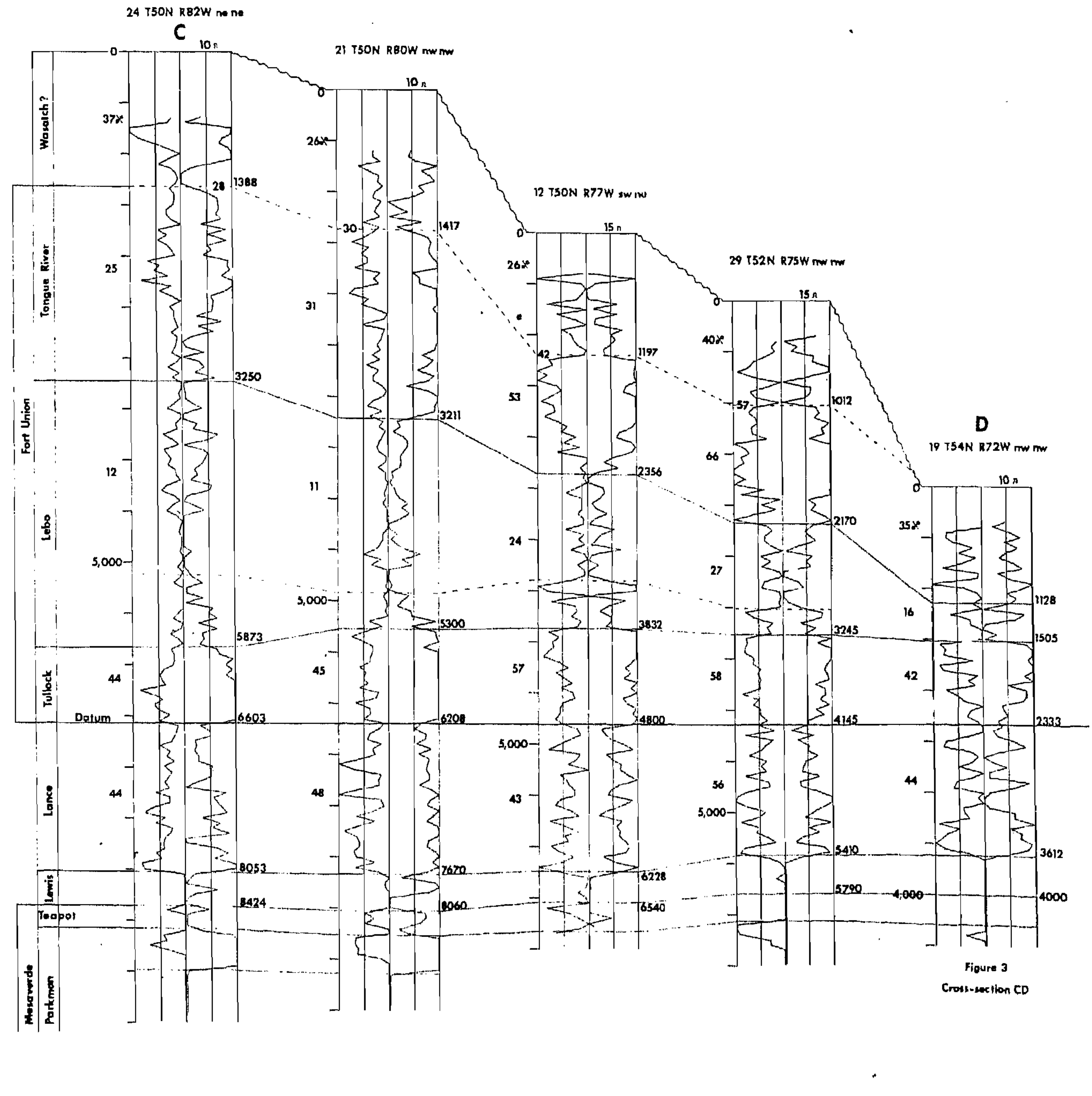


Figure 3
Cross-section CD

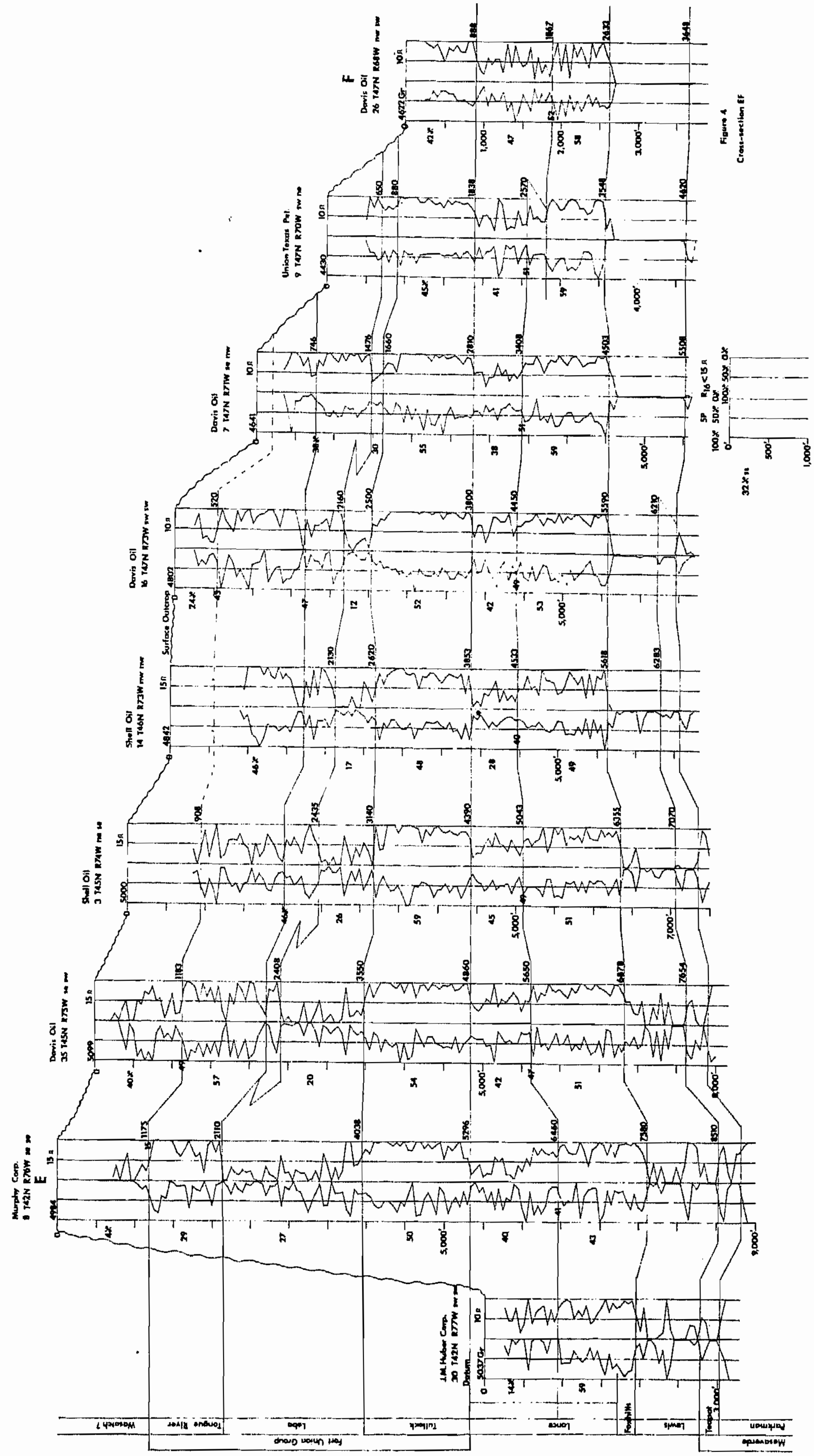


Figure 4
Cross-section EF

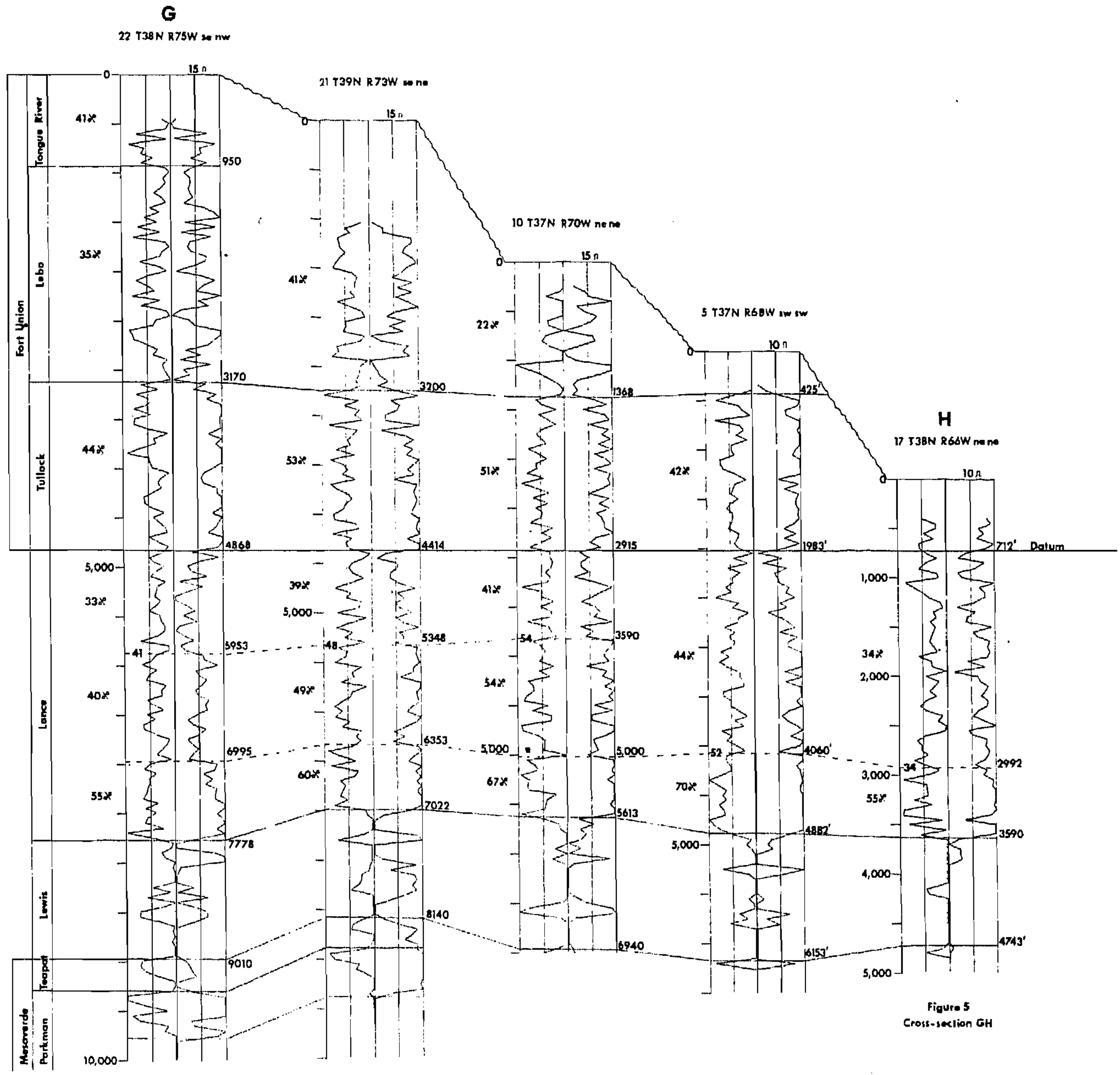


Figure 5
Cross-section GH

Kingsbury conglomerate are not known. Probably, these coarser clastics were deposited closer to the exposed cores of the uplifts and were subsequently eroded. It appears likely that this was the first time the Bighorn Mountains, Black Hills, Laramie Range, and Casper Arch were uplifted significantly.

The Tongue River and Wasatch in the Powder River Basin of Wyoming and Montana are reported to contain some of the largest coal reserves in the world (Fig. 7, Mines and Minerals Map of Wyoming, 1970).

EOCENE WASATCH

Outcrops of the Kingsbury conglomerate along the edge of the Bighorn Mountains (Fig. 10) contain Eocene *Eohippus* fossils (Brown, 1958, p. 112) and rare igneous and metamorphic rock fragments (Hose, 1954) indicating that the Bighorn Mountains were uplifted and eroded to the basement by Eocene time. Basinward, this conglomerate grades into finer grained Wasatch. Brown (1958, p. 112) states that ". . . . at many localities, the uppermost Fort Union and lowermost Wasatch are not readily distinguishable by eye." Accordingly, since 1909, the Roland coal bed on the north and east side of the basin has been used to mark the Ft. Union-Wasatch contact.

Structural movements continued through the Eocene because even the Kingsbury conglomerate has been tilted locally as much as 45° (Hose, 1954, sheet 2).

