Chapter PA

ASHLAND COALFIELD, POWDER RIVER BASIN, MONTANA: GEOLOGY, COAL QUALITY, AND COAL RESOURCES

by S.B. Roberts,[1] E.M. Wilde,[2] G.S. Rossi,[1] Dorsey Blake,[1] M.S. Ellis,[1] G.D. Stricker,[1] A.M. Ochs,[3] G.L. Gunther,[3] J.H. Schuenemeyer,[1] and H.C. Power[4]

in U.S. Geological Survey Professional Paper 1625-A

[1]U.S. Geological Survey

[2]Montana Bureau of Mines and Geology, Butte, Montana

[3]Consultant, U.S. Geological Survey, Denver, Colorado

[4]University of Delaware, Newark, Delaware

Click here or on this symbol
in the toolbar to return.

Contents

Figures

Figures—continued

Tables

Tables—continued

INTRODUCTION

The Ashland coalfield, as defined here, incorporates an area of some 520 square miles in parts of Powder River and Rosebud counties in southeastern Montana (fig. PA-1). The coalfield is named for the town of Ashland, which is on the banks of the Tongue River just west and north of the main part of the coalfield. Access through the area is provided by a limited network of U.S. highways and secondary or unimproved roads.

The coalfield is defined by both geologic and geographic parameters. The western boundary is delimited by the outcrop or burn line (clinker contact) of the Knobloch coal bed, and the remaining boundary of the coalfield is defined primarily by geographic limits of 7.5' quadrangles within the study area (fig. PA-2). In the Cook Creek Reservoir 7.5' quadrangle, the boundary represents the geographic limit of subsurface data of sufficient spacing for viable coal correlations. The Ashland coalfield in this study is more areally restricted than the Ashland coalfield of Bass (1932) (520 square miles versus 975 square miles), and encompasses all or part of the Ashland, Beaver Creek-Liscom Creek, and Poker Jim-Odell Creek coal deposits of Matson and Blumer (1973). Most of the coal in the Ashland coalfield is Federally owned (fig. PA-3). Other than small wagon mines that produced coal locally for ranchers in the early 1900's (Bass, 1932), there has been no substantial coal mining in the coalfield.

The Tongue River is west of the Ashland coalfield, and the central part of the coalfield is dissected by the Otter Creek drainage (fig. PA-4). The majority of the Ashland coalfield (approximately 66 percent) underlies the Custer National Forest. Because section 522 (e) (2) (b) of the Surface Mining Control and Reclamation Act of 1977 [SMCRA; Public Law 95-87 (30 U.S.C. 1201 et seq.)] strictly prohibits surface coal mining within the boundaries of Custer National Forest, this coal resource assessment addresses only those lands within the coalfield that fall outside the Forest boundaries (fig. PA-4).

GEOLOGIC OVERVIEW AND COAL STRATIGRAPHY

The Fort Union Formation (Paleocene) outcrops throughout the Ashland coalfield; younger rocks of the Wasatch Formation (Eocene) are exposed in areas just south of the coalfield (fig. PA-5). Fort Union strata exposed in the coalfield are included in the Tongue River Member; the underlying Lebo Member of the Fort Union Formation is present in outcrops north of the coalfield (fig. PA-5). Rocks of the Tongue River Member are essentially flat-lying, and are composed primarily of shale, sandy shale, sandstone and thick coal beds. The thickness of the Tongue River Member in this area ranges between 1,150 ft and 1,660 ft (Bass, 1932).

Clinker, formed from the natural burning of coal beds (see, for example, Heffern and Coates, 1997) is prevalent throughout the area, and clinker of the Knobloch coal bed is a prominent feature of the coalfield (fig. PA-5). In places, clinker deposits may attain a thickness of greater than 100 ft (Matson and Blumer, 1973), and clinker cliffs and ridges typically support the extensive growth of Ponderosa pine.

Coal beds are present throughout the Fort Union Formation in the Ashland coalfield. The Knobloch coal bed in the lower part of the Tongue River Member (fig. PA-6) has been targeted as the priority coal resource assessment unit in the coalfield, primarily because of its thickness and continuity. In this report, the single Knobloch coal bed is designated as the Knobloch coal resource unit (fig. PA-6), following

Click here or on this symbol
in the toolbar to return.

criteria used by Culbertson and Saperstone (1987). Within this framework, the term "Knobloch coal resource unit" identifies the thick, single body of coal formed by the merging of multiple beds in northern areas of the coalfield, as well as the uppermost coal bed in the Knobloch coal zone in southern and eastern areas of the coalfield where the thick coal bed has split (fig. PA-6). The Knobloch coal resource unit or its interpreted equivalent has been identified in drill holes beyond the limits of the Ashland coalfield; however, the paucity and distribution of data make correlations difficult in the more peripheral areas, and for this reason, we have restricted our area of Knobloch coal resource assessment to the Ashland coalfield as defined here (fig. PA-4).

The net coal thickness (excluding partings) of the Knobloch coal resource unit ranges from 3 to 71 ft, and the wide variability in thickness reflects the merging and splitting of individual components comprising the coal resource unit. The coal beds considered to comprise the Knobloch coal resource unit where several coal beds have merged into one thick bed include the Knobloch (uppermost), Calvert, Nance, Lay Creek, and Flowers-Goodale (lowermost) coal beds (Culbertson and Saperstone, 1987; Sholes and Daniel, 1992; Wilde, in press) (fig. PA-6). The King coal bed, which is present above the Knobloch coal bed in some areas, may merge locally with the Knobloch coal resource unit (Culbertson and Saperstone, 1987; Sholes and Daniel, 1992). The Lay Creek coal bed, which occurs stratigraphically between the Knobloch coal bed and the underlying Flowers-Goodale coal bed in the Foster Creek area (fig. PA-6) is interpreted to merge with the Knobloch coal resource unit (Knobloch coal bed) in T. 2 S., R. 45 E., in the northern part of the Ashland coalfield (see, for example, Sholes and Daniel, 1992). McKay (1976) and Wilde (in press) have also identified a Lay Creek coal bed in the southern part of the Willow Crossing 7.5' quadrangle in T. 3 S., R. 45 E. In this area, the Lay Creek coal bed is about 100 ft below the Knobloch coal resource unit. The stratigraphic relationship between the Lay Creek coal bed in the Willow Crossing 7.5’ quadrangle and the Lay Creek coal bed as identified in the Foster Creek area is unclear. However, the stratigraphic position of this coal bed in the Willow Crossing quadrangle, which is well below the Knobloch coal resource unit, suggests that the Lay Creek coal bed in the southern part of the Willow Crossing quadrangle may not be equivalent to the Lay Creek coal bed in the Foster Creek area. Additionally, the reader should note that we do not correlate the Flowers-Goodale bed in the Ashland coalfield with the Flowers-Goodale coal bed in areas to the south and east of the coalfield as has been done by previous workers (see, for example, Culbertson and Saperstone, 1987; McClellan and Biewick, 1988). This is primarily because the stratigraphic position of the “Flowers-Goodale” bed as identified in those previous reports is as much as 100 to 150 ft below the Flowers-Goodale coal bed in the Ashland coalfield, and we suggest that the Flowers-Goodale bed in the Ashland coalfield pinches out in eastern and southern areas of the field (fig. PA-6). The stratigraphic relationship between the Flowers-Goodale coal bed in the Foster Creek area and the Flowers-Goodale coal bed as we identify it in the Ashland coalfield is unclear, and no attempt at correlation is made in this study.

In areas east of the Ashland coalfield, the Knobloch coal resource unit (Knobloch coal bed) is interpreted to be equivalent (in part) to the Sawyer coal bed (McClellan and Biewick, 1988; Sholes and Daniel, 1992). Based on limited subsurface data, we suggest that the Knobloch coal bed in the Foster Creek area may be stratigraphically lower than the Knobloch coal bed in the Ashland coalfield. In the Greenleaf Creek-Miller Creek area north of the coalfield, the Knobloch coal bed is identified below the Sawyer coal bed and above the Rosebud coal bed (Matson and Blumer, 1973) (fig. PA-6). Sholes and Daniel (1992) suggest that the Rosebud coal bed is equivalent to a lower split of the Knobloch coal bed, and based on available data, this conclusion seems highly plausible.

Two lines of cross section (fig. PA-7) derived from drill-hole data, depict our interpretations of Knobloch coal resource unit continuity within the Ashland coalfield. Cross section A-A' (fig. PA-8) depicts north-south correlations of the Knobloch coal resource unit and associated coal beds in a 30 mile transect of the coalfield. West-east cross section B-B' (fig. PA-9) traverses some 22 miles of the Ashland coalfield. The cross sections include natural-gamma (NG), spontaneous potential (SP), and resistivity (RES) geophysical log profiles. The majority of the natural-gamma logs are products of coal exploration drilling, whereas the spontaneous potential and resistivity logs are from oil and gas test wells. The datum is mean sea level (MSL) for both cross sections, and the horizontal distribution of drill-hole control points along each line of section is scaled to reflect the relative map distance between drill holes, although this horizontal scaling is approximate.

The log profiles used in the cross sections were constructed from reduced geophysical logs. Where natural-gamma logs were used, the data point displays a "mirrored" image of the log profile to highlight the response in coal beds. Spontaneous potential and resistivity logs are displayed in tandem as is typical of these geophysical log records in oil and gas exploration. In this area, coal beds are characterized by low natural-gamma and high resistivity responses. Spontaneous potential logs were used primarily for differentiating high resistivity responses in sandstone from similar high resistivity responses characteristic in coal beds.

The main coal-bed split area and split line B (fig. PA-7) approximate areas of coal-bed splitting associated with the Knobloch coal resource unit. The location of these areas is highly inferred and is based on drill-hole data used in this assessment, as well as some modification of interpretations of Culbertson and Saperstone (1987). The area of the coalfield north of the main coal-bed split area is where the Knobloch coal resource unit is formed from the merging of multiple beds, and the single bed reaches a thickness in excess of 70 ft. South and southeast of this area, the Nance and Flowers-Goodale coal beds are interpreted to split from the Knobloch coal resource unit (fig. PA-8). Split line B delimits the point where the Calvert coal bed splits from the Knobloch coal resource unit.

