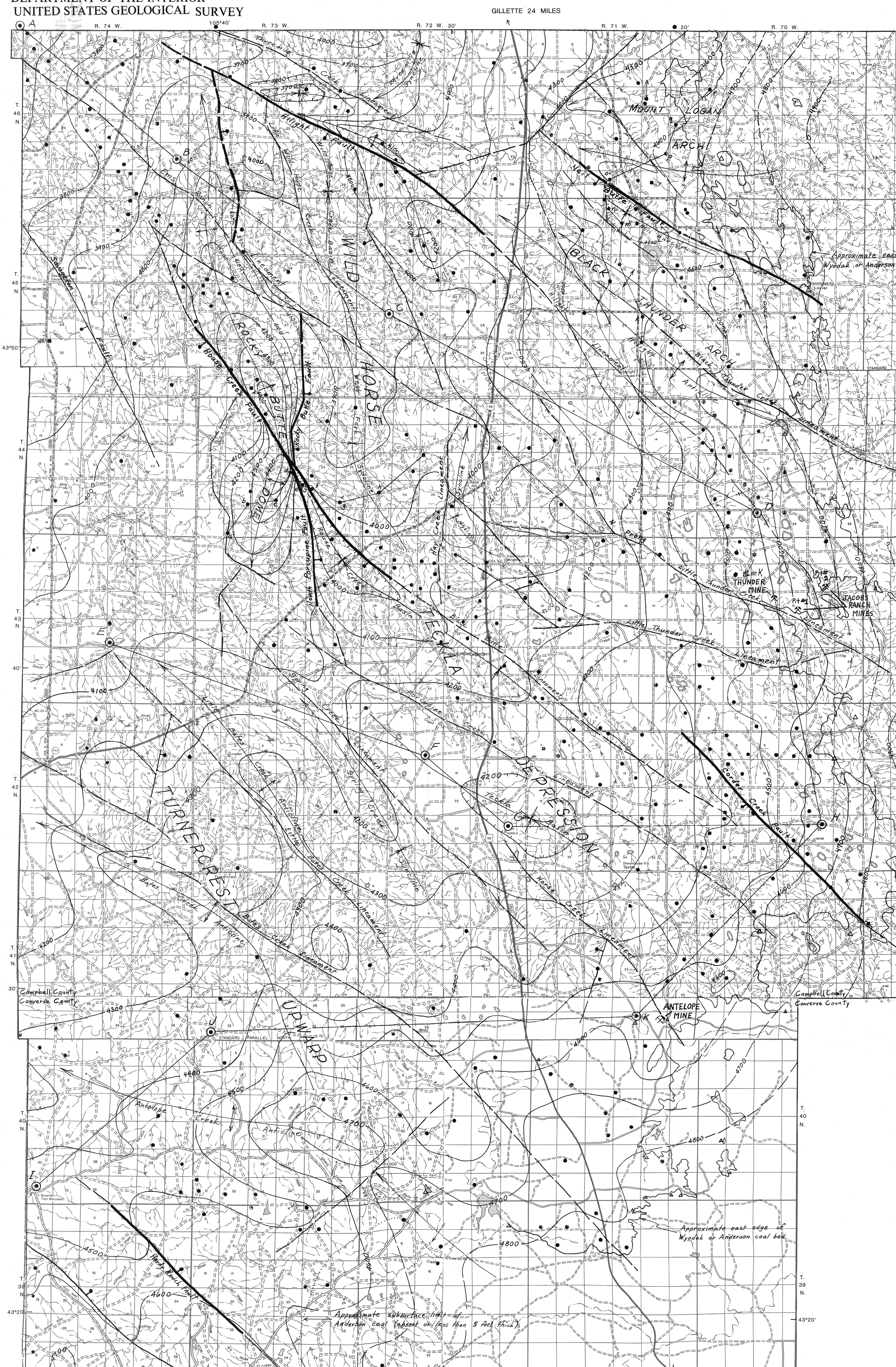


Base map from Wyoming State Highway Commission county map series, 1956, with main highway system updated to 1969. Land grid and roads in T39-40N and R70W through center of R72W revised to conform with U.S. Geological Survey Betty Reservoir quadrangle (1:62,500).

