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PALEOZOIC STRATIGRAPHY OF TWO AREAS IN SOUTHWESTERN INDIANA

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September 1976

MASTER

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OFFICE OF WASTE ISOLATION
OAK RIDGE, TENNESSEE

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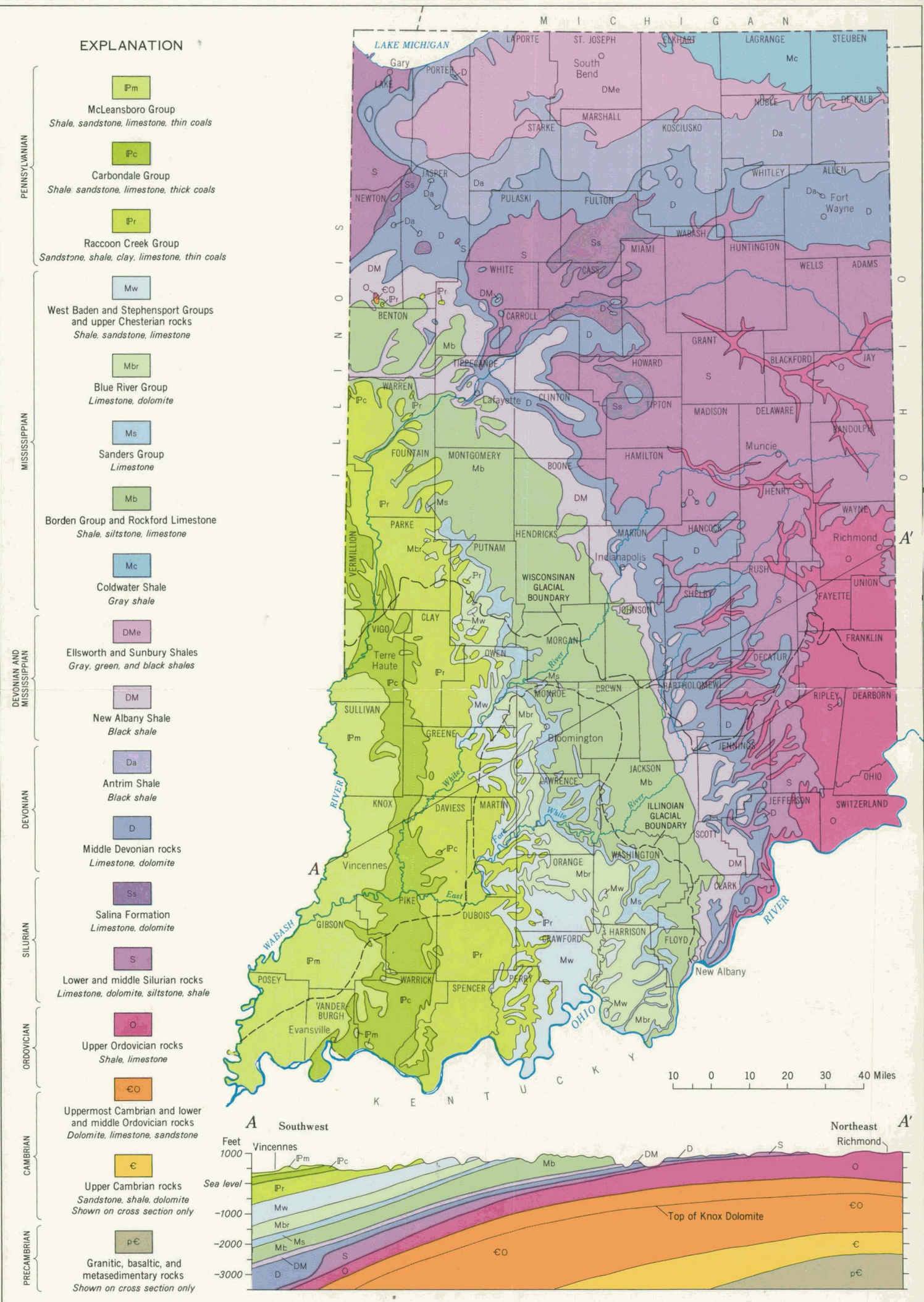
MISCELLANEOUS MAP NO. 16