COAL QUALITY

Based on chemical analyses (as-received basis) from the Knobloch coal resource unit in Tps. 3 and 4 S., R. 45 E. (Otter Creek EMRIA Site) (Culbertson and Saperstone, 1987, *after* the U.S. Bureau of Land Management, 1975), the average heat-of-combustion value for the Knobloch coal is 8,110 Btu/lb, the average ash yield is 5.5 percent, and the average total sulfur content is 0.15 percent. The apparent coal rank in this area is subbituminous C.

Based on as-received analyses, Matson and Blumer (1973) report calorific values ranging from 7,761-9,070 Btu/lb, an ash yield ranging from 3.7-6.8 percent, and total sulfur content ranging from 0.1-0.5 percent for the Knobloch coal bed in the Ashland coal field. In the Foster Creek area (fig. PA-5), as-received analyses of the Knobloch coal bed indicate heat-of-combustion values ranging from 7,380-7,840 Btu/lb, ash yield ranging from 6.7-8.7 percent, and total sulfur content from 0.3-1.6 percent (Matson and Blumer, 1973).

In the Greenleaf Creek-Miller Creek area (fig. PA-5), Matson and Blumer (1973) report as-received analyses of calorific value ranging from 8,209-8,935 Btu/lb, ash yield ranging from 5.5-6.7 percent, and total sulfur content ranging from 0.42-0.44 percent for the Knobloch coal bed.

NET COAL THICKNESS (ISOPACH) MAP

The net coal thickness (isopach) map (fig. PA-10) is based on subsurface data from 202 drill holes, and is an interpretive map depicting the distribution and variation in net coal thickness (excluding partings) of the Knobloch coal resource unit in areas of the Ashland coalfield not included in Custer National Forest. Thicker net coal is represented by warmer color shades (red and yellow), whereas cooler shades (blue) represent areas of minimum net coal thickness.

Net coal thickness for the Knobloch coal resource unit varies from a minimum of 3 ft to a maximum of 71 ft. The thickest coal is found in areas north of the main coal-bed split area (Tps. 2-4 S., Rs. 44-46 E.), where multiple beds have coalesced to form a single thick coal body that typically ranges from 40 to 70 ft in thickness. The Knobloch coal resource unit generally thins southward, with minimum net coal in the southwestern part of the coalfield (T. 6 S., Rs. 42-46 E.) shrinking to 3 ft or less (fig. PA-10).

OVERBURDEN THICKNESS (ISOPACH) MAP

The overburden thickness (isopach) map (fig. PA-11) is an interpretive map showing the thickness of rock estimated to overlie the top of the Knobloch coal resource unit. In the Ashland coalfield, the overburden thickness in areas outside Custer National Forest ranges from 0 at points along the Knobloch coal bed outcrop/burn line (clinker contact) to more than 1,000 ft in the southwestern part of the coalfield. Areas of thicker overburden are represented by shades of green and yellow, while areas of less overburden are highlighted by shades of blue.

Comparison of the overburden and net coal thickness maps for the Knobloch coal resource unit indicate that the thickest coal (north of the main coal-bed split area; fig. PA-10) is present under overburden ranging typically from 0 to 500 ft thick (fig. PA-11).

COAL RESOURCES

Coal resource estimates for the Knobloch coal resource unit are reported in tables PA-1 through PA-3. In table PA-1, resources are tabulated by county, net coal thickness categories, and overburden categories. Table PA-2 includes a summary of coal resources reported by 7.5' quadrangle, and table PA-3 includes a summary of coal resources reported by county and Federal surface and subsurface ownership criteria. It is important to note that these resource estimates are not comparable to 'reserve' estimates, and therefore, do not reflect in any way the amount of coal that can be economically produced at the present time.

The quantification of coal resources in the Ashland coalfield follows a scheme of resource calculation reported in Wood and others (1983). The basic quantification formula is as follows: $R = A \times T \times C$,

where

R is the coal resource estimate (in short tons)

A is the area underlain by coal (in acres)

T is the net coal thickness (in feet; excluding partings) based on isopach grids, and

C is a weight/unit volume (density) conversion factor (in short tons/acre-foot).

All resources are reported in millions of short tons and are reported in accordance with criteria established by Wood and others (1983). Coal tonnages were calculated for net coal-bed thickness greater than 2.5 ft using an average density (*C*) for subbituminous coal of 1,770 short tons per acre-foot. Tonnage values are rounded to two significant figures and the tabulated totals may not equal the sum of the components because of independent rounding. Coal resources are not tabulated for areas within the Custer National Forest. However, based on data used in this study, it is estimated that an additional 10-11 billion short tons of coal in the Kobloch coal resource unit may underlie those areas of Custer National Forest included within the Ashland coalfield as defined here.

Reported reliability categories (table PA-1) include measured, indicated, inferred, and hypothetical coal resources. Measured resources occur within a 0.25-mile radius of a data point, indicated resources within the area between 0.25 miles and 0.75 miles from a data point, and inferred resources are present within a radius from 0.75 miles to 3 miles surrounding a data point. Hypothetical resources are present in areas more than 3 miles beyond a data point (Wood and others, 1983). Overburden categories (table PA-1) represent the thickness of overburden above the top of the Knobloch coal resource unit.

Confidence limits and estimates of uncertainty for total coal resources in the Knobloch coal resource unit are shown in table PA-4 and table PA-5, respectively.

A confidence interval is a statistic designed to capture uncertainty associated with a point estimate. Confidence limits reported here are based on net coal thickness measurements from 187 drill-hole locations. From these data, we computed 90-percent confidence intervals on the volume of coal in the Knobloch coal resource unit in the measured, indicated, inferred, and hypothetical categories. In this case, volume refers to the calculated resource in millions of short tons (MST).

The confidence limits were derived through a complex series of steps. These steps included modeling coal thickness trends and removing the trends using a nonparametric regression algorithm called loess (with span = 0.75), and using residual thickness to compute a semivariogram and fitting the semivariogram to a spherical model. Parameter estimates were sill = 47.03 ft^2, nugget = 10.37 ft^2, and range = 4.70 miles. Standard deviations of coal thickness were obtained from the semivariogram model. Differences in point densities were compensated for by calculating sample size, called pseudo *n*, within each reliability category and calculating the variability of volume for each of the reliability categories. The volume of coal in the Knobloch coal resource unit was then calculated at a 90-percent confidence interval with measurement error. A description of the methodology used is given in Schuenemeyer and Power (1998) and Ellis and others (1999).

The three main potential sources of error that might bias the confidence intervals are preferential sampling, measurement errors, and model fitting. The probabilistic interpretation of a confidence interval is based upon a random sample, which does not exist in this situation, because there is preferential sampling in those areas deemed to be minable. Measurement error can be caused by an error in recording the coal-bed thickness or in the definition of coverage areas. Modeling fitting variability and bias result from the choice of models and fitting procedures.

SOURCES OF DATA

DRILL-HOLE DATA

The following drilling reports contain much of the drill hole information used in this study, although additional point data was collated from the U.S. Geological Survey National Coal Resources Data System (NCRDS), unpublished field logs, and from a limited set of proprietary records. Collectors and compilers of these data files include W.C. Culbertson, E.J. McKay, M.W. McClellan, and L.R.H. Biewick of the U.S. Geological Survey.

Culbertson, W.C., Gaffke, T.M., and Correia, G., 1980, Coal exploratory holes drilled in 1978-79 in the Birney 1° x 1/2° quadrangle, Big Horn and Rosebud Counties, Montana, for coal beds in the Tongue River Member of the Paleocene Fort Union Formation: U.S. Geological Survey Open-File Report 80-55, 68 p.

Hansen, W.B., and Culbertson, W.C., 1985, Correlated lithologic logs and analyses from 1982 coal drilling in Big Horn, Prairie, Rosebud, and Treasure Counties, Montana: U.S. Geological Survey Open-File Report 85-738, 125 p.

Kirschbaum, M.A., Correia, G.A., and McPhillips, M., 1982, Coal exploratory drilling during 1979 in western Powder River County, Montana: U.S. Geological Survey Open-File Report 82-748, 141 p.

U.S. Geological Survey and Montana Bureau of Mines and Geology, 1977, Geophysical logs for Big Horn, Fallon, and Powder River Counties, Montana; Chapter A of preliminary report of 1977 coal drilling in eastern Montana and northeastern Wyoming: U.S. Geological Survey Open-File Report 77-721-A, 77 p.

_____ 1982, Coal drilling during 1980 in Big Horn, Dawson, McCone, Powder River, Prairie, Richland, Rosebud, and Treasure Counties, Montana: U.S. Geological Survey Open-File Report 82-026, 256 p.

GEOLOGIC MAP DATA

Derkey, P.M., 1986, Coal stratigraphy of the Lame Deer quadrangle, southeastern Montana: Montana Bureau of Mines and Geology Geologic Map No. 43, scale 1:100,000.

Matson, R.E., and Blumer, J.W., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bulletin 91, 135 pages with plates.

Culbertson, W.C., U.S. Geological Survey, unpublished map compilation, 1970-1987.

GEOGRAPHIC BOUNDARY DATA

Federal lands and mineral status from:

Biewick, L.R.H., Urbanowski, S.R., Cain, Sheila, and Neasloney, Larry, 1998, Land status and Federal Mineral ownership in the Powder River Basin, Wyoming and Montana: a digital data set for geographic information systems: U.S. Geological Survey Open File Report 98-108, coverage scale 1:100,000.

U.S. Bureau of Land Management, 1980, Surface and mineral management status map, Lame Deer 30’ x 60’ quadrangle, Montana, scale 1:100,000.

