DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

COAL INVESTIGATIONS
MAP C–126–A (SHEET 1 OF 2)

INTRODUCTION AND CURRENT STUDY

The Paleocene Mammoth coal bed underlies and crops out along the scenic central buttes of the Bull Mountain structural basin in south-central Montana (figs. 1 and 2). This high-volatile C bituminous to subbituminous A coal lies about 1,000 feet above the base of the Tongue River Member of the Fort Union Formation (fig. 3). It ranges from 5 to 16 feet thick and covers an area of 85 square miles.

The Mammoth was first described in any detail during the course of the Northern Transcontinental Survey, reported in "Montana Coal-fields" by George Eldridge (1886). There were several preliminary USGS (U.S. Geological Survey) reports on the Bull Mountain coal field between 1907 and 1914, and the major publication on the field, USGS Bulletin 647, appeared in 1917 (Woolsey and others, 1917). It included a map (1:62,500 scale) and coal sections for each township.

Although considered the major economic coal in the field, the Mammoth has never been extensively mined. A lower coal, the Roundup bed, came into prominence in 1906 when the Chicago, Milwaukee, and St. Paul Railway was extended through its outcrop area in the northwest part of the field. That coal was mined into the 1950's. There was some mining of the Mammoth coal bed for a brief time in the late 1880's by the Northern Pacific Railroad (localities B5–B18 and B5–C5, fig. 5). This coal was transported by wagon some 25 miles south to the railroad. Two small strip mines in the Mammoth, the PM mine and the Divide mine, less than one-eighth section each, have operated in recent years (localities B4–C78 and B4–C79).

The current study to describe and map the Mammoth coal bed began with an attempt to recover the localities of coal sections shown in Bulletin 647 (Woolsey and others, 1917) in order to assess whether the measurements and the locations were sufficiently accurate for those sections to be included in this report. Although that publication was a great help as a guide to the general areas of coal exposures, it could not be used to pinpoint localities because of numerous inaccuracies in the bulletin's topographic maps. That early field party traveled on foot and horseback, measured distances by pacing on foot or by horse pace, and sketched the topography, 100-foot contours, as it went. Elevations were by aneroid barometer surveys. Modern topographic base maps of the area, except at a scale of 1:250,000, were not available until 1977, when preliminary 1:24,000 maps began to be available. This lack of base maps may explain the lack of substantive reports on the area since the 1917 bulletin.

The original coal localities that were found were replotted on the 1:24,000-scale base maps and the sections were remeasured. For the most part, the original descriptions were accurate, but in some places local erosion had uncovered a little more section below, or a split was found above that had not been reported. Other exposures were also found, and patches and zones of coal "bloom" in the expected interval helped locate the approximate position of the Mammoth coal bed where exposures were absent. Exposures of the Mammoth are generally poor. Figure 4 shows one of the few excellent natural exposures.

This report presents the first drill-hole data for the Mammoth coal bed. Most of those data were obtained from selected coal-exploratory hole records from the Burlington Northern Railroad, the Meridian Land and Mineral Company, and the Louisiana Land and Exploration Company, and some from The Consolidation Coal Company. The Montana Bureau of Mines and Geology drilled five holes for the USGS that intercepted the Mammoth coal bed. Lithologic data were mostly derived from geophysical logs, some by this author, most by company geologists in conjunction with geologists' or drillers' logs. Coal intervals were commonly cored, so the coal data are particularly reliable. All outcrop and drill-hole localities are shown on figure 5. Available data for all drill holes and for most surface localities have been entered in the NCRDS (National Coal Resources Data System) of the USGS.

Part B of this Coal Investigations series will be concerned with the resources of the Mammoth coal bed: location of split boundaries, isopachs of splits, overburden lines, tables of resources, and discussion of coal quality (Connor, in press).

OUTCROP AND STRUCTURE

The drill-hole data were combined with the outcrop data to construct the structure contours on the base of the Mammoth coal bed (fig. 6). The structure contours, in turn, provided the control for the outcrop line (figs. 5 and 6) between the surface data points. A preliminary version of the outcrop and structure maps, without drill-hole locations, was published by Connor and Griffith (1980).

The general structure of the Bull Mountain coal field, and of the Mammoth coal bed, was known as early as 1886 when Eldridge (1886, p. 754) said:

> "The [Mammoth] coal lies nearly horizontally, but still, by close examination and comparison of the strata over wide areas, it is proved to occupy an exceedingly shallow synclinal basin, the shape of which is not positively determined, but it seems to have its center somewhere near the center of the mountains themselves, the strata dipping inward from the periphery, but never over 2°30′."

As it turns out, the deepest part of the syncline, based on the Mammoth structure, is about 8 miles northwest of the center of the mountains. The dips are indeed slight, generally less than 1° (92 ft/mi), but they occasionally exceed Eldridge's estimate of a maximum of 230 feet per mile. The trend of the axis is northwest–southeast. The maximum difference in elevations on the coal bed is 500 feet (4,120–3,620 ft).