MAP OF INDIANA SHOWING BEDROCK GEOLOGY



Adapted from Regional Geologic Map Series Indiana Geological Survey, published and in preparation. Drafted by Roger L. Purcell

SUPPLEMENTARY REPORT

on the

GEOLOGY OF TWO AREAS IN SOUTHWESTERN INDIANA

as

POTENTIAL SOLID WASTE REPOSITORY SITES

prepared for

The Office of Waste Isolation, U.C.C.N.D.
Energy Research and Development Administration

John B. Droste
Bloomington, Indiana

CONTENTS

ABSTRACT

Two areas recommended for evaluation as solid waste disposal sites lie along the strike of Paleozoic rocks in southwestern Indiana. Thin Pennsylvanian rocks and rocks of the upper Mississippian are at the bedrock surface in maturely dissected uplands in both areas. The gross subsurface stratigraphy beneath both areas is the same, but facies and thickness variation in some of the subsurface Paleozoic units provide for some minor differences between the areas.

Thick middle Mississippi carbonates grade downward into clastics of lower Mississippian (Borden Group) and upper Devonian (New Albany Shale) rocks. Middle Devonian and Silurian rocks are dominated by carbonate lithologies. Upper Ordovician (Maquoketa Group) overly carbonates of middle Ordovician age.

Thick siltstone and shale of the Borden Group-New Albany Shale zone and Maquoketa Group rocks should be suitable for repository development.

INTRODUCTION

A preliminary report (Droste and Vitaliano, 1976) recommended two areas (Fig. 1) in Indiana for additional study in search for a location of an underground solid waste disposal facility. The present study is supplementary to that earlier report, and treats in more detail the geology of the two areas previously recommended.

The two areas are designated northern and southern herein. Crane Naval Ammunition Depot in Martin County, Indiana is the northern area. The three separate but nearby sites in Crawford and Perry Counties, Indiana are combined in this report into the southern area. Both areas lie along the strike of the Pennsylvanian and Mississippian outcrop of southwestern Indiana and overly the same Paleozoic subsurface rocks. Both areas lie just to the east of the area of major oil and gas exploration in southwestern Indiana, and the only commercially exploited gypsum deposits in Indiana lies between the northern and southern areas (Fig. 1). Both areas lie to the east of commercially exploited coal beds in southwestern Indiana.

The general geology of southwestern Indiana will be treated first in this report, and then there will follow a separate treatment of each area with emphasis on the rock most suitable for repository development.