U.S. Bureau of Land Management, 1980, Surface and mineral management status map, Birney 30’ x 60’ quadrangle, Montana, scale 1:100,000.

U.S. Bureau of Land Management, 1980, Surface and mineral management status map, Broadus 30’ x 60’ quadrangle, Montana, scale 1:100,000.

U.S. Bureau of Land Management, 1980, Surface and mineral management status map, Powderville 30’ x 60’ quadrangle, Montana, scale 1:100,000.

State and County boundary data from U.S. Geological Survey National Mapping Division and based on 1990 TIGER files digitally compiled by the Water Resources Division of the U.S. Geological Survey.

Digital coverages of 1:100,000- and 1:24,000-scale quadrangle map index acquired from National Mapping Division, U.S. Geological Survey.

Public Land Survey System (PLSS) data from Montana Natural Resource Information System (NRIS), Montana State Library, scale 1:100,000.

Digital hydrologic coverage from U.S. Environmental Protection Agency, Reach File Version 3, scale 1:100,000.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the diligent and exhaustive efforts of W.C. Culbertson (Emeritus, USGS) in his past field studies and compilation of pertinent stratigraphic and geologic information that was critical to the completion of this study. His foundation of published and unpublished work facilitated our study in many ways. We also thank Laura Roberts for her expertise in resource calculation methodology, Laura Biewick, and Shane Urbanowski their diligence in creating accurate and available digital coverages of Federal Lands and Minerals ownership status, David Ferderer for locating, obtaining, and formatting public domain files of road and drainage networks in Montana, Gerald Sullivan for his GIS coverage development in the initial stages of the project, and Jim Hunsicker for his compilation of coal quality information. This report also benefited greatly from the thoughtful comments and reviews of Mitch Henry (USGS, Denver, CO), Tim Rohrbacher (USGS, Denver, CO), Craig Brunstein (USGS, Denver, CO), and Katharine Varnes (USGS, Denver, CO).

REFERENCES CITED

Bass, N.W., 1932, The Ashland coalfield, Rosebud, Powder River, and Custer Counties, Montana: U.S. Geological Survey Bulletin 831, p. 19-105.

Culbertson, W.C., 1987, Diagrams showing proposed correlation and nomenclature of Eocene and Paleocene coal beds in the Birney 30’ x 60’ quadrangle, Big Horn, Rosebud, and Powder River Counties, Montana: U.S. Geological Survey Coal Investigations Map C-113, plates with text.

Culbertson, W.C., and Saperstone, H.I., 1987, Structure, coal thickness, and overburden thickness of the Knobloch coal resource unit, Birney area, Big Horn, Rosebud, and Powder River Counties, Montana: U.S. Geological Survey Coal Investigations Map C-112, scale 1:100,000.

Ellis, M.S., Gunther, G.L., Flores, R.M., Ochs, A.M., Stricker, G.D., Roberts, S.B., Taber, T.T., Bader, L.R., and Schuenemeyer, J.H., 1999, Preliminary report on coal resources of the Wyodak-Anderson coal zone, Powder River Basin, Wyoming and Montana: U.S. Geological Survey Open-File Report 98-789A, 49 p.

Gilmour, E.H., and Williams, L.A., 1969, Geology and coal resources of the Foster Creek coal deposit, eastern Montana: Montana Bureau of Mines and Geology, Bulletin 73, 9 p.

Heffern, E.L., and Coates, D.A., 1997, Clinker--Its occurrence, uses, and effects on coal mining in the Powder River Basin: Wyoming State Geological Survey, Public Information Circular 38, p. 151-165.

Matson, R.E., and Blumer, J.W., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bulletin 91, 135 pages with plates.

McClellan M.W., and Biewick, L.R.H., 1988, Stratigraphic framework of the Paleocene coal beds in the Broadus 30’ x 60’ quadrangle, Powder River Basin, Montana-Wyoming: U.S. Geological Survey Coal Investigations Map C-119-A; scale 1:100,000.

McKay, E.J., 1976, Preliminary geologic map and coal sections of the Willow Crossing quadrangle, Rosebud and Powder River counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-802, 1:24,000.

Schuenemeyer, J.H., and Power, H., 1998, An uncertainty estimation procedure for U.S. coal resources, [abs.], *in* Pittsburgh Coal Conference, 15th Annual Meeting, Abstracts with Programs (CD-ROM): Pittsburgh, Pennsylvania, 13 p.

Sholes, M.A., and Daniel J.A., 1992, The Knobloch coal bed, Powder River and Rosebud Counties, Montana: Correlation and petrography, *in* Sholes, M.A., Coal Geology of Montana: Montana Bureau of Mines and Geology, Special Publication 102, p. 105-135.

U.S. Bureau of Land Management, 1975, Resource and potential reclamation evaluation, Otter Creek study site: U.S. Bureau of Land Management EMRIA Report No. 1, 200 p.

Wilde, E.M., (in press), Available coal resources of the Willow Crossing 7.5-minute quadrangle, Rosebud and Powder River counties, Montana: to be published as a Montana Bureau of Mines and Geology Open-File Report.

Wood, G.H., Jr., Kehn, T.M., Carter, M.D., and Culbertson, W.C., 1983, Coal Resource Classification System of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p.

Click here or on this symbol in the toolbar to return.

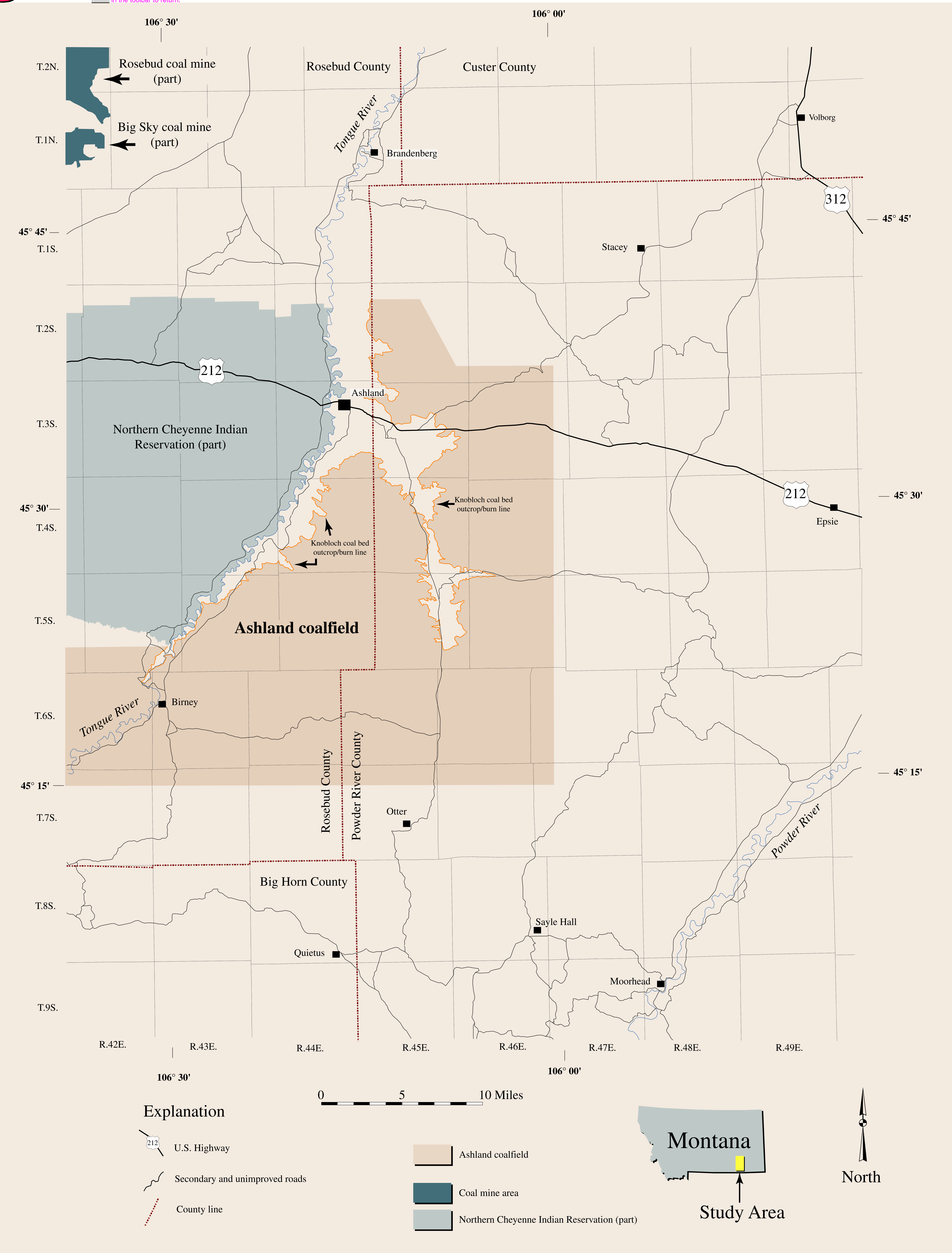

Figure PA-1. Index map showing the Ashland coalfield and vicinity, southeast Montana.