CROSS SECTIONS

Previous reports on the Mammoth coal bed showed individual coal sections but no cross sections, except for the preliminary cross sections by this author (Connor, 1981). Combining the coverage provided by the current drill-hole data with that of the old and new surface data, it is now possible to understand the three-dimensional distribution of the coal, as shown in cross sections *A–A′* through *I–I′* (fig. 7). The locations of the lines of section are shown on figure 5. The cross sections clearly indicate the geometry of the Mammoth coal bed. However, this was not evident early in the current field work when only outcrop data were available. Correlation across the Bull Mountains was puzzling, as it must have been to the early field parties, who dealt with similar data. Sections *H–H′* and *I–I′*, which are close to and generally parallel the outcrop on the northeast and southwest sides of the mountains, respectively, show how different the distribution and geometry of the Mammoth is from one side of the mountains to the other.

The Rehder split (fig. 3) of this report was considered in Bulletin 647 (Woolsey and others, 1917) to be a separate bed above the Mammoth, although Richards (1910, p. 75) had said earlier "in the northwestern part of the field the coal bed now called the Rehder is undoubtedly what Eldridge designated as the upper bench of the Mammoth. It is clearly possible that Eldridge's interpretation may be correct and final determination must await the development of mining." Richards was correct that Eldridge (1886) was correct. The cross sections (except *A–A′* and *I–I′*), incorporating subsurface data, reveal that the Rehder is a split of the Mammoth. The cross sections also show that the Mammoth splits more than once. Three splits of the Mammoth are here designated, from base to top, Mammoth 1, Mammoth 2, and Mammoth 3 (equivalent to Rehder) (fig. 8). All three splits occur as individual beds in the north part of the area of occurrence of the Mammoth. In the southwest Mammoth 1 and Mammoth 2 join, forming Mammoth 1+2; Mammoth 3 (equivalent to Rehder) is a separate bed. In the northeast Mammoth 1 is a separate bed; Mammoth 2 and Mammoth 3 join to form Mammoth 2+3 (thought to be the Rehder alone by Woolsey and others, 1917). Mammoth 1, 2, and 3 join to form Mammoth 1+2+3 in the east-central part. This area where all three splits join corresponds roughly with the "area under which the Mammoth and Rehder coal beds can probably be mined as one" (Woolsey and others, 1917, pl. IX) (fig. 8), not a bad estimate considering the absence of subsurface data at that time. Where all three splits join, the Mammoth averages 13 1/2 feet thick. Where splits 1 and 2 join, it averages 9 feet, and where 2 and 3 join, 7 feet. "Join" means that splits are not separated by a parting thicker than either of the splits.

The two major partings that split the Mammoth coal bed are designated lower parting and upper parting on the cross sections. There is not much lithologic data for the thinner lower parting, which runs along the northeast side of the area of occurrence of the Mammoth. The upper parting, along the southwest side, is mostly sandstone, or sandstone interbedded with siltstone or with shale, where it is thickest, and mostly shale where it thins.

Besides the major partings there are minor ones, one of which lies consistently 2–3 feet above the base of the Mammoth (see cross sections). This parting was observed at all but two of the core or outcrop data points, and was recorded in 60 percent of the drill-hole records. Because this layer appears to be ubiquitous, and because a couple of outcrop samples of the layer were identified as altered volcanic ash (Bruce Bohor, oral commun., 1981), this parting is presumed to represent a volcanic ash fall. It is possible that some of the other partings, which are less continuous, represent less well preserved ash falls. It is apparent, however, that there was not a lot of volcanic activity during deposition of the Mammoth. Nor are there more than one or two ash falls in any other coal of the Tongue River Member observed in the Bull Mountain field. This is in sharp contrast with the Big Dirty coal bed in the Lebo Shale Member, which averages an ash layer every 4 inches (Connor, 1982, 1984, 1985)—there clearly was much more volcanic activity in early Fort Union time.

ISOPACHS OF PARTINGS

The two major partings were isopached (figs. 9 and 10). Especially for the upper parting, located along the southwest side of the Mammoth area, the lithosome geometry as represented by the isopach pattern confirms the impression given by field observations and by the cross-section configurations and lithologies: these are stream channels and attendant overbank splays. Both channels trend northwest-southeast. The flow direction, based on field observations of the dominant orientation of cross beds, is to the southeast. The southeast flow suggests this area drained into the Powder River basin during middle Tongue River time. This flow direction does not agree precisely with that of Shurr's measurements (1972), which indicated a southerly flow, with very little variation, throughout Tongue River time in the Bull Mountain area. That study was based on cross-bed measurements of sandstone beds, with the majority of measurements in a 400-foot interval below the Mammoth, which may explain the apparent discrepancy.

RESOURCES

Resources for the Mammoth coal bed have been computed using the kriging method (Pierce and others, 1983). Total tonnage, mostly with less than 500 feet of overburden, is 1.1 billion short tons. The resources, with confidence limits, are reported by split, by county, and by township for each of three thickness categories.

Mammoth coal bed resources will be discussed and illustrated in detail in Part B of this Coal Investigations series (Connor, in press).

ACKNOWLEDGMENTS

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Figure 1.—Location of Mammoth coal bed, south-central Montana. Bull Mountain coal field and Powder River basin and Williston basin boundaries drawn at K-T (Cretaceous-Tertiary) boundary. Modified from American Association of Petroleum Geologists (1972).