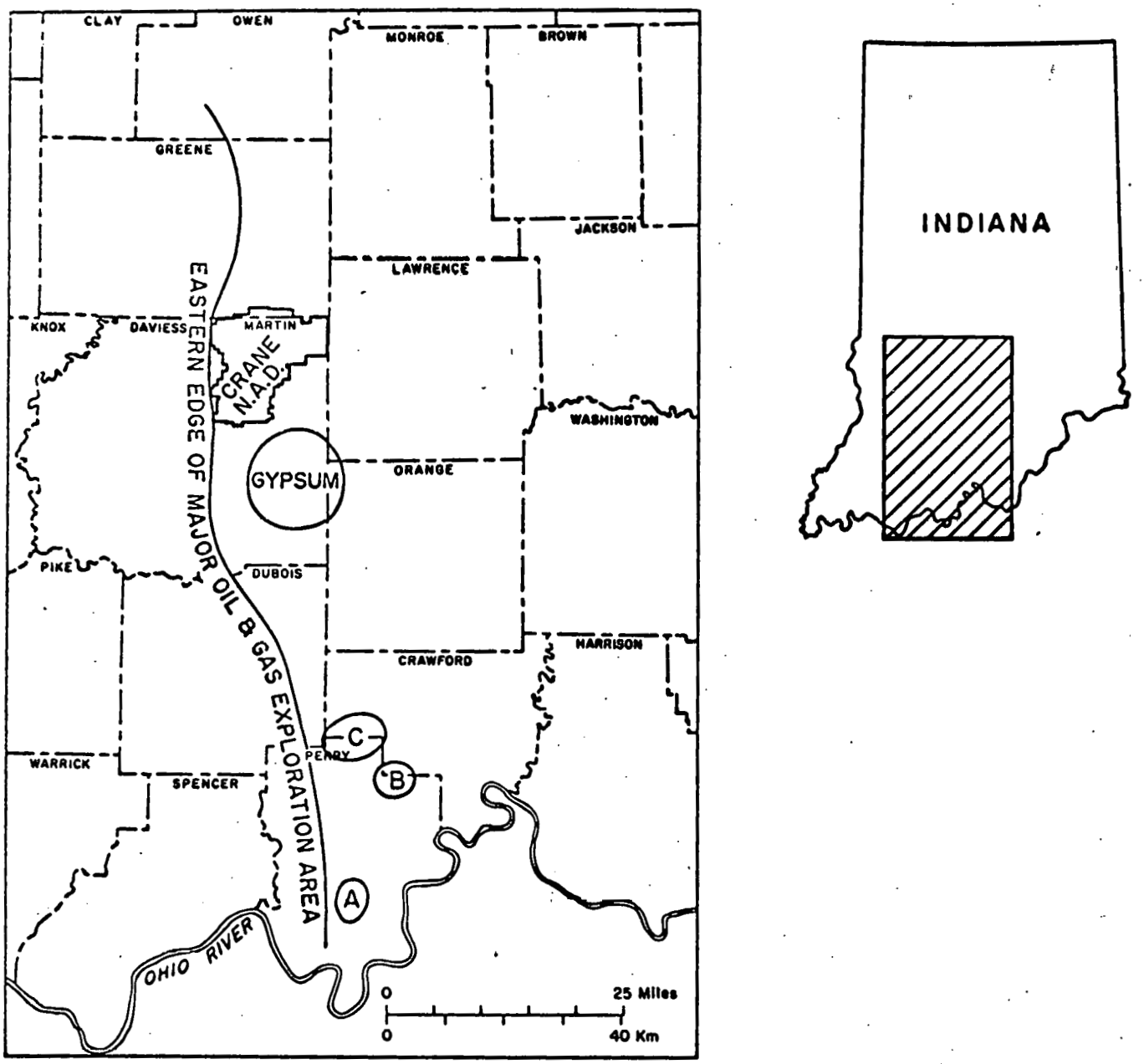


Figure 1. Map of southwestern Indiana showing location of areas selected for possible repository sites. The northern area is within Crane Naval Ammunition Depot; the southern area includes three sites, A, B, and C in Perry County and western Crawford County. Shown also is the eastern limit of major oil and gas exploration and the area of gypsum mining.

GENERAL GEOLOGY

Introduction

All of northern and central Indiana was covered by ice in the Pleistocene. Two lobes of ice extended from central Indiana southward, one lobe to the west and one lobe to the east of central southern Indiana. The southern area of this report is unglaciated and the eastern ice boundary of the western lobe lies about one mile within the western boundary of Martin County (northern area) of this report. The unglaciated, maturely dissected uplands of the two areas lie within the Crawford Upland physiographic division of Indiana. Rocks of Paleozoic age ranging from Ordovician into Pennsylvanian crop out on the west flank of the Cincinnati Arch in southeastern Indiana with a general north-south strike and very low dip to the west. The outcrop belt of lower Pennsylvanian and upper Mississippian cross the northern and southern study areas.

Pennsylvanian

Sandstone, siltstone and shale crop out on about 80 percent of the uplands of the Crane NAD area. Rocks of Mississippian age crop out in the walls and floor of all the major valleys. Thin discontinuous coal beds are found from place to place, and in earlier years several small drift mines were in operation.

Hutchinson (1967 and personal communication) indicated that the reserves within the northern area are so low that little commercial mining will occur in the foreseeable future. In the southern area, in western Perry County and west of the recommended repository site, Saint Meinrad Coal is taken by surface and subsurface mining methods. No commercial mines since 1970 have been in operation except for two mines in Sec. 31 and 30, T. 3 S., R. 3 W. (Hutchinson, 1971 and personal communication). Except for the possibility of commercial quantities of St. Meinrad in far western Perry County, the southern area is free of developable coals in the foreseeable future. A major unconformity separates rocks of Pennsylvanian and Mississippian age.