STRUCTURE CONTOUR MAP

EXPLANATION

STRUCTURE CONTOUR MAP

4100 — STRUCTURE CONTOUR CONSTRUCTED ON BASE OF WYODAK OR ANDERSON COAL BEDS--Dashed where projected above ground level in eastern part of map; contour interval 100 feet

4300 — STRUCTURE CONTOUR DEFINING A CLOSED STRUCTURAL DEPRESSION--Contour interval 100 feet

AXIAL TRACE OF ANTICLINE SHOWING DIRECTION OF PLUNGE

AXIAL TRACE OF SYNCLINE SHOWING DIRECTION OF PLUNGE

DRILL HOLE USED FOR MAP CONTROL--Subsurface data from electrical and radioactivity logs available as of September 1, 1977

ELEVATION TAKEN FROM PUBLISHED REPORT--Elevation at base of Wyodak or Anderson coal beds (or at base of its clinker where coal is burned)

EAST EDGE OF WYODAK OR ANDERSON COAL BED--Represents eastern outcrop limit, or contact with clinker (burned coal); where dotted in southern part of map, indicates approximate subsurface limit of Anderson coal that is 5 feet or more thick

HIGH-ANGLE FAULT INFERRED FROM ABRUPT SUBSURFACE CHANGE IN DISTRIBUTION, STRUCTURAL CONFIGURATION, OR THICKNESS OF COAL--Dashed where approximately located; bar and ball on downthrown side where separation known, or on side with contoured datum horizon predominantly down where apparent reversals in sense of separation occurred. Dips uncertain but probably steep judging from linearity of fault traces. Movement on some faults is interpreted to have occurred intermittently during sedimentation. Inferred faults generally coincide with surface lineaments. These faults have little or no displacement, but subsurface data suggest that greater movement occurred on some faults prior to deposition of the Wasatch Formation

HIGH-ANGLE FAULT INFERRED FROM CONFIGURATION OF STRUCTURE CONTOURS ONLY--Bar and ball on downthrown side as inferred from separation of contoured datum horizon

TOPOGRAPHIC LINEAMENT REPRESENTING LINEAR STREAM COURSE OR ALINED TOPOGRAPHIC FEATURES

A — DRILL HOLE USED IN CONSTRUCTING FENCE DIAGRAM A-K (See Map I-)

a — DRILL HOLE USED IN CONSTRUCTING STRUCTURAL SECTIONS a-i and j-r

COAL MINE

100 — ISOPACH LINE SHOWING THICKNESS IN FEET OF WYODAK OR ANDERSON COAL BED--Separates categories of Wyodak or Anderson Coal bed thicknesses

Wyodak / Anderson — APPROXIMATE BOUNDARY BETWEEN AREAS UNDERLAIN BY WYODAK AND BY ANDERSON COAL BEDS

EAST EDGE OF WYODAK OR ANDERSON COAL BED--Represents eastern outcrop limit, or contact with clinker (burned coal); where dotted in southern part of map, indicates approximate subsurface limit of Anderson coal that is 5 feet or more thick

73 W — DRILL HOLE USED FOR MAP CONTROL--Shows thickness of Wyodak (W) or Anderson coal bed. (±) indicates Wyodak or Anderson not logged and thickness estimated from adjacent drill holes; (+) indicates minimum thickness in drill hole that bottomed in Wyodak or Anderson coal bed. Thick- in feet

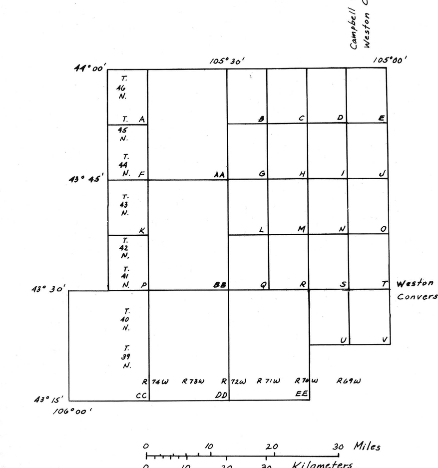
DRILL HOLE IN WHICH ANDERSON COAL BED IS ABSENT

37 — LOCALITY WHERE THICKNESS OF WYODAK (W) OR ANDERSON COAL BED TAKEN FROM PUBLISHED REPORT--Thickness in feet

Scale 1:125,000

0 2 4 6 8 10 MILES

0 2 6 8 10 KILOMETERS



INDEX TO TOPOGRAPHC QUADRANGLE MAPS IN THE RENO JUNCTION-ANTELOPE CREEK AREA

71/2-Minute Quadrangle Maps (1:24,000 scale)