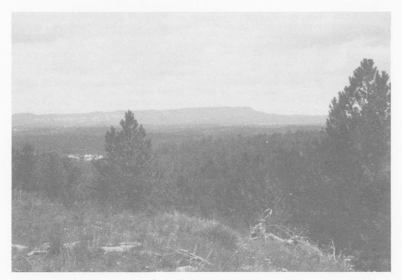


Figure 2.—The central Bull Mountains viewed from the west.

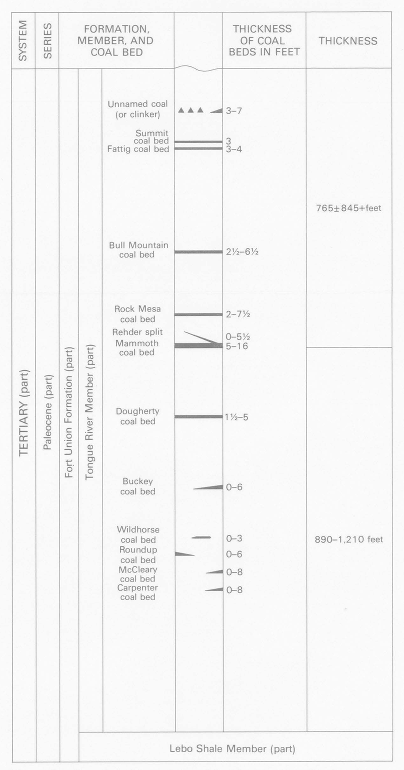


Figure 3.—Stratigraphic position of the Mammoth coal bed and other relatively persistent coal beds in the Bull Mountain coal field.

Figure 4.—Unusually good natural exposure of the Mammoth coal bed, 13 feet thick here. Locality B5–C20. The obvious parting near the top of the bed marks the boundary between the uppermost split (Mammoth 3, equivalent to Rehder coal bed of other authors) and the rest of the Mammoth. See cross section *E–E′*.