Mississippian

Chester Series. Rocks of late Mississippian age crop out in the eastern portions of both areas and are at the surface in the lower parts of deeper valleys throughout both areas. The Chester rocks are alternating sandstones, shales and limestones. The sandstones are important oil reservoirs and two horizons within the Chester serve as routine structural reference surfaces. The contact between the Barlow Limestone and Cypress Formation is the shallower of the

two and has been used to produce the structure map shown in Figure 2. The contact between the Bethel Formation and Renault Formation is the lower Chester horizon used to produce the structure map shown in Figure 3.

Saint Genevieve Limestone. The St. Genevieve rocks are carbonates of various lithologies and textures interbedded with dolostone, shale and calcareous sandstone.

Saint Louis Limestone. On the basis of carbonate type, the St. Louis is divisible generally into upper and lower parts. The upper part contains normal marine, thin bedded limestone with abundant gray vitreous chert. The lower division is interbedded fine textured carbonaceous limestones and dolomites with beds of gypsum and anhydrite. Where the evaporites are present green calcareous shales are found. In the region between the two study areas the evaporite beds are thick and continuous enough to be mined (Fig. 1).

Salem Limestone. The Salem rocks are coarse to medium texture bioclastic limestones in the northern area and grade southward into interbedded bioclastic carbonate, argillaceous limestones and dolomitic limestones. East of the northern area, and at the outcrop surface, this formation is quarried extensively as dimension stone. In the subsurface the Salem is an important oil reservoir.