Pumpkin Buttes and Monument Hill uranium districts in the southern part of the basin (Fig. 10) produce uranium from Wasatch and possibly upper Ft. Union fluvial sandstones. Although there are no known oil-shales in this basin, the amount of energy stored in coal, uranium, and possibly natural gas in these non-marine rocks is noteworthy.

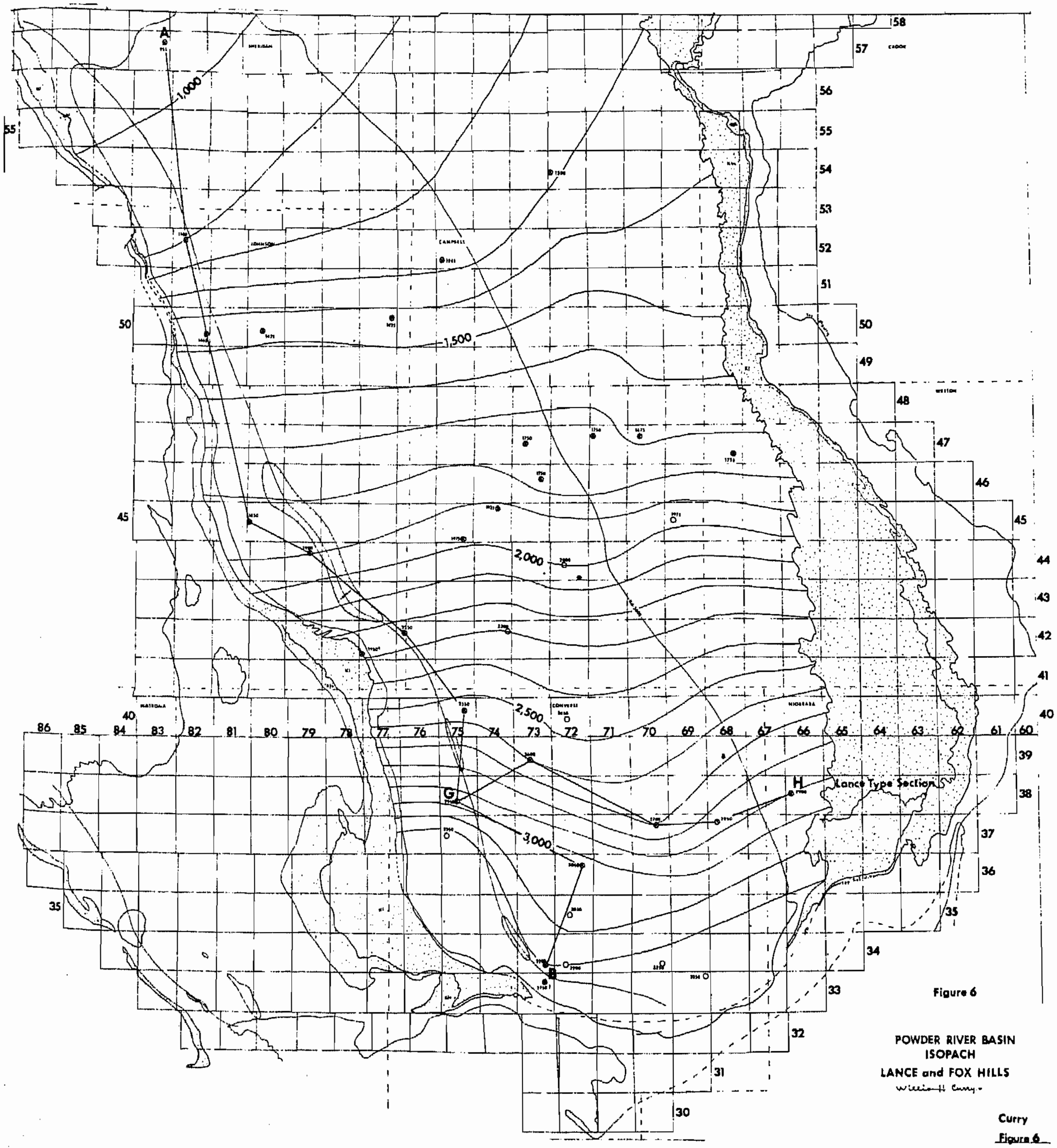


Figure 6

POWDER RIVER BASIN
ISOPACH
LANCE and FOX HILLS

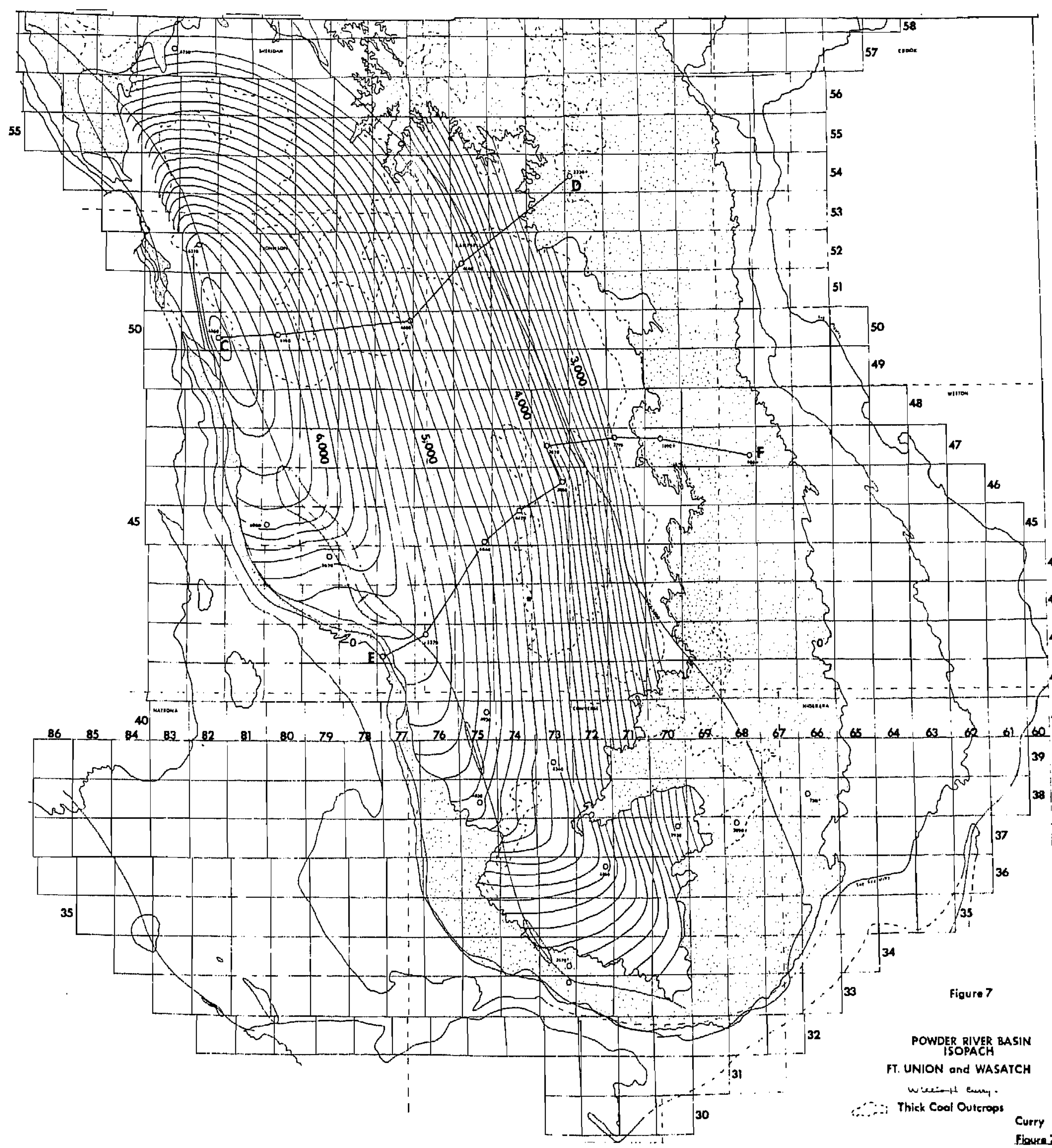
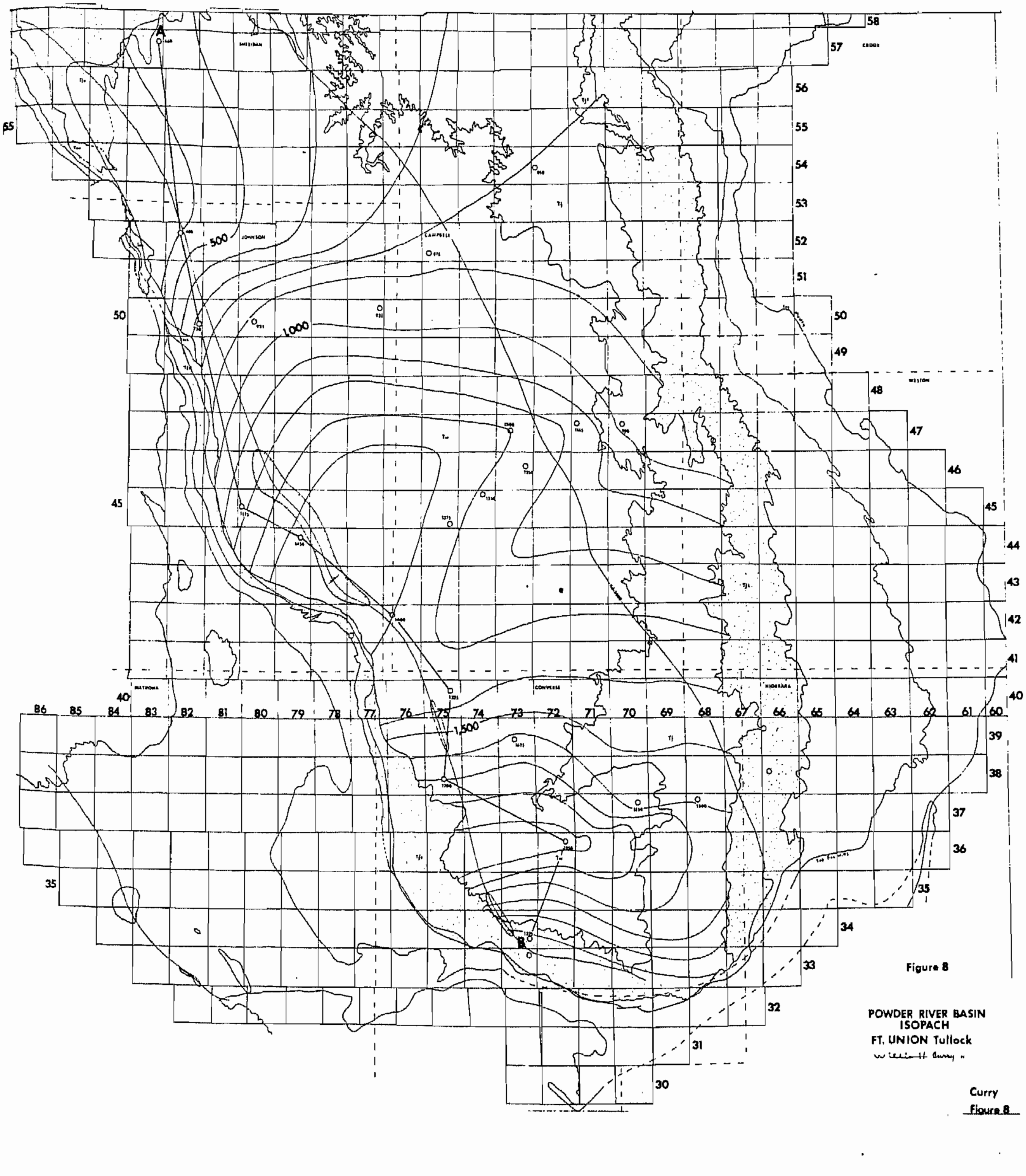