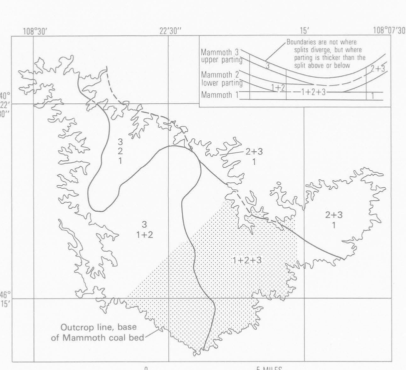
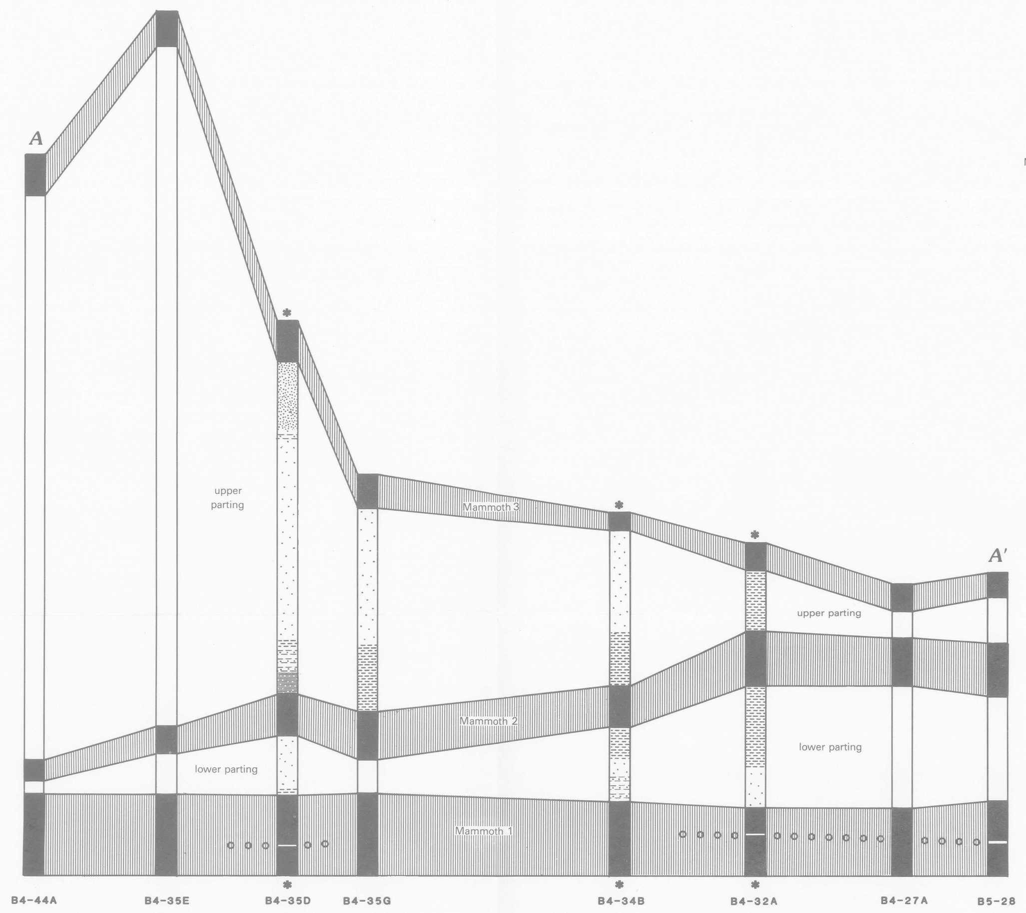
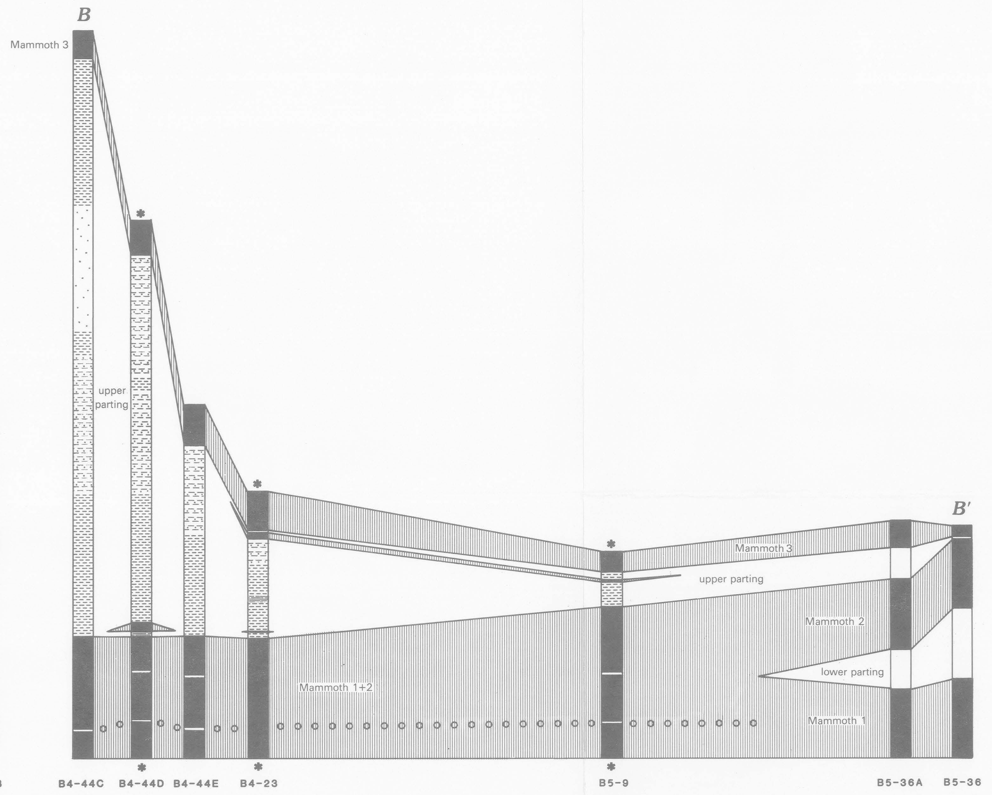