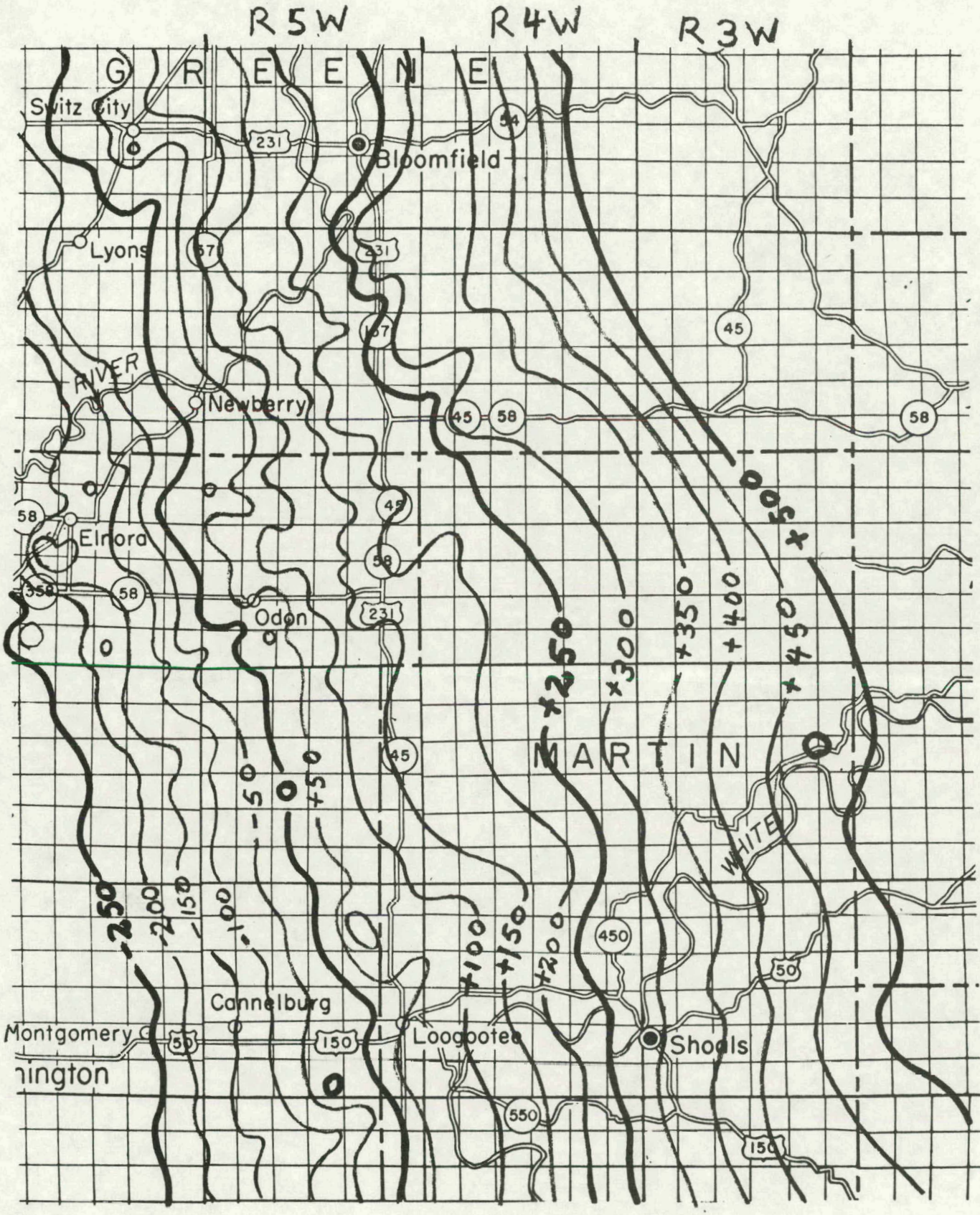


Figure 3. Map showing the structure on top of the Renault Formation in the northern area. Contour interval is 50 feet.