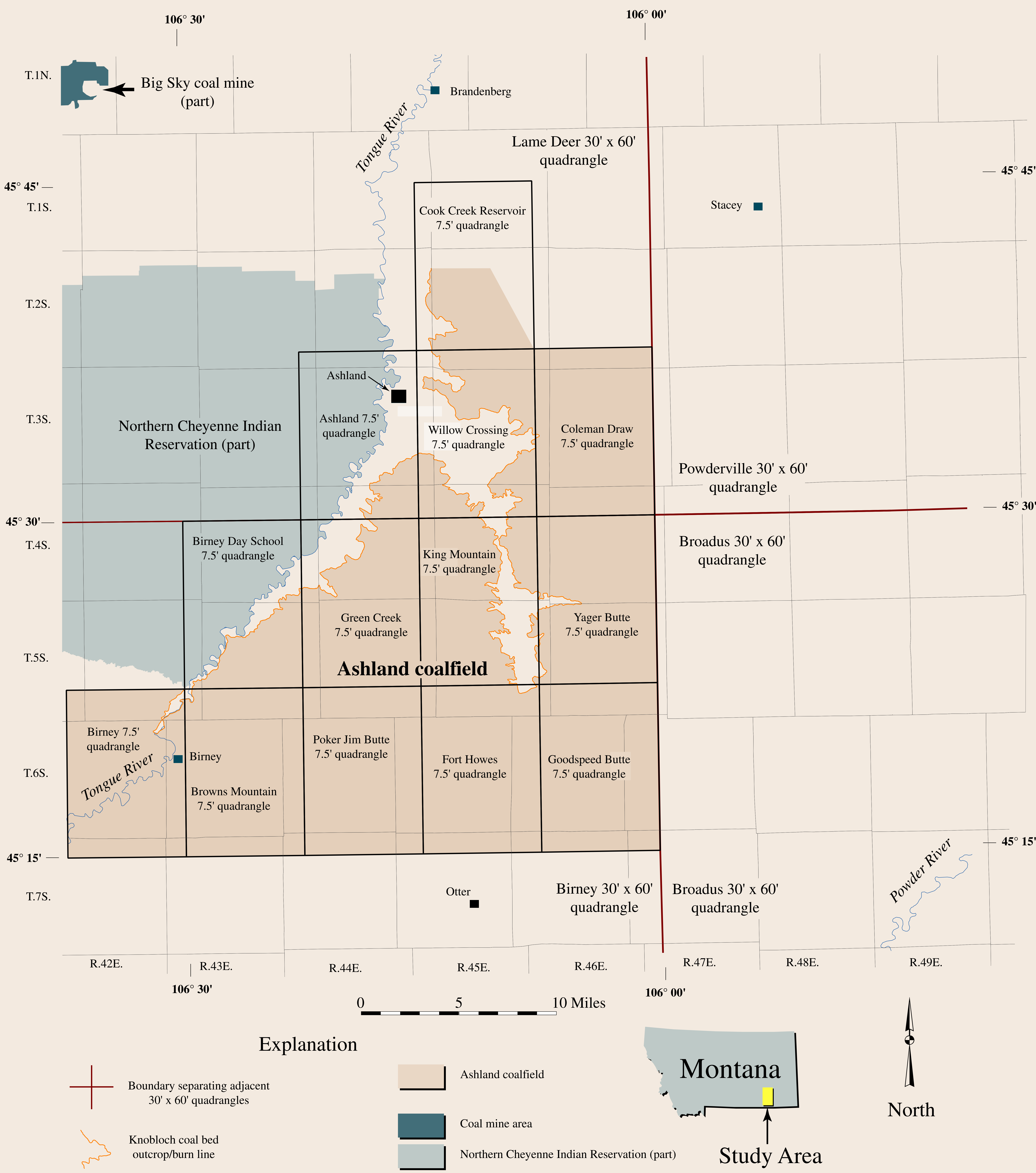

Figure PA-2. Index map showing 7.5' and 30' x 60' quadrangle maps, Ashland coalfield, southeast Montana.

Click here or on this symbol in the toolbar to return.

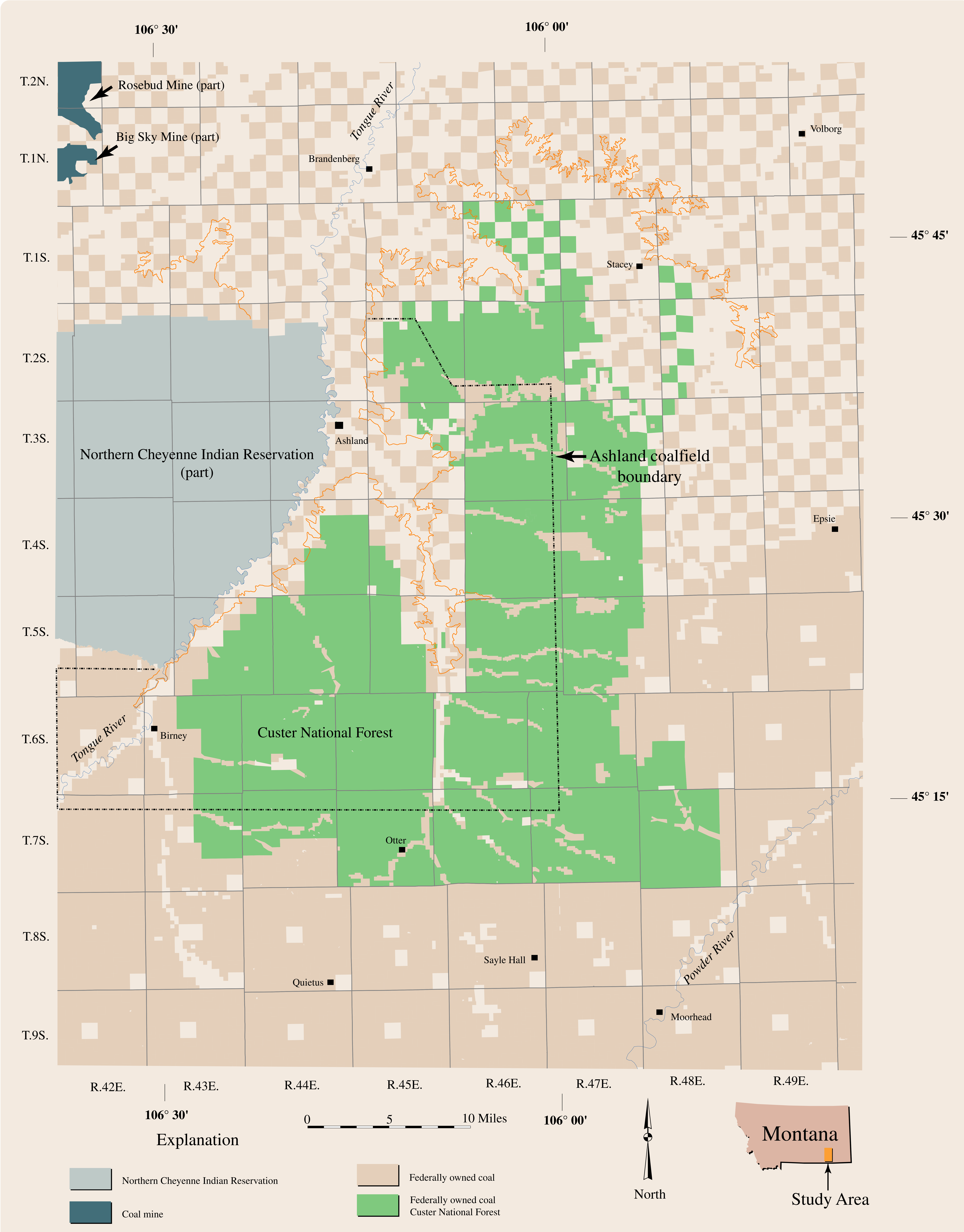

Figure PA-3. Map showing Federally owned coal, Ashland coalfield and vicinity, southeast Montana.

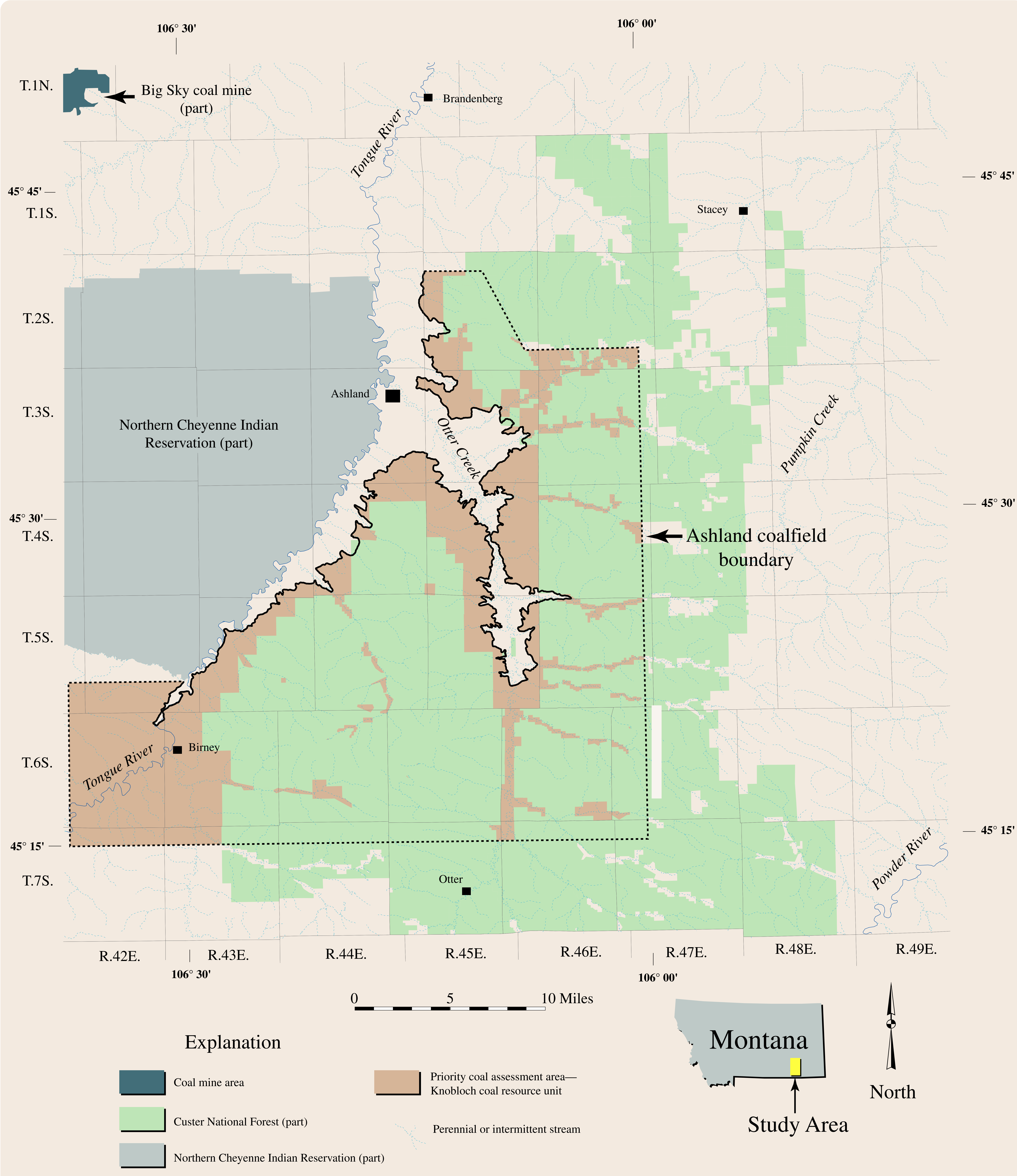

Figure PA-4. Index map showing the priority coal assessment area, Ashland coalfield, southeast Montana.