A - NE1/4 of Savageton 15' map
B - Eagle Rock
C - Neil Butte
D - Rough Creek
E - Jim Creek
F - Savageton
G - Reno Junction
H - Hilight
I - Open A Ranch
J - Buck Creek
K - South Butte
L - Little Thunder Reservoir
M - Reno Reservoir
N - Piney Canyon NW
O - Piney Canyon NE
P - Pine Tree
Q - Teckla SW
R - Teckla
S - Piney Canyon SW
T - Piney Canyon SE
U - Coal Bank Draw
V - Fiddleback Ranch

15-Minute Quadrangle Maps (1:62,500 scale)

AA - North Star School
BB - Turnercrest
CC - Ross
DD - Coal Draw
EE - Betty Reservoir

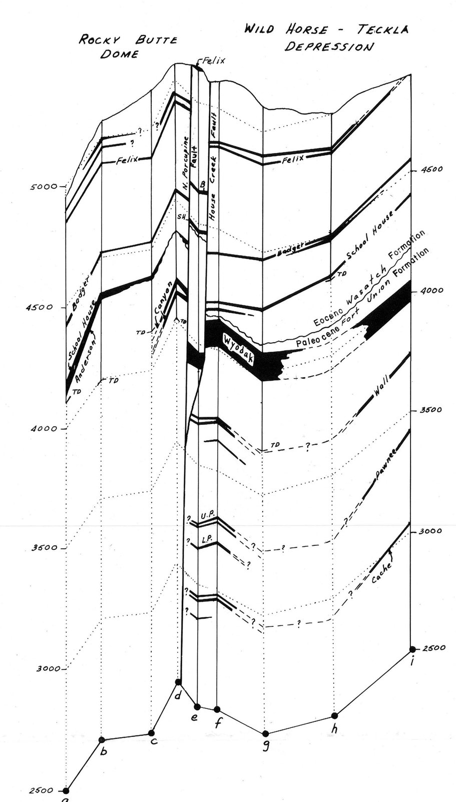


Figure 1.--Fence diagram across House Creek Fault showing drill holes a-i, total depth (T.D.), and coal beds