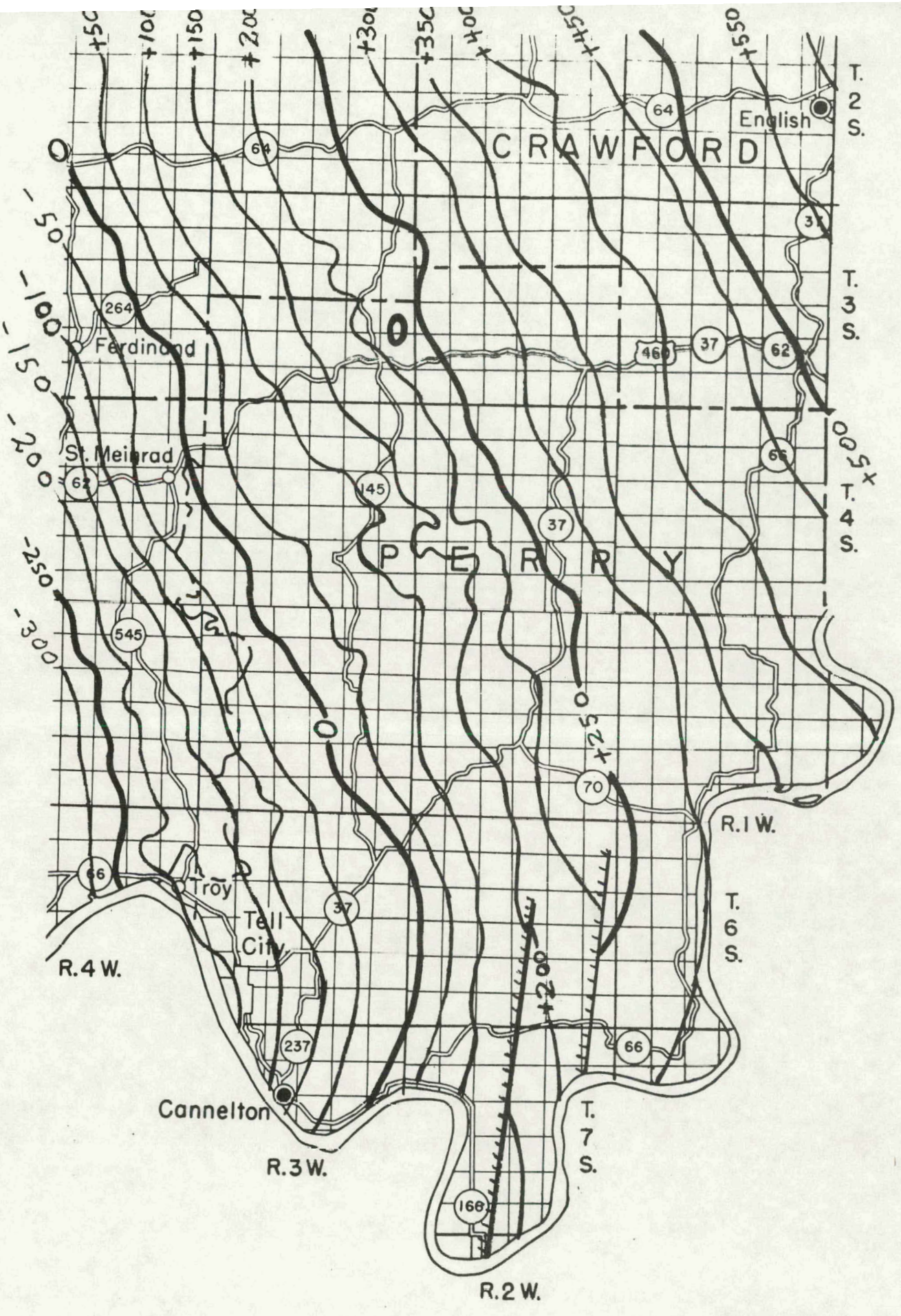


Figure 2. Map showing the structure of the top of the Cypress Formation in the southern area. Contour interval is 50 feet.

Harrodsburg Limestone. Harrodsburg rocks are divisable into upper and lower parts. The upper division is very similar in rock characteristics to the overlying Salem, bioclastic northward and interbedded calcarenite and argillaceous limestone southward. Chert, clay, and quartz silt become more abundant downward in the formation, and the lower Harrodsburg grades into the underlying rocks of the Borden Group.

Borden Group. The upper boundary of the Borden Group is vague and is transitional to the overlying Harrodsburg. The complex variation in lithology within the Borden Group can be testified to by noting that the Group contains 5 formations, 24 facies, and 9 members (Pinsak, 1957). Rock types include sandstones, siltstones, shales, and various limestones. Few geologists even attempt to recognize in the subsurface the named stratigraphic units of the outcrop. Overall the Borden in the study areas is a complex of siltstone and shale interbedded with thin limestones. Good well samples and geophysical logs make it possible to trace some of the units; continuous core is required to do detailed work with the subsurface Borden.

In the northern study area, thickness ranges between 420 to 550 feet (Fig. 4), and the siltstone and shale:limestone