Click here or on this symbol in the toolbar to return.

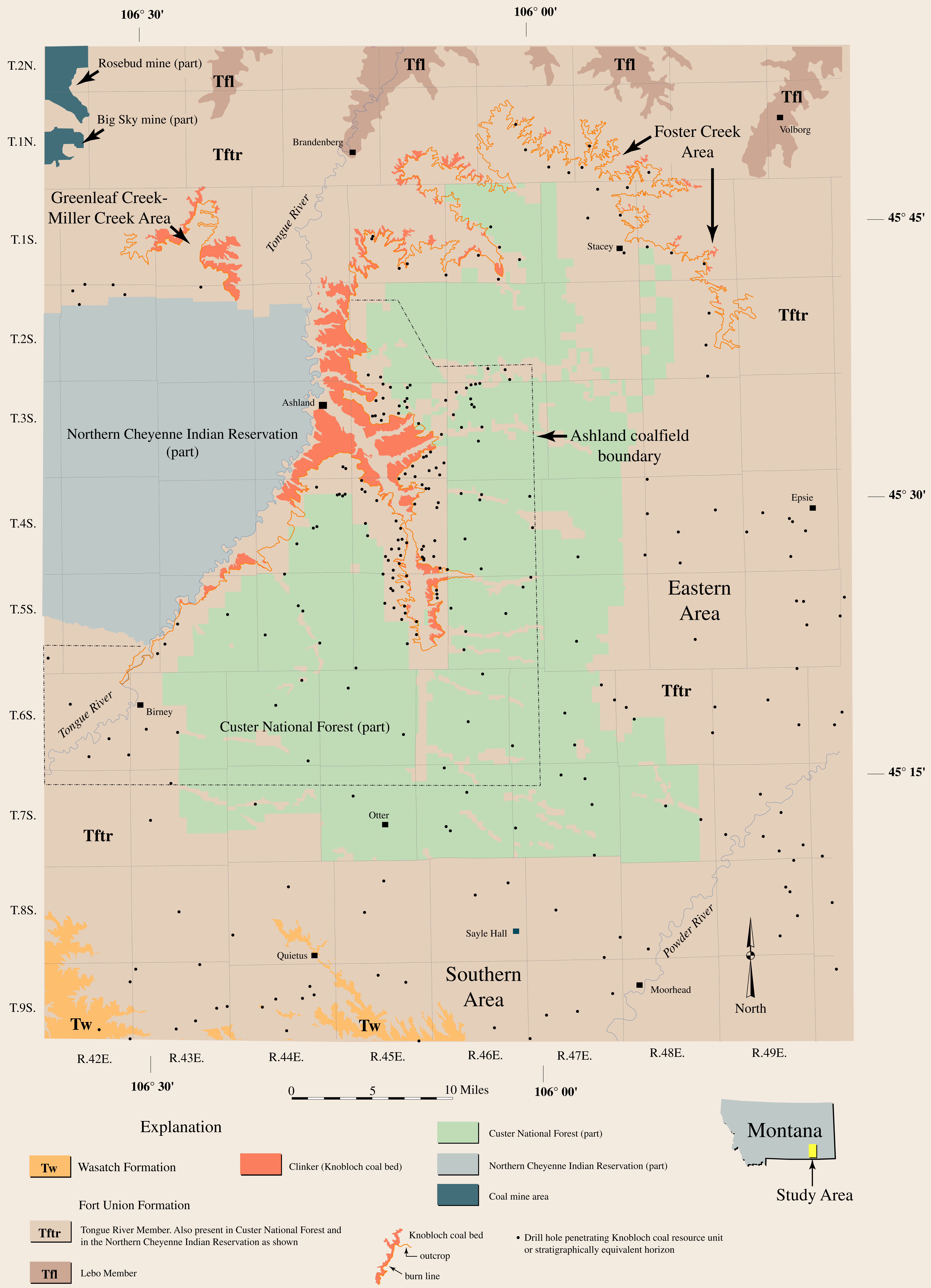

Figure PA-5. Index map showing generalized bedrock geology, drill-hole locations, and the Ashland coalfield boundary, southeast Montana. Geology based on Matson and Blumer (1973), Lewis and Roberts (1976), and Derkey (1986).

Click here or on this symbol in the toolbar to return.

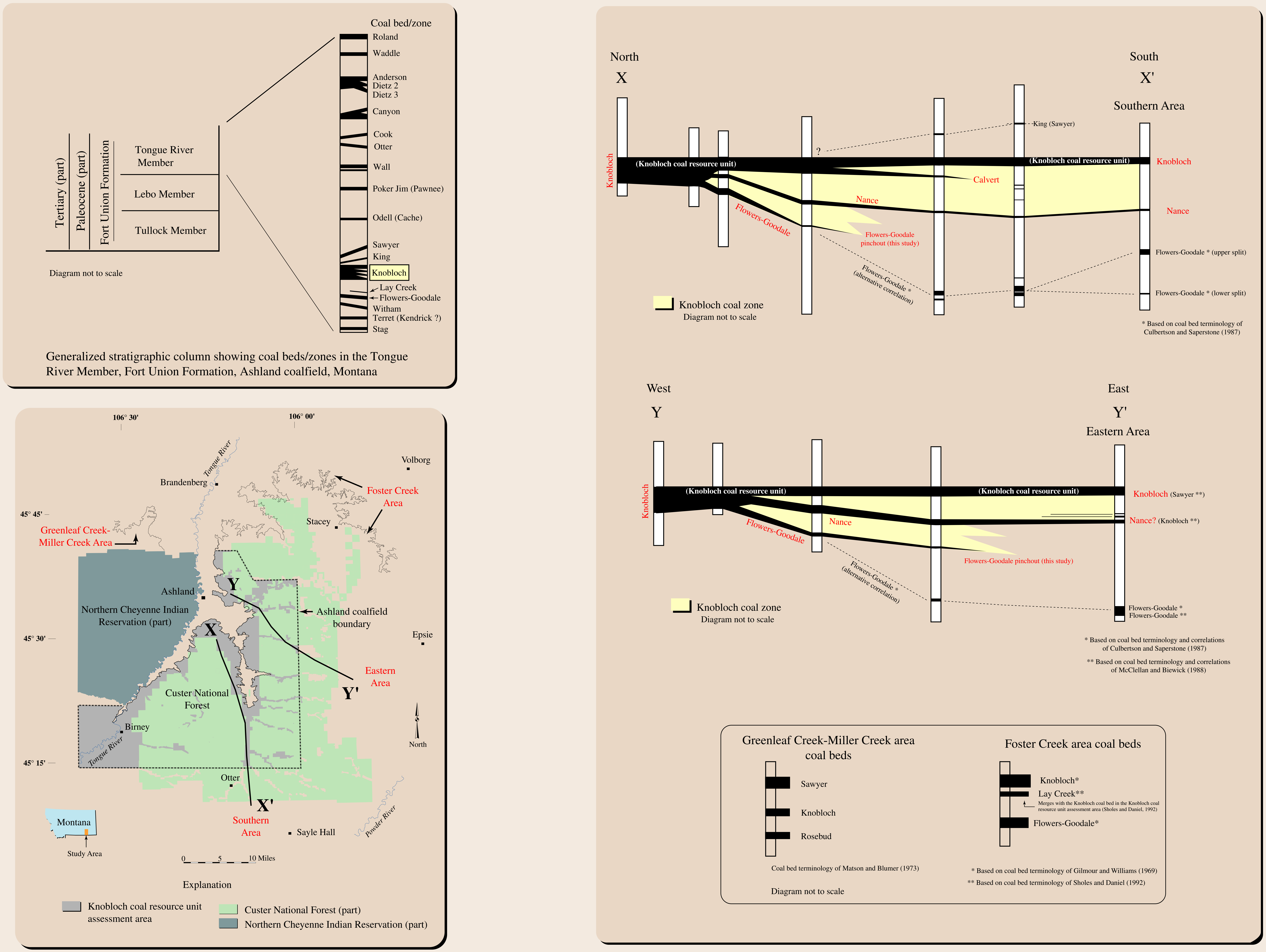

Figure PA-6. Coal-bed terminology applied to the Knobloch coal resource unit and associated coal beds, Ashland coalfield and adjacent areas, southeastern Montana. Terminology modified from Gilmour and Williams (1969), Matson and Blumer (1973), McKay (1976), Culbertson and Saperstone (1987), McClellan and Biewick (1988), and Sholes and Daniel (1992).

Click here or on this symbol
in the toolbar to return.

