Chapter HN

COAL RESOURCES OF THE HANNA AND CARBON BASINS

By M.S. Ellis,[1] G.L. Gunther,[2] A.M. Ochs,[2] V.V. Cavaroc,[3]
J.H. Schuenemeyer,[1] H.C. Power,[4] G.D. Stricker,[1]
and Dorsey Blake[1]

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

[1] U.S. Geological Survey

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

[3] North Carolina State University, Raleigh, North Carolina

[4] University of Delaware, Newark, Delaware

Contents

Figures

Figures—continued

Tables

Tables—continued

Tables—continued

Tables—continued

COAL RESOURCES—FERRIS 23, 25, 31, 50, AND 65 COAL ZONES, FERRIS COALFIELD, HANNA BASIN, WYOMING

FERRIS COAL ZONES RESOURCE ESTIMATES—AN OVERVIEW

- Coal resources are calculated using the specific gravity of the coal calculated from apparent coal rank, which is based on weight of coal per unit volume, net coal thickness, and areal extent of the coal.

- Resource tables for the Ferris 23, 25, 31, 50, and 65 coal zones in the Ferris coalfield include coal and overburden thickness categories from Wood and others (1983) that are based on apparent coal rank, and additional categories to provide more detail. Resources are also reported by Federal coal and surface ownership categories and by 7.5-minute quadrangle areas for each of the coal zones.

- Following USGS published guidelines (Wood and others, 1983), coal resource estimates are divided into measured, indicated, and inferred categories according to relative abundance and reliability of data.

- Where data are widely spaced, a hypothetical resource is extrapolated.

- Measured resources are tonnage estimates of coal in the coal zone within a radius of 0.25 mi of a control point where the net thickness of coal is measured.

- Indicated resources are tonnage estimates of coal that is within a radius of 0.25-0.75 mi of a control point where the net thickness of the coal is measured.

- Inferred resources are tonnage estimates of coal that is within a radius of 0.75-3 mi of a control point where the net thickness of the coal is measured.

- Hypothetical resources are tonnage estimates of coal that is beyond a radius of 3 mi of a control point where the net thickness of coal is measured.

- These resource categories assume a high to low degree of geologic assurance. A statistical method, which measures levels of uncertainty (confidence limits) for the Ferris 23, 25, 31, 50, and 65 coal resource estimates in the Ferris coalfield, is also included in this study.

- Resource estimates are reported in millions of short tons with two significant figures.

FERRIS COAL ZONES COAL RESOURCES

The assessment units in the Ferris coalfield were investigated as the Ferris 23, 25, 31, 50, and 65 coal zones. Each coal zone has a specific lateral extent (study limit) based on outcrop data, unpublished maps, drill hole data availability and distribution, and extrapolated overburden. Where overburden was very thick and data were scarce, a generalized boundary was drawn along a geographic or cultural feature that was about three miles from the deepest control point(s).

The study areas in the Ferris coalfield were defined as follows. The Ferris 23 study limit (fig. HN-1) is defined by the outer edge of the Seminoe Reservoir to the northwest, the Ferris 23 outcrop from Glass and Roberts (1980) to the south and southwest, and the contact of the Ferris and Hanna Formations to the east from Dobbin and others (1929). The entire study area is about 50,800 acres (20,558 hectares) in size.

The Ferris 25 study limit (fig. HN-2) is defined by the outer edge of the Seminoe Reservoir to the northwest, the Ferris 25 outcrop to the south and southwest from Glass and Roberts (1980), and the contact of the Ferris and Hanna Formations to the east and northeast from Dobbin and others (1929). The entire study area is about 47,900 acres (19,384 hectares) in size.

The Ferris 31 study limit (fig. HN-3) is defined by the Ferris 31 outcrop to the south from Glass and Roberts (1980), the contact of the Ferris and Hanna Formations to the east from Dobbin and others (1929), and the outer edge of the Seminoe Reservoir to the west. The southeastern boundary is generalized to show the approximate extent of the Ferris 23 coal (where the coal appears to pinch out) based on the drill hole data. The entire study area is about 25,600 acres (10,560 hectares) in size.

The Ferris 50 study limit (fig. HN-4) is defined by the Ferris 50 outcrop to the south and southwest from Glass and Roberts (1980), the contact of the Ferris and Hanna Formations to the east and fault lines in the northwest from Dobbin and others (1929). The northeastern extent is a generalized boundary approximately 3 miles from the deepest control points. The entire study area is about 30,200 acres (12,222 hectares) in size.

The Ferris 65 study limit (fig. HN-5) is defined by the Ferris 65 outcrop to the south and west from Glass and Roberts (1980) and the contact of the Ferris and Hanna Formations to the east from Dobbin and others (1929). The northern extent is a generalized boundary approximately 3 miles from the deepest control points in the eastern part of the study area. The generalized boundary extends west and terminates in the northwest to include an area that contains several control points

between two bounding faults. The entire study area is about 19,600 acres (7,932 hectares) in size.

Ferris coal resources were calculated using several software packages and custom programs. Details of the resource calculation methodology are given in Ellis and others (1999, in press).

To calculate the Ferris coal resources, data was compiled in a StratiFact* (GRG Corporation, 1996) relational database. The coal beds to be included in the Ferris 23, 25, 31, 50, and 65 coal zones were correlated in the database and data were initially managed in one data set. Data for each coal zone were down loaded individually and a custom program was used to calculate net coal thickness at each data point (drill hole or measured section) location. From this point on, the data for each coal zone were managed separately.

For each coal zone, net coal thickness and overburden thickness was gridded, and isopach maps were produced using EarthVision* (Dynamic Graphics, Inc., 1997) software. The grids were made using an isopach grid option (special handling of 0 values and terminated data) with grid spacings of 50 x 50 meters.

The spatial parameters for querying coal resources (for example, 7.5-minute quadrangle map area (fig. HN-6) (U.S. Geological Survey National Mapping Division unpublished data, undated), Federal coal and surface ownership (figs. HN-7 through HN-11) (Bureau of Land Management unpublished data, undated), reliability, net coal thickness (figs. HN-1 through HN-5), and overburden categories (figs. HN-12 through HN-16)) were created on individual layers as ARC/INFO* (ESRI, 1998a) polygon coverages. The coverages for each coal zone were unioned to make one polygon coverage for each of the five coal zone study

areas.   These union coverages contained all of the polygons for each coal zone, with many attributes in every polygon. The polygons in the union coverages were edited in ARC/INFO* and ArcView* (ESRI, 1998b).

Coal resources were calculated for each study area using the EarthVision* (EV) volumetrics tool, which calculates tonnages in each polygon in the union coverage using the net coal thickness grid, the area of each polygon, and a conversion factor of 1,770 short tons per acre-ft for subbituminous rank coal (Wood and others, 1983). Data from the EV volumetrics report and the union coverage polygon attribute table for each of the study areas were combined in Excel* (Microsoft, 1997) spreadsheet software. In each of the five Excel spreadsheets, data for polygons containing mine or lease areas or areas of coal less than 2.5 ft in thickness were deleted from the data sets. Resource tables were created using the data from the remaining polygons (tables HN-1 through HN-10). Lease areas may include public and/or State leases in addition to Federal leases. The final resource areas (areas that met all coal resource criteria) were 24,900 acres (10,077 hectares) in size for Ferris 23 (fig. HN-1), 36,900 acres (14,933 hectares) in size for Ferris 25 (fig. HN-2), 18,900 acres (7,649 hectares) for Ferris 31 (fig. HN-3), 24,300 acres (9,834 hectares) in size for Ferris 50 (fig. HN-4), and 16,800 acres (6,799 hectares) in size for Ferris 65 (fig. HN-5).

*Commercial software package

CONFIDENCE LIMITS FOR FERRIS COAL ZONES COAL RESOURCES

A confidence interval is a statistic designed to capture uncertainty associated with a point estimate. In this study we computed 90-percent confidence intervals on the

volume of coal in the Ferris 23, 25, 31, 50, and 65 coal zones in the measured, indicated, inferred, and hypothetical categories.

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 apply 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.

Confidence limits for coal resources of the Ferris 23, 25, 31, 50, 65 coal zones in the Ferris coalfield were calculated by J.H. Schuenemeyer and H.C. Power. The data sets that they used contained net coal measurements from 69 locations for the Ferris 23, 68 locations for the Ferris 25, 14 locations for the Ferris 31, 12 locations for the Ferris 50, and 93 locations for the Ferris 65 coal zones. These data sets only included data points for locations where net coal was greater than or equal to 2.5 ft in thickness (no 0 net coal thickness values) and data that were representative of the entire coal zone (no terminated holes) being represented.

The confidence limits were derived through a complex series of steps. These steps included investigating coal thickness trends and spatial correlation. Ferris 23 and 25 coal zones showed no significant coal thickness trends, therefore coal thickness was used to compute semivariograms, and the semivariograms were fitted to linear models. Parameter estimates for Ferris 23 were sill=40.00 ft^2, nugget=0.00 ft^2, range=2.50 miles, and slope=16.00. Parameter estimates for Ferris 25 were sill=40.00 ft^2, nugget=20.00 ft^2, range=3.00 miles, and slope=8.57. Standard deviations of coal thickness were obtained from the semivariogram models. Ferris

31, 50, and 65 coal zones showed no coal thickness trends or spatial correlations that were statistically significant. The standard deviations of coal thickness were obtained directly from the data.

Differences in point densities were compensated for by calculating sample size, called a pseudo n, within each reliability category and calculating the variability of volume for each of the reliability categories. Volumes of Ferris 23, 25, 31, 50, and 65 coal were then calculated at a 90-percent confidence interval with measurement error. Sample sizes for the Ferris 31, 50, and 65 coal zones were small, therefore the computed confidence limits are not statistically meaningful. Some of the parameters used and results of the confidence interval calculations are shown in tables HN-11 through HN-15. A detailed description of the methodology used is given in Schuenemeyer and Power (in press) and in Ellis and others (1999, in press).

COAL RESOURCES—HANNA 77, 78, 79, AND 81 COAL ZONES, HANNA COALFIELD, HANNA BASIN, WYOMING

HANNA COAL ZONES RESOURCE ESTIMATES—AN OVERVIEW

- Coal resources are calculated using the specific gravity of the coal calculated from apparent coal rank, which is the weight of coal per unit volume, net coal thickness, and areal extent of the coal.

- Resource tables for the Hanna 77, 78, 79, and 81 coal zones in the Hanna coalfield include coal and overburden thickness categories from Wood and others (1983) that are based on apparent coal rank, and additional categories to provide more detail. Resources are also reported by Federal coal and surface ownership categories and by 7.5-minute quadrangle areas for each of the coal zones.

- Following USGS published guidelines (Wood and others, 1983), coal resource estimates are divided into measured, indicated, and inferred categories according to relative abundance and reliability of data.

- Where data are widely spaced, a hypothetical resource is extrapolated.

- Measured resources are tonnage estimates of coal in the coal zone within a radius of 0.25 mi of a control point where the net thickness of coal is measured.

- Indicated resources are tonnage estimates of coal that is within a radius of 0.25-0.75 mi of a control point where the net thickness of the coal is measured.

- Inferred resources are tonnage estimates of coal that is within a radius of 0.75-3 mi of a control point where the net thickness of the coal is measured.

- Hypothetical resources are tonnage estimates of coal that is beyond a radius of 3 mi of a control point where the net thickness of coal is measured.

- These resource categories assume a high to low degree of geologic assurance. A statistical method, which measures levels of uncertainty (confidence limits) for the Hanna 77, 78, 79, and 81 coal resource estimates in the Hanna coalfield, is also included in this study.

- Resource estimates are reported in millions of short tons with two significant figures.

HANNA COAL ZONES COAL RESOURCES

The assessment units in the Hanna coalfield were investigated as the Hanna 77, 78, 79, and 81 coal zones. Each coal zone has a specific lateral extent (study limit) based on outcrop data, unpublished maps, drill hole data availability and distribution, and extrapolated overburden. Where overburden was very thick and data were scarce, a generalized boundary was drawn along a geographic or cultural feature that was about three miles from the deepest control point(s). The study areas in the Hanna coalfield were defined as follows: The Hanna 77 study limit (fig. HN-17) is defined by the Medicine Bow River along the northern margin and the Hanna 77 coal outcrop from Dobbin and others (1929). The entire study area is about 38,100 acres (15,519 hectares) in size. The Hanna 78 study limit (fig. HN-18) is defined by the Medicine Bow River along the northern margin and the Hanna 78 coal outcrop from Dobbin and others (1929). The entire study area is about 36,100 acres (14,609 hectares) in size. The Hanna 79 study limit (fig. HN-

19) is defined by the Medicine Bow River along the northern margin and the Hanna 79 outcrop from Dobbin and others (1929). The entire study area is about 27,500 acres (11,129 hectares) in size. The Hanna 81 study limit (fig. HN-20) is defined by the Medicine Bow River along the northern margin and the Hanna 81 outcrop from Dobbin and others (1929). The entire study area is about 25,800 acres (10,441 hectares) in size.

Hanna coal resources were calculated using several software packages and custom programs. Details of the resource calculation methodology are given in Ellis and others (1999, in press). To calculate the Hanna coal resources, data was compiled in a StratiFact* (GRG Corporation, 1996) relational database. Coal beds to be included in the Hanna 77, 78, 79, and 81 coal zones were correlated in the database. Data were initially managed in one data set. Data for each coal zone were downloaded individually. A custom program was used to calculate net coal thickness at each data point (drill hole or measured section) location. From this point on, data for each coal zone were managed separately.

For each coal zone, net coal thickness and overburden thickness were gridded, and isopach maps were produced using EarthVision* (Dynamic Graphics, Inc., 1997) software. The grids were made using an isopach grid option (special handling of 0 values and terminated data) with grid spacings of 50 x 50 meters.

The spatial parameters for querying coal resources (for example, 7.5-minute quadrangle map (fig. HN-21) area (U.S. Geological Survey National Mapping Division unpublished data, undated), Federal coal and surface ownership (fig. HN-22 through HN-25) (Bureau of Land Management unpublished data, undated), reliability, net coal thickness (figs. HN-17 through HN-20), and overburden categories (figs. HN-26 through HN-29)) were created on individual layers as ARC/INFO* (ESRI, 1998a) polygon coverages. The coverages for each coal zone

were unioned to make one polygon coverage for each of the four study areas. These union coverages contained all of the polygons for each coal zone, with many attributes in every polygon. The polygons in the union coverages were edited in ARC/INFO* and ArcView* (ESRI, 1998b).

Coal resources were calculated for each study area using the EarthVision* (EV) volumetrics tool, which calculates tonnages in each polygon in the union coverage using the net coal thickness grid, the area of each polygon, and a conversion factor of 1,770 short tons per acre-ft for subbituminous rank coal (Wood and others, 1983). Data from the EV volumetrics report and the union coverage polygon attribute table for each of the study areas were combined in Excel* (Microsoft, 1997) spreadsheet software. In each of the five Excel spreadsheets, data for polygons containing mine or lease areas or areas of net coal less than 2.5 ft in thickness were deleted from the data sets. Resource tables were created using the data from the remaining polygons (tables HN-16 through HN-23). Lease areas may include public and/or state leases in addition to Federal leases. The final resource areas (areas that met all coal resource criteria) were about 32,400 acres (13,112 hectares) in size for Hanna 77 (fig. HN-17), about 30,900 acres (12,505 hectares) in size for Hanna 78 (fig. HN-18), about 24,100 acres (9,753 hectares) in size for Hanna 79 (fig. HN-19), and 21,700 acres (8,782 hectares) in size for Hanna 81 (fig. HN-20).

*Commercial software package

CONFIDENCE LIMITS FOR HANNA COAL ZONES COAL RESOURCES

A confidence interval is a statistic designed to capture uncertainty associated with a point estimate. In this study we computed 90-percent confidence intervals on the

volume (total resource in millions of short tons) of coal in the Hanna 77, 78, 79, and 81 coal zones in the measured, indicated, inferred, and hypothetical categories.

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 apply 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.

Confidence limits for coal resources of the Hanna 77, 78, 79, and 81 coal zones in the Hanna Basin were calculated by J.H. Schuenemeyer and H.C. Power. The data sets that they used contained net coal measurements from 74 locations for Hanna 77, 217 locations for Hanna 78, 117 locations for Hanna 79, and 108 locations for Hanna 81. These data sets only included locations that contained Ferris coal in each of the individual coal zones (no 0 values) and data that were representative of the entire coal zones (no terminated holes). Each data set was studied separately.

The confidence limits were derived through a complex series of steps. These steps included investigating coal thickness trends and spatial correlation. Neither the trends nor the spatial correlations in the coal zones were found to be statistically significant. Standard deviations of coal thickness for each coal zone were obtained from the data directly. Volumes of Hanna 77, 78, 79, and 81 coal were calculated at a 90-percent confidence interval with measurement error. Some of the parameters used and results of the confidence interval calculations are shown in tables HN-24 through HN-27. A detailed description of the methodology used is

given in Schuenemeyer and Power (in press) and in Ellis and others (1999, in press).

COAL RESOURCES—JOHNSON-107 COAL ZONE, SOUTH CARBON COALFIELD, CARBON BASIN, WYOMING

JOHNSON-107 COAL ZONE RESOURCE ESTIMATES—AN OVERVIEW

- Coal resources are calculated using the specific gravity of the coal calculated from apparent coal rank, which is the weight of coal per unit volume, net coal thickness, and areal extent of the coal.

- Resource tables for the Johnson-107 coal zone in the South Carbon coalfield include coal and overburden thickness categories from Wood and others (1983) that are based on apparent coal rank, and additional categories to provide more detail. Resources are also reported by Federal coal and surface ownership categories and by 7.5-minute quadrangle areas.

- Following USGS published guidelines (Wood and others, 1983), coal resource estimates are divided into measured, indicated, and inferred categories according to relative abundance and reliability of data.

- Measured resources are tonnage estimates of coal in the coal zone within a radius of 0.25 mi of a control point where the net thickness of coal is measured.

- Indicated resources are tonnage estimates of coal that is within a radius of 0.25-0.75 mi of a control point where the net thickness of the coal is measured.

- Inferred resources are tonnage estimates of coal that is within a radius of 0.75-3 mi of a control point where the net thickness of the coal is measured.

- These resource categories assume a high to low degree of geologic assurance. A statistical method, which measures levels of uncertainty (confidence limits) for Johnson-107 coal resource estimates in the South Carbon coalfield, is also included in this study.

- Resource estimates are reported in millions of short tons with two significant figures.

JOHNSON-107 COAL ZONE COAL RESOURCES

The lateral extent (study limit) of the Johnson-107 coal zone is defined by the outcrop of the Johnson coal bed as defined by Dobbin and others (1929) to the south and the zero net coal thickness isopach line in the northwest and north central area. The northeastern area was defined by a generalized boundary along a three-mile buffer from the data locations. The entire study area is about 19,400 acres (7,851 hectares) in size.

Johnson-107 coal resources were calculated using several software packages and custom programs. Details of the resource calculation methodology are given in Ellis and others (1999, in press).

To calculate the Johnson-107 coal resources, data was compiled in a StratiFact* (GRG Corporation, 1996) relational database. The beds included in the Johnson-107 coal zone, the Johnson, Finch, C106, and C107 coal beds, were then correlated in the database. A custom program was used to calculate net coal thickness of coal in the Johnson-107 coal zone at each data point (drill hole or measured section) location.

The net coal thickness and overburden thickness were gridded, and isopach maps were produced using EarthVision* (Dynamic Graphics, Inc., 1997) software. The

grids were made using an isopach grid option (special handling of 0 values and terminated data) with grid spacings of 50 x 50 meters.

The spatial parameters for querying coal resources (for example, 7.5-minute quadrangle (fig. HN-30) map area (U.S. Geological Survey National Mapping Division, unpublished data, undated), Federal coal and surface ownership (fig. HN-31) (Bureau of Land Management, unpublished data, undated), reliability, net coal thickness (fig. HN-32), and overburden categories (fig. HN-33)) were created on individual layers as ARC/INFO* (ESRI, 1998a) polygon coverages. The coverages were unioned to make one polygon coverage with many attributes for each polygon. The polygons in the union coverage were edited in ARC/INFO* and ArcView* (ESRI, 1998b).

Coal resources were calculated using the EarthVision* volumetrics tool, which calculates tonnages in each union coverage polygon using the net coal thickness grid, the area of each polygon, and a conversion factor of 1,770 short tons per acre-ft for subbituminous rank coal (Wood and others, 1983). Data from the EV volumetrics report and the union coverage polygon attribute table were combined in Excel* (Microsoft, 1997) spreadsheet software. Data for polygons containing mine or lease areas (fig. HN-32) or areas of net coal less than 2.5 ft thick were deleted from the data set. Lease areas may include public and/or State leases in addition to Federal leases. Resource tables were created using data from the remaining polygons (tables HN-28 and HN-29). The final resource area (fig. HN-32) (area that met all coal resource criteria) was about 14,700 acres (5,949 hectares) in size.

*Commercial software package

CONFIDENCE LIMITS FOR JOHNSON-107 COAL ZONE COAL RESOURCES

A confidence interval is a statistic designed to capture uncertainty associated with a point estimate. In this study we computed 90-percent confidence intervals on the volume (total resource in millions of short tons) of coal in the Johnson-107 coal zone in the measured, indicated, and inferred categories.

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 apply 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.

Confidence limits for coal resources of the Johnson-107 coal zone in the South Carbon coalfield were calculated by J.H. Schuenemeyer and H.C. Power. The data set that they used contained net coal measurements from 35 locations. This data set only included data points for locations where net coal was greater than or equal to 2.5 ft in thickness (no 0 net coal thickness values) and data that were representative of the entire coal zone (no terminated holes).

The confidence limits were derived through a complex series of steps. These steps included modeling coal thickness trends and removing the coal thickness trends using a nonparametric regression algorithm called loess (with span=0.5). Spatial correlation, as determined from the semivariogram of residual thickness, was negligible. Standard deviation of coal thickness was computed from residual thickness. Differences in point densities were compensated for by calculating

sample size, called a pseudo *n*, within each reliability category and calculating the variability of volume for each of the reliability categories. The estimated pseudo *n* for the inferred category was less than one, thus the uncertainty estimates are not statistically meaningful. Volumes of Johnson-107 coal were then calculated at a 90-percent confidence interval with measurement error. Some of the parameters used and results of the confidence interval calculations are shown in tables HN-30 and HN-31. A detailed description of the methodology used is given in Schuenemeyer and Power (in press) and in Ellis and others (1999, in press).

REFERENCES CITED

Dobbin, C.E., Bowen, C.F., and Hoots, H.W., 1929, Geology and coal and oil and gas resources of the Hanna and Carbon Basins, Carbon County, Wyoming: U.S. Geological Survey Bulletin 804, Plate 27.

Dynamic Graphics, Inc., 1997, EarthVision, v.4, 1015 Atlantic Ave., Alameda, CA 94501.

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 (digital version available at http://greenwood.cr.usgs.gov/pub/open-file-reports/ofr-98-0789-a/).

Ellis, M.S., Gunther, G.L., Flores, R.M. Stricker, G.D., and Ochs, A.M., in press, Preliminary report on methodolgy for calculating coal resources of the Wyodak-Anderson coal zone in the Powder River Basin, Wyoming and Montana, U.S. Geological Survey Open-File Report 98-789B.

ESRI-Environmental Systems Research Institute, Inc., 1998, ARC/INFO, v. 7.1.1: Environmental Systems Research Institute, Inc., 380 New York Street, Redlands, CA 92373, USA.

_____ 1998, ArcView, v.3.0a: Environmental Systems Research Institute, Inc., 380 New York Street, Redlands, CA 92373, USA.

Glass, G.B. and Roberts, J.T., 1980, Coals and coal-bearing rocks of the Hanna
coalfield, Wyoming: Geological Survey of Wyoming Report of
Investigations No. 11.

GRG Corporation, 1996, StratiFact, relational database software, v. 4.5: GRG
Corporation, 4175 Harlan Street, Wheatridge, CO 80033-5150, USA.

Microsoft, 1997, Excel spreadsheet software, v. Office 97: Microsoft Corporation,
1 Microsoft Way, Redman, WA 98052.

Schuenemeyer, J. H. and Power H., in press, Uncertainty estimation for resource
assessment—An application to coal: Mathematical Geology.