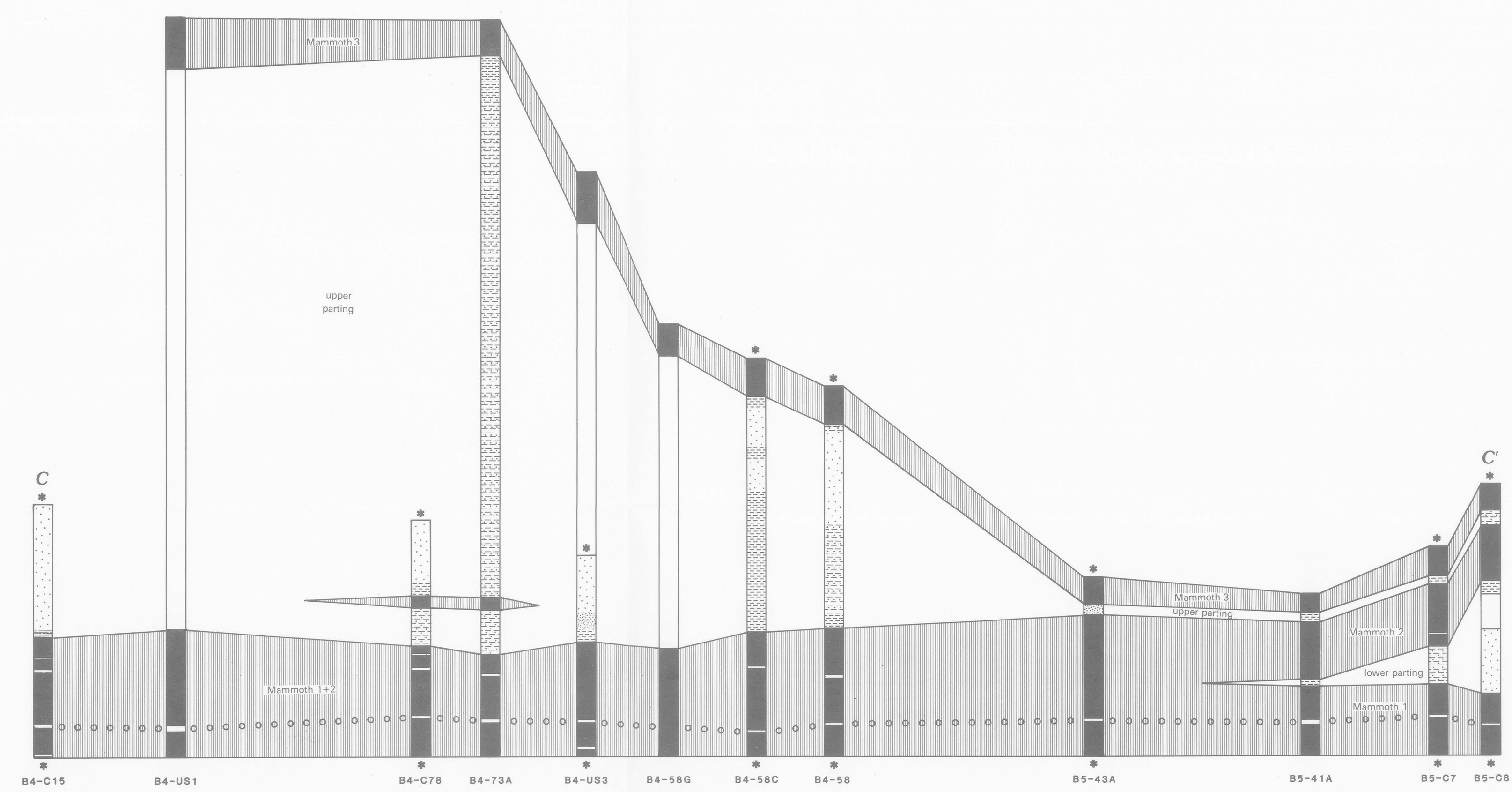
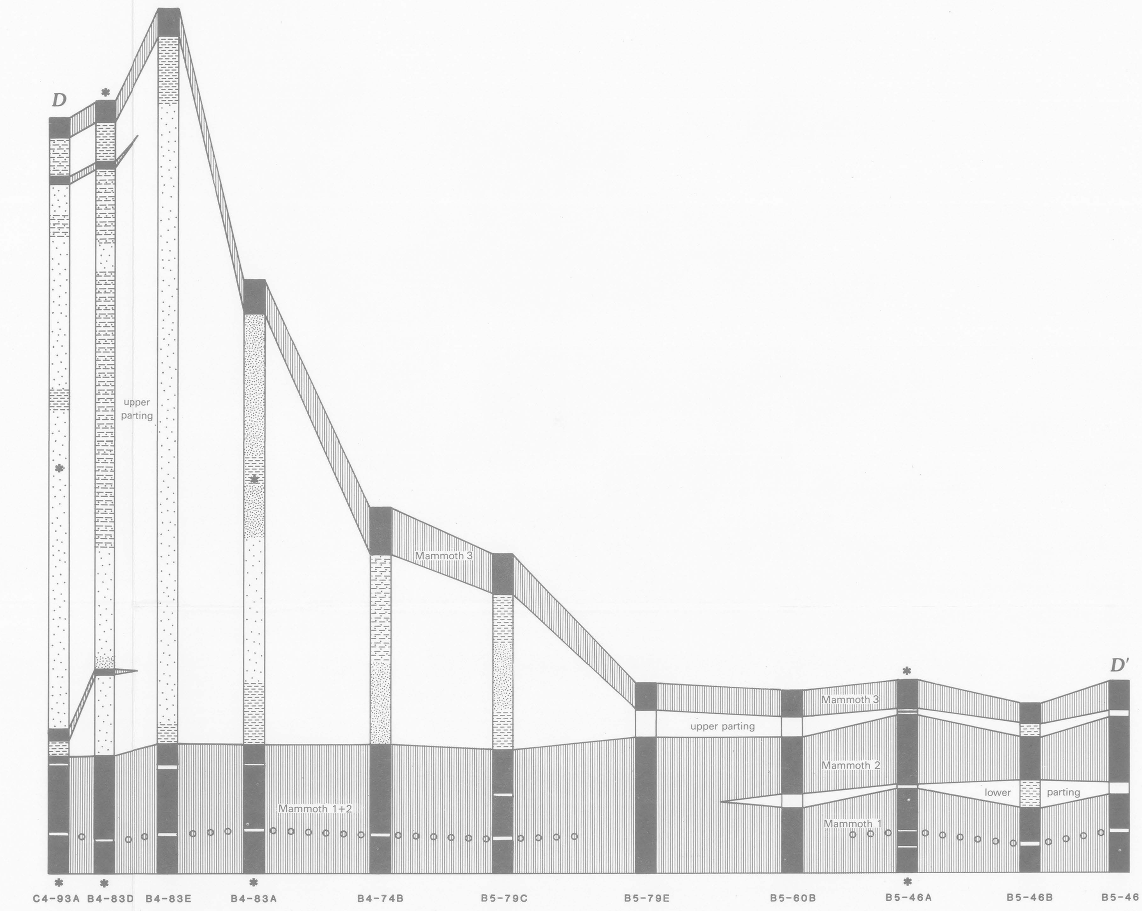