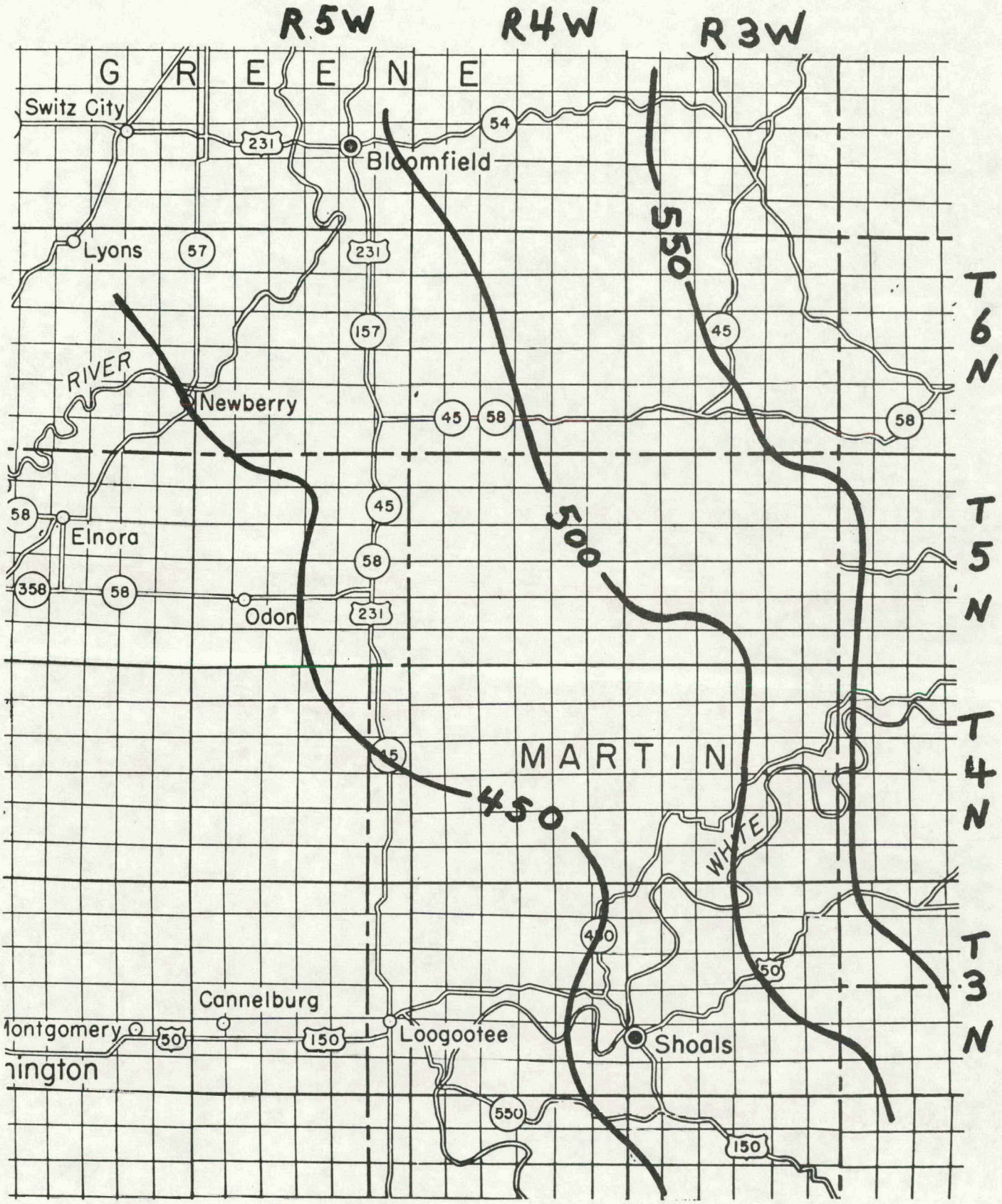


Figure 4. Map showing thickness distribution of the Borden Group in the northern area. Thickness interval is 50 feet.

ratio ranges from 2:1 to 4:1. In the southern area, thickness ranges between 350 to 400 feet (Fig. 5); the siltstone and shale:limestone ratio ranges from near 1:1 to 3:1.

The New Providence Formation of the Borden Group is impermeable siltstone and shale. This unit is thickest in the northern area and dominates the entire Borden Group there. The New Providence Formation thins southward and makes up at least 100 feet of the Borden in the southern area. Limestones, particularly cherty limestones, become much more abundant in the southern area.

The lower boundary of the Borden is well defined in much of Indiana. A thin but persistent limestone, the Rockford Limestone, marks the base of the Borden and is readily identifiable on geophysical logs. The Rockford is up to 10 feet thick in the northern area but is very thin or absent in the southern area. The rocks of the Borden Group and the underlying New Albany should be suitable for repository development.

Devonian

New Albany Shale. The New Albany is both Mississippian and Devonian in age but is catalogued herein as a Devonian