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.
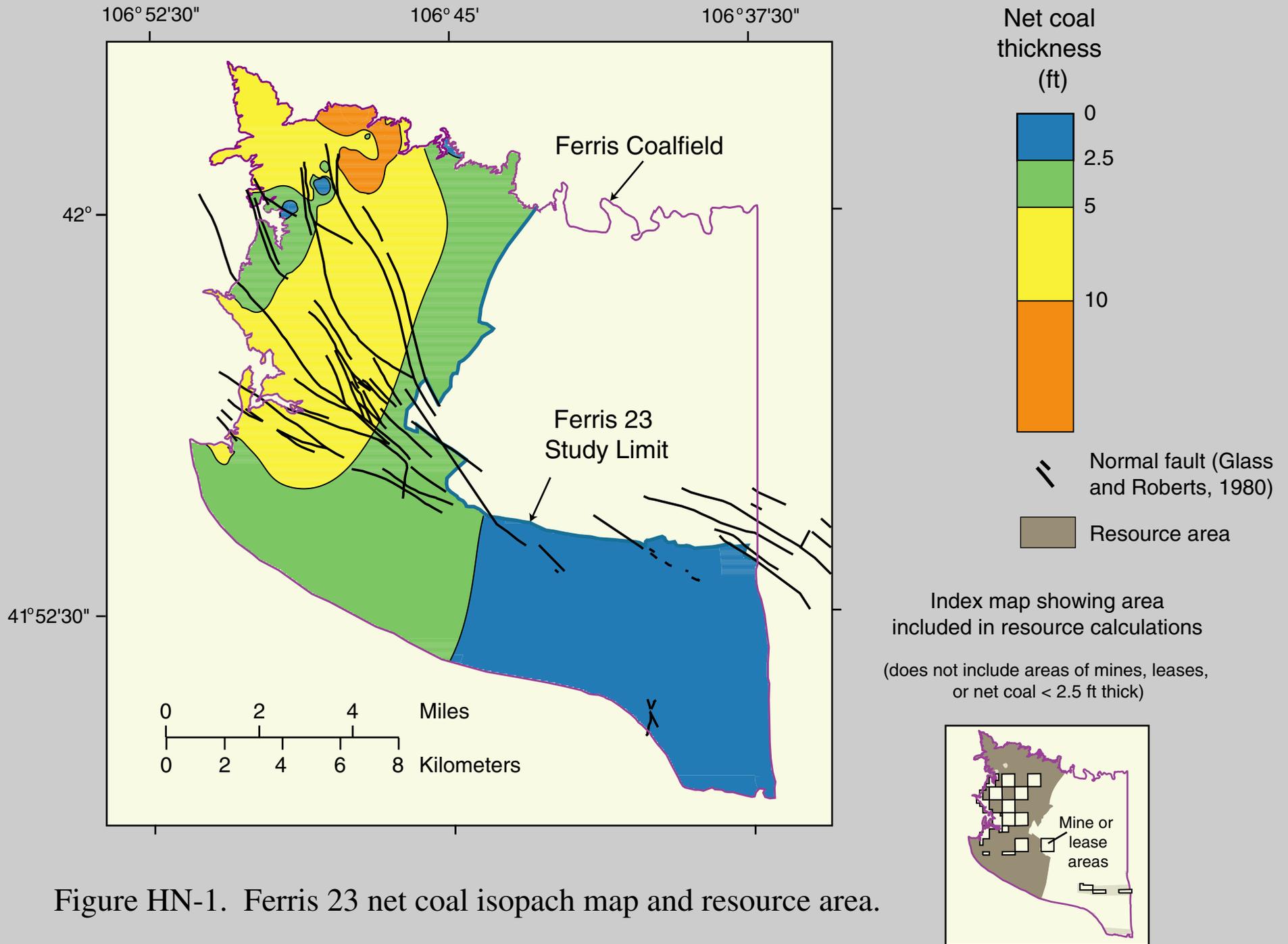
Figure HN-1. Ferris 23 net coal isopach map and resource area.
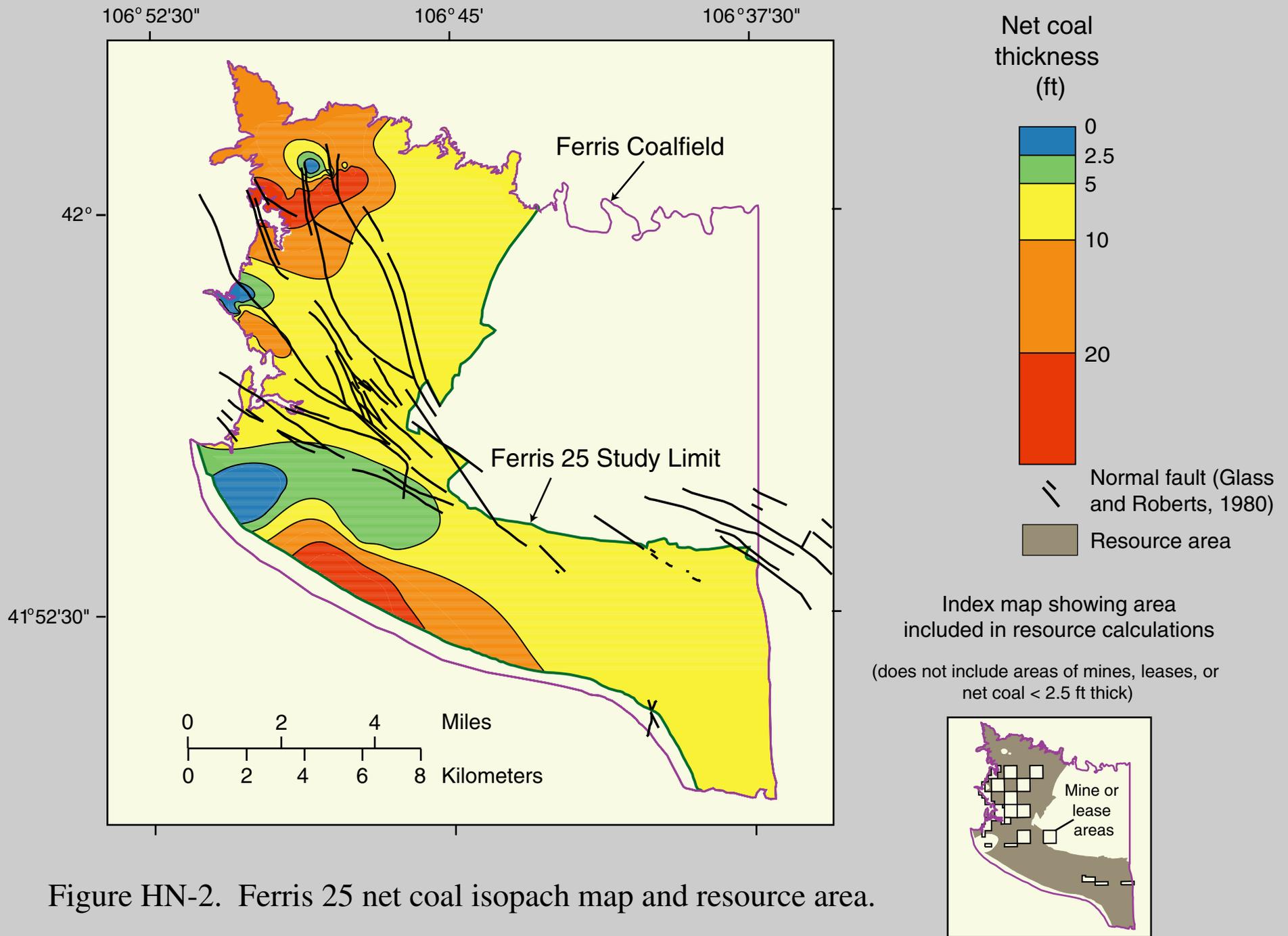
Figure HN-2. Ferris 25 net coal isopach map and resource area.

Net coal thickness (ft)

0
2.5
5
10
20

Normal fault (Glass and Roberts, 1980)

Resource area

Ferris Coalfield

Ferris 31 Study Limit

0   2   4   Miles

0   2   4   6   8   Kilometers

106° 52'30"

106° 45'

106° 37'30"

42°

41° 52'30"

Index map showing area included in resource calculations

(does not include areas of mines, leases, or net coal < 2.5 ft thick)

Mine or lease areas
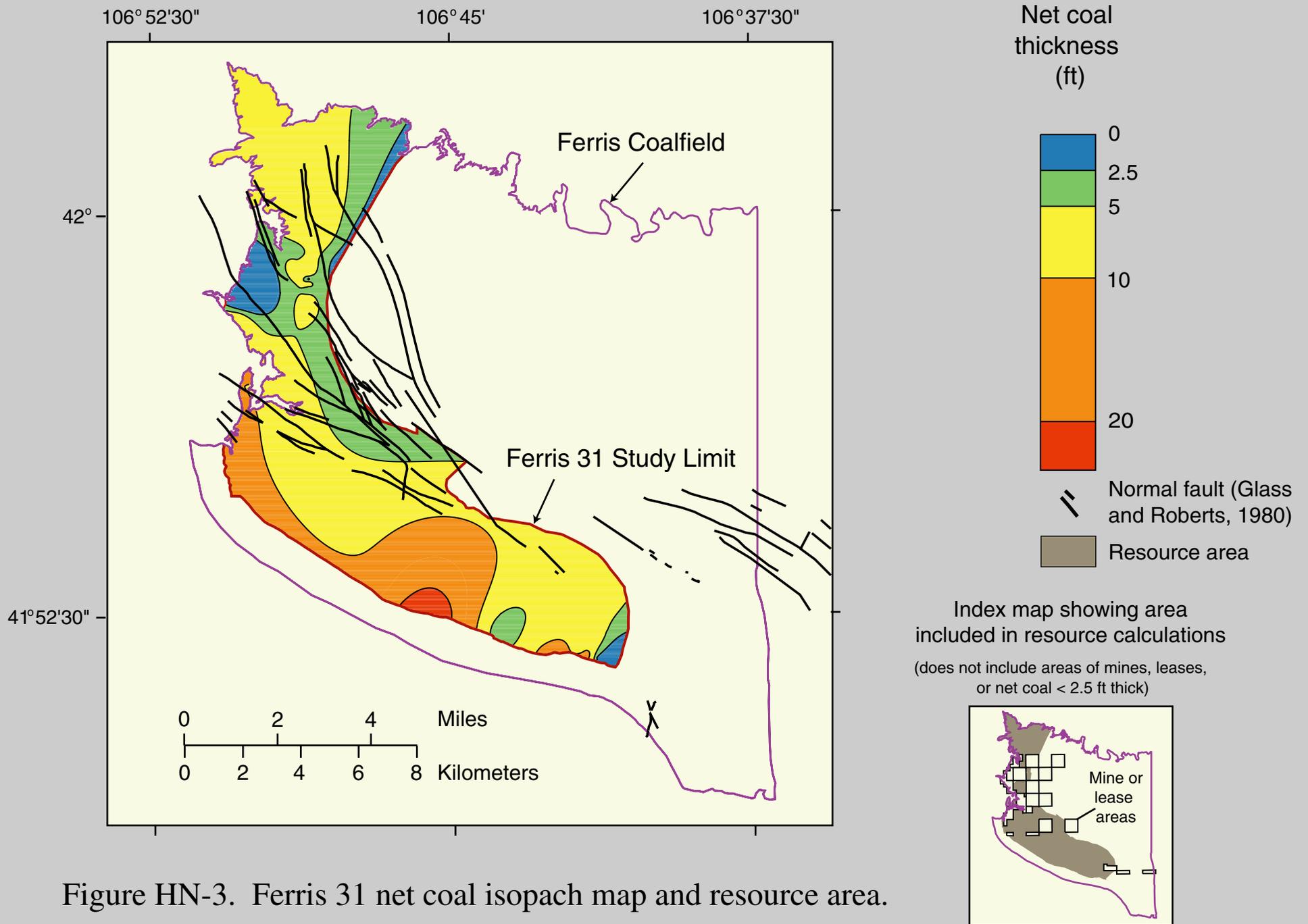
Figure HN-3. Ferris 31 net coal isopach map and resource area.
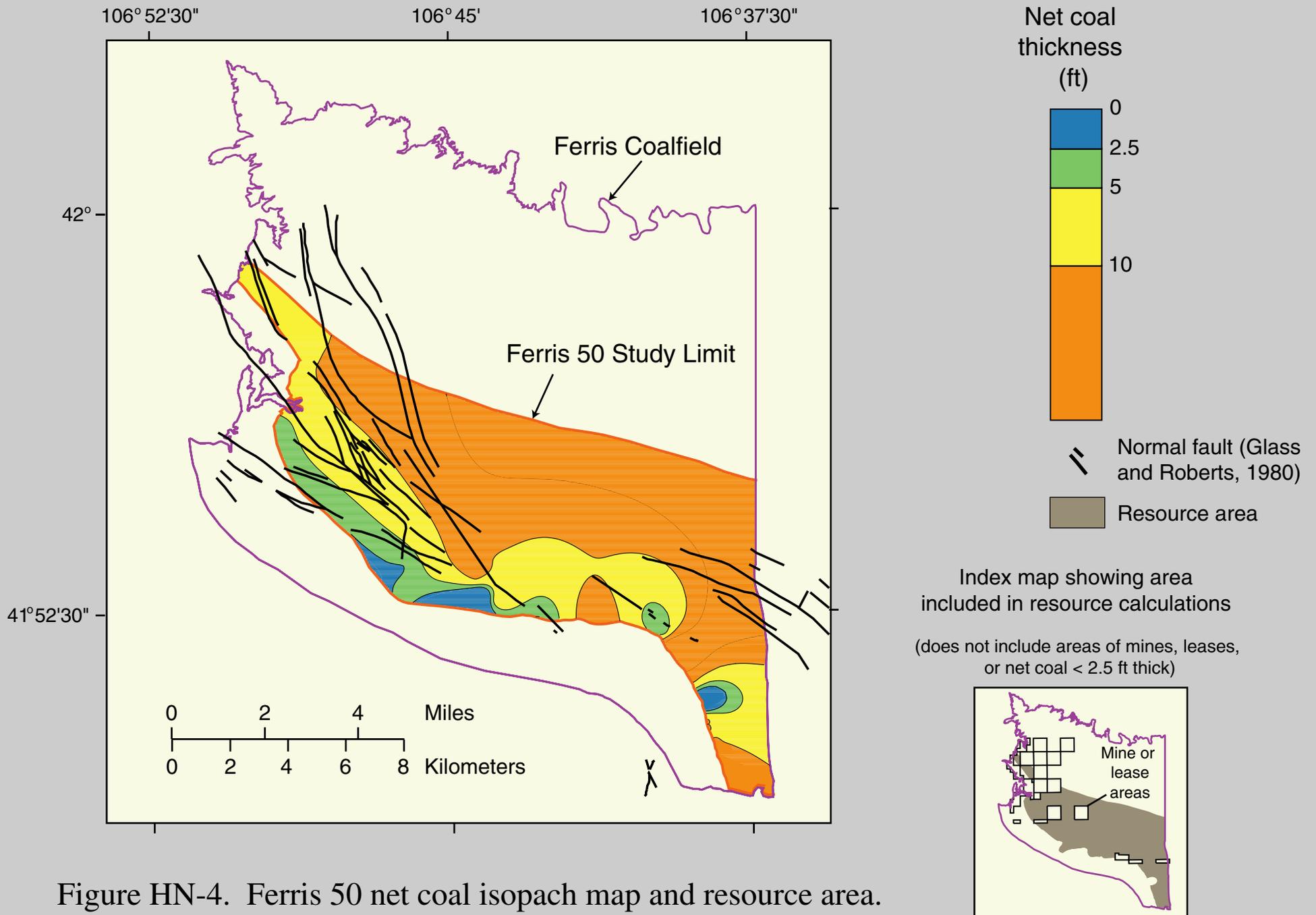
Figure HN-4. Ferris 50 net coal isopach map and resource area.
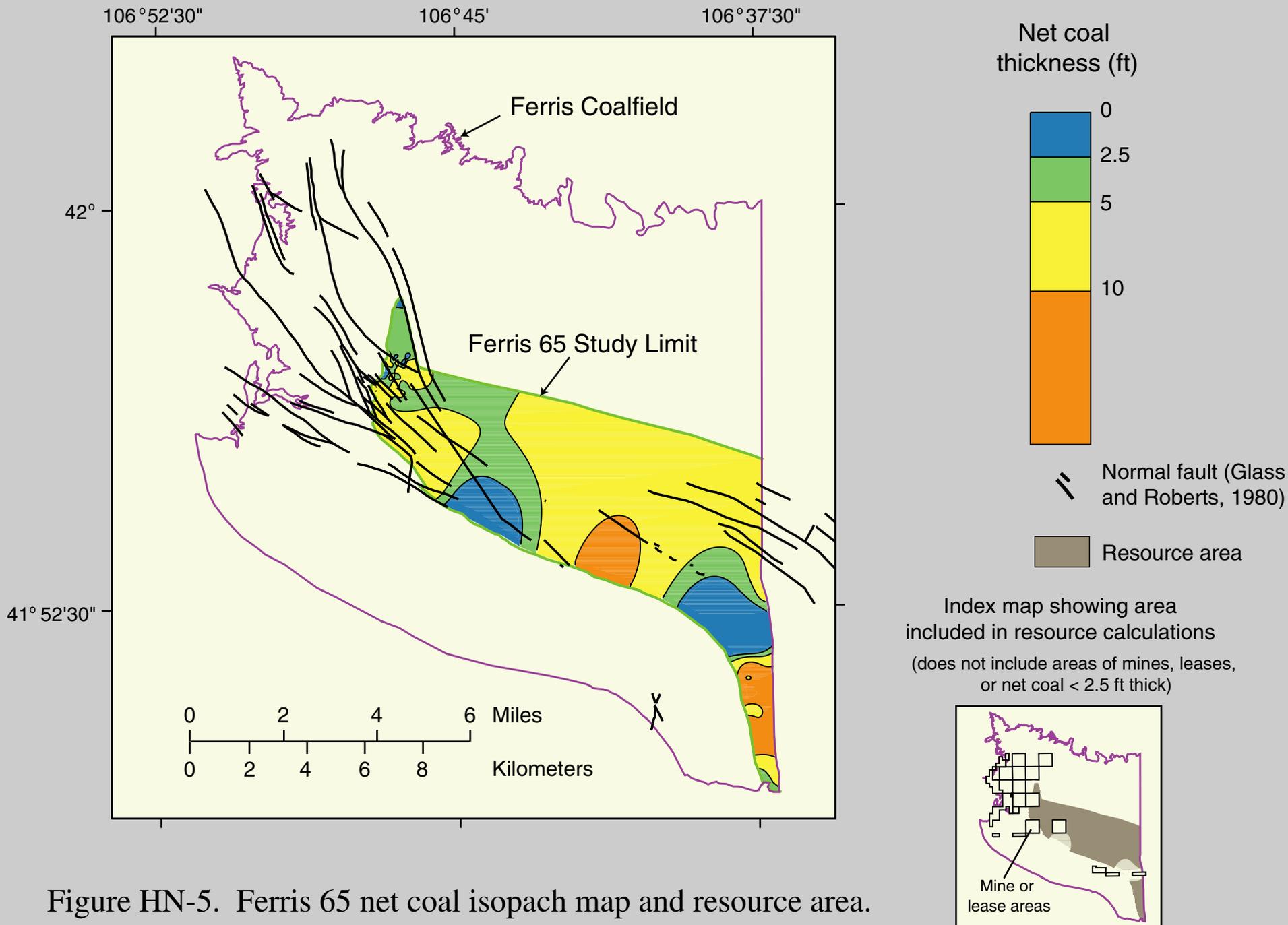
Figure HN-5. Ferris 65 net coal isopach map and resource area.