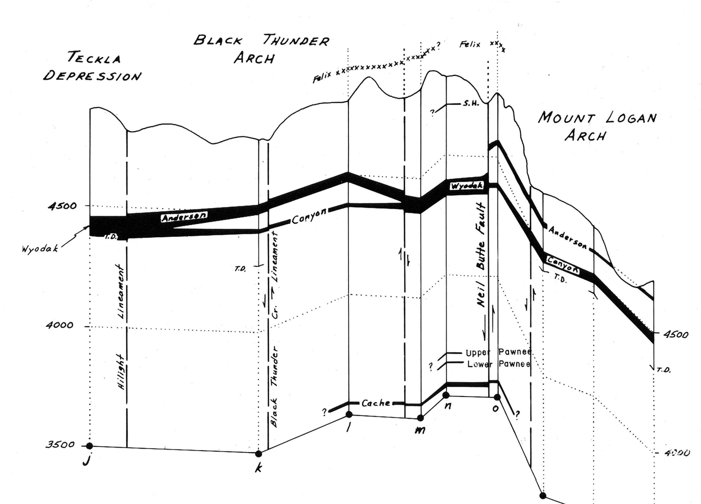
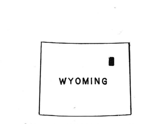
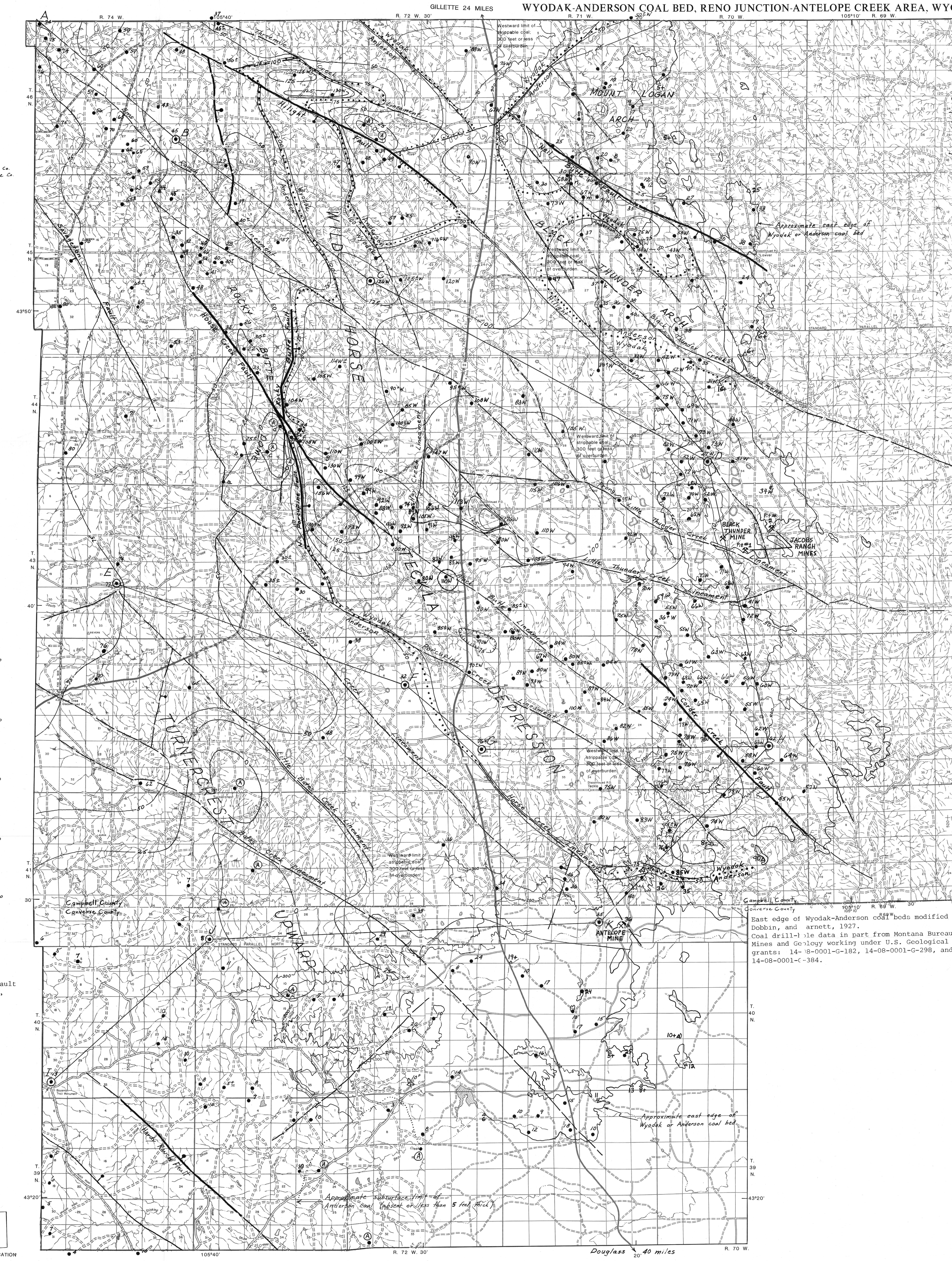


Figure 2.--Fence diagram across Neil Butte Fault showing drill holes j-r, total depth (T.D.), faults and lineaments, and coal beds



QUADRANGLE LOCATION



East edge of Wyodak-Anderson coal beds modified from: Dobbin, and arnett, 1927.
Coal drill-hole data in part from Montana Bureau of Mines and Geology working under U.S. Geological Survey grants: 14-08-0001-G-182, 14-08-0001-G-298, and 14-08-0001-G-384.