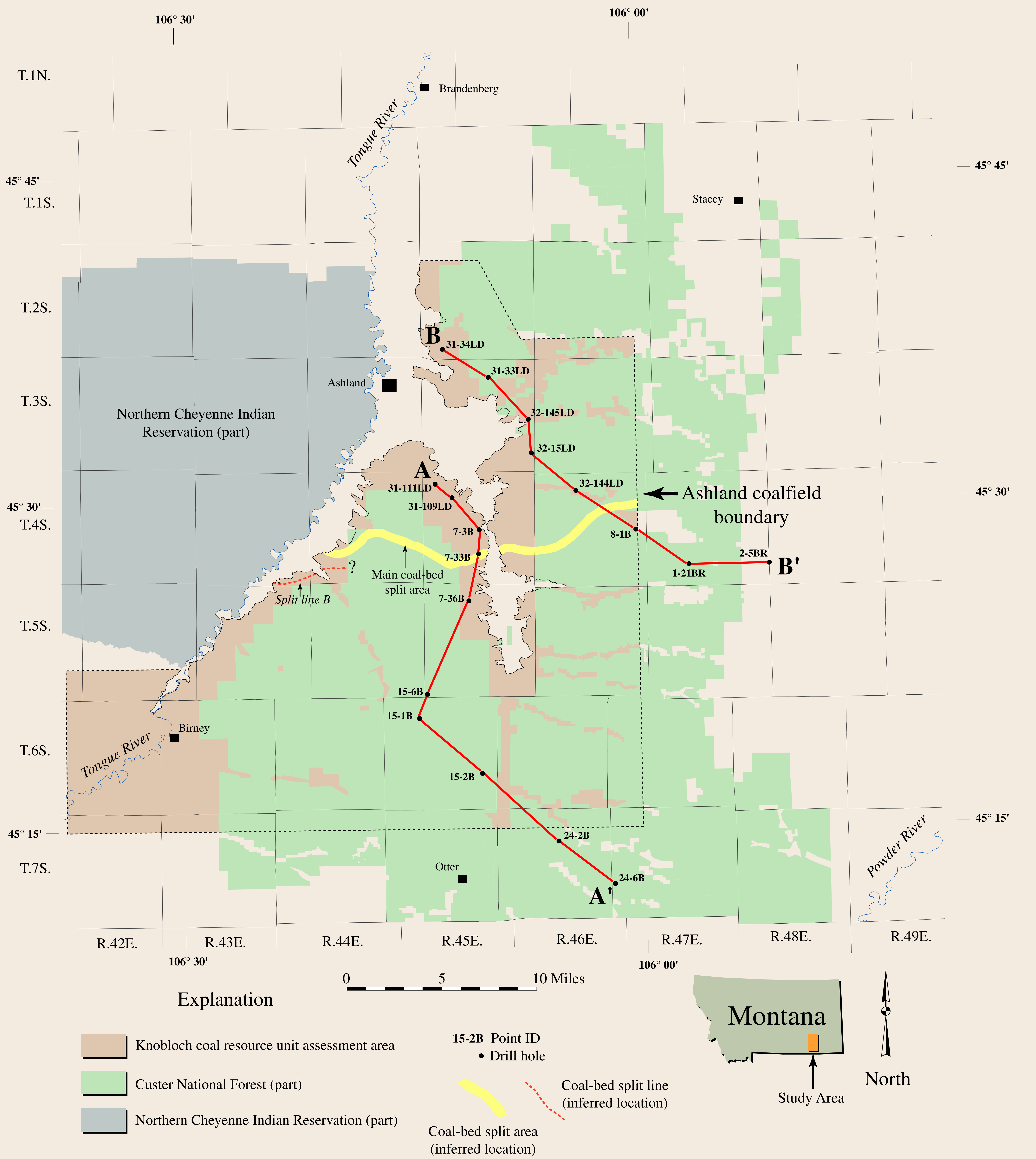

Figure PA-7. Map showing the location of cross sections A-A' and B-B', Ashland coalfield and vicinity, southeast Montana. The locations of the main coal-bed split area and coal-bed split line B are highly inferred and modified from Culbertson and Saperstone (1987).

Click here or on this symbol in the toolbar to return.

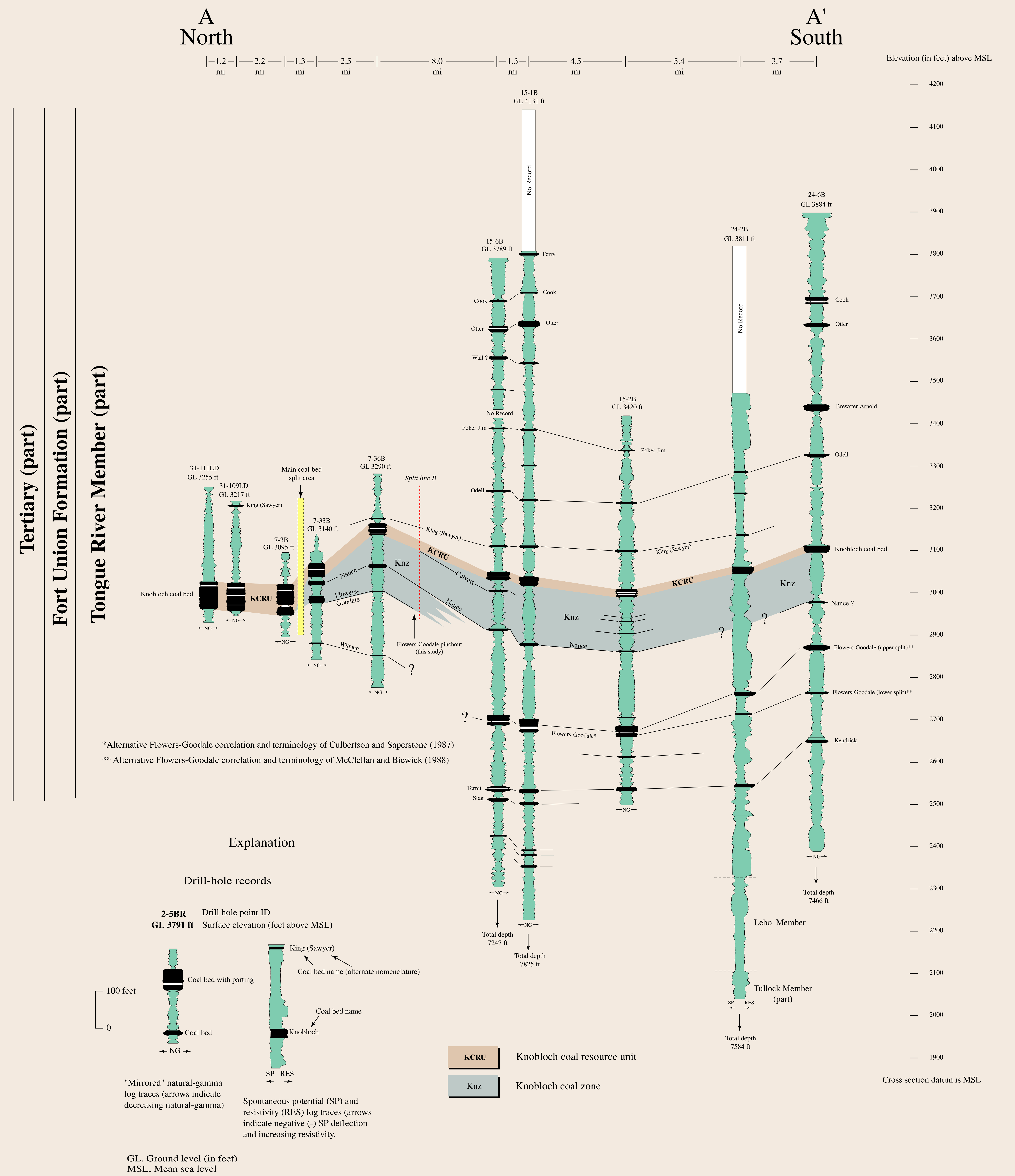

Figure PA-8. North-south cross section A-A' showing proposed coal bed correlations, Ashland coalfield and vicinity, southeast Montana. Coal-bed and coal-zone terminology modified from unpublished drill-hole information (1996) of W.C. Culbertson and L.R.H. Biewick in the National Coal Resources Data System (NCRDS) of the U.S. Geological Survey. Location of the main coal-bed split area and split line B is highly inferred and modified from Culbertson and Saperstone (1987).

Click here or on this symbol in the toolbar to return.