Figure HN-6. Location of 7.5-minute quadrangle maps in the Ferris coalfield.
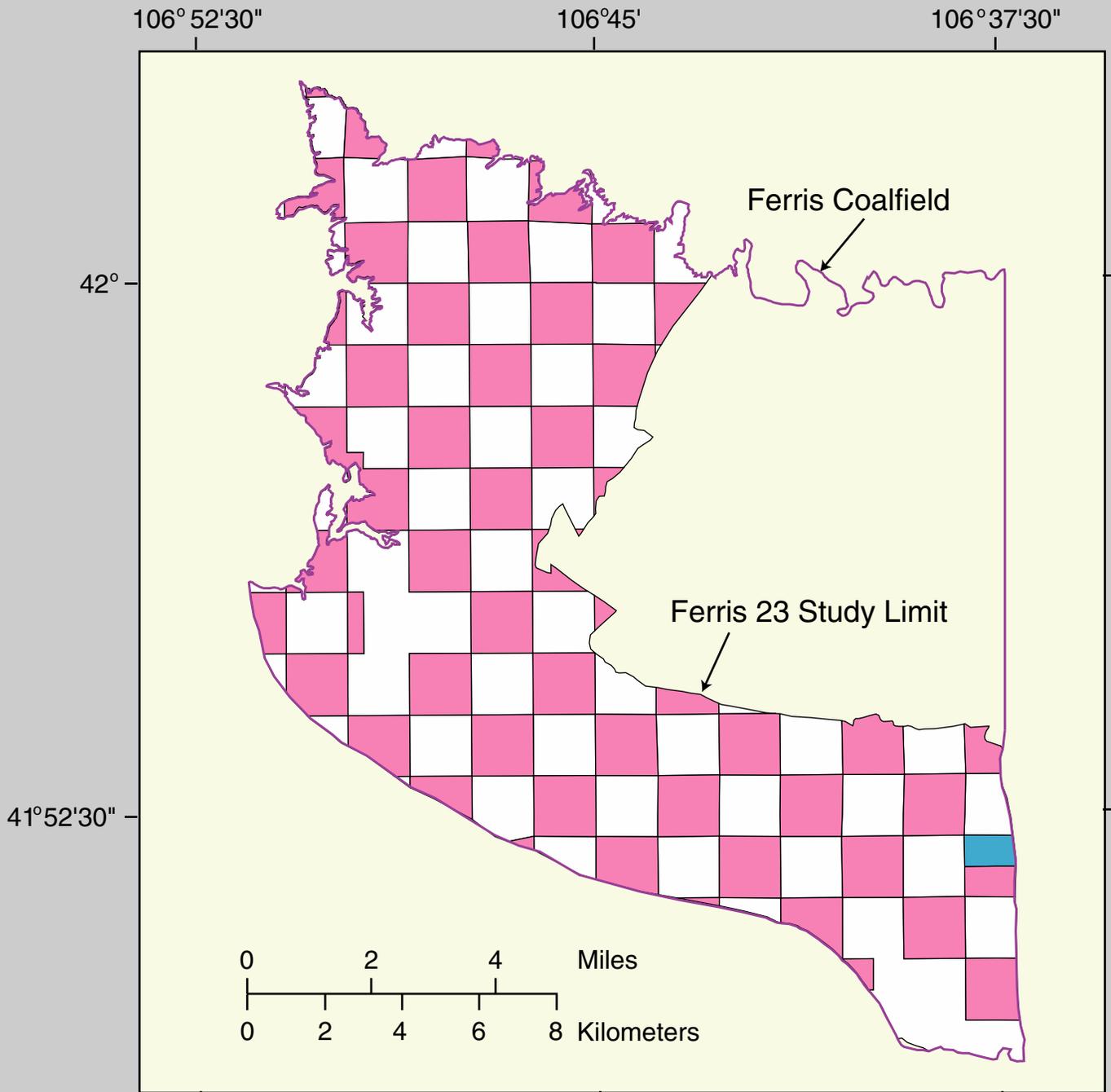
Figure HN-7. Federal coal and surface ownership in the Ferris 23 study limit.
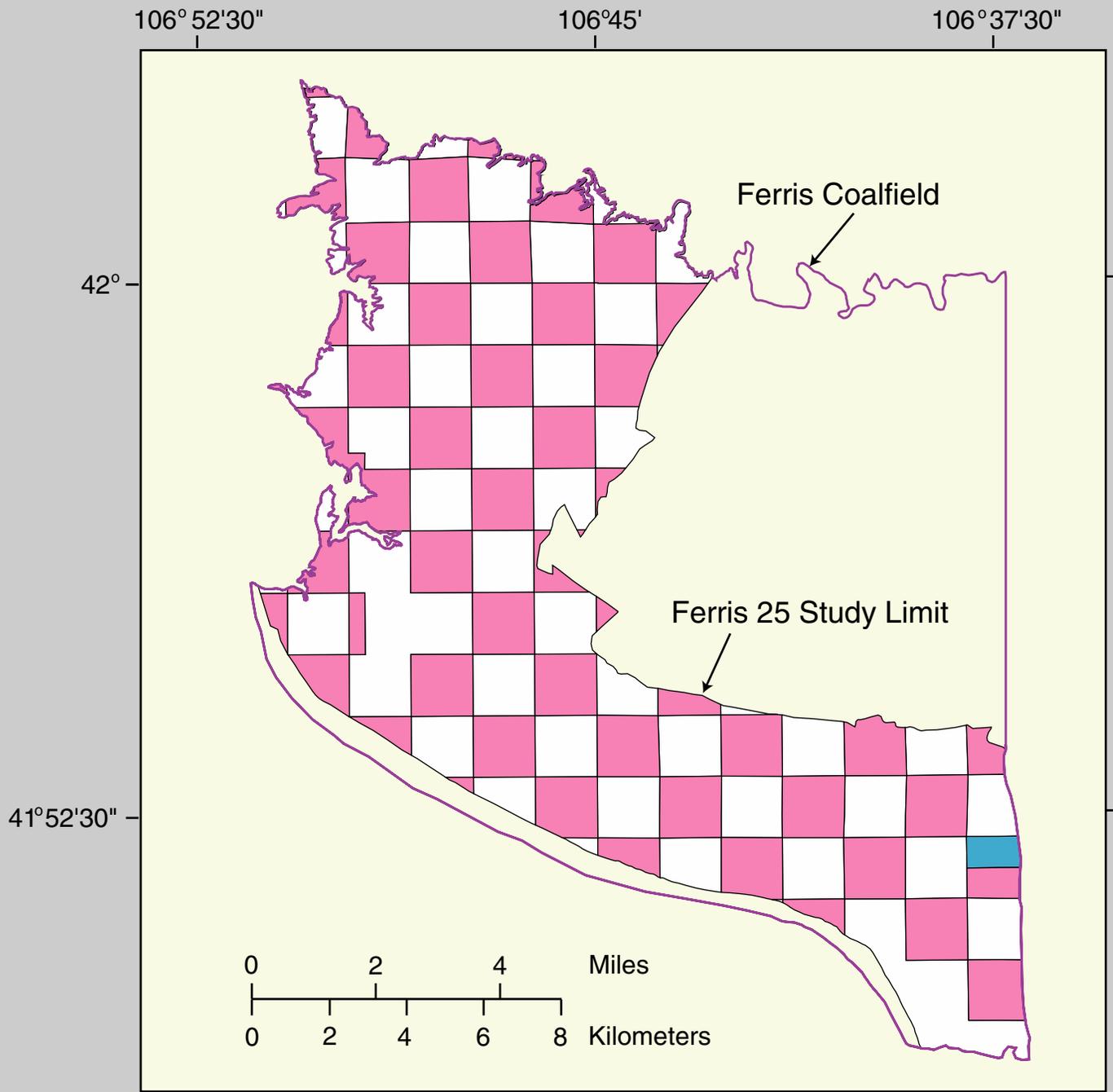
Figure HN-8. Federal coal and surface ownership in the Ferris 25 study limit.
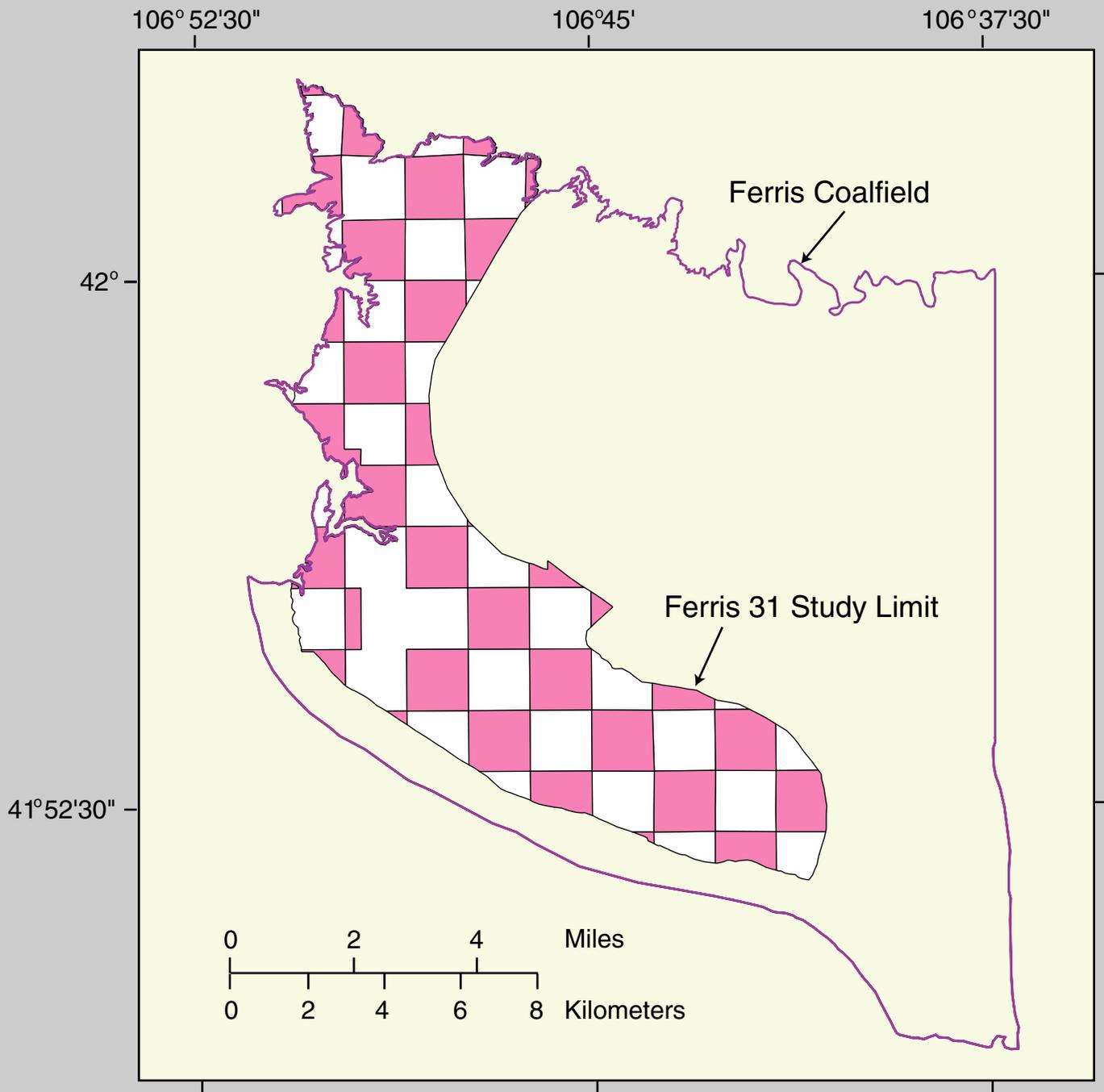
Figure HN-9. Federal coal and surface ownership in the Ferris 31 study limit.
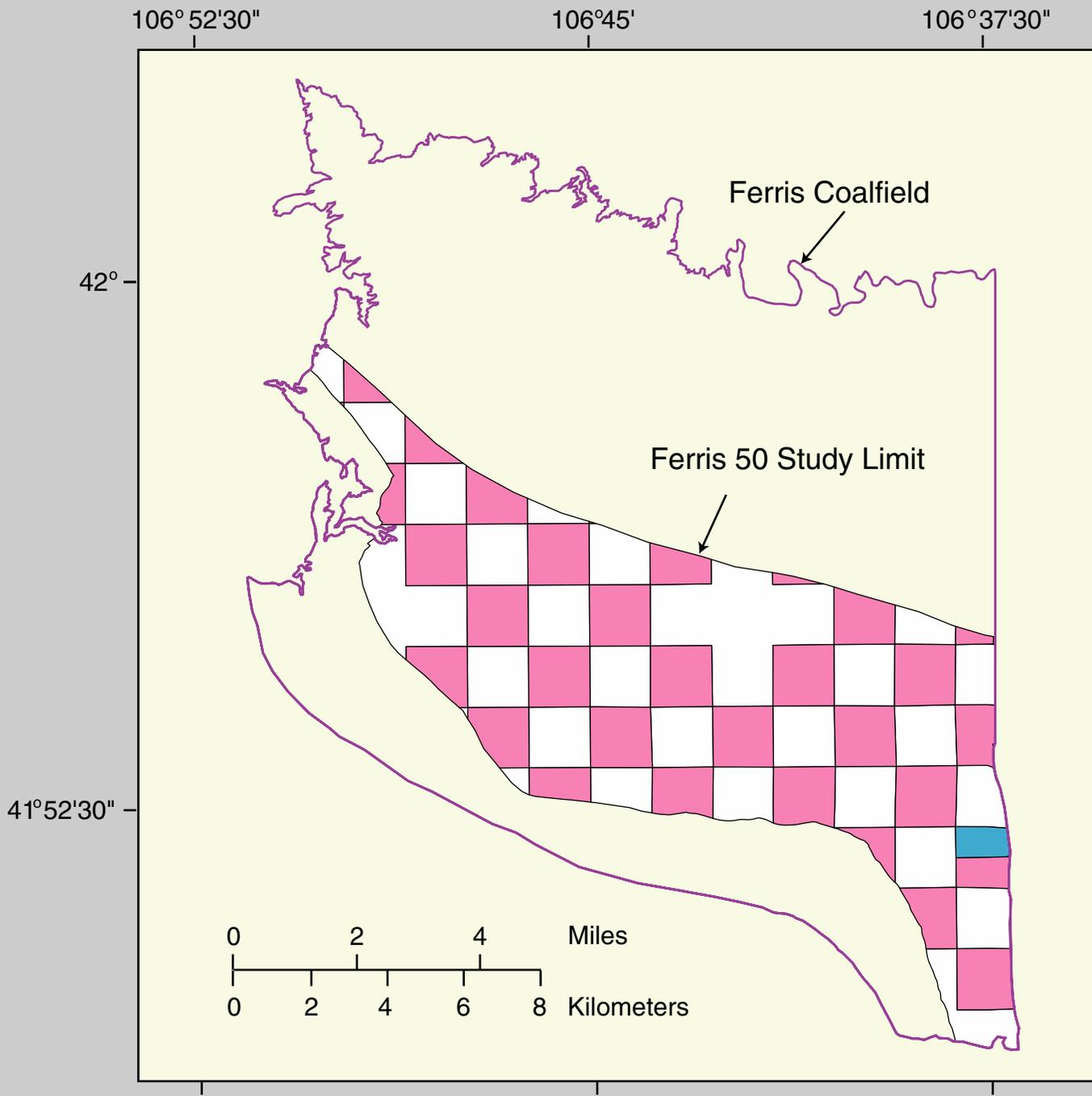
106° 52'30" 106°45' 106°37'30"

42°

Ferris Coalfield

Ferris 50 Study Limit

41°52'30"

| 0 | 2 | 4 | Miles |
| 0 | 2 | 4 | 6 | 8 | Kilometers |

Federal Coal = Federal subsurface management of all minerals, coal only, or oil, gas, and coal

Federal Surface = Federal surface ownership

Federal coal and Federal surface

Federal coal, but no Federal surface

No Federal coal or Federal surface

Figure HN-10. Federal coal and surface ownership in the Ferris 50 study limit.
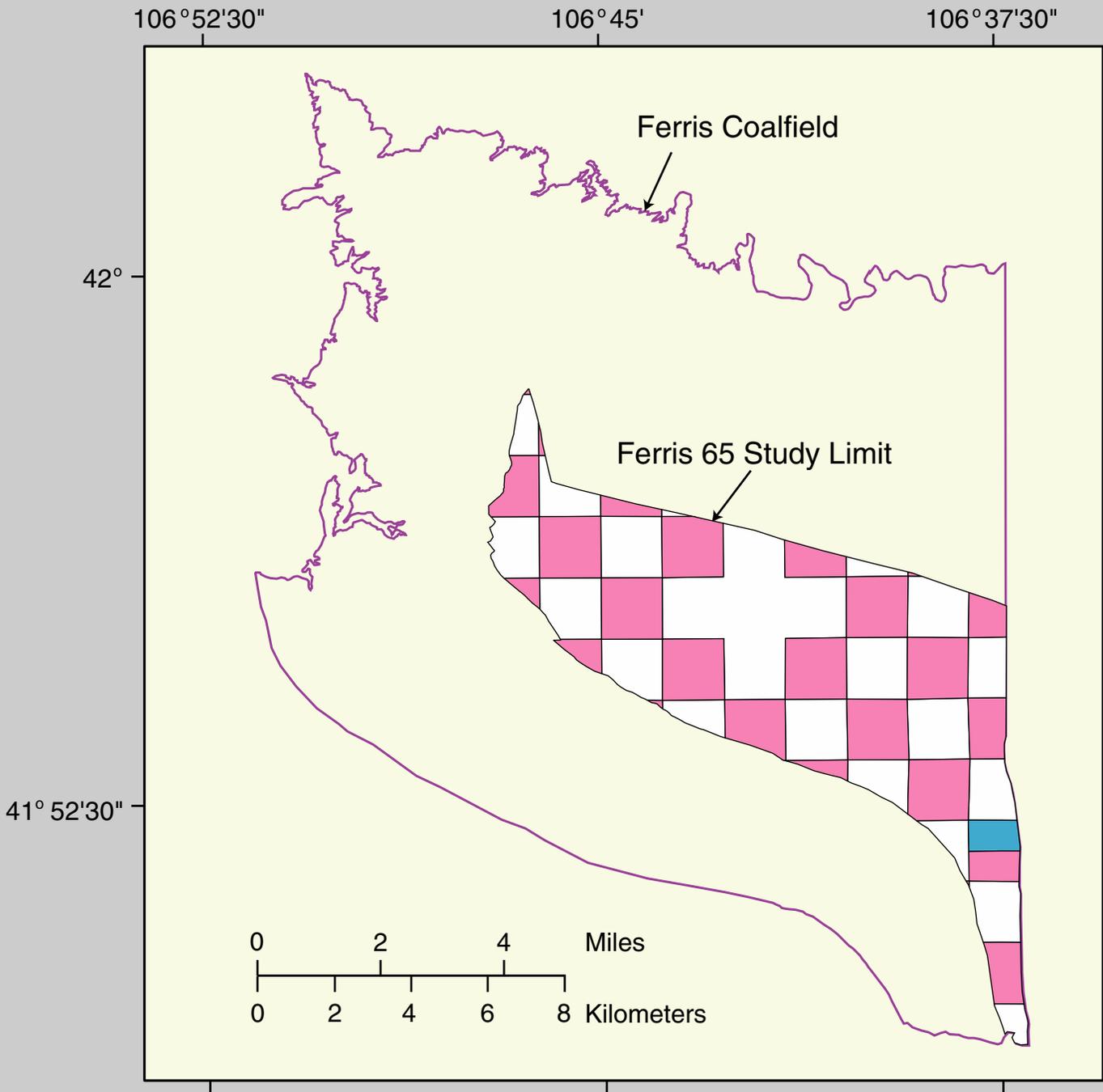
Figure HN-11. Federal coal and surface ownership in the Ferris 65 study limit.
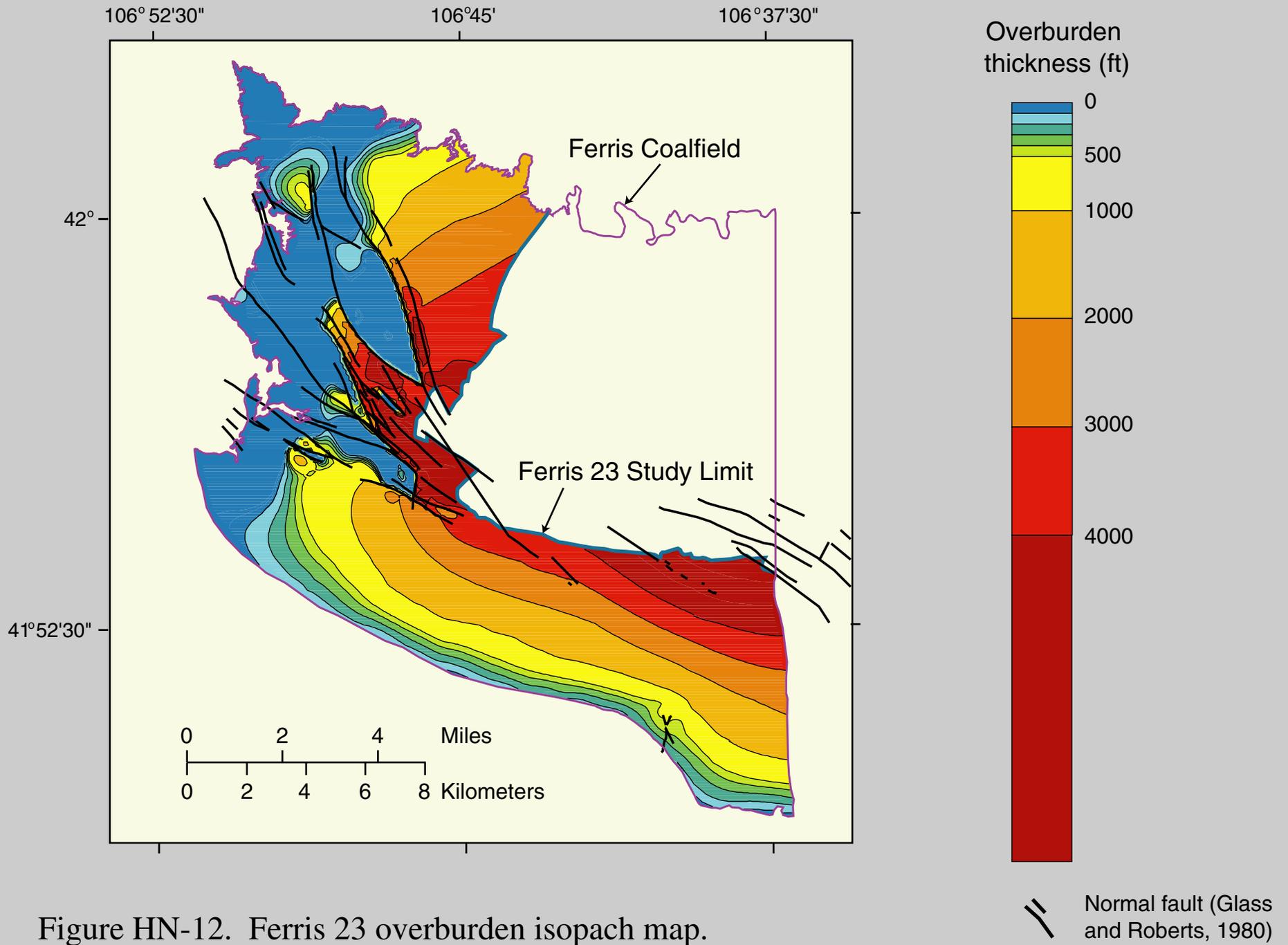
Figure HN-12. Ferris 23 overburden isopach map.

Overburden
thickness (ft)

0

500

1000

2000

3000

4000

Normal fault (Glass
and Roberts, 1980)

106° 52'30"   106°45'   106°37'30"

42°

41°52'30"