ISOPACH MAP

DISCUSSION

The Wyodak and Anderson coal beds in the Paleocene Fort Union Formation are the most important strippable coal beds in the eastern Powder River Basin, and constitute one of the world's largest coal deposits. The coal occurs as a single bed or as a group of beds separated by thin, shaly interbeds of noncoaly rock in the upper part of the Fort Union. The beds range in thickness from 0 to 176 feet. The Anderson coal bed is recognized mainly in the western part of the area where the stratigraphically lower coal bed, the Canyon is present and is as thick or thicker than the Anderson; the Anderson and Canyon beds also are present in the northeast corner of the area. The name Wyodak is used where the Anderson and Canyon Coal beds converge, mainly in the east-central part of the area (see Denson and others, 1978, and isopach map.) As used in this report, Wyodak consists of either a single coal bed without shale partings or it comprises two merging coal beds that are separated by noncoaly rocks generally less than 12 feet thick. Where the Anderson and Canyon coal beds diverge and the noncoaly rocks between them exceeds the thickness of either coal, then they are referred to separately as the Anderson and Canyon. Because the Wyodak coal bed includes coal stratigraphically lower than the Anderson coal bed, the terms Wyodak and Anderson are not equivalent. The Wyodak coal bed corresponds to the D bed of earlier usage (Dobbin and Barnett, 1927; Wegeman and others, 1928). The Wyodak and Anderson coal beds underlie at least 1,175 mi^2 in the Reno-Junction-Antelope Creek area, as well as large regions to the north and west.

In most of the area, the east edge of the Wyodak and Anderson beds is marked either by outcrop or by clinker and is shown on the maps by the limits of color or shading. However, in the southern part of the map where the Anderson is thin and coal exposures are poor, a line of fine dots on the maps show the approximate subsurface limit of the Anderson coal bed where it is 5 ft or more thick. Generally, coal beds are poorly exposed because they are weathered and covered by overburden slump or by other surficial deposits. Clinker, which is easily recognized by its conspicuous red and purple colors, is hard-baked or partly fused rock from directly above burned coal, as well as the noncombustible residue (ash) of coal itself. Coal beds have been burned over wide areas of the eastern Powder River Basin. The great majority of the fires occurred from natural causes during prehistoric times. Clinker associated with the Wyodak coal bed is especially prominent, and the base of the clinker is taken as the approximate base of the coal bed for purposes of map construction. In most instances it is not possible to determine former coal thickness from clinker, except perhaps to distinguish thick coals from relatively thin ones, because the clinker has collapsed into the void created by the burned coal. Distribution of hills and buttes capped by clinker (not shown on these maps) indicates that the Wyodak coal bed originally extended at least several miles east of its present mapped limits.

STRUCTURE CONTOUR MAP

The structure contour map shows structure contours on the base of the Wyodak and Anderson coal beds. Because the base of the Anderson is not at the same stratigraphic level as the base of the Wyodak, these represent two different datum horizons. This difference has no effect whatever on structural interpretation within an area contoured solely on one or the other of the datum horizons--that is, within the area underlain only by the Anderson coal bed, or within the area of Wyodak coal alone; a line of heavy dots line separates subsurface occurrences of the Anderson and Wyodak on the isopach map at the right. However, the use of two different datum horizons does complicate comparison of structures based on one datum with structures based on the other, the effect being to artificially introduce a difference in structural level between the two structural surfaces, and to exaggerate the structural relief where they join. Fortunately, the amount of these discrepancies is no more than the local difference in thickness between the Wyodak and Anderson coal beds, and with the exceptions discussed in a later section of this report, are negligible at the scale of the map. A contour interval of 100 feet is used and contours are labeled in feet above sea level.

The data used in constructing this map are mainly from logs of oil and gas wells, shown by black dots, following interpretive methods described by Denson and others (1978), and from published reports of field observations (Dobbin and Barnett, 1927; Schell and Mowat, 1972), shown by open triangles chiefly along the eastern edge of the coal zone. Four hundred control points were used in constructing the map; wells A-K correspond with post A-K on the fence diagram of Denson and others (1978). New data indicate that the 3,600 feet structure contour, which is shown on the adjacent Gillette Folio (Denson and Keefer, 1974) to project into the northwest corner of the Reno Junction-Antelope Creek area, actually lies farther to the west.

The structure contours show that (1) the base of the Wyodak and Anderson coal beds generally slope (dip) gently to the north in the southern part of the area and to the west in the northern part at 35-50 feet/mile (equivalent to one-half degree of dip or less), (2) structural irregularities representing broad folds of low amplitude and dips as much as about 17 degrees complicate the regional trends, and that (3) several well-defined linear features interpreted as faults cut the datum surfaces. The regional westward dip is toward the interior of the Powder River Basin to the west, which was relatively lower and accumulated more sediment than did the basin margins. Axial traces of the most prominent of the local folds are shown, and most are named for convenient reference. These include (a) the Rocky Butte dome, an elongate north-trending dome that is segmented by faults and has 300-400 feet of structural closure; (b) the Turnercrest upwarp, a broad compound structural high that plunges gently northwest and consists of several folds of low amplitude; (c) the Black Thunder and Neil Butte arches, two broad northwest-trending anticlinal upwarps separated by the fault-controlled Neil Butte syncline; and (d) the Wild Horse-Teckla depression, a complex arcuate structural depression encompassing the Wild Horse Creek, House Creek, and Teckla basins and the West Fork and Wright synclines.