Figure 7

POWDER RIVER BASIN ISOPACH

FT. UNION and WASATCH


A
B
500
1,000
1,500
Figure 8
POWDER RIVER BASIN
ISOPACH
FT. UNION Tullock
Curry
Figure 8

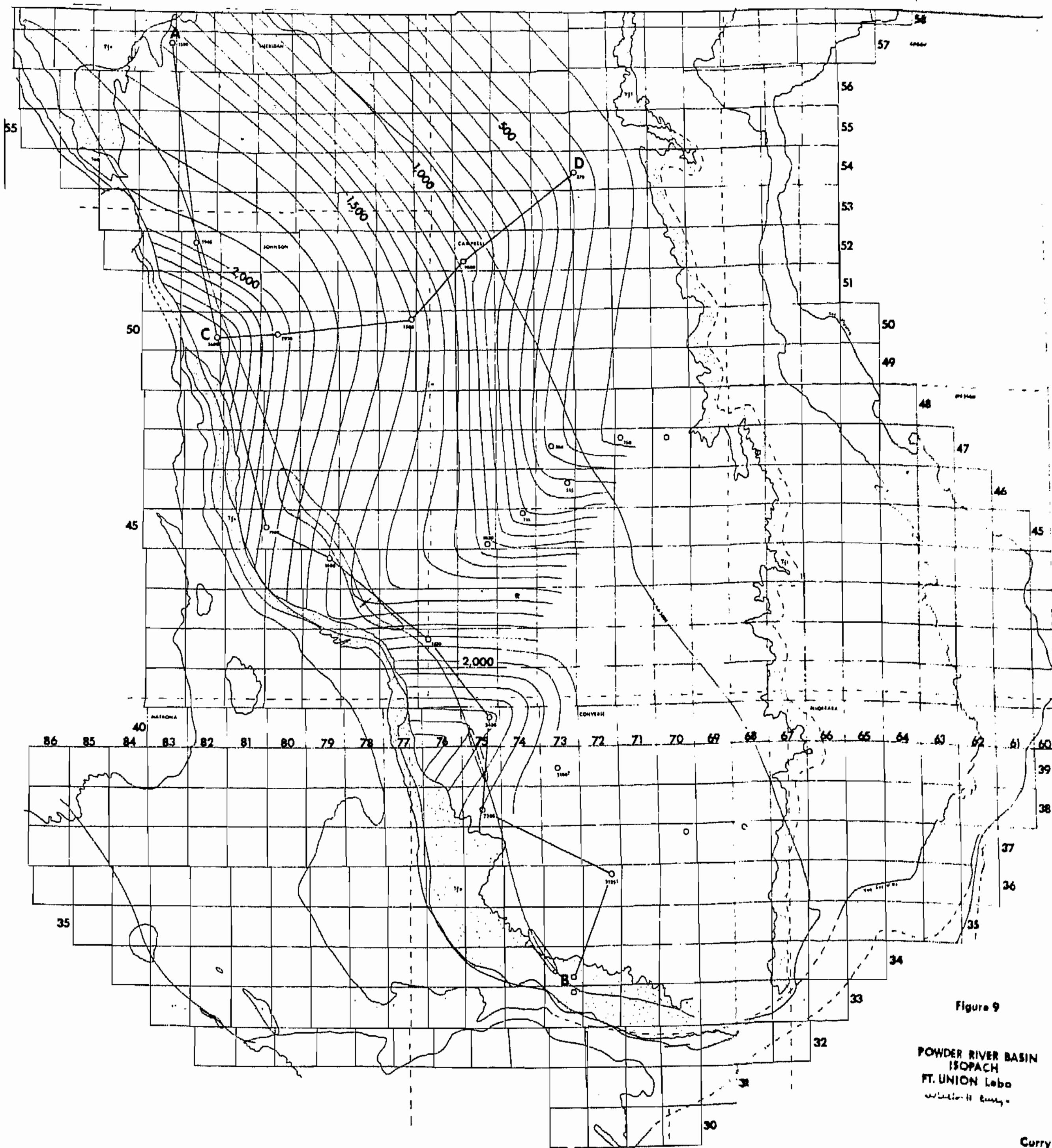
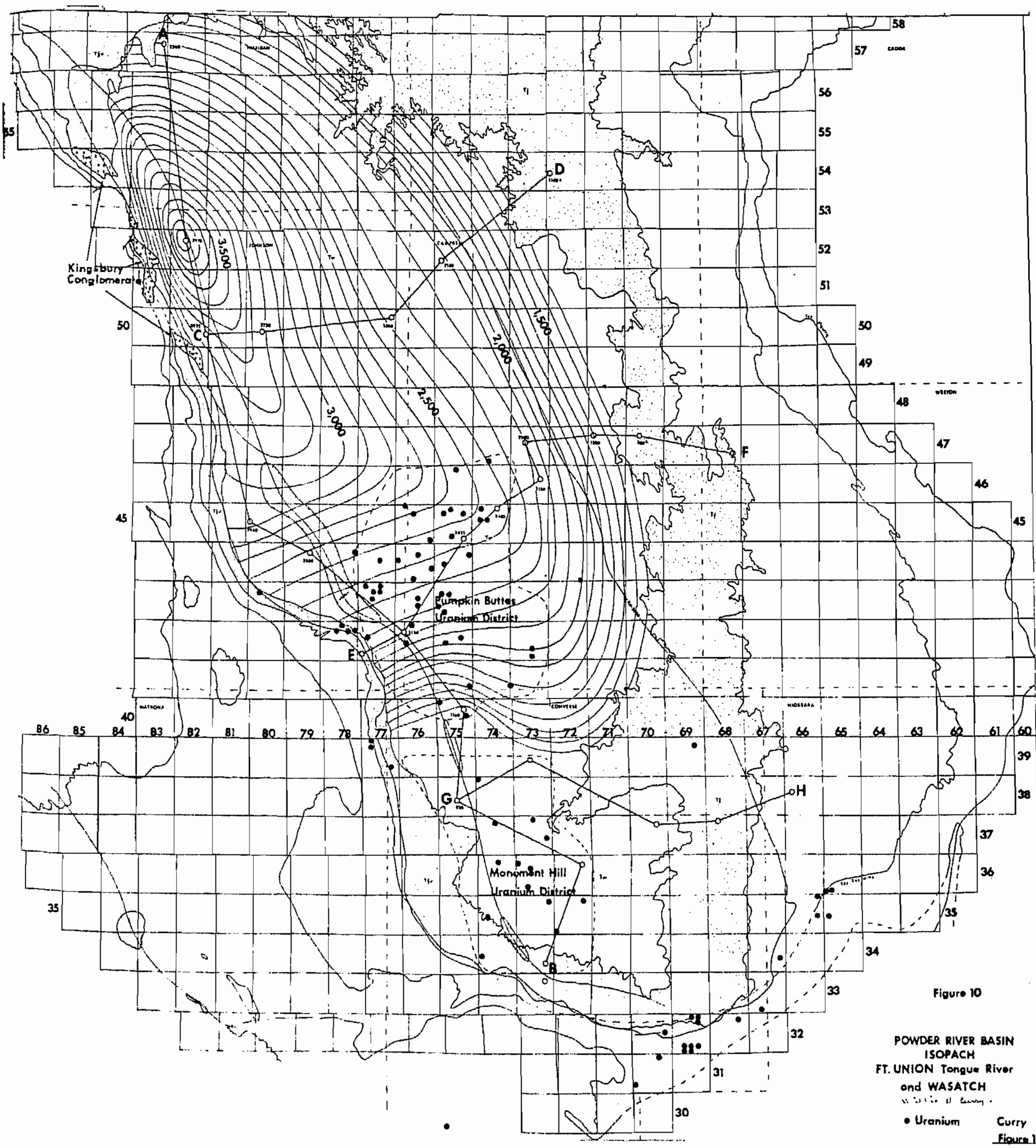