Ferris Coalfield

Ferris 23 Study Limit

0   2   4   Miles

0   2   4   6   8 Kilometers
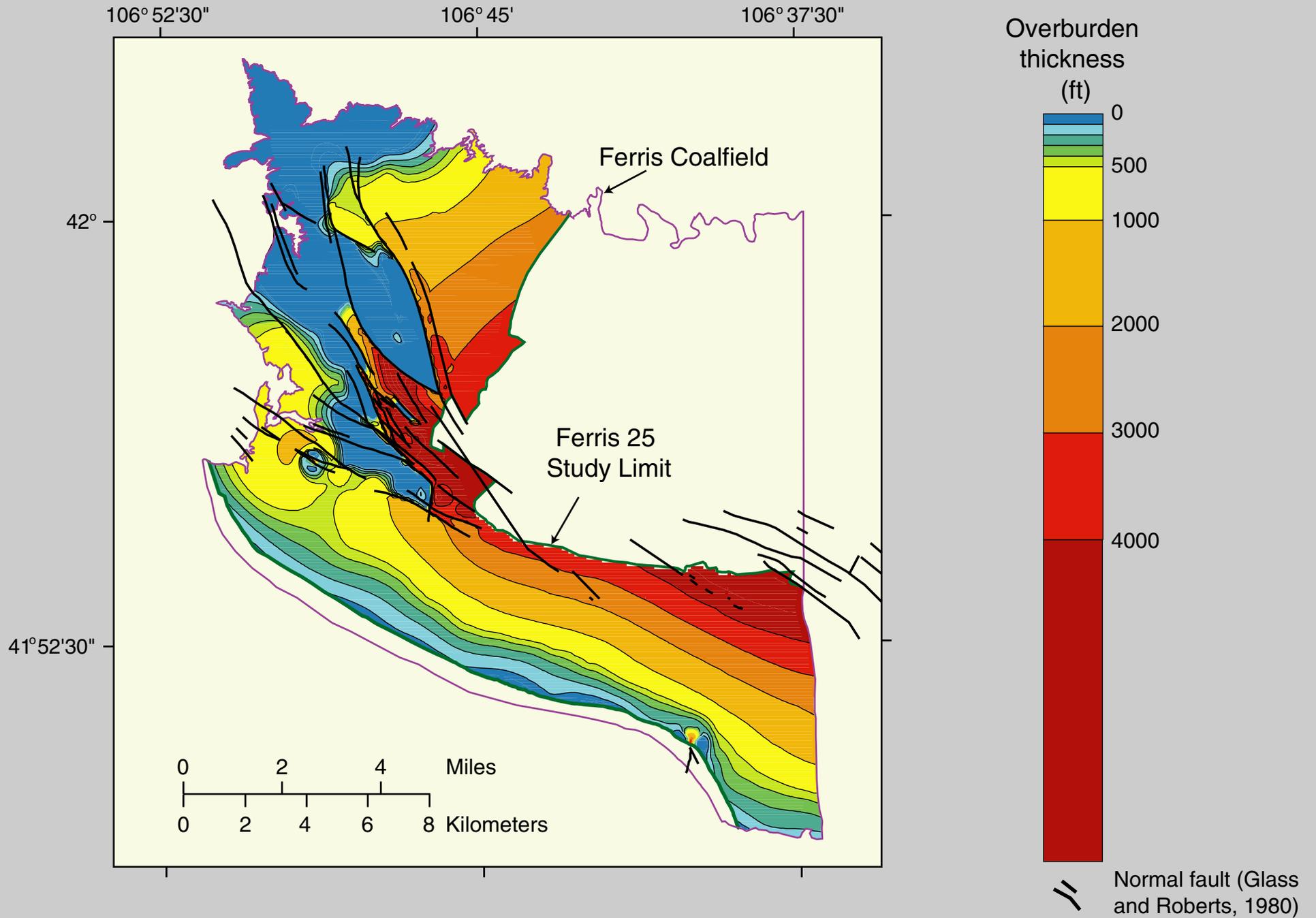
Figure HN-13. Ferris 25 overburden isopach map.
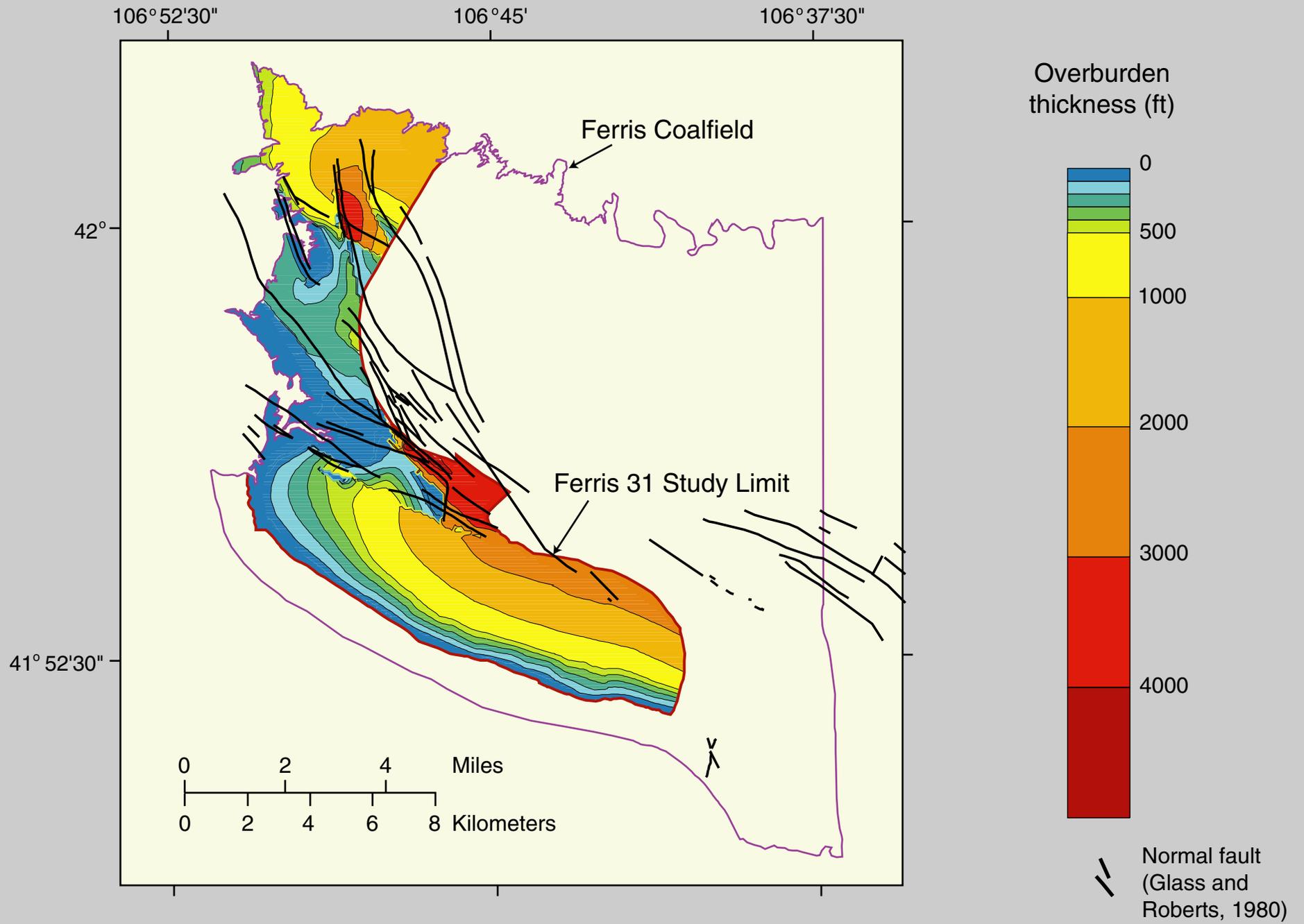
Figure HN-14. Ferris 31 overburden isopach map.
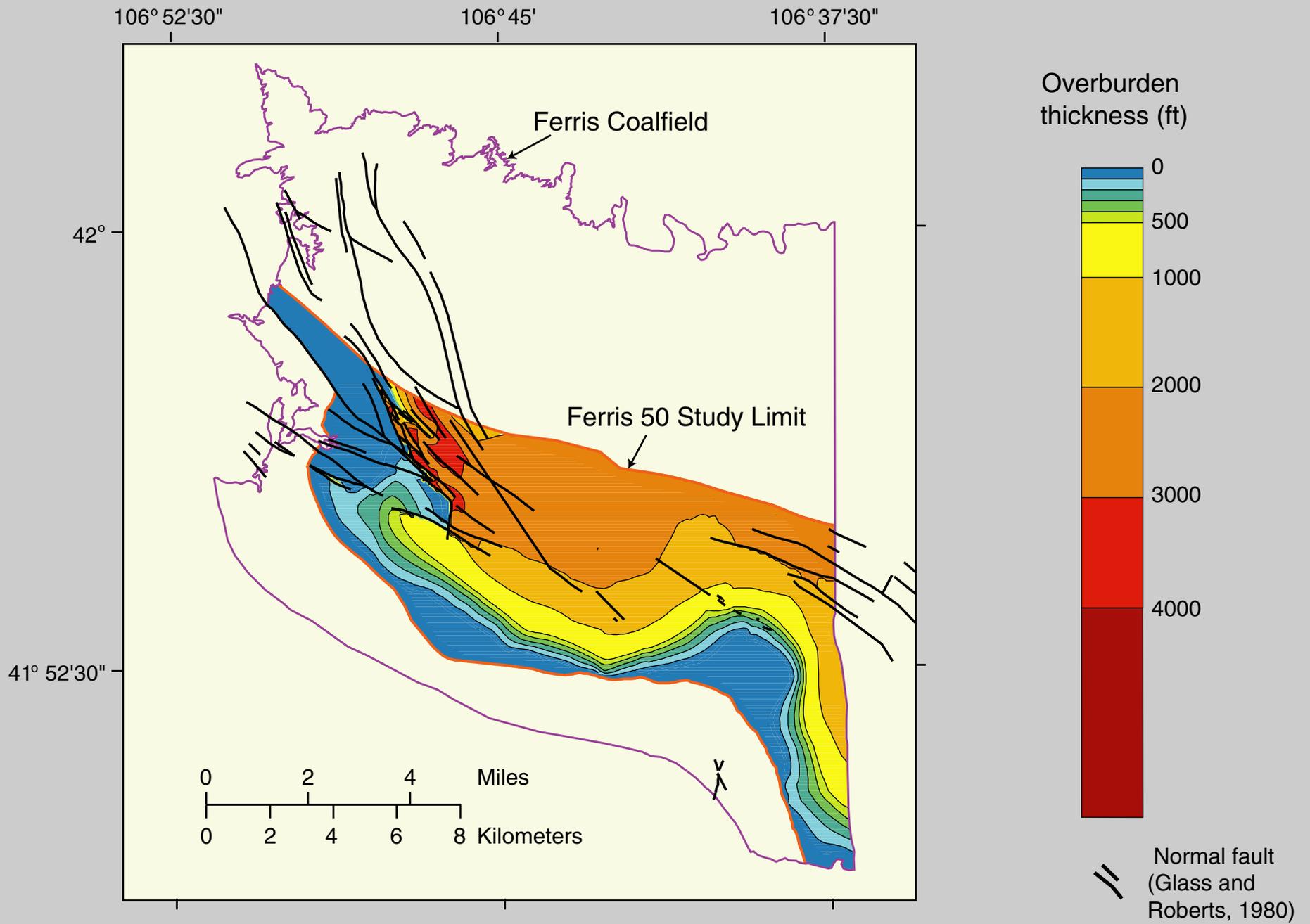
Figure HN-15. Ferris 50 overburden isopach map.
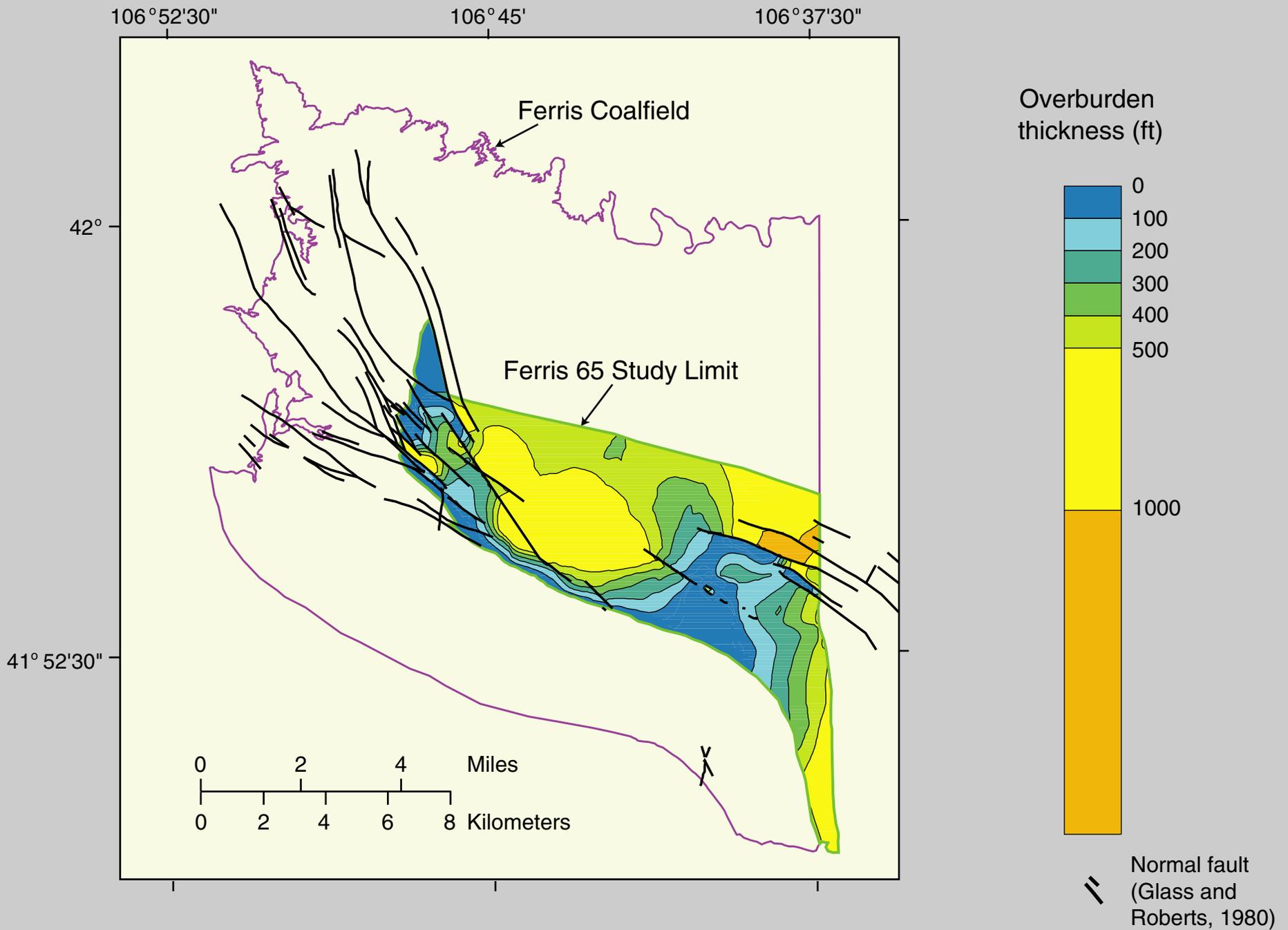
Figure HN-16. Ferris 65 overburden isopach map.
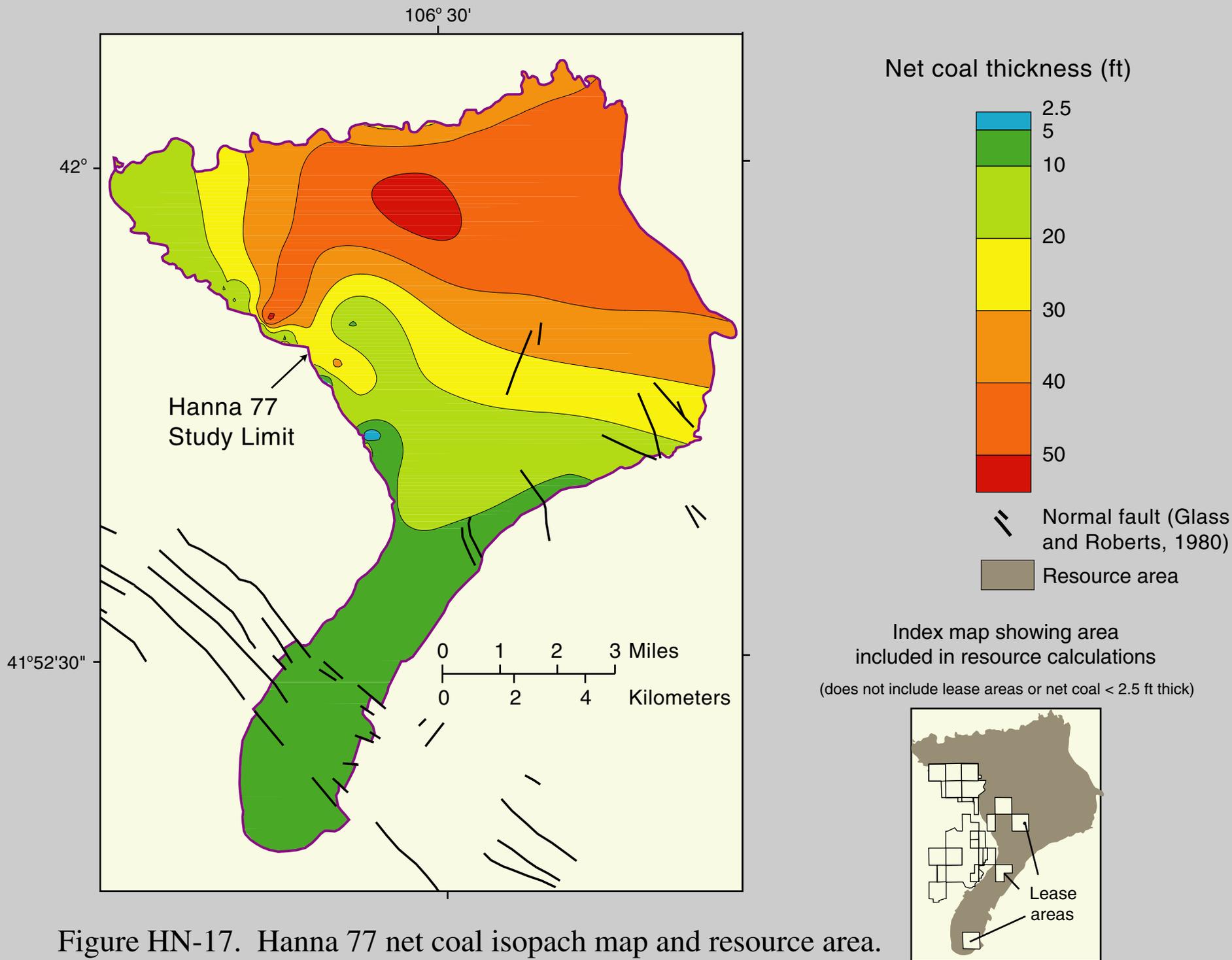
Figure HN-17. Hanna 77 net coal isopach map and resource area.

Net coal thickness (ft)

2.5
5
10
20
30
40
50

Normal fault (Glass and Roberts, 1980)

Resource area

Index map showing area included in resource calculations

(does not include lease areas or net coal < 2.5 ft thick)

Lease areas

Hanna 77 Study Limit

106° 30'

42°

41°52'30"

0   1   2   3 Miles

0   2   4   Kilometers
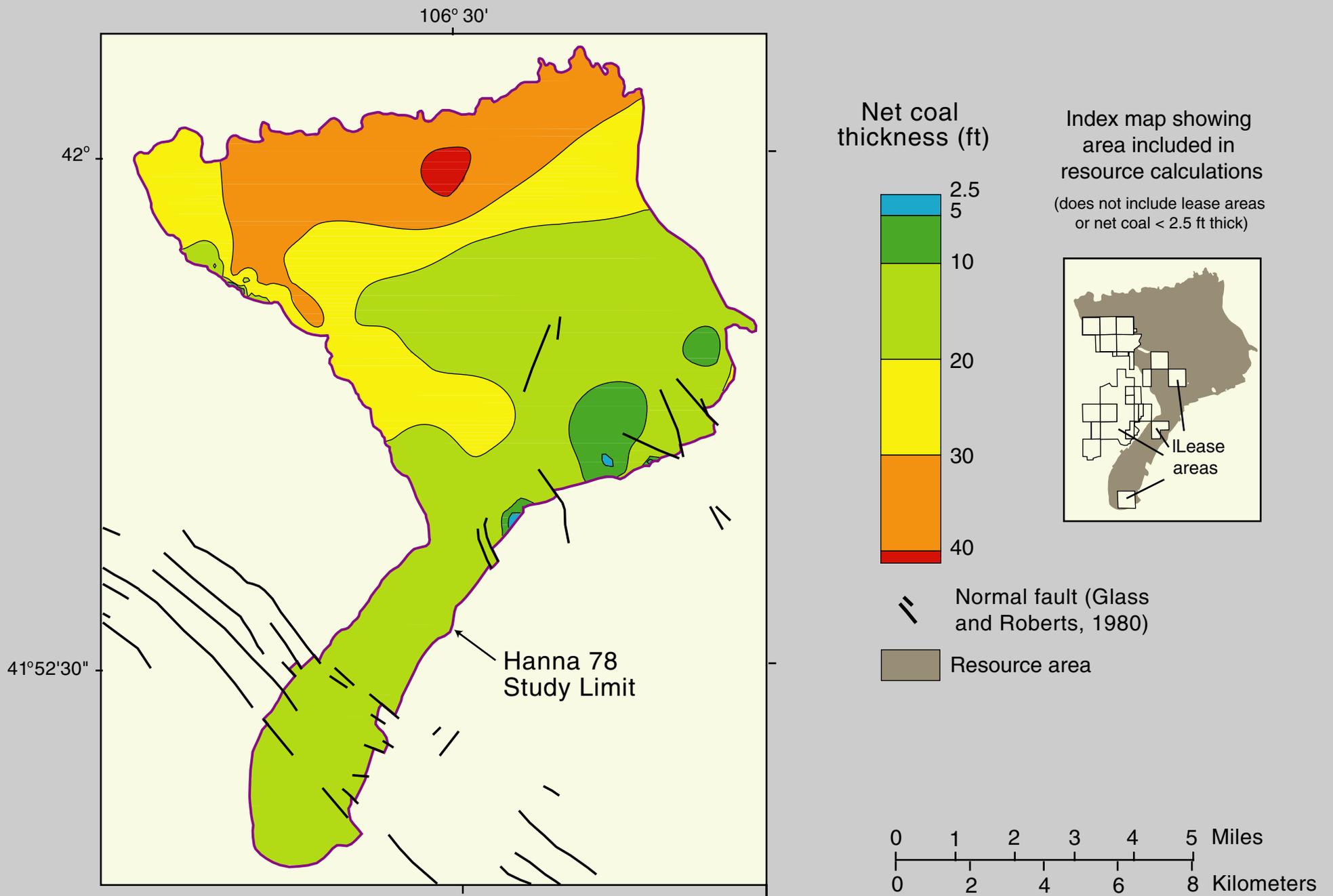
Figure HN-18. Hanna 78 net coal isopach map and resource area.
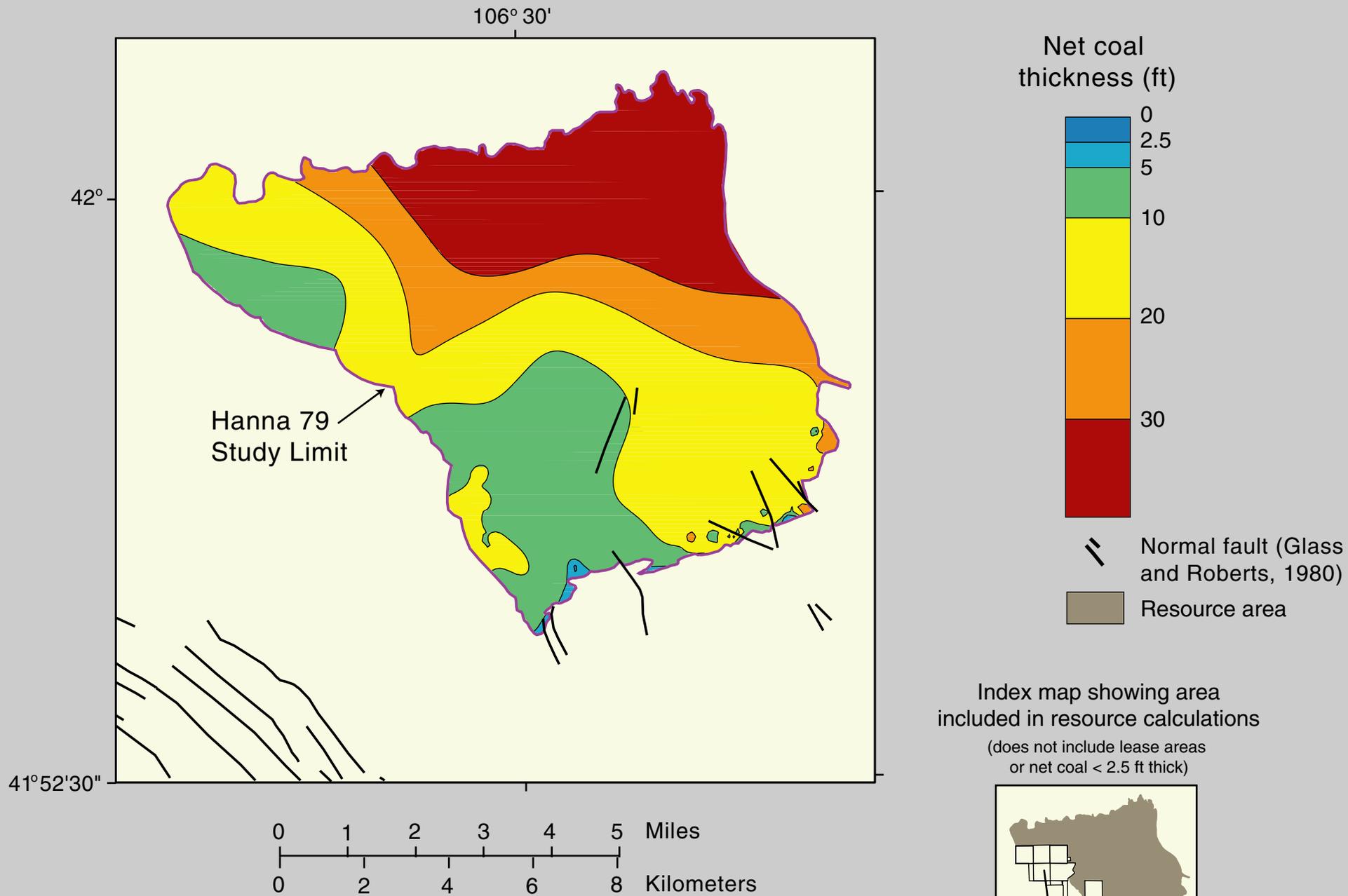
Figure HN-19. Hanna 79 net coal isopach map and resource area.
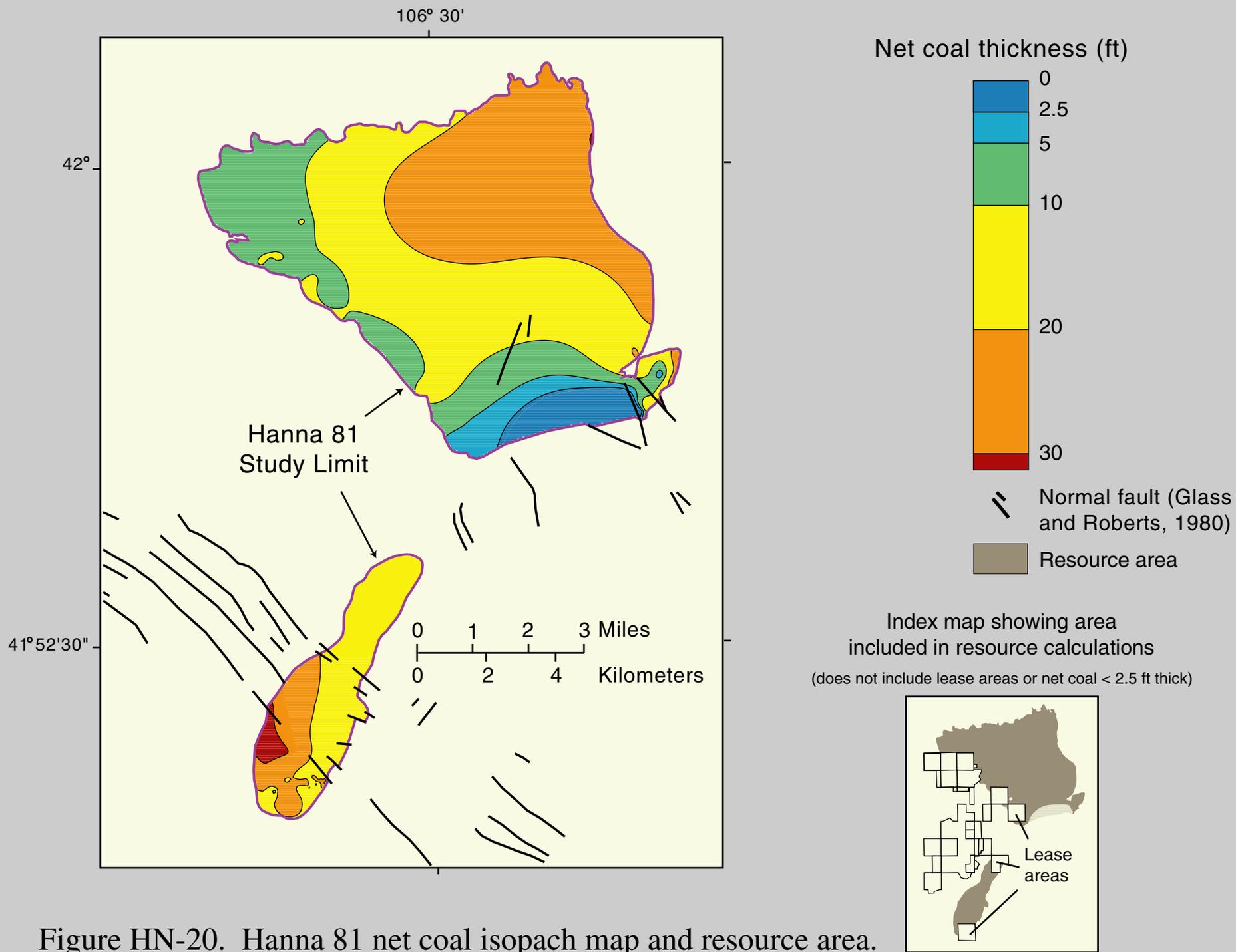
Figure HN-20. Hanna 81 net coal isopach map and resource area.
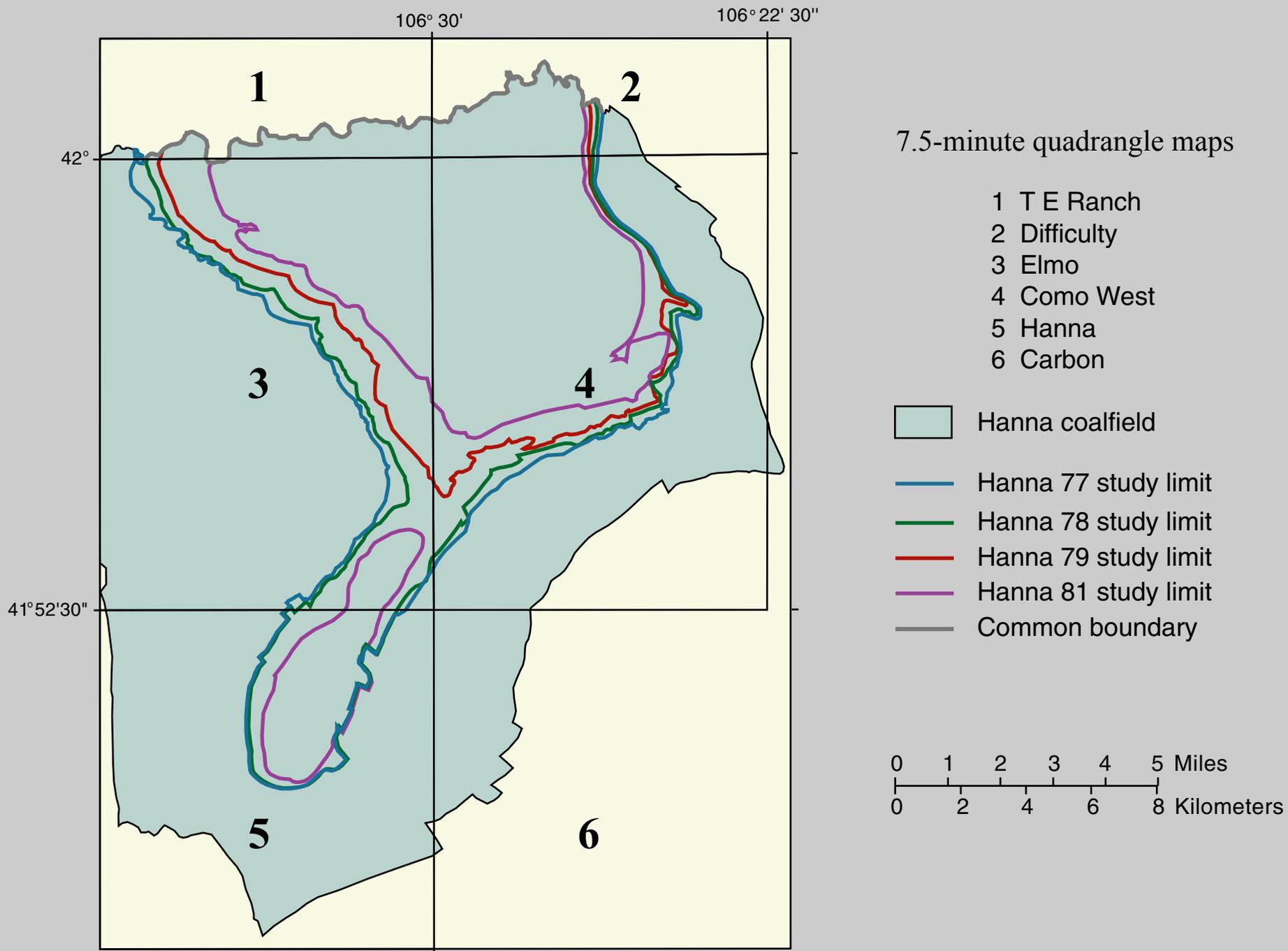
Figure HN-21. Location of 7.5-minute quadrangle maps in the Hanna coalfield.