Faults and lineaments depicted on the structure contour map are the same as those shown on MF-960 by Denson and others (1978). The locations of faults are based on the configuration and spacing of structure contour lines. Those shown by heavy black lines also mark abrupt changes in the distribution, sequence, or thickness of coal beds and intercoal sediments as interpreted from closely spaced wells. The most prominent of these, the House Creek fault, trends northwestward diagonally across the Rocky Butte dome and the south end of the Wild Horse depression and is shown on fence diagram a-i (fig. 1). This fault may extend well beyond its mapped limits into areas where control is sparse; wells of the House Creek oil field are distributed parallel to the fault trend and are concentrated mainly on the northeast side of its possible extension to the northw st. Other inferred faults with similar trends include the Hilight, Neil Butte, Corder Creek, and Hardy Ranch faults. Three faults, including the North Porcupine and Rocky Butte faults, trend nearly north-south. The fact that faults cut the contoured datum horizon in the subsurface does not necessarily require their presence at the present ground surface. However, topographic lineaments defined by linear, fracture-controlled stream courses or alined topographic features coincide with or mark extensions of some inferred faults, such as the Neil Butte, Hilight, House Creek, and Corder Creek faults. Lineaments are shown on the map to demonstrate their similarity to inferred faults in orientation and pattern, and their distribution relative to major folds.

ISOPACH MAP

This map, through use of isopachs, shows how the Wyodak and Anderson coal beds vary in thickness in the Reno-Junction Antelope Creek area. The dashed line separates the areas underlain by Wyodak coal from those underlain by the Anderson. A mismatch of the 75-foot isopach between the northwest corner of this map and the southwest corner of the adjoining Gillette map (Denson and Keefer, 1974) reflects the availability of new data and closer control in the Reno Junction-Antelope Creek area. Three hundred seventy control points are shown on the map; the fence diagram of Denson and others (1978) is keyed to this isopach map by points A-K. Major structures defined primarily on the structure contour map and topographic lineaments, are also shown on the isopach map for easy reference.

GEOLOGIC IMPLICATIONS

In general, the Wyodak coal bed should be thicker than the Anderson bed, because the Wyodak includes the Canyon coal bed that lies stratigraphically below the Anderson. This systematic difference in thickness influences but does not account for the pattern of prominent coal thickness anomalies defined by the isopach map. Comparison of the isopach and structure contour maps shows (1) the remarkable degree to which areas of anomalous coal thickness coincide with major folds, and (2) that abrupt differences between coal thickness categories are commonly marked by linear discontinuities. The first observation strikingly illustrates the relationship between structure and coal thickness already shown in cross section on the fence diagram of Denson and others (1978) and attributed to variations in coal deposition during folding, and(or) to folding and erosion of these coal beds subsequent to their formation but prior to Wasatch deposition. For example, (a) the Anderson coal bed is anomalously thin or absent in a narrow north-trending band coincident with the Rocky Butte dome in the northwest part of the map; (b) the Anderson is also thin or absent across the Turnercrest upwarp; and (c) the area underlain by the Wyodak coal bed is not only restricted mainly to the broad Wild Horse-Teckla depression, but smaller areas of unusually thick Wyodak coal invariably coincide with local synclines or structural basins within the depression.