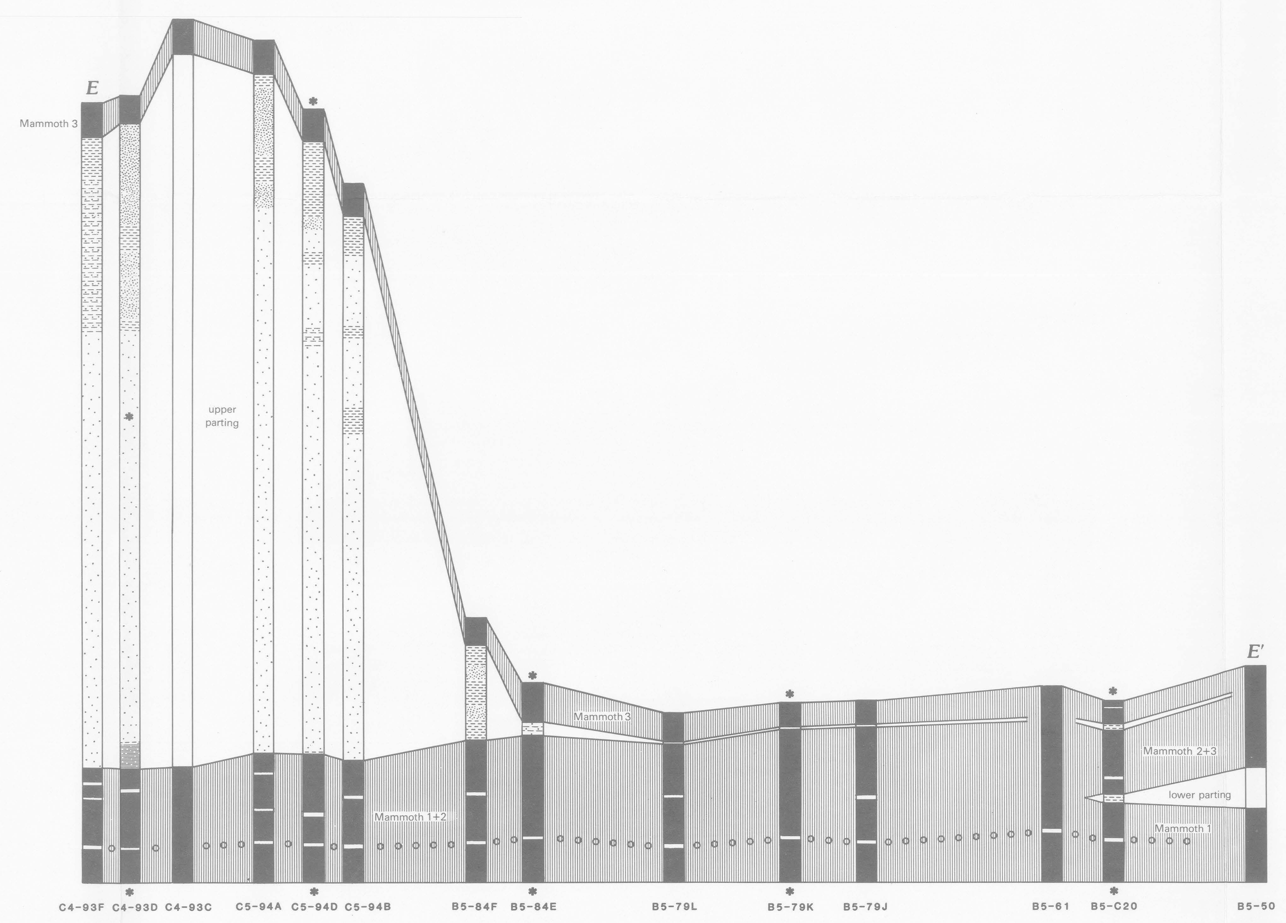
Figure 8.—Boundaries of coal splits (dashed where inferred), Mammoth coal bed. Patterned area is that shown in Bulletin 647 (Woolsey and others, 1917, pl. IX) where the Mammoth and Rehder coal beds can probably be mined as one.