Federal coal = Federal subsurface management of all minerals, coal only, or oil, gas, and coal

Federal surface = Federal surface ownership

Federal coal and Federal surface

Federal coal, but no Federal surface

No Federal coal or Federal surface

Hanna 77 Study Limit

106° 30'

42°

41°52'30"

0   1   2   3   4   5   Miles

0   2   4   6   8   Kilometers
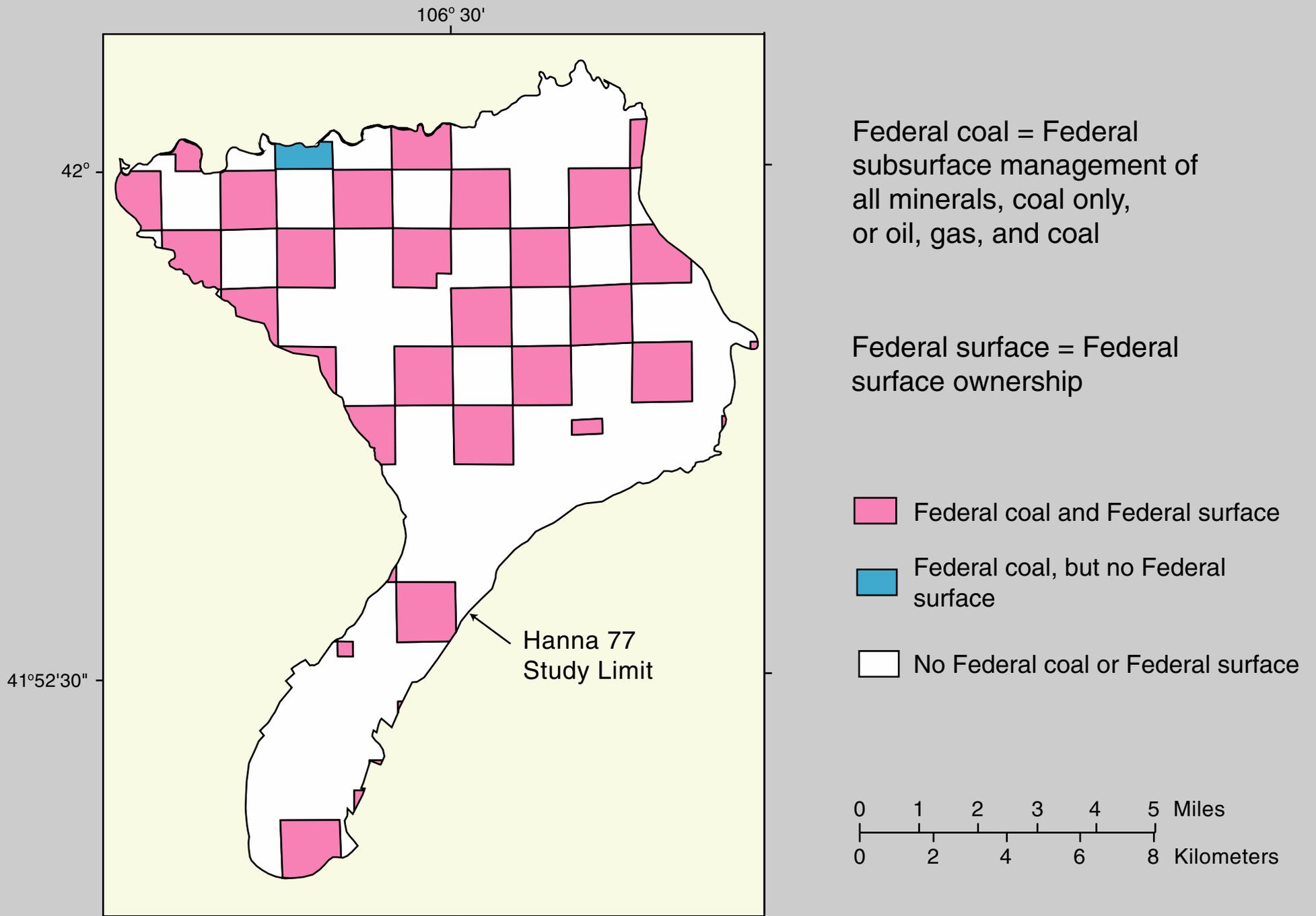
Figure HN-22. Federal coal and surface ownership in the Hanna 77 study limit.
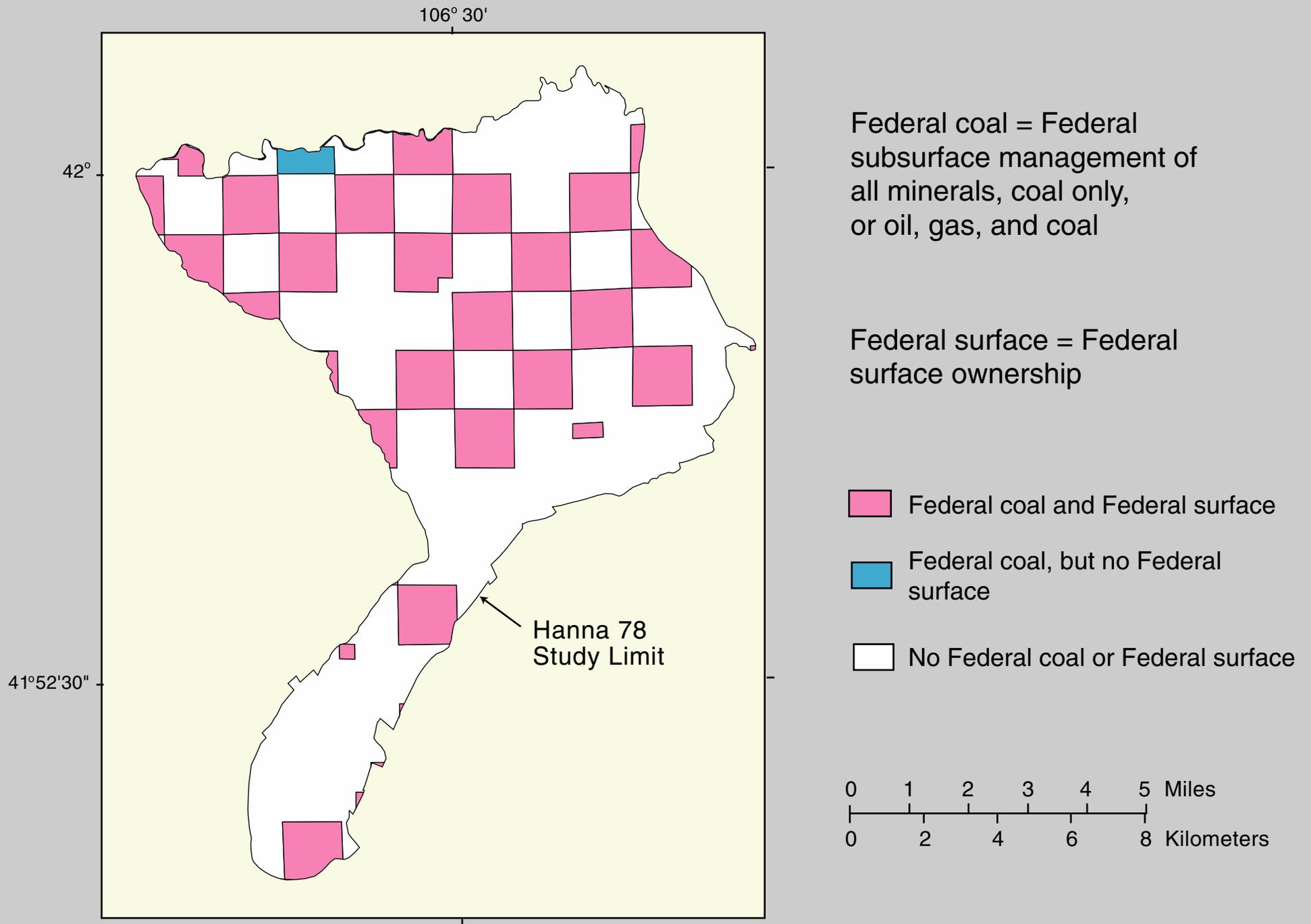
Figure HN-23. Federal coal and surface ownership in the Hanna 78 study limit.

Federal coal = Federal
subsurface management of
all minerals, coal only,
or oil, gas, and coal

Federal surface = Federal
surface ownership

Federal coal and Federal
surface

Federal coal, but no Federal
surface

No Federal coal or Federal
surface
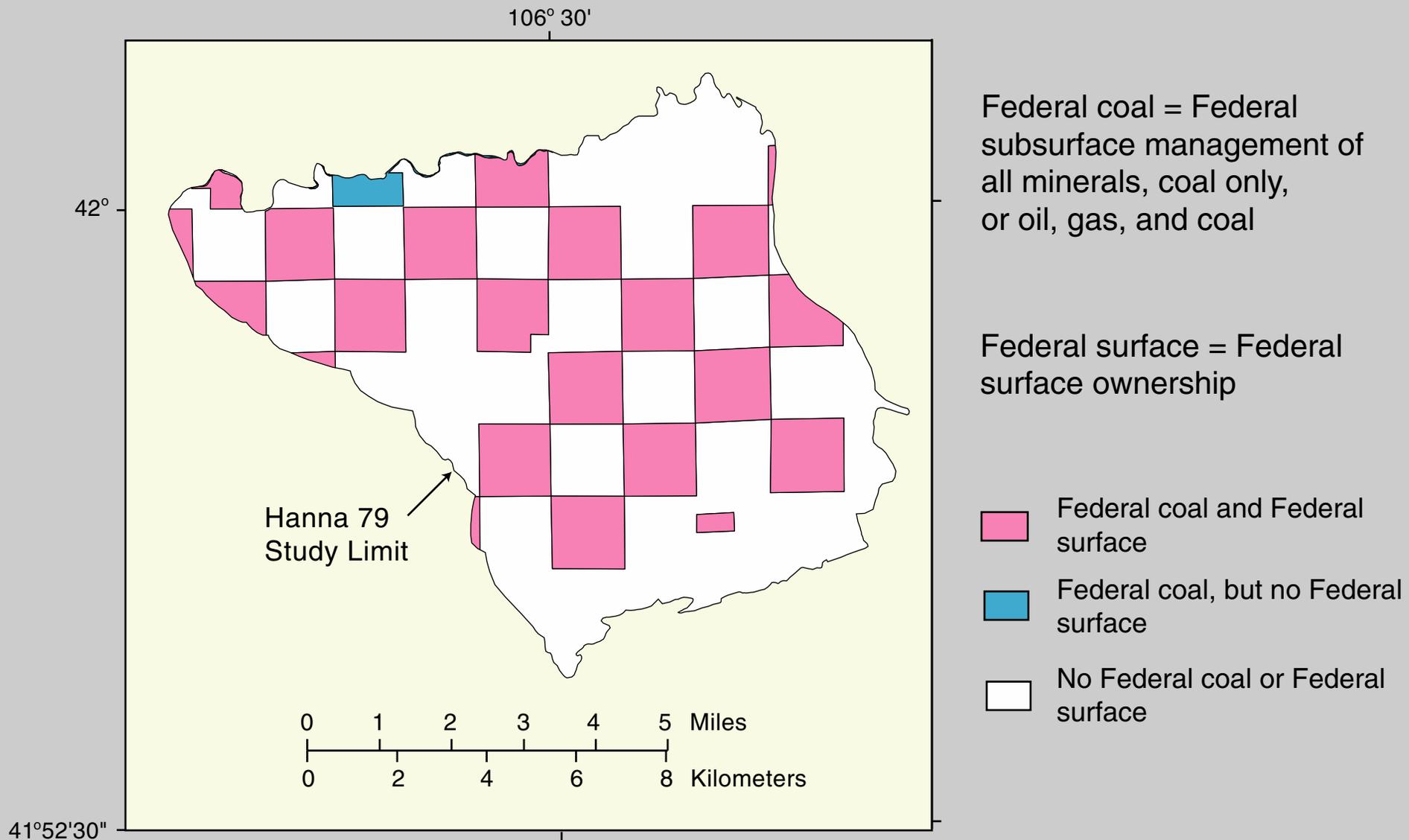
Figure HN-24. Federal coal and surface ownership in the Hanna 79 study limit.

106° 30'

42°

41° 52'30"

Federal coal = Federal
subsurface management of
all minerals, coal only,
or oil, gas, and coal