The second observation graphically represents the kind of evidence by which some linear discontinuities are interpreted as faults. The western part of the Wild Horse-Teckla depression is a case in point, involving the zone across which the Anderson and Canyon coal beds converge to form the Wyodak. Structure section a-i across the House Creek and North Porcupine faults illustrates the stratigraphic problems (fig. 1) Considering the vertical exaggeration of the cross section, the stratigraphic differences between wells d, e, and f possibly could be accommodated without faults--perhaps by a combination of facies changes related to complex folding. However, the fault interpretation is preferred in view of the areal extent and apparent linearity of the zone across which these differences occur, the stratigraphic continuity and low dips of the sequences adjacent to it, and the association with topographic lineaments of similar trend. A complex history of recurrent fault movement involving reversals in sense of separation seems unavoidable. On both the House Creek and North Porcupine faults (fig. 1), pre-Wasatch separation of at least several hundred feet in a sense opposite that affecting the Felix coal bed in the lower part of the Eocene Wasatch Formation is required to account for the present distribution of coal beds. An apparent reversal in sense of separation also occurs in space (rather than time) elsewhere along the House Creek fault. Vertical stratigraphic separation of the contoured datum surface near Rocky Butte is as much as 400 ft with the southwest side up, whereas 3 miles northwest of Rocky Butte about 200 ft of vertical separation with the northeast side up is indicated. Stratigraphic separations do not necessarily indicate the nature of fault slip; data are insufficient to determine actual fault movement. Structural complexities also characterize other inferred faults, including the Neil Butte fault bounding the northeast side of the small Neil Butte Syncline located between the Black Thunder and Mount Logan arches (fig. 2). However, mappable displacements of Wasatch strata along the lineament marking the surface trace of the Neil Butte fault may be absent or small compared with pre-Wasatch offset inferred for Fort Union strata.

From the structure contour and thickness data on these maps, it is concluded that (1) coal splits and thickness variations are closely controlled by structure, including both growth faults and broad folds; (2) faults active intermittently during (and after) coal formation may have played a key role in localizing folds and in controlling patterns of deposition and subsequent erosion; and (3) pre-Wasatch structural activity was generally more intense than that during Wasatch deposition.

Furthermore, the similarity of fault and lineament patterns in Tertiary rocks throughout the Powder River Basin with orientations of Precambrian discontinuities in the crystalline basement of adjacent block uplifts, suggests that recurrent Tertiary (and older?) growth faults and modern fracture systems in the basin may be propagated from an underlying mosaic of differential moving, fault-bounded basement blocks.

COAL RESOURCES

A principal use of the information shown on these maps is to delineate areas of the Wyodak and Anderson coal beds favorable for strip mining and to determine depths involved in mining the coal at any place within the map area. For this purpose, topographic contour maps showing ground surface elevations are necessary. The index map shows the U.S. Geological Survey 7½-minute and 15-minute topographic quadrangle maps available for the Reno Junction-Antelope Creek area. The difference between the surface altitude as indicated on a topographic map and the altitude of the base of the coal at the same locality, as indicated on the structure contour map, gives the total depth of mining (coal plus overburden) required at that point. Subtracting from this figure the thickness of the coal at the same locality, as determined from the isopach map gives the amount of overburden that would have to be removed during strip mining. By this process, the 200-foot and 300-foot overburden isopachs have been constructed on the coal isopach map. Other factors being equal, optimum areas for strip mining are those where relatively thick Wyodak and Anderson coal beds occur within the zone of relatively thin overburden.

On the basis of geologic and drill-hole data, the Wyodak and Anderson coal beds in the Reno Junction-Antelope Creek area are estimated to contain about 65 billion tons of coal. Of that, at least 6.5 billion tons lie within the 120,000-acre area where overburden is 200 feet or less thick. At least 5 billion additional tons of coal are buried under 200-300 feet of overburden in an area covering more than 55,000 acres.

In the map area, the Wyodak and Anderson coal beds are subbituminous B rank. Available analyses of coal (as received) from localities widely spread throughout the area indicate a sulfur content of less than 1 percent, ash content of 4.2-8.3 percent, and heat value generally ranging from 8,450 to 9,840 Btu/lb (Wegemann and others, 1928; and Wyoming Coal Gas Co. and Rochelle Coal Co., written commun., 1974). An analysis of the Anderson coal at the Antelope mine shows 4.2 percent ash 0.4 percent sulfur, and 9,950 Btu/lb (V. E. Swanson, written commun., 1975)

Surface and mineral ownership of lands within the Reno Junction-Antelope Creek area can be determined from U.S. Bur. of Land Management surface management and surface-minerals management color quadrangle maps Nos. NE-15 (Pumpkin Butte), NE-16 (Hilight), NE-21 (Eegerton), and NE-22 (Teckla).

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STRUCTURE CONTOUR AND ISOPACH MAPS OF THE WYODAK-ANDERSON COAL BED IN THE RENO JUNCTION-ANTELOPE CREEK AREA, CAMPBELL AND CONVERSE COUNTIES, WYOMING