Figure 9

POWDER RIVER BASIN
ISOPACH
FT. UNION Lebo

Curry
Figure 9


A
B
C
D
E
F
G
H
3,500
3,000
2,500
2,000
1,500
Kingsbury Conglomerate
Pumpkin Buttes Uranium District
Monument Hill Uranium District
Figure 10
POWDER RIVER BASIN
ISOPACH
FT. UNION Tongue River
and WASATCH
• Uranium
Curry
Figure 10

OLIGOCENE WHITE RIVER

Laramide deformation abruptly ceased before Oligocene time, when White River volcanic deposits buried the exposed Precambrian core of the Laramie Range (Fig. 1). Evidence of post Oligocene movements along the mountain fronts usually shows subsidence of the mountain uplifts along faults and moderate tilting of the White River toward the mountains.

SUMMARY

Subsurface mapping of the non-marine Lance, Ft. Union, and Wasatch rocks in the Powder River Basin, using accessory curves derived from electrical logs and outcrop evidence, indicates the following sequence of structural events during the Laramide Orogeny in this part of Wyoming:

1. Late Maestrichtian Lance: Subsidence increased southward but there is no evidence of local basin subsidence.

2. Early Paleocene Tullock: First slight subsidence was present in the southern and southwestern parts of the basin, but there was no prominent subsidence along the axis of the basin.

3. Middle Paleocene Lebo: First strong subsidence along the axis of the Powder River Basin is found but there is no evidence of influx of coarse clastics from adjacent uplifts. Middle Paleocene marks the first strong evidence of the Laramide Orogeny.

4. Late Paleocene Tongue River: Strong subsidence continued along the axis of the basin and the influx of sandstone is the first indication of uplift and erosion of the adjacent mountain uplifts.

5. Eocene Wasatch: Mountains continued to be uplifted and were eroded to their Precambrian cores. Conglomerate fans along the flank of the Bighorn Mountains were deposited and subsequently deformed.

6. Oligocene White River: Orogenic movements abruptly stopped before the Oligocene and White River volcanic rocks filled the basin and buried the Precambrian cores of the mountains.

7. Post Oligocene: Moderate subsidence of the mountain uplifts along faults, caused local tilting of the White River toward the sinking mountain blocks.

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