Federal surface = Federal
surface ownership

Hanna 81
Study Limit

Federal coal and Federal surface

Federal coal, but no Federal
surface

No Federal coal or Federal surface

| 0 | 1 | 2 | 3 | 4 | 5 | Miles |

| 0 | 2 | 4 | 6 | 8 | Kilometers |
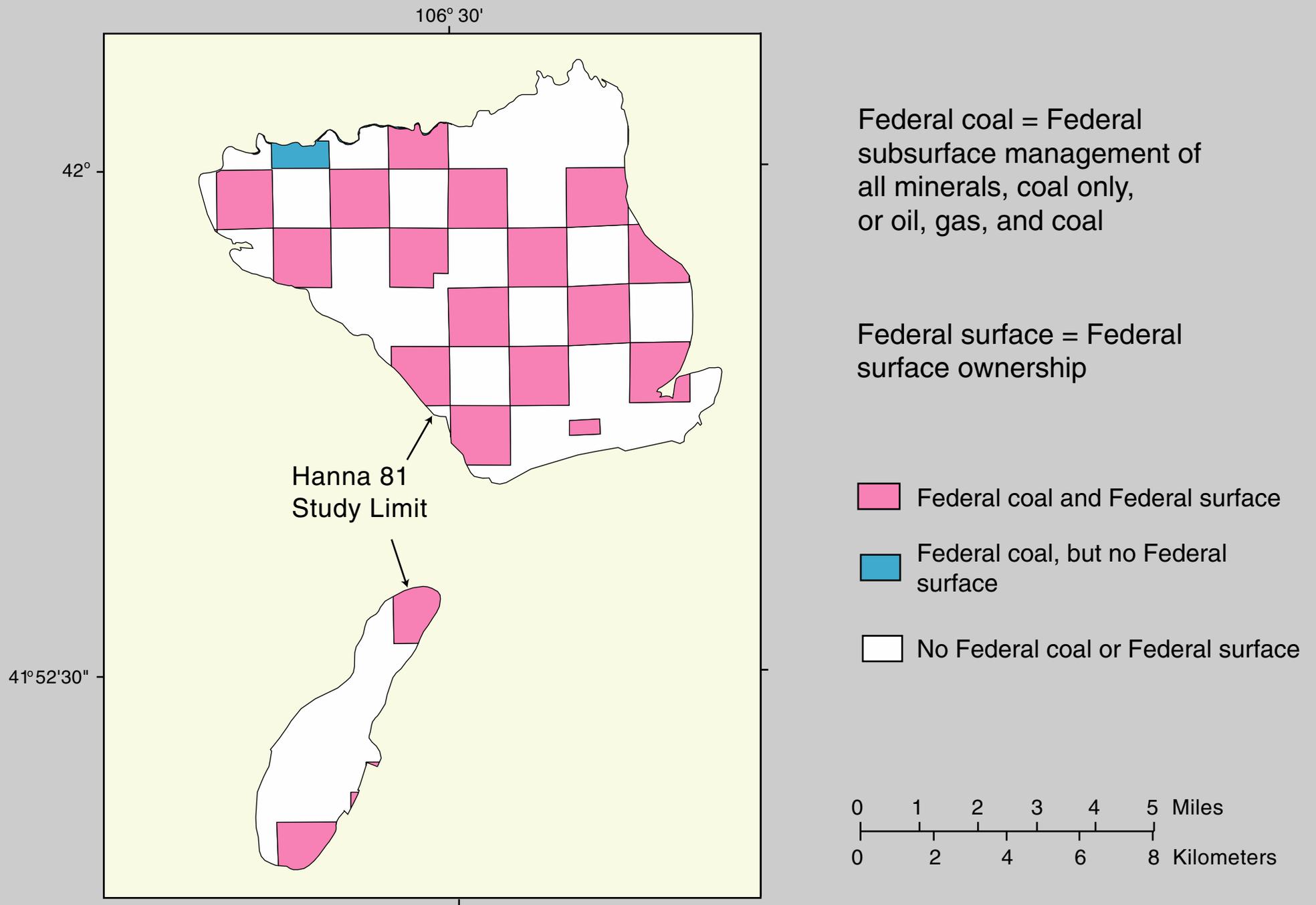
Figure HN-25. Federal coal and surface ownership in the Hanna 81 study limit.
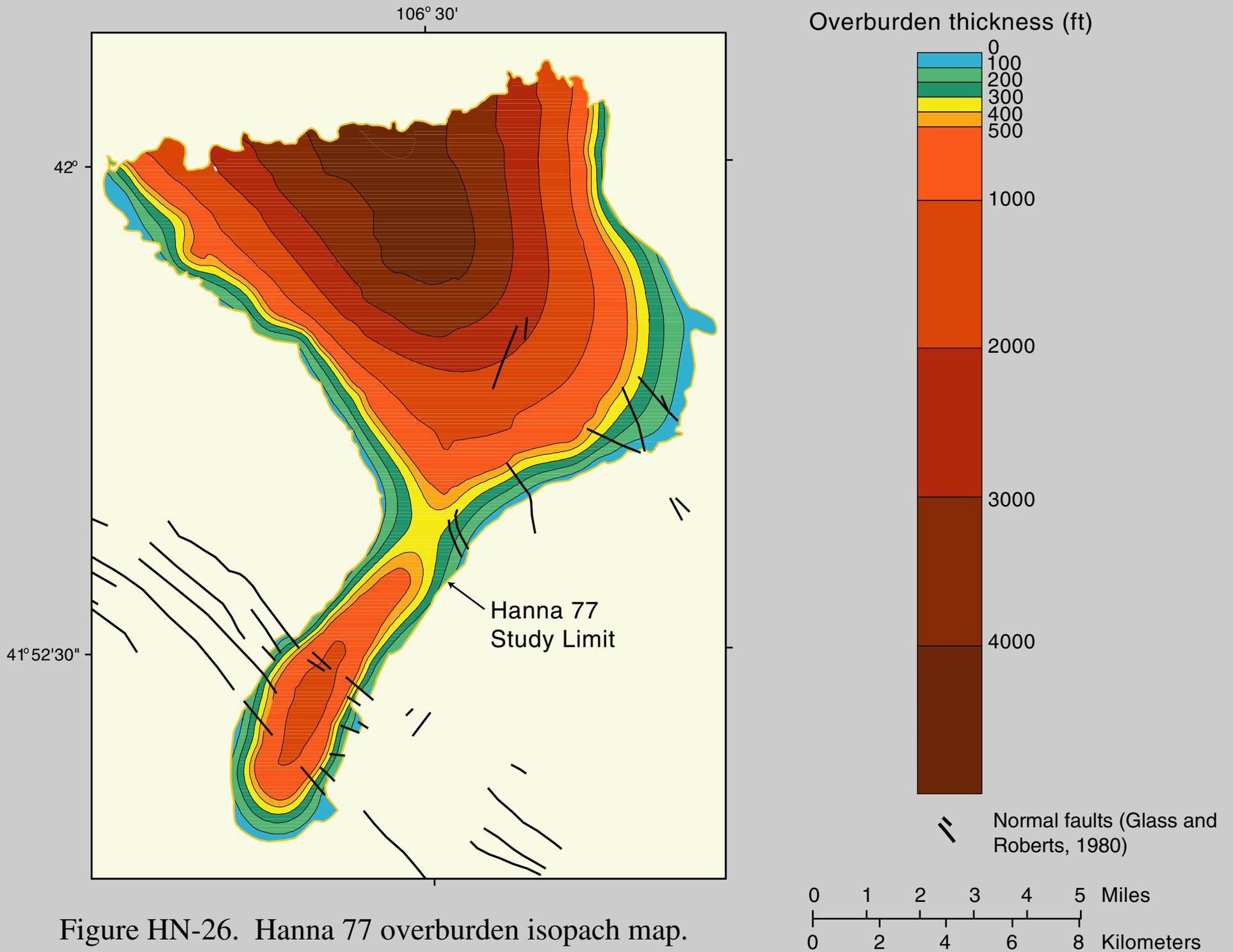
Figure HN-26. Hanna 77 overburden isopach map.
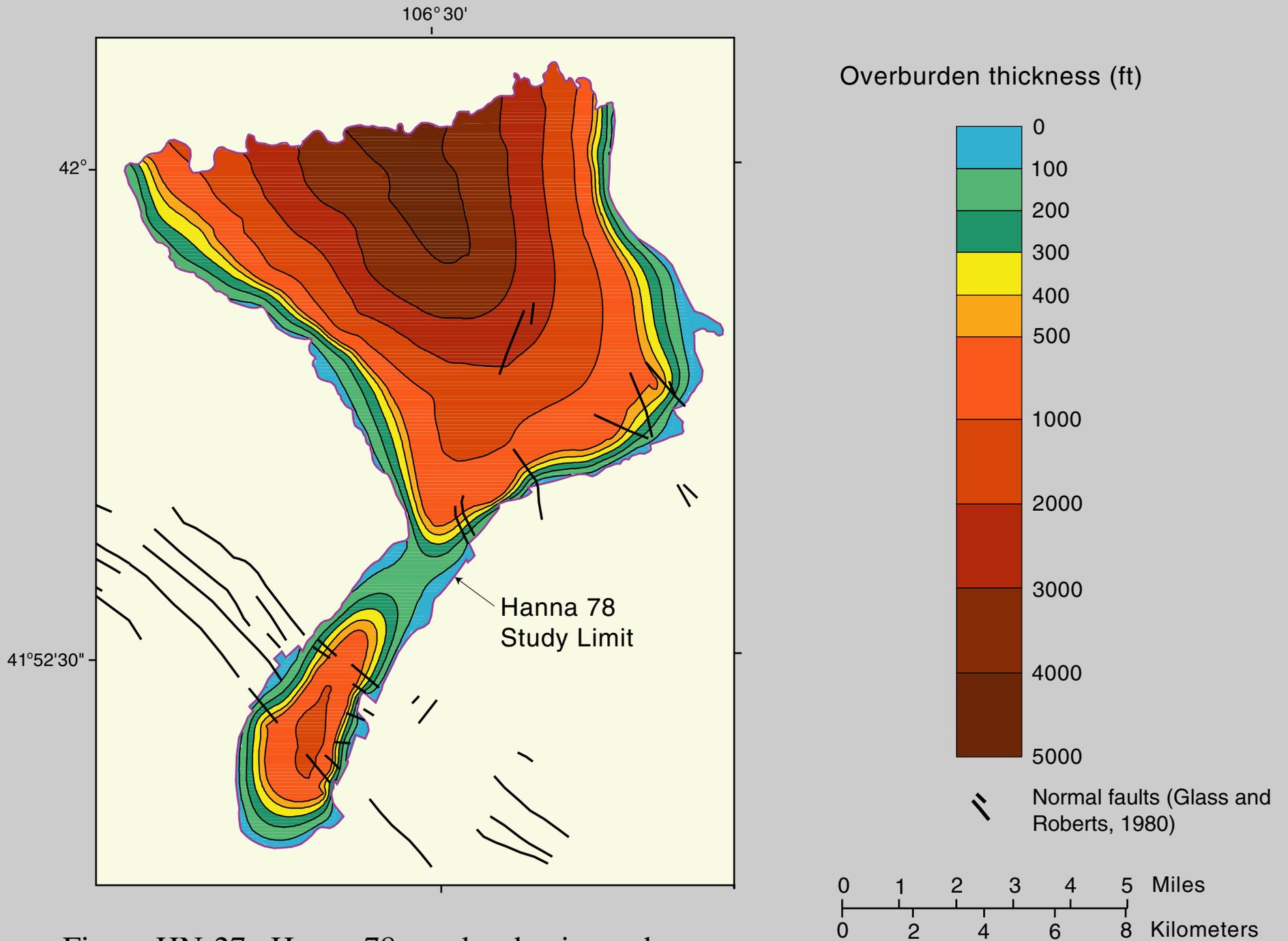
Figure HN-27. Hanna 78 overburden isopach map.
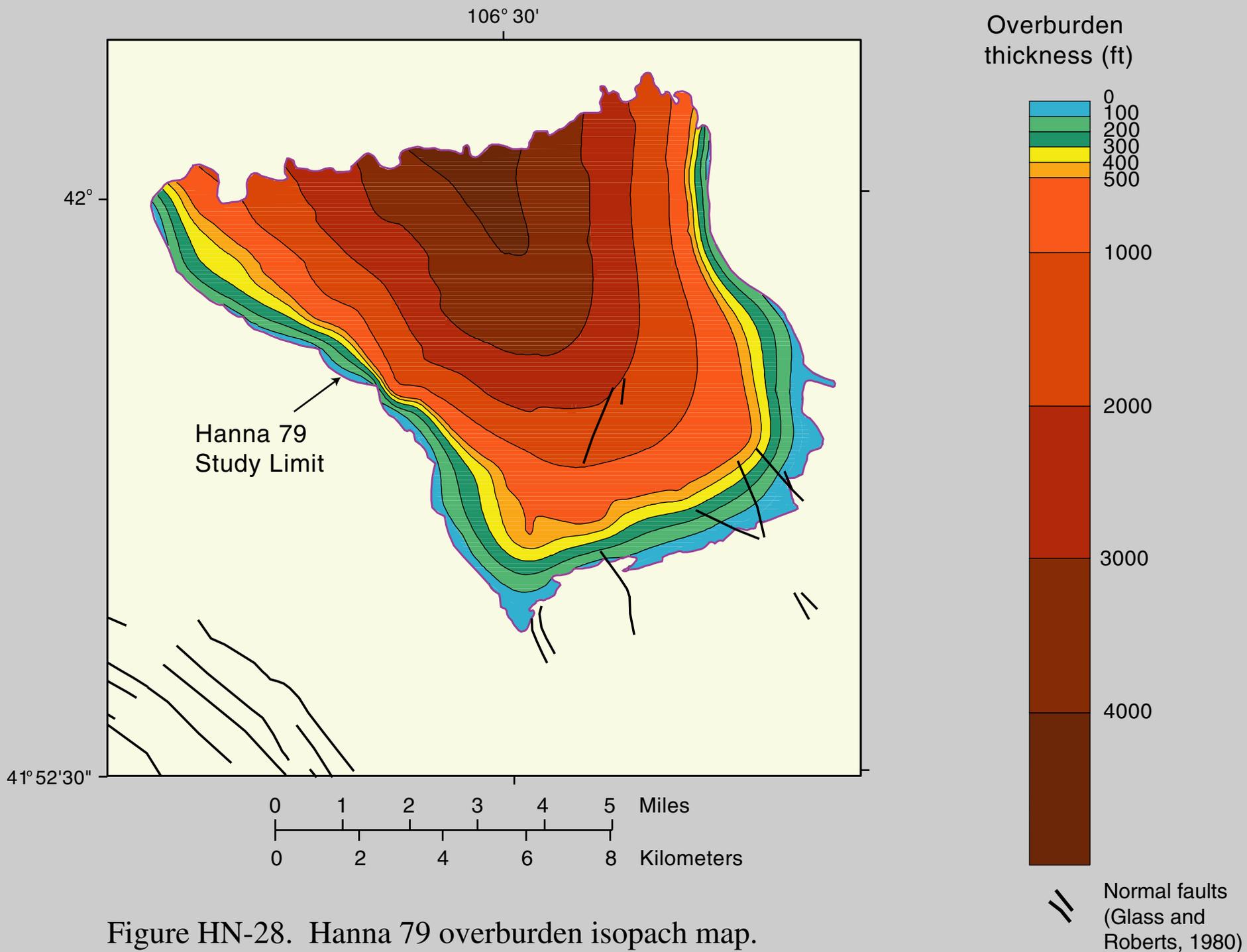
Figure HN-28. Hanna 79 overburden isopach map.
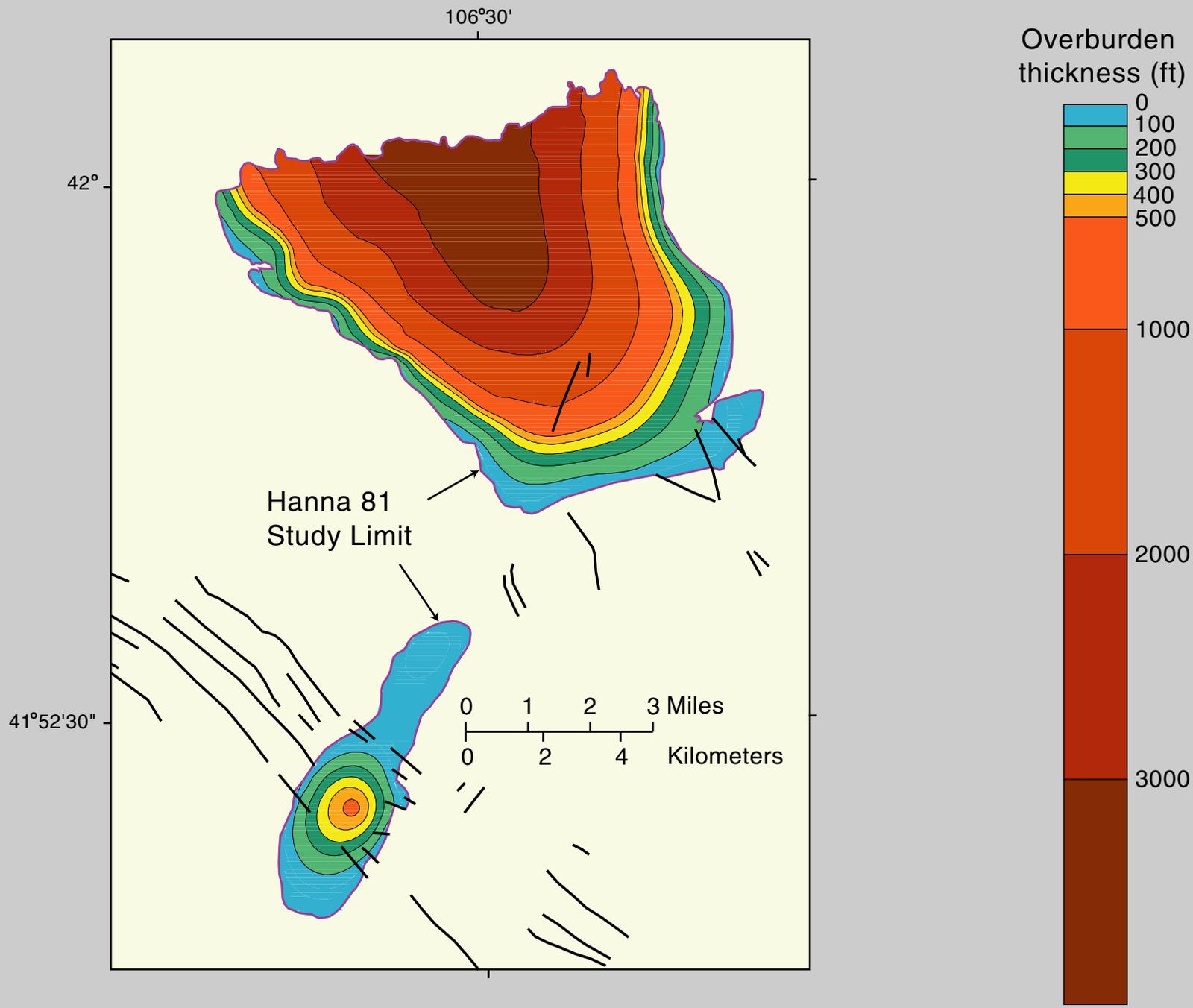
Figure HN-29. Hanna 81 overburden isopach map.
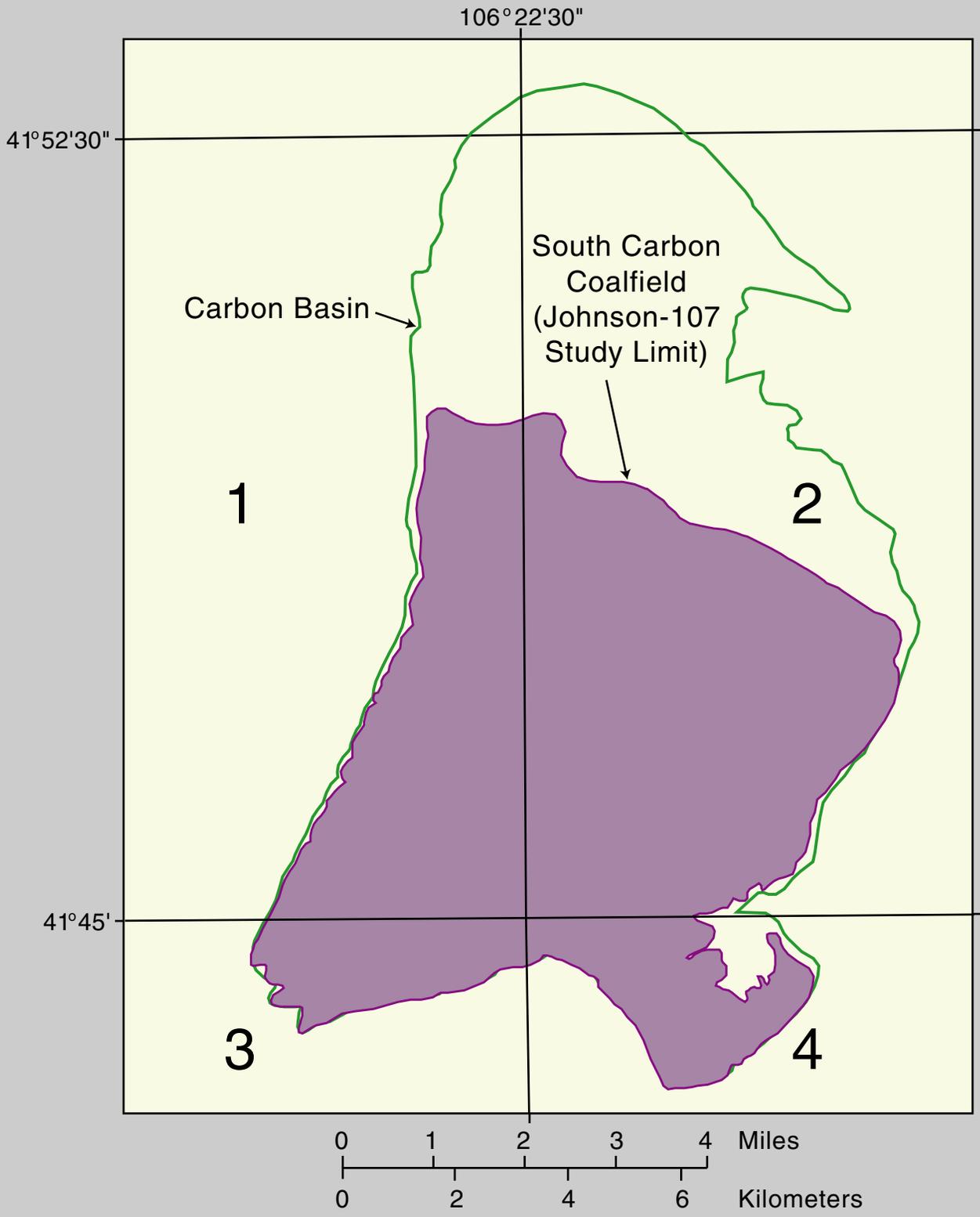
Figure HN-30. Location of 7.5-minute quadrangle maps in the South Carbon coalfield.
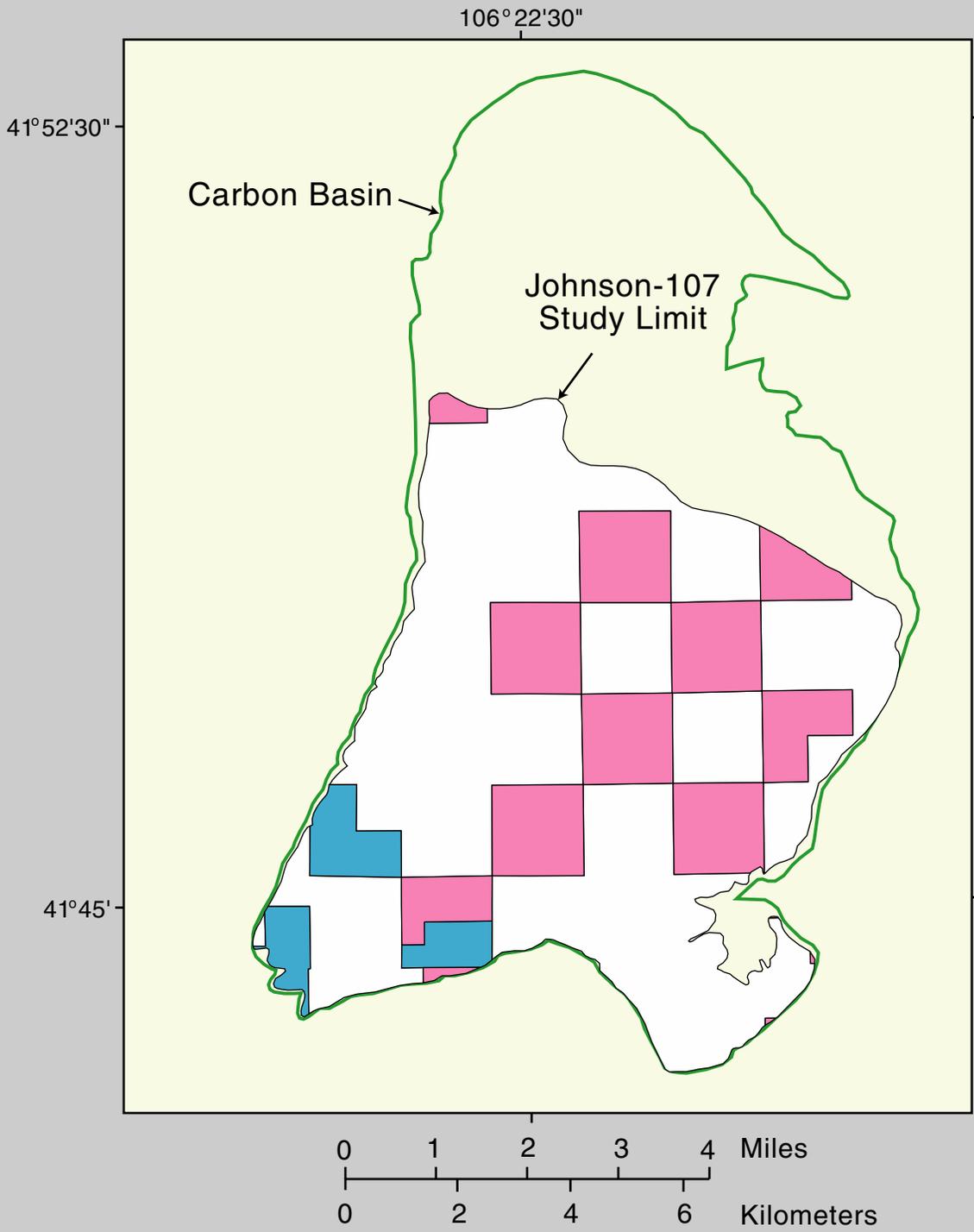
Figure HN-31. Federal coal and surface ownership in the Johnson-107 study limit.
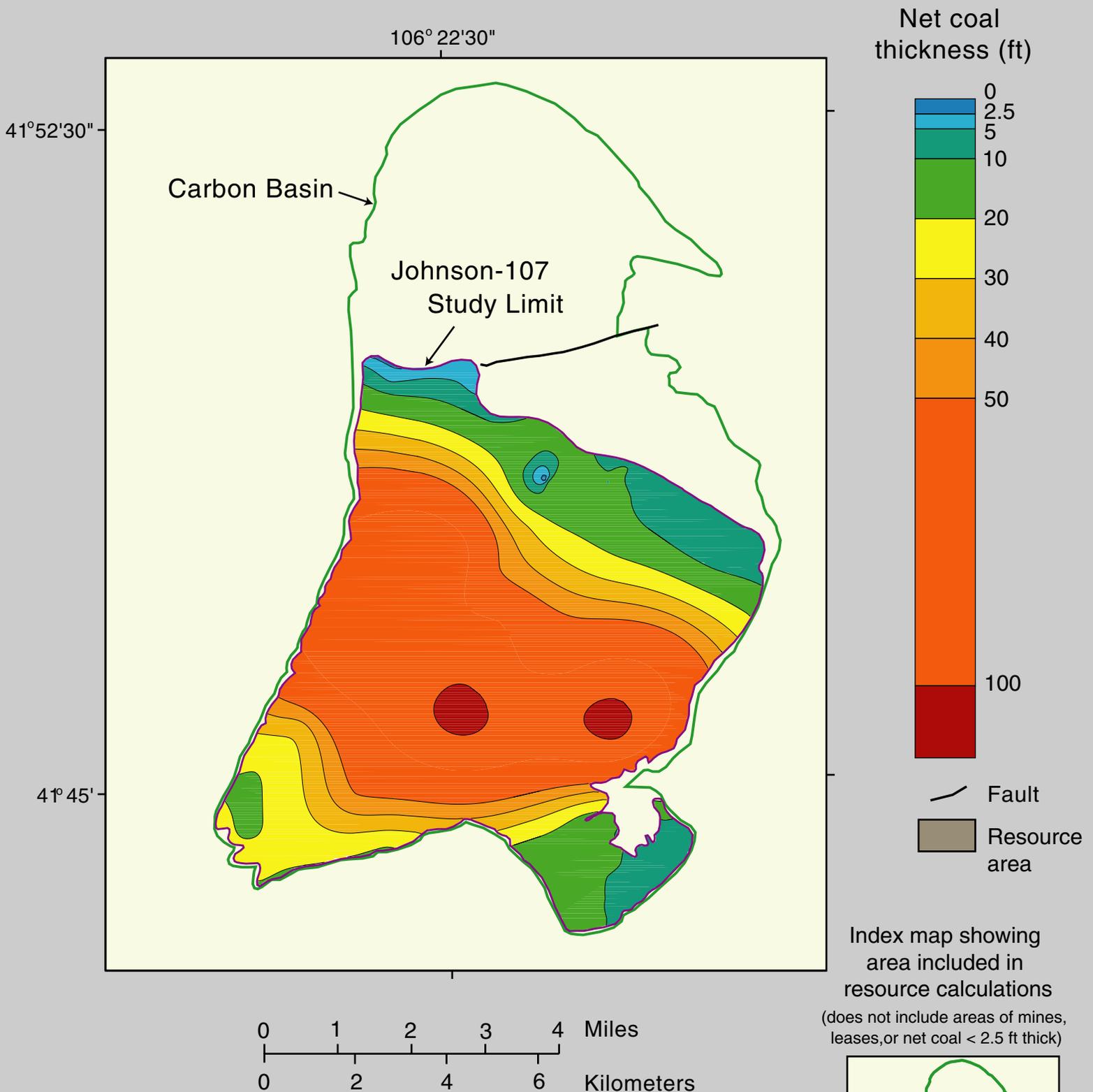
Figure HN-32. Johnson-107 net coal isopach map and resource area.