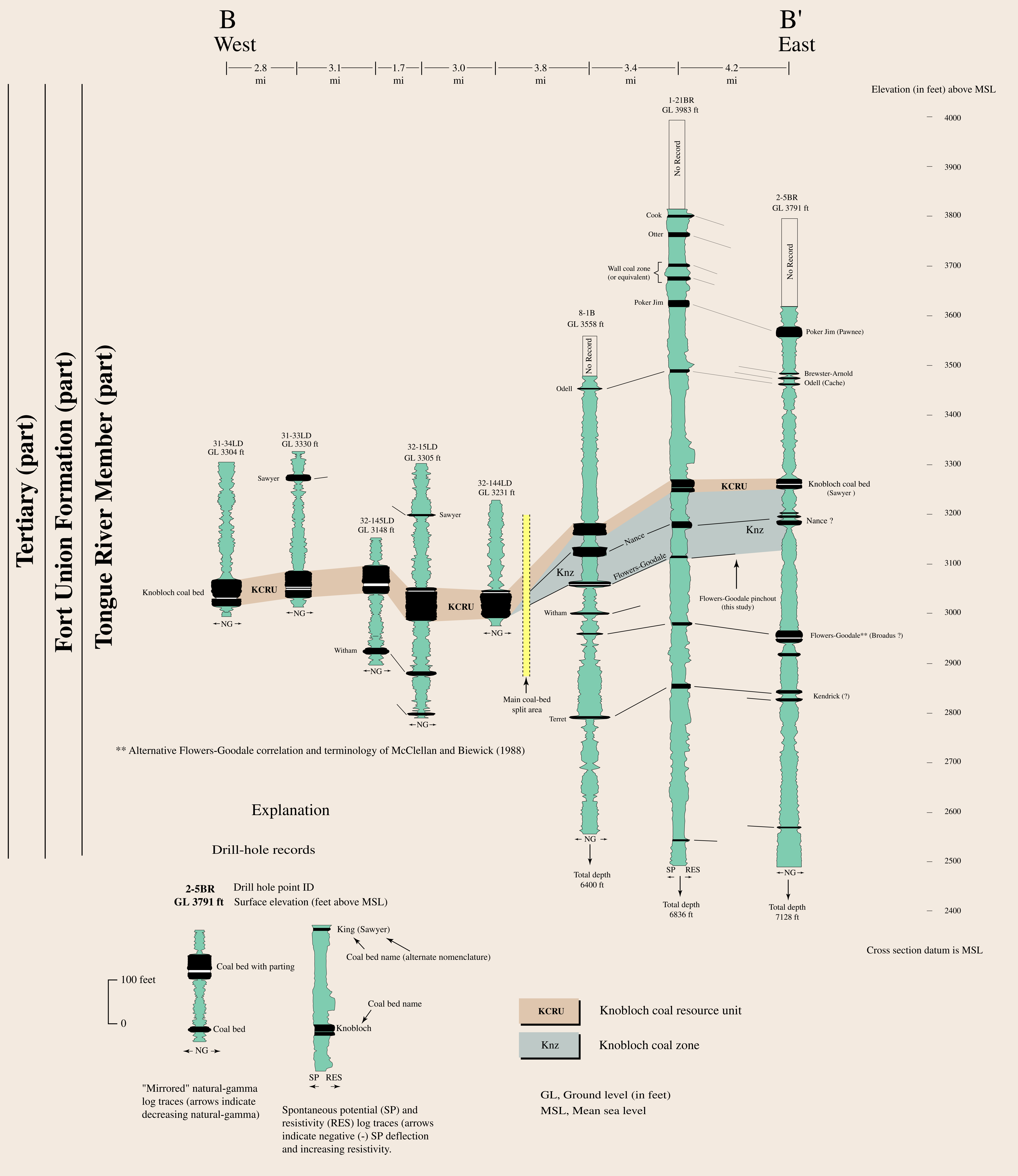

Figure PA-9. West-east cross section B-B' showing proposed coal bed correlations, Ashland coalfield and vicinity, southeast Montana. Coal-bed and coal-zone terminology modified from unpublished drill-hole information (1996) of W.C. Culbertson and L.R.H. Biewick in the National Coal Resources Data System (NCRDS) of the U.S. Geological Survey. Location of the main coal-bed split area is highly inferred and modified from Culbertson and Saperstone (1987).

Click here or on this symbol in the toolbar to return.

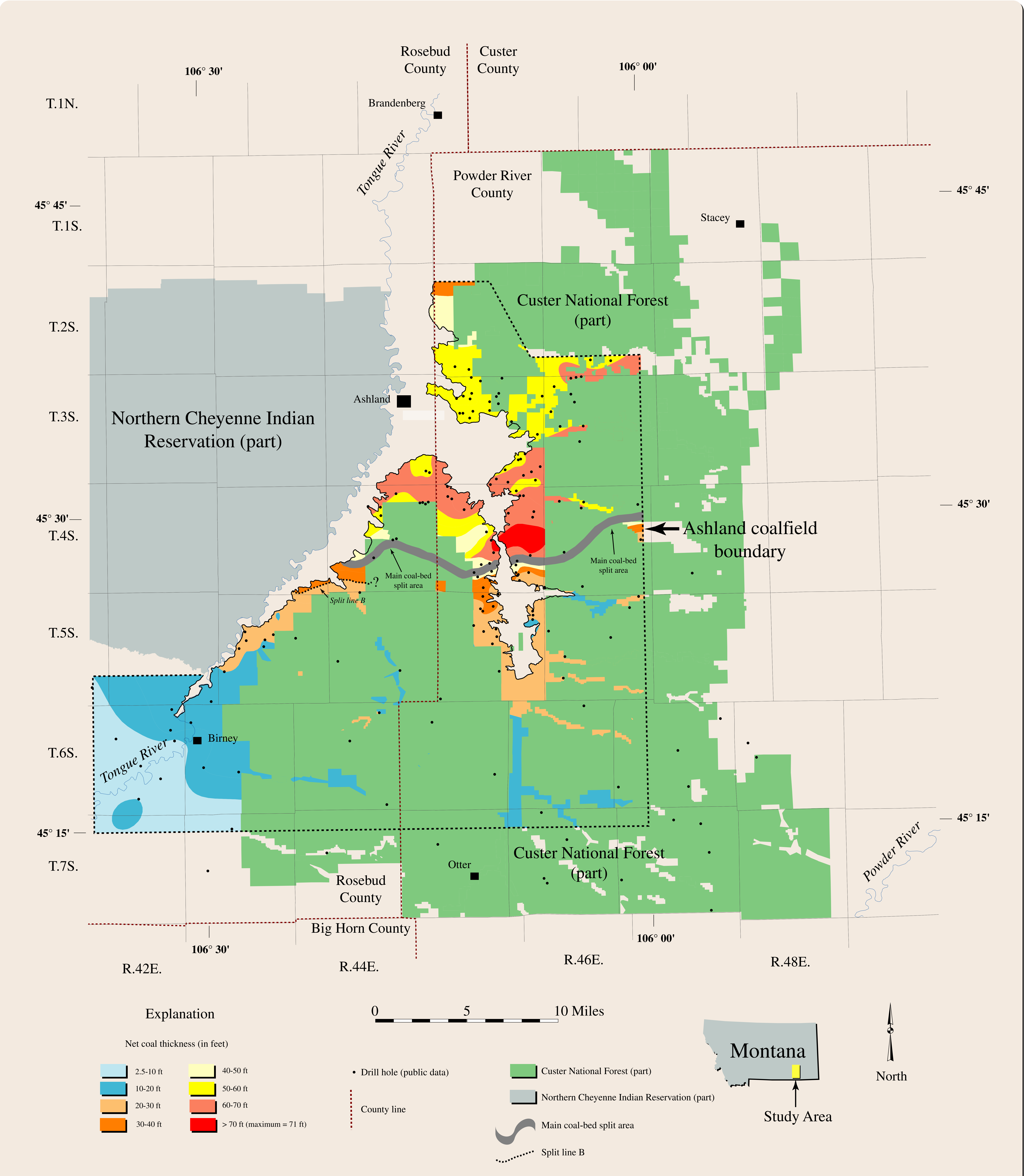

Figure PA-10. Net coal thickness (isopach) map of the Knobloch coal resource unit, Ashland coalfield, southeast Montana.

USGS
science for a changing world

Click here or on this symbol in the toolbar to return.

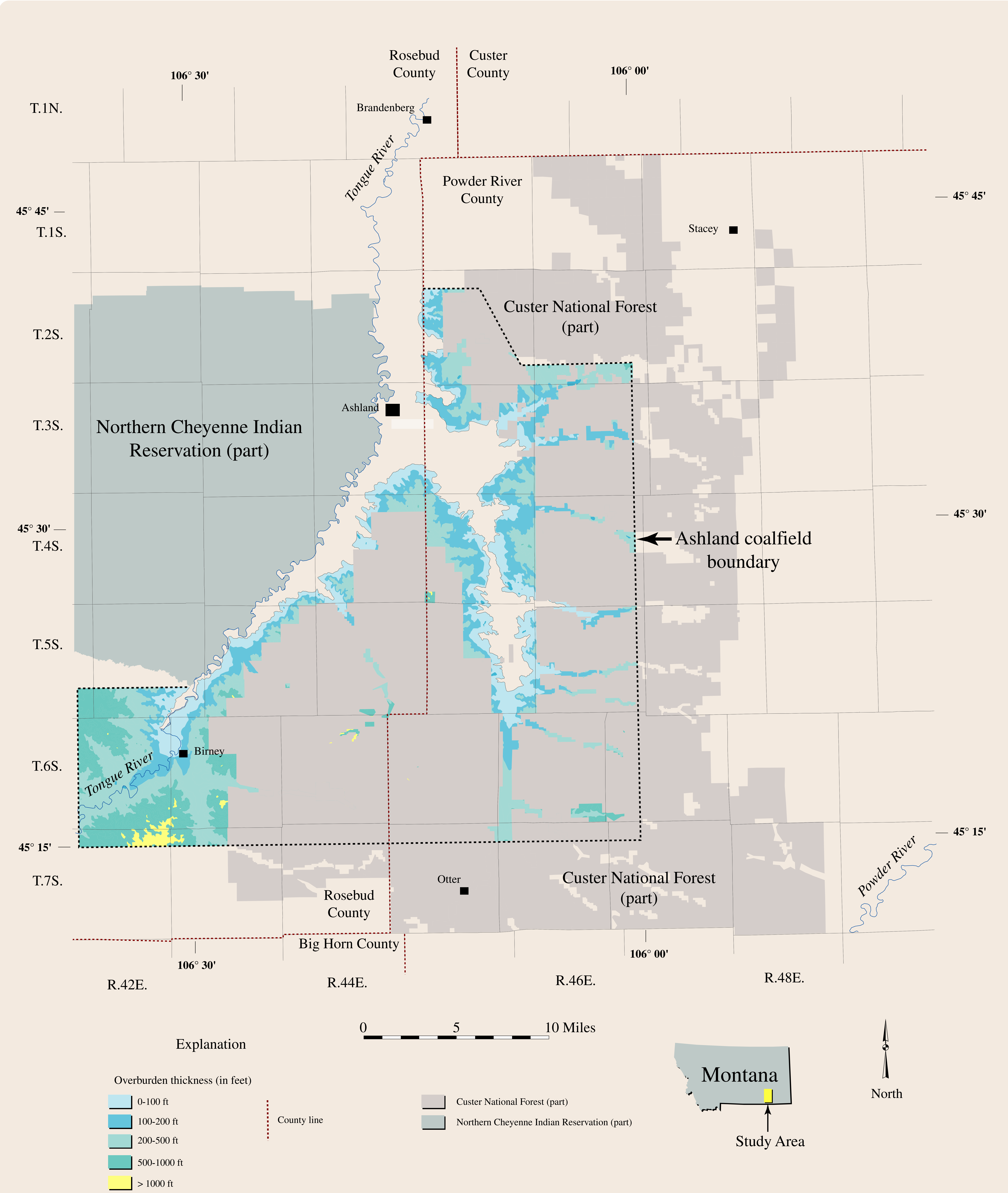

Figure PA-11. Overburden thickness (isopach) map for the Knobloch coal resource unit, Ashland coalfield, southeast Montana.