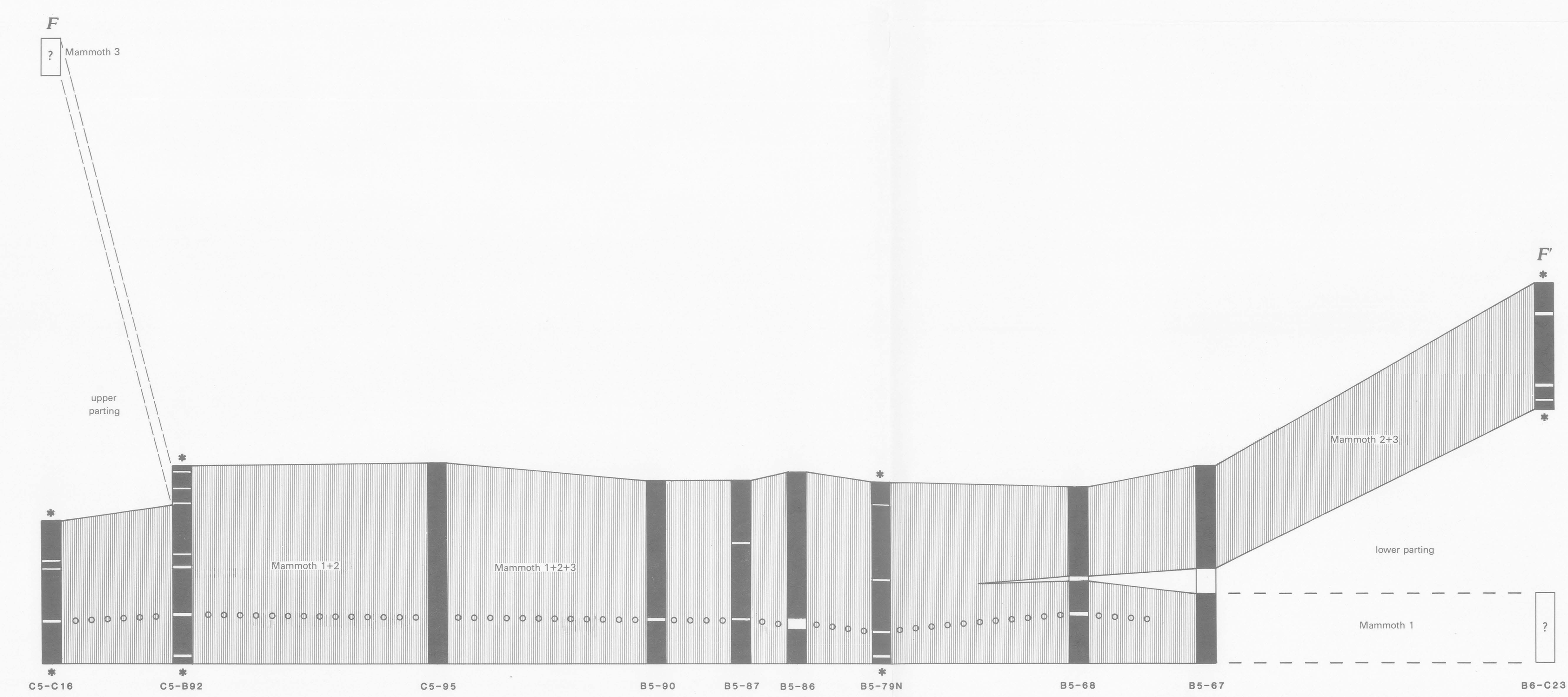


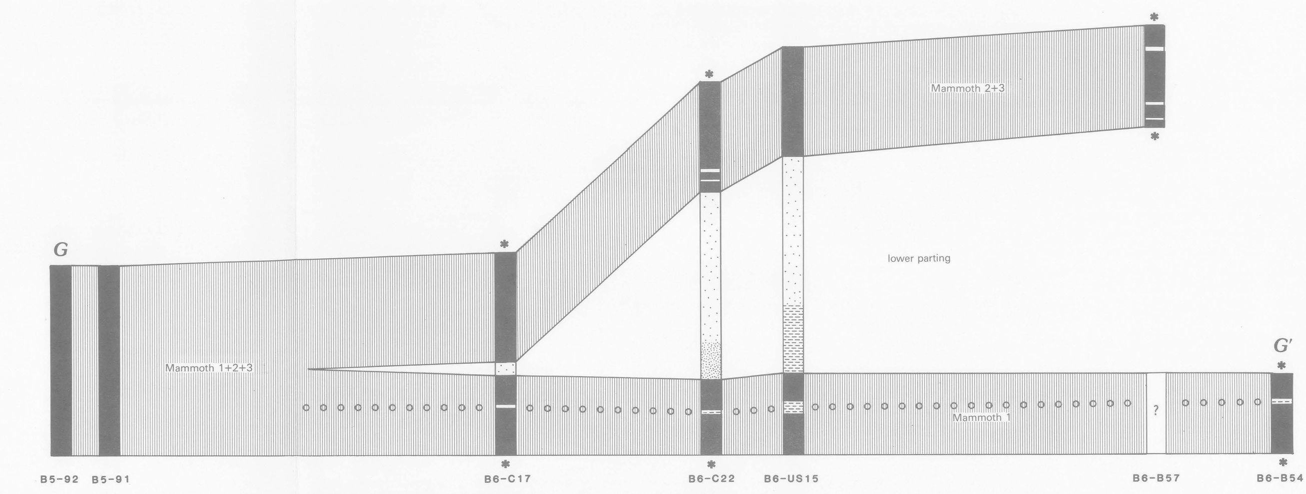


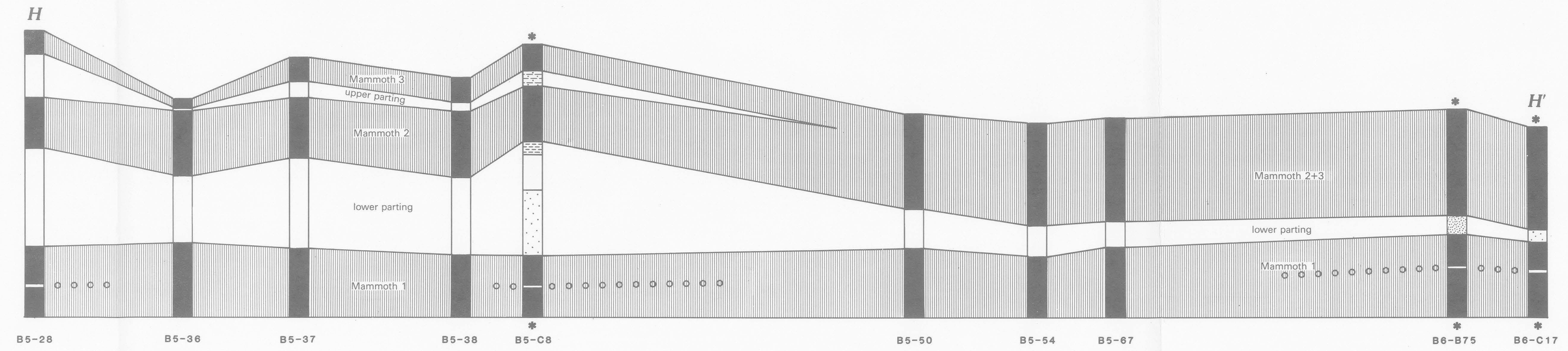


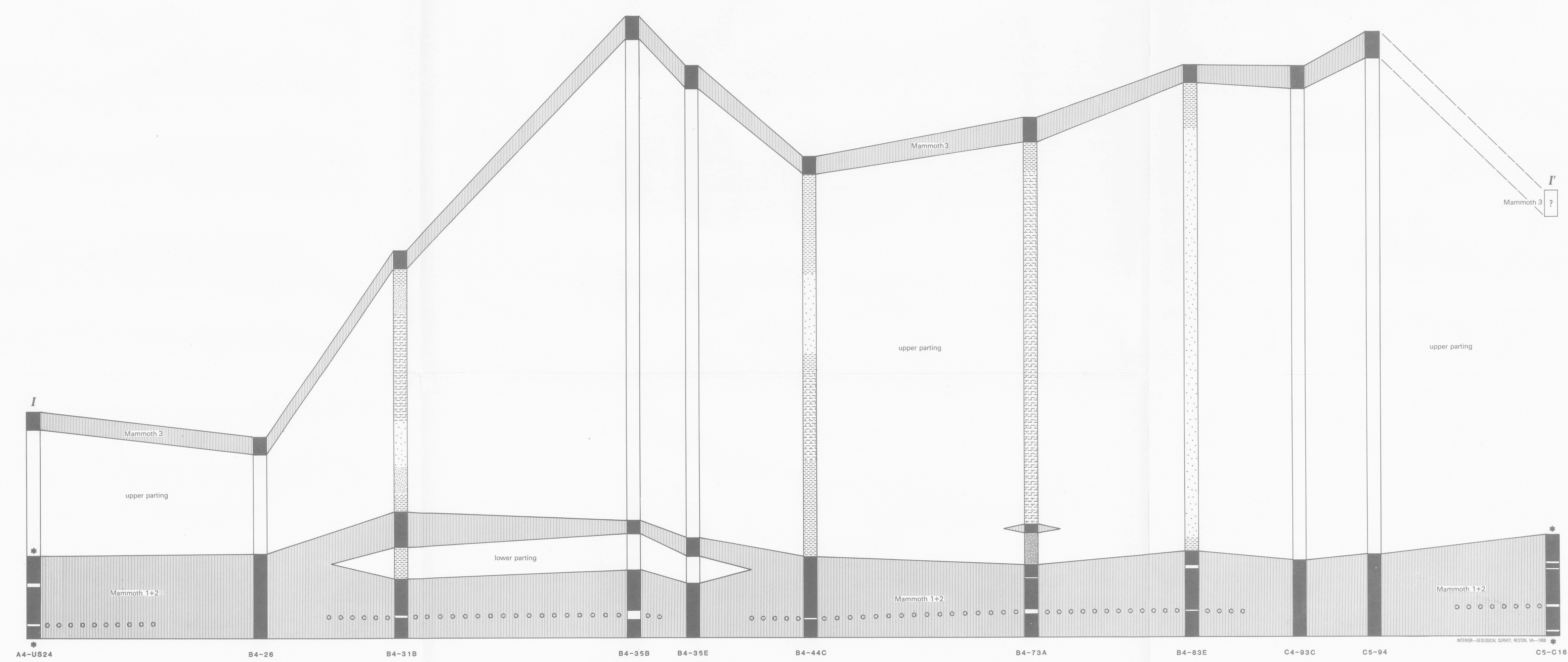












EXPLANATION

(Lines of cross sections shown on figure 5, sheet 2)

B4–C78 **Drill-hole or surface locality number**—Locations shown on figure 5

Correlation line—Datum is base of Mammoth coal bed. Dashed at likely position of a split that either is missing on outcrop due to erosion or is below ground level. Designation of splits (Mammoth 1, etc.) is not in all cases the same as recorded in NCRDS: there, to facilitate computation of resources, wherever a parting is thinner than the coal above or below, those coals are designated as a single split

Interval between asterisks indicates core or outcrop; interval not encompassed by asterisks indicates geophysical logs

Sandstone

Siltstone

Shale

Sandy or silty shale

Interbedded sandstone and siltstone, or interbedded sandstone and shale—Sandstone intervals are less than 5 feet thick

Carbonaceous shale

Coal

Coal—Projected between control points

Lithology not recorded

o o **Probable volcanic ash parting**

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Figure 7.—Cross sections *A–A′* through *I–I′*

MAPS SHOWING OUTCROP, STRUCTURE CONTOURS, CROSS SECTIONS, AND ISOPACHS OF PARTINGS—MAMMOTH COAL BED, PALEOCENE TONGUE RIVER MEMBER OF THE FORT UNION FORMATION, BULL MOUNTAIN COAL FIELD, SOUTH-CENTRAL MONTANA

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