Net coal thickness (ft)

0
2.5
5
10
20
30
40
50
100

Fault

Resource area

Index map showing area included in resource calculations

(does not include areas of mines, leases, or net coal < 2.5 ft thick)

Mine and lease Areas

Carbon Basin

Johnson-107 Study Limit

106° 22'30"

41°52'30"

41° 45'

0   1   2   3   4   Miles

0   2   4   6   Kilometers
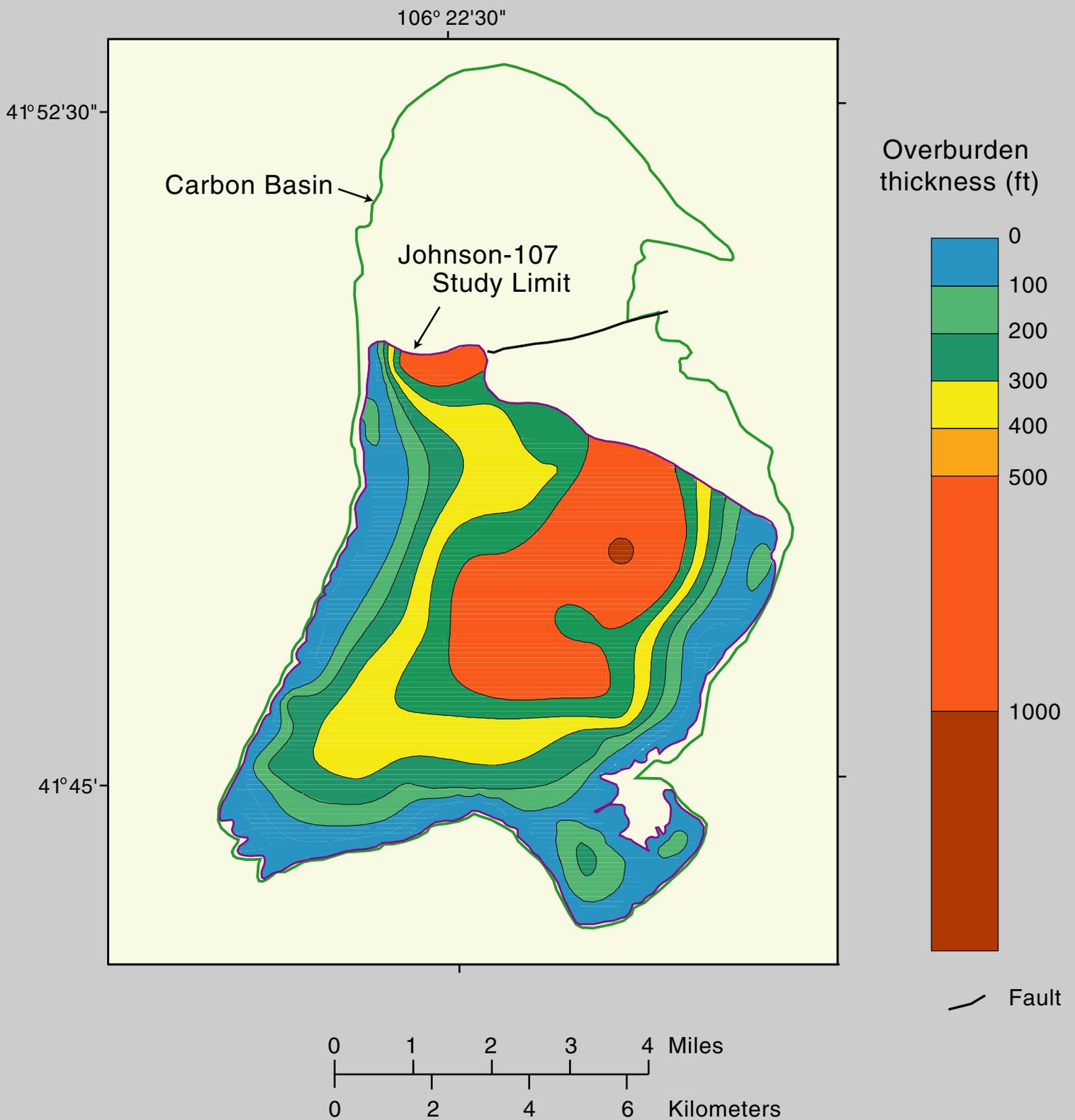
Figure HN-33. Johnson-107 overburden isopach map.

Table HN-1. Coal resources of the Ferris 23 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-12), net coal thickness (fig. HN-1), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-1). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	2.5-5 ft	1.8	8.7	5.1	0.27	16
	5-10 ft	4.1	7.8	37	2.7	52
	10-20 ft	6.5	5.8	0.17	0	12
0-100 ft total		12	22	42	3.0	80
100-200 ft	2.5-5 ft	0.24	0.025	1.3	0.62	2.2
	5-10 ft	0.71	2.2	1.1	0.11	4.1
	10-20 ft	0.78	0	0	0	0.78
100-200 ft total		1.7	2.2	2.4	0.73	7.1
200-500 ft	2.5-5 ft	0.53	0.13	6.8	6.1	14
	5-10 ft	2.1	3.4	8.2	0.16	14
	10-20 ft	3.7	1.2	0	0	4.9
200-500 ft total		6.3	4.8	15	6.3	32
500-1,000 ft	2.5-5 ft	0.23	0.069	7.2	4.4	12
	5-10 ft	0.78	4.1	13	0.15	18
	10-20 ft	1.2	4.4	0.26	0	5.9
500-1,000 ft total		2.2	8.6	20	4.6	36
1,000-1,500 ft	2.5-5 ft	0	0	3.5	5.8	9.3
	5-10 ft	0	0	7.8	0.065	7.9
1,000-1,500 ft total		0	0	11	5.8	17
1,000-2,000 ft	2.5-5 ft	0	0	4.2	5.2	9.5
	5-10 ft	0	0	2.5	0.061	2.6
1,500-2,000 ft total		0	0	6.8	5.3	12
>2,000 ft	2.5-5 ft	0	0	7.5	35	42
	5-10 ft	0	0	3.8	3.3	7.2
>2,000 ft total		0	0	11	38	50
Grand total (MST)		23	38	110	64	230

Table HN-2. Coal resources of the Ferris 23 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle (fig. HN-6) and Federal coal and surface ownership (fig. HN-7). Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-1). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
DANA	No Federal coal or surface ownership	0.15
	Federal coal and surface ownership	0.14
DANA total		0.29
PATS BOTTOM	No Federal coal or surface ownership	88
	No Federal coal, but Federal surface ownership	9.0
	Federal coal and surface ownership	27
PATS BOTTOM total		120
SCHNEIDER RIDGE	No Federal coal or surface ownership	2.6
	No Federal coal, but Federal surface ownership	0.24
	Federal coal and surface ownership	3.8
SCHNEIDER RIDGE total		6.7
SEMINOE DAM SE	No Federal coal or surface ownership	42
	Federal coal and surface ownership	39
SEMINOE DAM SE total		80
TENMILE SPRING	No Federal coal or surface ownership	9.8
	Federal coal and surface ownership	7.9
TENMILE SPRING total		18
WALCOTT	No Federal coal or surface ownership	3.2
	No Federal coal, but Federal surface ownership	0.48
	Federal coal and surface ownership	0.28
WALCOTT total		4.0
Grand total of Federal coal (MST)		78
Grand total (MST)		230

Table HN-3. Coal resources of the Ferris 25 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-13), net coal thickness (fig HN-2), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. Table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-2). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	2.5-5 ft	0.067	0.39	0.12	0	0.58
	5-10 ft	0.30	0.86	1.5	2.9	5.6
	10-20 ft	1.0	0.20	0	6.8	8.0
	20-30 ft	1.4	0.70	0	0.77	2.9
0-100 ft total		2.8	2.1	1.6	10	17
100-200 ft	2.5-5 ft	0.14	0.091	0.33	0	0.56
	5-10 ft	0.54	1.3	1.7	6.4	9.9
	10-20 ft	1.7	0.21	0	7	8.9
	20-30 ft	0.5	0.35	0	5.9	6.8
100-200 ft total		2.8	1.9	2.0	19	26
200-500 ft	2.5-5 ft	0.40	0.65	3.7	1.8	6.5
	5-10 ft	1.7	8.9	24	33	68
	10-20 ft	15	23	46	33	120
	20-30 ft	17	9.6	0	13	40
200-500 ft total		34	42	73	81	230
500-1,000 ft	2.5-5 ft	0	0	3.2	4.3	7.5
	5-10 ft	0.45	2.8	13	28	45
	10-20 ft	2.9	10	0.25	7.3	21
	20-30 ft	1.8	6.9	0	0	8.6
500-1,000 ft total		5.1	20	17	40	82

Table HN-3. Ferris 25 coal resources—continued

| Overburden thickness | Net coal thickness | Reliability category (distance from data point) | | | | Total (MST) |
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
1,000-1,500 ft	2.5-5 ft	0	0	0.051	2.6	2.7
	5-10 ft	0.81	3.2	10	21	35
	10-20 ft	0.23	0.13	0	0	0.36
1,000-1,500 ft total		1.0	3.4	11	23	38
1,500-2,000 ft	2.5-5 ft	0	0	0.010	1.2	1.2
	5-10 ft	0	0.41	9.7	14	24
1,500-2,000 ft total		0	0.41	9.7	15	25
>2,000 ft	2.5-5 ft	0	0	0.0092	1.5	1.5
	5-10 ft	0	0	29	90	120
>2,000 ft total		0	0	29	92	120
Grand total (MST)		46	70	140	280	540

Table HN-4. Coal resources of the Ferris 25 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle (fig. HN-6) and Federal coal and surface ownership (fig. HN-8). Resources are reported in millions of short tons (MST) with two significant figures. Table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-2). Resource numbers will not sum to match total due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
DANA	No Federal coal or surface ownership	52
	No Federal coal, but Federal surface ownership	2.2
	Federal coal, but no Federal surface ownership	2.6
	Federal coal and surface ownership	36
DANA total		93
ELMO	No Federal coal or surface ownership	0.63
	Federal coal and surface ownership	0.25
ELMO total		0.88
HANNA	No Federal coal or surface ownership	4.0
	Federal coal, but no Federal surface ownership	0.54
	Federal coal and surface ownership	3.0
HANNA total		7.6
PATS BOTTOM	No Federal coal or surface ownership	120
	No Federal coal, but Federal surface ownership	17
	Federal coal and surface ownership	38
PATS BOTTOM total		180

Table HN-4. Ferris 25 coal resources—continued

7.5-minute quadrangle map	Federal ownership	Total (MST)
SCHNEIDER RIDGE	No Federal coal or surface ownership	5.0
	Federal coal and surface ownership	6.7
SCHNEIDER RIDGE total		12
SEMINOE DAM SE	No Federal coal or surface ownership	74
	Federal coal and surface ownership	73
SEMINOE DAM SE total		150
TENMILE SPRING	No Federal coal or surface ownership	52
	No Federal coal, but Federal surface ownership	4.1
	Federal coal and Surface ownership	41
TENMILE SPRING total		97
WALCOTT	No Federal coal or surface ownership	2.3
	Federal coal and surface ownership	0.20
	No Federal coal, but Federal surface ownership	1.4
WALCOTT total		3.8
Grand total Federal coal		200
Grand total (MST)		540

Table HN-5. Coal resources of the Ferris 31 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-14), net coal thickness (fig. HN-3), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-3). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	2.5-5 ft	0.40	0.30	1.3	0.37	2.4
	5-10 ft	0.087	0.33	6.0	0.92	7.3
	10-20 ft	0	0	1.8	9.1	11
	20-30 ft	0	0	0	1.3	1.3
0-100 ft total		0.49	0.63	9.1	12	22
100-200 ft	2.5-5 ft	0.094	0.035	0.021	0.36	0.51
	5-10 ft	0.24	0.63	0.66	1.1	2.7
	10-20 ft	0	0	0	7.2	7.2
	20-30 ft	0	0	0	0.62	0.62
100-200 ft total		0.33	0.67	0.68	9.3	11
200-500 ft	2.5-5 ft	0.68	1.5	2.0	2.1	6.3
	5-10 ft	0.60	1.9	5.4	34	42
	10-20 ft	0	0	0	28	28
	20-30 ft	0	0	0	7.3	7.3
200-500 ft total		1.3	3.4	7.4	71	83
500-1,000 ft	2.5-5 ft	0	0.57	0.31	0.56	1.4
	5-10 ft	0	0.39	13	19	32
	10-20 ft	0	0	0	20	20
	20-30 ft	0	0	0	0.038	0.038
500-1,000 ft total		0	0.96	13	39	53

Table HN-5. Ferris 31 coal resources—continued

| Overburden thickness | Net coal thickness | Reliability category (distance from data point) | | | | Total (MST) |
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
1,000-1,500 ft	2.5-5 ft	0	0.0065	3.7	0.12	3.8
	5-10 ft	0	0.063	9.7	12	22
	10-20 ft	0	0	0	14	14
1,000-1,500 ft total		0	0.069	13	26	39
1,500-2,000 ft	2.5-5 ft	0	0.015	2.4	0.12	2.5
	5-10 ft	0	0.036	2.6	10	13
	10-20 ft	0	0	0	8.7	8.7
1,500-2,000 ft total		0	0.051	5.0	19	24
>2,000 ft	2.5-5 ft	0	0.012	0.26	3.6	3.8
	5-10 ft	0	2.0	3.6	22	28
	10-20 ft	0	0	0	4.1	4.1
>2,000 ft total (MST)		0	2.0	3.9	30	36
Grand total (MST)		2.1	7.8	53	210	270

Table HN-6. Coal resources of the Ferris 31 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle (fig. HN-6) and Federal coal and surface ownership (fig. HN-9). Resources are reported in millions of short tons (MST) with two significant figures. Table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-3). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
DANA	No Federal coal or surface ownership	10
	Federal coal and surface ownership	7.5
DANA total		18
PATS BOTTOM	No Federal coal or surface ownership	93
	No Federal coal, but Federal surface ownership	15
	Federal coal and surface ownership	36
PATS BOTTOM total		140
SEMINOE DAM SE	No Federal coal or surface ownership	25
	Federal coal and surface ownership	23
SEMINOE DAM SE total		47
TENMILE SPRING	No Federal coal or surface ownership	31
	Federal coal and surface ownership	29
TENMILE SPRING total		60
WALCOTT	No Federal coal or surface ownership	0.080
	No Federal coal, but Federal surface ownership	0.36
WALCOTT total		0.44
Grand total of Federal coal (MST)		95
Grand total (MST)		270

Table HN-7. Coal resources of the Ferris 50 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-15), net coal thickness (fig. HN-4), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-4). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	2.5-5 ft	0.36	2.1	3.4	2.4	8.3
	5-10 ft	0.35	0.76	7.7	16	25
	10-20 ft	2.3	12	19	1.5	34
0-100 ft total		3.0	15	30	20	67
100-200 ft	2.5-5 ft	0.14	0.39	0.8	1.5	2.8
	5-10 ft	1.0	1.4	2.5	1.8	6.7
	10-20 ft	0.89	3.4	4.8	0.82	9.9
100-200 ft total		2.0	5.2	8.1	4.1	19
200-500 ft	2.5-5 ft	0.50	0.91	1.1	0.072	2.6
	5-10 ft	0.58	6.6	13	3.1	24
	10-20 ft	1.8	6.3	8.6	0.25	17
200-500 ft total		2.8	14	23	3.4	43
500-1,000 ft	2.5-5 ft	0.012	0.13	0.049	0.044	0.24
	5-10 ft	1.1	7.6	16	0.061	25
	10-20 ft	1.9	11	21	0.18	34
500-1,000 ft total		3.1	19	36	0.28	59
1,000-1,500 ft	2.5-5 ft	0	0	0	0.033	0.033
	5-10 ft	2.3	3.7	1.6	0.0016	7.6
	10-20 ft	0.30	7.8	39	0.19	47
1,000-1,500 ft total		2.6	11	40	0.22	55

Table HN-7 Ferris 50 coal resources—continued

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
1,500-2,000 ft	2.5-5 ft	0	0	0	0.013	0.013
	5-10 ft	0.091	4.3	0.029	0	4.4
	10-20 ft	0	4.4	39	3.3	46
1,500-2,000 ft total		0.091	8.7	39	3.3	51
>2,000 ft	2.5-5 ft	0	0	0	0.0071	0.0071
	5-10 ft	0	0.0056	0.025	0	0.031
	10-20 ft	0	0.80	160	49	210
>2,000 ft total		0	0.80	160	49	210
Grand total (MST)		14	73	340	80	510

Table HN-8. Coal resources of the Ferris 50 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle (fig. HN-6) and Federal coal and surface ownership (fig. HN-10). Resources are reported in millions of short tons (MST) with two significant figures. Table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-4). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
DANA	No Federal coal or surface ownership	36
	No Federal coal, but Federal surface ownership	6.0
	Federal coal, but no Federal surface ownership	3.2
	Federal coal and surface ownership	15
DANA total		61
ELMO	No Federal coal or surface ownership	4.2
	Federal coal and surface ownership	1.5
ELMO total		5.7
HANNA	No Federal coal or surface ownership	7.2
	Federal coal, but no Federal surface ownership	1.3
	Federal coal and surface ownership	5.0
HANNA total		14
PATS BOTTOM	No Federal coal or surface ownership	62
	No Federal coal, but Federal surface ownership	1.1
	Federal coal and surface ownership	35
PATS BOTTOM total		97
TENMILE SPRING	No Federal coal or surface ownership	190
	No Federal coal, but Federal surface ownership	10
	Federal coal and surface ownership	130
TENMILE SPRING total		330
Grand total of Federal coal		190
Grand total (MST)		510

Table HN-9. Coal resources of the Ferris 65 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-16), net coal thickness (fig. HN-5), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-5). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	2.5-5 ft	0.27	1.6	0.35	0	2.2
	5-10 ft	4.1	11	2.4	0	17
	10-20 ft	0.79	4.8	0	0	5.6
0-100 ft total		5.2	17	2.7	0	25
100-200 ft	2.5-5 ft	0.23	1.3	0.65	0	2.1
	5-10 ft	0.4	6.9	3.5	0	11
	10-20 ft	1.0	2.6	0	0	3.7
100-200 ft total		1.7	11	4.2	0	17
200-500 ft	2.5-5 ft	1.1	3.8	9.0	0	14
	5-10 ft	0.91	7.2	54	0.98	64
	10-20 ft	4.9	5.1	1.1	0	11
200-500 ft total		6.9	16	65	0.98	88
500-1,000 ft	2.5-5 ft	0.075	0.62	7.4	0	8.1
	5-10 ft	1.5	2.5	40	0	44
	10-20 ft	4.3	6.5	0	0	11
500-1,000 ft total		5.9	9.6	47	0	63
1,000-1,500 ft	5-10 ft	0	0	4.6	0	4.6
1,000-1,500 ft total		0	0	4.6	0	4.6
Grand total (MST)		20	54	120	0.98	200

Table HN-10. Coal resources of the Ferris 65 coal zone in the Ferris coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle map area (fig. HN-6) and Federal coal and surface ownership (fig. HN-11). Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-5). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
DANA	No Federal coal or surface ownership	6.7
	No Federal coal, but Federal surface ownership	0.39
	Federal coal, but no Federal surface ownership	0.16
	Federal coal and surface ownership	3.3
DANA total		11
ELMO	No Federal coal or surface ownership	1.5
	Federal coal and surface ownership	0.94
ELMO total		2.5
HANNA	No Federal coal or surface ownership	6.4
	Federal coal, but no Federal surface ownership	0.093
	Federal coal and surface ownership	5.1
HANNA total		12
PATS BOTTOM	No Federal coal or surface ownership	18
	No Federal coal, but Federal surface ownership	0.11
	Federal coal and surface ownership	7.6
PATS BOTTOM total		25
TENMILE SPRING	No Federal coal or surface ownership	86
	No Federal coal, but Federal surface ownership	1.4
	Federal coal and surface ownership	61
TENMILE SPRING total		150
Grand total of Federal coal		78
Grand total (MST)		200

Table HN-11. Parameters and confidence intervals within reliability categories for Ferris 23 coal resources, Ferris coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	6,116,176	12,591,713	46,035,986	36,008,928	100,752,804
Percent of area	6	12	46	36	100
Acres (area x .0002471)	1,511	3,111	11,376	8,898	24,897
SD (standard deviation (in ft) from semivariogram model)	2.000	3.464	6.325	6.325	NA
Acre feet (acres x SD)	3,023	10,778	71,946	56,276	NA
Volume standard deviation (MST)	2	12	161	100	273
Pseudo n	12	3	1	1	NA
Total calculated resource (MST)	22.60	38.00	109.3	64.00	233.8
Lower 90% confidence limit (MST)	20.00	19.00	0	0	0
Upper 90% confidence limit (MST)	25.00	57.00	374.0	228.0	683.0

Table HN-12. Parameters and confidence intervals within reliability categories for Ferris 25 coal resources, Ferris coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	6,563,920	12,895,672	40,318,426	89,497,646	149,275,664
Percent of area	4	9	27	60	100
Acres (area x 0.0002471)	1,622	3,187	9,963	22,115	36,887
SD (standard deviation (in ft) from semivariogram model)	4.705	5.141	6.760	6.760	NA
Acre feet (acres x SD)	7,632	16,382	67,351	149,504	NA
Volume standard deviation (MST)	4	17	161	265	446
Pseudo n	13	3	1	1	NA
Volume (MST)	45.60	70.10	142.2	281.8	539.7
Lower 90% confidence limit (MST)	39.00	42.00	0	0	0
Upper 90% confidence limit (MST)	52.00	99.00	407.0	717.0	1,274

Table HN-13. Parameters and confidence intervals within reliability categories for Ferris 31 coal resources, Ferris coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability Category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	1,023,193	3,264,636	20,455,234	51,626,255	76,369,319
Percent of area	1	4	27	68	100
Acres (area x 0.0002471)	253	807	5,055	12,757	18,871
SD (standard deviation (in ft) from data)	2.241	2.241	2.241	2.241	NA
Acre feet (acres x SD)	567	1,808	11,328	28,591	NA
Volume standard deviation (MST)	1	4	38	51	93
Pseudo n	2.0	0.7	0.3	1.0	NA
Volume (MST)	2.095	7.832	52.89	206.1	268.9
Lower 90% confidence limit (MST)	0.9300	1.600	0	122.9	115.9
Upper 90% confidence limit (MST)	3.260	14.07	115.3	289.4	422.0

Table HN-14. Parameters and confidence intervals within reliability categories for Ferris 50 coal resources, Ferris coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	3,330,441	16,842,693	60,894,465	17,082,509	98,150,108
Percent of area	3	17	62	17	100
Acres (area x 0.0002471)	823	4,162	15,047	4,221	24,253
SD (standard deviation (in ft) from data)	3.438	3,438	3.438	3.438	NA
Acre feet (acres x SD)	2,830	14,310	51,739	14,514	NA
Volume standard deviation (MST)	2	13	100	26	141
Pseudo n	6.5	3.7	0.8	1.0	NA
Volume (MST)	13.61	73.43	338.2	80.31	505.5
Lower 90% confidence limit (MST)	10.39	51.71	173.0	38.05	273.1
Upper 90% confidence limit (MST)	16.83	95.15	503.4	122.6	737.9

Table HN-15. Parameters and confidence intervals within reliability categories for Ferris 65 coal resources, Ferris coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	5,417,001	17,736,198	44,443,346	352,117	67,948,662
Percent of area	8	26	65	1	100
Acres (area x 0.0002471)	1,339	4,383	10,982	87	16,790
SD (standard deviation (in ft) from data)	2.469	2.469	2.469	2.469	NA
Acre feet (acres x SD)	3,305	10,820	27,113	215	NA
Volume standard deviation (MST)	2	10	62	0	74
Pseudo n	10.7	3.9	0.6	1.0	NA
Volume (MST)	19.65	53.66	123.5	0.980	197.8
Lower 90% confidence limit (MST)	16.70	37.66	22.18	0.3600	76.90
Upper 90% confidence limit (MST)	22.60	69.67	224.9	1.610	318.7