Click here or on this symbol
in the toolbar to return.

Table PA-1. Estimated net coal resources for the Knobloch coal resource unit reported by county, overburden, net coal thickness, and reliability categories. Resources are reported in millions of short tons (MST) and with two significant figures. Zeros (0) indicate that no coal resources were calculated within those categories. Reported resources do not include areas within Custer National Forest. Columns may not sum correctly because of independent rounding

County	Overburden thickness	Net coal thickness	Reliability categories (distance from data point)				Total
			Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	Total (MST)
POWDER RIVER	0-100 ft	10-20 ft	1.8	7.8	10	0	20
		20-30 ft	33	88	100	0	220
		30-40 ft	23	21	17	0	61
		40-50 ft	20	44	8.4	0	73
		50-100 ft	110	360	140	0	610
	0-100 ft total		190	520	280	0	980
	100-200 ft	10-20 ft	0.27	0	34	2.0	36
		20-30 ft	17	46	52	0	110
		30-40 ft	14	20	18	0	52
		40-50 ft	43	56	49	0	150
		50-100 ft	310	720	260	0.91	1,300
	100-200 ft total		380	840	410	2.9	1,600
	200-300 ft	10-20 ft	0	0	35	0.11	35
		20-30 ft	6.7	14	39	0	59
		30-40 ft	0	11	12	0	23
		40-50 ft	6.7	23	72	0	100
		50-100 ft	170	460	210	0	840
	200-300 ft total		180	510	370	0.11	1,100
	300-400 ft	10-20 ft	0	1.4	37	0	38
		20-30 ft	1.7	5.9	15	1.5	24
		30-40 ft	0	2.2	4.9	0	7.1
		40-50 ft	0	0.67	11	0	12
		50-100 ft	9.3	64	140	0	220
	300-400 ft total		11	75	210	1.5	300

Click here or on this symbol in the toolbar to return.

Table PA-1. Net coal resources, Knobloch coal resource unit—continued.

County	Overburden thickness	Net coal thickness	Reliability categories (distance from data point)				Total (MST)
			Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
POWDER RIVER	400-500 ft	10-20 ft	0	0	16	0	16
		20-30 ft	1.6	0.41	6.0	0.082	8.1
		30-40 ft	0	0	0.29	0	0.29
		40-50 ft	0	0	2.9	0	2.9
		50-100 ft	0	6.0	66	0	72
	400-500 ft total		1.6	6.4	92	0.082	100
	500-1000 ft	10-20 ft	0	2.1	24	0	26
		20-30 ft	0	0	0.74	0	0.74
		40-50 ft	0	0	12	0	12
		50-100 ft	0	0.36	16	0	17
	500-1000 ft total		0	2.4	53	0	55
POWDER RIVER total			770	1,900	1,400	4.6	4,100
ROSEBUD	0-100 ft	5-10 ft	0.19	0.30	0	0	0.48
		10-20 ft	12	56	35	0	100
		20-30 ft	26	61	0	0	87
		30-40 ft	5.7	22	9.8	0	38
		40-50 ft	13	29	12	0	53
		50-100 ft	11	81	130	0	230
	0-100 ft total		68	250	190	0	510
	100-200 ft	2.5-5 ft	0	0.30	0	0	0.3
		5-10 ft	1.1	8.3	7.8	0	17
		10-20 ft	21	53	24	0	98
		20-30 ft	32	39	4.4	0	76
		30-40 ft	2.7	14	0.18	0	17
		40-50 ft	5.2	5.9	0.58	0	12
		50-100 ft	31	82	28	0	140
	100-200 ft total		93	200	64	0	360

Table PA-1. Net coal resources, Knobloch coal resource unit—continued.

County	Overburden thickness	Net coal thickness	Reliability categories (distance from data point) Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	Total (MST)
ROSEBUD	200-300 ft	2.5-5 ft	0.24	0.06	0	0	0.30
		5-10 ft	0.36	8.8	17	0	26
		10-20 ft	9.4	46	59	0	110
		20-30 ft	3.2	17	2.1	0	22
		30-40 ft	2.1	17	0.61	0	20
		40-50 ft	0	0.35	0	0	0.35
		50-100 ft	17	78	15	0	110
	200-300 ft total		32	170	94	0	290
	300-400 ft	2.5-5 ft	0.078	0.56	0.12	0	0.75
		5-10 ft	2.8	9.6	38	0	50
		10-20 ft	4.1	29	61	0	94
		20-30 ft	0.98	11	1.7	0	14
		30-40 ft	0	3.7	2.5	0	6.2
		50-100 ft	4.4	24	3.3	0	32
	300-400 ft total		12	78	110	0	200
	400-500 ft	2.5-5 ft	0.42	1.7	0.74	0	2.9
		5-10 ft	1.9	11	26	0	39
		10-20 ft	1.3	17	60	0	78
		20-30 ft	0	2.9	1.9	0	4.8
		30-40 ft	0	0.44	2.2	0	2.6
		50-100 ft	1.2	9.3	0	0	11
	400-500 ft total		4.8	42	91	0	140
	500-1000 ft	2.5-5 ft	0.10	0.79	0.076	0	0.97
		5-10 ft	1.0	20	120	0.042	140
		10-20 ft	2.3	22	180	4.2	210
		20-30 ft	0.37	2.0	3.0	0	5.4
		30-40 ft	0	0	0.18	0	0.18
		50-100 ft	0	0.66	0	0	0.66
	500-1000 ft total		3.8	45	300	4.2	360

Table PA-1. Net coal resources, Knobloch coal resource unit—continued.

County	Overburden thickness	Net coal thickness	Reliability categories (distance from data point)				Total (MST)
			Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
ROSEBUD	1000-1500 ft	5-10 ft	0	0	20	0	20
		10-20 ft	0	0.16	4.4	0	4.5
		20-30 ft	0	0	2.2	0	2.2
	1000-1500 ft total		0	0.16	26	0	27
ROSEBUD total			210	780	880	4.2	1900
Grand total (MST)			980	2,700	2,300	8.8	6,000

Table PA-2. Net coal resources in the Knobloch coal resource unit reported by 7.5-minute quadrangle. Coal resources are reported in millions of short tons (MST) and with two significant figures. Reported resources do not include areas within Custer National Forest. Column may not sum correctly because of independent rounding

7.5-minute quadrangle	Total (MST)
ASHLAND	330
BIRNEY	620
BIRNEY DAY SCHOOL	200
BROWNS MOUNTAIN	280
COLEMAN DRAW	1,000
COOK CREEK RESERVOIR	300
FORT HOWES	180
GOODSPEED BUTTE	130
GREEN CREEK	220
KING MOUNTAIN	1,000
POKER JIM BUTTE	56
WILLOW CROSSING	1,400
YAGER BUTTE	330
Grand total (MST)	6,000

Click here or on this symbol
in the toolbar to return.

Table PA-3. Net coal resources in the Knobloch coal resource unit reported by county and by Federal coal and surface ownership. Resources within Custer National Forest are not included in the resource tabulation. Coal resources are reported in millions of short tons (MST) and with two significant figures. Column may not sum because of independent rounding

County	Federal ownership	Total (MST)
POWDER RIVER	No Federal coal or surface ownership	1,800
	Federal coal, but no Federal surface ownership	2,100
	Federal coal and Federal surface ownership	200
POWDER RIVER total Federal coal		2,300
POWDER RIVER total		4,100
ROSEBUD	No Federal coal or surface ownership	730
	Federal coal, but no Federal surface ownership	790
	Federal coal and Federal surface ownership	360
ROSEBUD total Federal Coal		1,100
ROSEBUD total		1,900
Total Federal coal		3,400
Grand total (MST)		6,000

Table PA-4. Computations of confidence intervals within reliability categories for the Knobloch coal resource unit, Ashland coalfield, Powder River Basin, Montana. Areas within Custer National Forest are not included in the table. Volume refers to the calculated resource in millions of short tons (MST). NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	55,222,034	168,110,743	225,695,422	1,060,821	450,089,020
Percent of area	12	37	50	0	100
Acres	13,646	41,541	55,771	262	111,219
SD (Standard deviation (in ft) from variogram model)	3.757	4.640	7.020	7.576	NA
Acre feet (Acres x SD)	51,264	192,732	391,488	1,986	NA
Volume standard deviation (in millions of short tons (MST))	9	56	395	4	463
Pseudo *n* (Minimum number of points in the area)	109	37	3	1	NA

Table PA-5. Volume and estimates of uncertainty for resources in the Knobloch coal resource unit, Ashland coalfield, Powder River Basin, Montana with measurement error. Coal resources in the Custer National Forest are not included in the resource tabulation. Volume refers to the calculated resource in millions of short tons (MST). Resources are reported in millions of short tons (MST) with four significant figures

Parameter	Reliability Category				Entire Area
	Measured	Indicated	Inferred	Hypothetical	
Volume (MST)	979.5	2,729	2,285	8.800	6,003
Lower 90% confidence bound (MST)	965.0	2,636	1,636	3.000	5,240
Upper 90% confidence bound (MST)	994.0	2,822	2,934	14.60	6,764