Table HN-16. Coal resources of the Hanna 77 coal zone in the Hanna coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-26), net coal thickness (fig. HN-17), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-17). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	10-20 ft	0.55	3.0	6.2	2.8	13
	40-50 ft	0.51	0.17	15	19	34
0-100 ft total		1.1	3.2	21	22	47
100-200 ft	5-10 ft	0	0.0034	0	0	0.0034
	10-20 ft	1.1	7.4	7.7	4.4	21
	40-50 ft	2.1	0.29	21	28	51
100-200 ft total		3.2	7.7	29	32	72
200-300 ft	5-10 ft	0	0.16	0	0	0.16
	10-20 ft	1.7	8.3	7.7	3.8	21
	30-40 ft	0.078	0	0	0	0.078
	40-50 ft	2.5	1.4	21	28	54
200-300 ft total		4.3	10	29	32	75
300-400 ft	5-10 ft	0	0.17	0	0	0.17
	10-20 ft	3.9	6.3	7.2	3.1	20
	30-40 ft	0.43	0	0	0	0.43
	40-50 ft	1.9	3.8	23	21	50
300-400 ft total		6.3	10	30	24	71
400-500 ft	10-20 ft	0.42	3.4	6.3	2.5	13
	30-40 ft	0.046	0	0	0	0.046
	40-50 ft	0.36	6.6	24	13	44
400-500 ft total		0.83	9.9	31	15	57
500-1,000 ft	10-20 ft	0.011	1.0	14	10	25
	40-50 ft	0	18	140	21	180
500-1,000 ft total		0.011	19	150	31	200

Table HN-16. Hanna 77 coal resources—continued

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
1,000-1,500 ft	10-20 ft	0.94	0.83	4.5	4.0	10
	20-40 ft	0	0	1.8	0.55	2.4
	40-50 ft	0.20	2.6	120	3.4	130
1,000-1,500 ft total		1.1	3.4	130	8.0	140
1500-2,000 ft	5-10 ft	0.063	0	0	0	0.063
	10-20 ft	0.99	2.0	0.69	0.27	3.9
	20-40 ft	0	0	7.5	0	7.5
	40-50 ft	0	0	100	0	100
1,500-2,000 ft total		1.1	2	110	0.27	120
>2,000 ft	10-20 ft	0.3	4.4	0.22	0	4.9
	20-30 ft	0	0.87	0.86	0	1.7
	30-40 ft	0	0.61	51	0	52
	40-50 ft	10	100	570	0	680
	50-100 ft	12	55	11	0	78
>2,000 ft total		23	160	630	0	810
Grand total (MST)		40	230	1,200	160	1,600

Table HN-17. Coal resources of the Hanna 77 coal zone in the Hanna coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle (fig. HN-21) and Federal coal and surface ownership (fig. HN-22). Resources are reported in millions of short tons (MST) with two significant figures. Table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-17). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
COMO WEST	No Federal coal or surface ownership	490
	Federal coal, but no Federal surface ownership	9.9
	Federal coal and surface ownership	340
COMO WEST total		830
DIFFICULTY	No Federal coal or surface ownership	150
	Federal coal, but no Federal surface ownership	18
	Federal coal and surface ownership	8.9
DIFFICULTY total		180
ELMO	No Federal coal or surface ownership	290
	Federal coal, but no Federal surface ownership	0.86
	Federal coal and Federal surface ownership	150
ELMO total		440
HANNA	No Federal coal or surface ownership	47
	Federal coal and surface ownership	0.45
HANNA total		47
T E RANCH	No Federal coal or surface ownership	44
	Federal coal, but no Federal surface ownership	16
	Federal coal and surface ownership	34
T E RANCH total		94
Grand total Federal coal		580
Grand total (MST)		1,600

Table HN-18. Coal resources of the Hanna 78 coal zone in the Hanna coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-27), net coal thickness (fig. HN-18), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-18). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	2.5-5 ft	0.018	0	0	0	0.018
	5-10 ft	0.32	0.27	0	0	0.59
	10-20 ft	2.1	2.9	3.4	0	8.3
	20-30 ft	4.4	0	0.68	1.4	6.5
	30-40 ft	8.3	7.0	9.2	5.2	30
0-100 ft total		15	10	13	6.6	45
100-200 ft	2.5-5 ft	0.055	0	0	0	0.055
	5-10 ft	1.3	0.79	0	0	2.1
	10-20 ft	3.2	0.84	2.5	0	6.5
	20-30 ft	6.9	0.69	3.9	3.2	15
	30-40 ft	11	4.2	14	7.7	37
100-200 ft total		22	6.6	21	11	60
200-300 ft	2.5-5 ft	0.059	0	0	0	0.059
	5-10 ft	1.0	0.85	0	0	1.9
	10-20 ft	4.0	1.1	2.1	0	7.2
	20-30 ft	4.7	2.7	5.1	3	16
	30-40 ft	7.3	1.5	13	6.3	28
200-300 ft total		17	6.2	20	9.2	53
300-400 ft	2.5-5 ft	0.075	0	0	0	0.075
	5-10 ft	0.67	0.93	0	0	1.6
	10-20 ft	3.4	2.1	1.8	0	7.3
	20-30 ft	4.2	4.7	5.9	2.3	17
	30-40 ft	5.7	0.43	13	5.1	24
300-400 ft total		14	8.1	21	7.4	50

Table HN-18. Hanna 78 coal resources—continued

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
400-500 ft	2.5-5 ft	0.027	0.002	0	0	0.029
	5-10 ft	0.26	0.82	0	0	1.1
	10-20 ft	2.7	4.0	1.6	0	8.4
	20-30 ft	4.0	2.5	7.6	1.4	15
	30-40 ft	4.8	0.92	11	4.6	22
400-500 ft total		12	8.3	20	6	47
500-1,000 ft	5-10 ft	0.098	5.0	6.3	0	11
	10-20 ft	7.0	11	11	0	29
	20-30 ft	7.9	9.0	33	1.2	51
	30-40 ft	16	13	41	24	93
500-1,000 ft total		31	38	91	25	180
1,000-1,500 ft	5-10 ft	0	0	0.61	0	0.61
	10-20 ft	0.12	0.57	15	0	16
	20-30 ft	0.74	4.1	14	0	19
	30-40 ft	1.7	13	37	9	60
1,000-1,500 ft total		2.5	18	67	9	96
1,500-2,000 ft	10-20 ft	0	0	10	0	10
	20-30 ft	0.085	4.1	12	0	16
	30-40 ft	1.3	13	45	4.4	64
1,500-2,000 ft total		1.4	17	67	4.4	90
>2,000 ft	10-20 ft	0.19	6.9	30	0	37
	20-30 ft	0.64	27	56	0	83
	30-40 ft	11	83	290	0	380
	40-50 ft	3.3	18	2.5	0	24
>2,000 ft total		15	130	370	0	520
Grand total (MST)		130	250	690	79	1,100

Table HN-19. Coal resources of the Hanna 78 coal zone in the Hanna coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle (fig. HN-21) and Federal coal and surface ownership (fig. HN-23). Resources are reported in millions of short tons (MST) with two significant figures. Table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-18). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
COMO WEST	No Federal coal or surface ownership	250
	Federal coal and surface ownership	170
COMO WEST total		420
DIFFICULTY	No Federal coal or surface ownership	130
	Federal coal and surface ownership	21
DIFFICULTY total		150
ELMO	No Federal coal or surface ownership	280
	Federal coal and surface ownership	120
ELMO total		390
HANNA	No Federal coal or surface ownership	90
	Federal coal and surface ownership	0.80
HANNA total		90
T E RANCH	No Federal coal or surface ownership	44
	Federal coal and surface ownership	51
T E RANCH total		95
Grand total Federal coal		360
Grand total (MST)		1,100

Table HN-20. Coal resources of the Hanna 79 coal zone in the Hanna coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-28), net coal thickness (fig. HN-19), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-19). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	2.5-5 ft	0.0090	0	0	0	0.0090
	5-10 ft	0.42	0.35	0	0	0.78
	10-20 ft	6.6	1.8	0.15	0	8.6
	20-30 ft	0.41	0	0	0	0.41
	30-40 ft	12	3.9	5.1	1.4	22
0-100 ft total		19	6.0	5.3	1.4	32
100-200 ft	5-10 ft	0.32	0.29	0	0	0.61
	10-20 ft	12	0.24	0.66	0	13
	20-30 ft	0.31	0	0	0	0.31
	30-40 ft	6.7	2.4	14	3.8	27
100-200 ft total		19		14	3.8	40
200-300 ft	5-10 ft	0.049	0.089	0	0	0.14
	10-20 ft	9.2	1.3	0.78	0	11
	30-40 ft	1.1	7.0	15	3.6	26
200-300 ft total		10	8.4	15	3.6	38
300-400 ft	10-20 ft	5.4	4.7	0.37	0	10
	30-40 ft	0.42	6.6	16	2.9	26
300-400 ft total		5.8	11	16	2.9	36
400-500 ft	10-20 ft	1.6	6.4	0.083	0	8.1
	30-40 ft	0.45	5.7	15	2.8	24
400-500 ft total		2.1	12	15	2.8	32
500-1,000 ft	10-20 ft	0.035	5.6	6.9	0	13
	30-40 ft	1.5	7.4	79	10	99
500-1,000 ft total		1.5	13	86	10	110

Table HN-20. Hanna 79 coal resources—continued

| Overburden thickness | Net coal thickness | Reliability category (distance from data point) | | | | Total (MST) |
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
1,000-1,500 ft	10-20 ft	0	2.0	4.1	0	6.1
	30-40 ft	1.7	4.7	61	5.6	73
1,000-1,500 ft total		1.7	6.6	65	5.6	79
1,500-2,000 ft	5-10 ft	0	0	1.1	0	1.1
	10-20 ft	0	0.73	3.5	0	4.3
	30-40 ft	0.98	14	55	3.7	74
1,500-2,000 ft total		0.98	14	60	3.7	79
>2,000 ft	5-10 ft	0	0	0.23	0	0.23
	10-20 ft	0	0.85	9.1	0	9.9
	30-40 ft	12	100	320	0	440
>2,000 ft total		12	110	330	0	450
Grand total (MST)		73	180	610	34	900

Table HN-21. Coal resources of the Hanna 79 coal zone in the Hanna coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle (fig. HN-21) and Federal coal and surface ownership (fig. HN-24). Resources are reported in millions of short tons (MST) with two significant figures. Table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-19). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
COMO WEST	No Federal coal or surface ownership	240
	Federal coal, but no Federal surface ownership	7.5
	Federal coal and surface ownership	190
COMO WEST total		440
DIFFICULTY	No Federal coal or surface ownership	130
	Federal coal, but no Federal surface ownership	17
	Federal coal and surface ownership	2.7
DIFFICULTY total		150
ELMO	No Federal coal or surface ownership	150
	Federal coal, but no Federal surface ownership	0.52
	Federal coal and surface ownership	78
ELMO total		230
T E RANCH	No Federal coal or surface ownership	35
	Federal coal, but no Federal surface ownership	11
	Federal coal and surface ownership	30
T E RANCH total		76
Grand total Federal coal		340
Grand total (MST)		900

Table HN-22. Coal resources of the Hanna 81 coal zone in the Hanna coalfield, Hanna Basin, Wyoming, reported by overburden (fig. HN-29), net coal thickness (fig. HN-20), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. The table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-20). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
0-100 ft	2.5-5 ft	0.10	1.2	0	0	1.3
	5-10 ft	0.86	0.31	0	0	1.2
	10-20 ft	2.0	0.053	0	0	2.0
	30-40 ft	14	10	36	3.2	64
0-100 ft total		17	12	36	3.2	68
100-200 ft	2.5-5 ft	0.00084	0.56	0.16	0	0.72
	5-10 ft	0.0098	0.74	0.086	0	0.84
	10-20 ft	0.40	0.50	0	0	0.90
	30-40 ft	7.1	16	22	3.9	49
100-200 ft total		7.5	18	22	3.9	51
200-300 ft	2.5-5 ft	0	0.40	0.52	0	0.93
	5-10 ft	0	0.39	0.40	0	0.79
	10-20 ft	0.37	0.68	0.33	0	1.4
	30-40 ft	3.9	13	17	3.1	37
200-300 ft total		4.3	14	18	3.1	40
300-400 ft	2.5-5 ft	0	0.18	0.92	0	1.1
	5-10 ft	0	0.41	0.43	0	0.84
	10-20 ft	0.20	0.74	0.77	0	1.7
	30-40 ft	3.3	7.5	14	2.4	27
300-400 ft total		3.5	8.9	16	2.4	31
400-500 ft	2.5-5 ft	0	0.0049	0.73	0	0.73
	5-10 ft	0	0.35	0.56	0	0.91
	10-20 ft	0.045	1.0	0.70	0	1.7
	30-40 ft	2.9	5.1	11	1.9	21
400-500 ft total		3.0	6.4	13	1.9	25

Table HN-22. Hanna 81 coal resources—continued

Overburden thickness	Net coal thickness	Reliability category (distance from data point)				Total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	Hypothetical (>3 mi)	
500-1,000 ft	2.5-5 ft	0	0	0.11	0	0.11
	5-10 ft	0	0.26	3.3	0	3.5
	10-20 ft	0.27	5.3	3.8	0	9.4
	30-40 ft	1.2	2.1	48	3.3	54
500-1,000 ft total		1.5	7.6	55	3.3	67
1,000-1,500 ft	10-20 ft	0.017	7.7	8.5	0	16
	30-40 ft	0.17	1.4	43	0	45
1,000-1,500 ft total		0.18	9.1	52	0	61
1,500-2,000 ft	10-20 ft	0.0051	3.9	3.9	0	7.8
	30-40 ft	0.42	4.6	50	0	55
1,500-2,000 ft total		0.43	8.5	54	0	63
>2,000 ft	5-10 ft	0	0	0.016	0	0.016
	10-20 ft	0	2.3	8.0	0	10
	20-30 ft	0	0	0.43	0	0.43
	30-40 ft	10	71	170	0	250
>2,000 ft total		10	73	170	0	260
Grand total (MST)		47	160	440	18	660

Table HN-23. Coal resources of the Hanna 81 coal zone in the Hanna coalfield, Hanna Basin, Wyoming, reported by 7.5-minute quadrangle (fig. HN-21) and Federal coal and surface ownership (fig. HN-25). Resources are reported in millions of short tons (MST) and in two significant figures. Table does not include resources for coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-20). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
COMO WEST	No Federal coal or surface ownership	150
	Federal coal and surface ownership	160
COMO WEST total		310
DIFFICULTY	No Federal coal or surface ownership	100
	Federal coal and surface ownership	0.089
DIFFICULTY total		100
ELMO	No Federal coal or Federal surface ownership	87
	Federal coal and Federal surface ownership	47
ELMO total		130
HANNA	No Federal coal or surface ownership	87
	Federal coal and surface ownership	0.42
HANNA total		87
T E RANCH	No Federal coal or surface ownership	17
	Federal coal and surface ownership	13
T E RANCH total		30
Grand total of Federal coal		160
Grand total (MST)		660

Table HN-24. Parameters and confidence intervals within reliability categories for Hanna 77 coal resources, Hanna coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	4,466,516	20,546,927	89,799,994	16,425,438	131,238,875
Percent of area	3	16	68	13	100
Acres (area x 0.0002471)	1,104	5,077	22,190	4,059	32,430
SD (standard deviation (in ft) derived directly from the data)	9.894	9.894	9.894	9.894	NA
Acre feet (acres x SD)	10,920	50,236	219,555	40,159	NA
Volume standard deviation (MST)	7	42	351	71	471
Pseudo n	9	4	1	1	NA
Total calculated resource (MST)	40.43	225.7	1,162	164.9	1,593
Lower 90% confidence limit (MST)	30.00	157.0	585.0	48.00	819.0
Upper 90% confidence limit (MST)	51.00	295.0	1,740	282.0	2,367

Table HN-25. Parameters and confidence intervals within reliability categories for Hanna 78 coal resources, Hanna coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	area
Area (in square meters)	17,355,245	27,276,139	71,020,583	9,390,185	125,042,152
Percent of area	14	22	57	8	100
Acres (Area x 0.0002471)	4,289	6,740	17,550	2,320	30,899
SD (Standard deviation (in ft) derived directly from the data)	6.827	6.827	6.827	6.827	NA
Acre feet (Acres x SD)	29,279	46,017	119,816	15,842	NA
Volume standard deviation (MST)	9	33	215	28	286
Pseudo n	34	6	1	1	NA
Total calculated resource (MST)	129.9	247.1	692.5	78.73	1,148
Lower 90% confidence limit (MST)	115.0	192.0	338.0	33.00	678.0
Upper 90% confidence limit (MST)	144.0	302.0	1,047	125.0	1,618

Table HN-26. Parameters and confidence intervals within reliability categories for Hanna 79 coal resources, Hanna coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	13,615,932	23,226,193	58,562,863	2,157,339	97,562,328
Percent of area	14	24	60	2	100
Acres (area x 0.0002471)	3,365	5,739	14,471	533	24,108
SD (standard deviation (in ft) derived directly from the data)	4.147	4.147	4.147	4.147	NA
Acre feet (acres x SD)	13,953	23,801	60,012	2,211	NA
Volume standard deviation (MST)	5	19	119	4	146
Pseudo n	27	5	1	1	NA
Total calculated resource (MST)	73.27	180.6	607.2	34.17	895.2
Lower 90% confidence limit (MST)	65.00	150.0	412.0	28.00	655.0
Upper 90% confidence limit (MST)	81.00	211.0	803.0	41.00	1,136

Table HN-27. Parameters and confidence intervals within reliability categories for Hanna 81 coal resources, Hanna coalfield, Hanna Basin, Wyoming. Estimates of uncertainty were calculated with measurement error. Volume refers to the calculated resource in millions of short tons (MST). To show detail, resources in this table are reported using four significant figures. NA, not applicable

Parameter	Reliability category				Entire area
	Measured	Indicated	Inferred	Hypothetical	
Area (in square meters)	6,030,945	23,789,170	60,454,785	1,459,792	91.734,691
Percent of area	7	26	66	2	100
Acres (area x 0.0002471)	1,490	5,878	14,939	361	22,668
SD (standard deviation (in ft) derived directly from the data)	7.145	7.145	7.145	7.145	NA
Acre feet (Acres x SD)	10,648	42,000	106,734	2,577	NA
Volume standard deviation (MST)	5	33	208	5	251
Pseudo n	12	5	1	1	NA
Total calculated resource (MST)	47.52	158.1	443.0	17.61	666.2
Lower 90% confidence limit (MST)	39.00	104.0	101.0	10.00	254.0
Upper 90% confidence limit (MST)	57.00	212.0	785.0	25.00	1,078

Table HN-28. Coal resources of the Johnson-107 coal zone in the South Carbon coalfield, Wyoming, reported by overburden (fig. HN-33), net coal thickness (fig. HN-32), and reliability categories. Zeros (0) indicate areas where no resources were calculated. Resources are reported in millions of short tons (MST) with two significant figures. Resources do not include coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-32). Resource numbers will not sum to match totals due to independent rounding

Overburden thickness	Net coal thickness	Reliability category (distance from data point)			Grand total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	
0-100 ft	2.5-5 ft	0	0.053	0	0.053
	5-10 ft	0.78	4.9	1.5	7.3
	10-20 ft	2.0	8.9	3.3	14
	20-30 ft	2.0	21	5.5	28
	30-40 ft	0	8.1	6.1	14
	>40 ft	0	71	120	190
0-100 ft total		4.8	110	130	250
100-200 ft	2.5-5 ft	0.022	0.036	0	0.059
	5-10 ft	1.2	1.3	0.31	2.8
	10-20 ft	0.48	5.5	3.6	9.6
	20-30 ft	0.63	9.1	0.34	10
	30-40 ft	0	6.8	4.8	12
	>40 ft	3.4	41	39	84
100-200 ft total		5.8	64	49	120
200-300 ft	2.5-5 ft	0.044	0.011	0	0.055
	5-10 ft	1.0	0.064	0	1.1
	10-20 ft	0.52	1.6	0.27	2.4
	20-30 ft	0.62	6.7	0.77	8.1
	30-40 ft	0	7.5	3.6	11
	>40 ft	4.1	57	64	130
200-300 ft total		6.3	73	69	150

Table HN-28. Johnson-107 coal resources—continued

Overburden thickness	Net coal thickness	Reliability category (distance from data point)			Grand total (MST)
		Measured (<1/4 mi)	Indicated (1/4-3/4 mi)	Inferred (3/4-3 mi)	
300-400 ft	2.5-5 ft	0.11	0.0003	0	0.11
	5-10 ft	0.89	0.65	0	1.5
	10-20 ft	2.5	6.5	0	9.0
	20-30 ft	0.25	11	0.63	12
	30-40 ft	0.24	9.4	0.17	9.8
	>40 ft	5.2	130	49	190
300-400 ft total		9.2	160	50	220
400-500 ft	2.5-5 ft	0.21	0	0	0.21
	5-10 ft	1.7	1.9	0	3.6
	10-20 ft	3.4	8.4	0	12
	20-30 ft	1.7	0.9	0	2.6
	30-40 ft	3.2	0.59	0	3.8
	>40 ft	48	99	0.37	150
400-500 ft total		58	110	0.37	170
>500 ft	2.5-5 ft	0.61	0.36	0	0.97
	5-10 ft	1.7	3.6	0.48	5.9
	10-20 ft	0.34	18	0.18	19
	20-30 ft	4.8	11	0	16
	30-40 ft	1.7	19	0	21
	>40 ft	48	130	0	170
>500 ft total		57	180	0.66	240
Grand total (MST)		140	700	300	1,100

Table HN-29. Coal resources of the Johnson-107 coal zone in the South Carbon coalfield, Wyoming, reported by 7.5-minute quadrangle map area (fig. HN-30) and Federal coal and surface ownership (fig HN-31). Resources are reported in millions of short tons (MST) with two significant figures. Resources do not include coal less than 2.5 ft thick or coal in mine or lease areas (fig. HN-32). Resource numbers will not sum to match totals due to independent rounding

7.5-minute quadrangle map	Federal ownership	Total (MST)
CARBON	No Federal coal or surface ownership	410
	Federal coal, but no Federal surface ownership	20
	Federal coal and surface ownership	48
CARBON total		470
ELK MOUNTAIN	No Federal coal or surface ownership	40
	Federal coal, but no Federal surface ownership	0.69
	Federal coal and surface ownership	0.65
ELK MOUNTAIN total		41
HALFWAY HILL	No Federal coal or surface ownership	420
	Federal coal, but no Federal surface ownership	3.4
	Federal coal and surface ownership	140
HALFWAY HILL total		560
T L RANCH	No Federal coal or surface ownership	66
	Federal coal, but no Federal surface ownership	0.37
	Federal coal and surface ownership	0.095
T L RANCH total		66
Grand total of Federal coal		210
Grand total (MST)		1,100

Table HN-30. Data used for computation of confidence intervals within reliability categories for Johnson-107 coal resources in the South Carbon coalfield, Carbon Basin, Wyoming. Volume refers to the calculated resource in millions of short tons (MST). NA, not applicable

Parameter	Reliability category			Entire area
	Measured	Indicated	Inferred	
Area (in square meters)	9,114,330	37,519,215	12,687,826	59,321,371
Percent of area	15	63	21	100
Acres (area x 0.0002471)	2,252	9,271	3,135	14,659
SD (standard deviation (in ft) from variogram model)	13.780	13.780	13.780	NA
Acre feet (acres x SD)	31,035	127,757	43,203	NA
Volume standard deviation (MST)	13	79	184	276
Pseudo n	18	8	0.17	NA

Table HN-31. Estimates of uncertainty (calculated with measurement error) for Johnson-107 coal resources in the South Carbon coalfield, Carbon Basin, Wyoming. To show detail, resources calculations are reported in millions of short tons (MST) with four significant figures

Parameter	Reliability category			Entire area
	Measured	Indicated	Inferred	
Total calculated resource (MST)	141.0	698.5	300.6	1,140
Lower 90% confidence limit (MST)	120.0	569.0	0	687.0
Upper 90% confidence limit (MST)	162.0	828.0	603.0	1,594