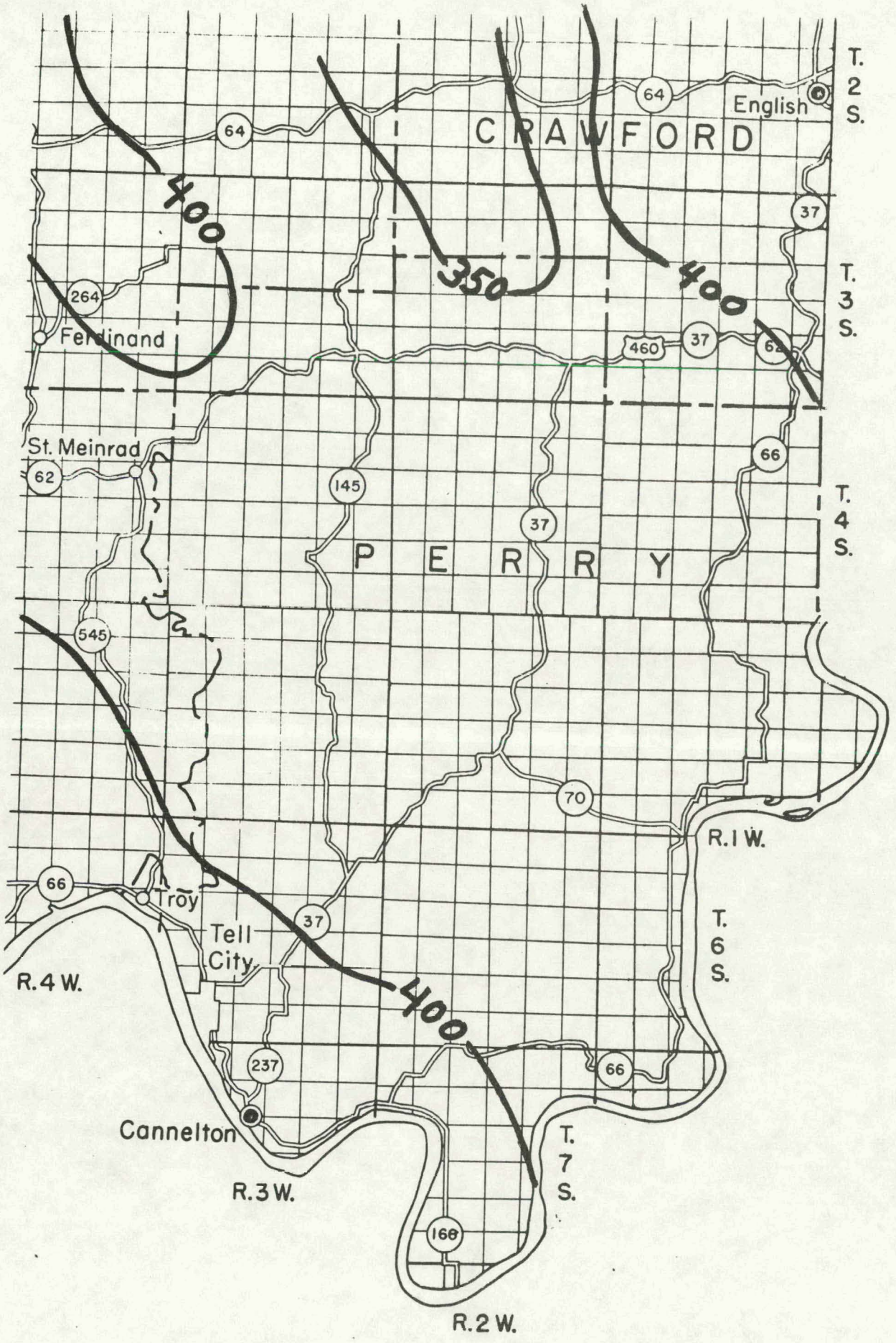


Figure 5. Map showing the thickness distribution of the Borden Group in the southern area. Thickness interval is 50 feet.

entry. In both the northern and southern areas the New Albany is uniformly distributed with general thickness of 100 to 120 feet. A number of members have been established in the outcrop areas (Lineback, 1970), but most geologists doing subsurface work usually separate out only the lower member, the Blocker. The Blocker is composed of brownish-black, carbon rich, calcareous to dolomitic shale and is identifiable in good well samples and on electric logs as a high-resistivity unit. The other members of the New Albany are shales of various colors including shades of gray, green, brown, and black. The Rockford Limestone, the lowest formation of the Borden, provides a good basis for separating the Borden from the New Albany in the northern area. Continuous core may be necessary to separate clearly Borden from New Albany in the southern area. The combined Borden and New Albany interval should contain suitable thickness and lithology for repository development.

Middle Devonian. The North Vernon and Jeffersonville Limestones range from 100 to 140 feet thick in the study areas (Droste, Shaver, and Lazor, 1975) and are of middle Devonian age. Both formations serve as important oil reservoirs in Indiana. No rocks of Early Devonian age are recognized in

either study area. The Devonian-Silurian contact is a major unconformity and is recognized readily in well samples and on geophysical logs.

Silurian

Silurian rock thickness in both study areas range from 400 to 500 feet and include predominantly carbonates of several types and some calcareous shale (Becker, 1974, and Droste and Shaver, in press). Of high interest, both in academic areas and in the petroleum industry, are the reefs in the Silurian rocks of Indiana. The location of known reefs has been outlined by Becker (1974) and by Droste and Shaver (in press). Reefs are found as isolated structures entirely surrounded by interreef rock, and within a massive, thick, reef carbonate bank complex, the Terre Haute Bank (Droste and Shaver, 1975). Both study areas are located just east of the Terre Haute Bank as will be seen by structural data presented later. The Silurian carbonate rocks are distinctive from the rocks of the Maquoketa below in well samples and on geophysical logs.

Ordovician

Maquoketa Group. The Indiana Geological Survey does not divide the Maquoketa into formal smaller units. Gray (1972) recognized informal units, and his two lower units (A and B)

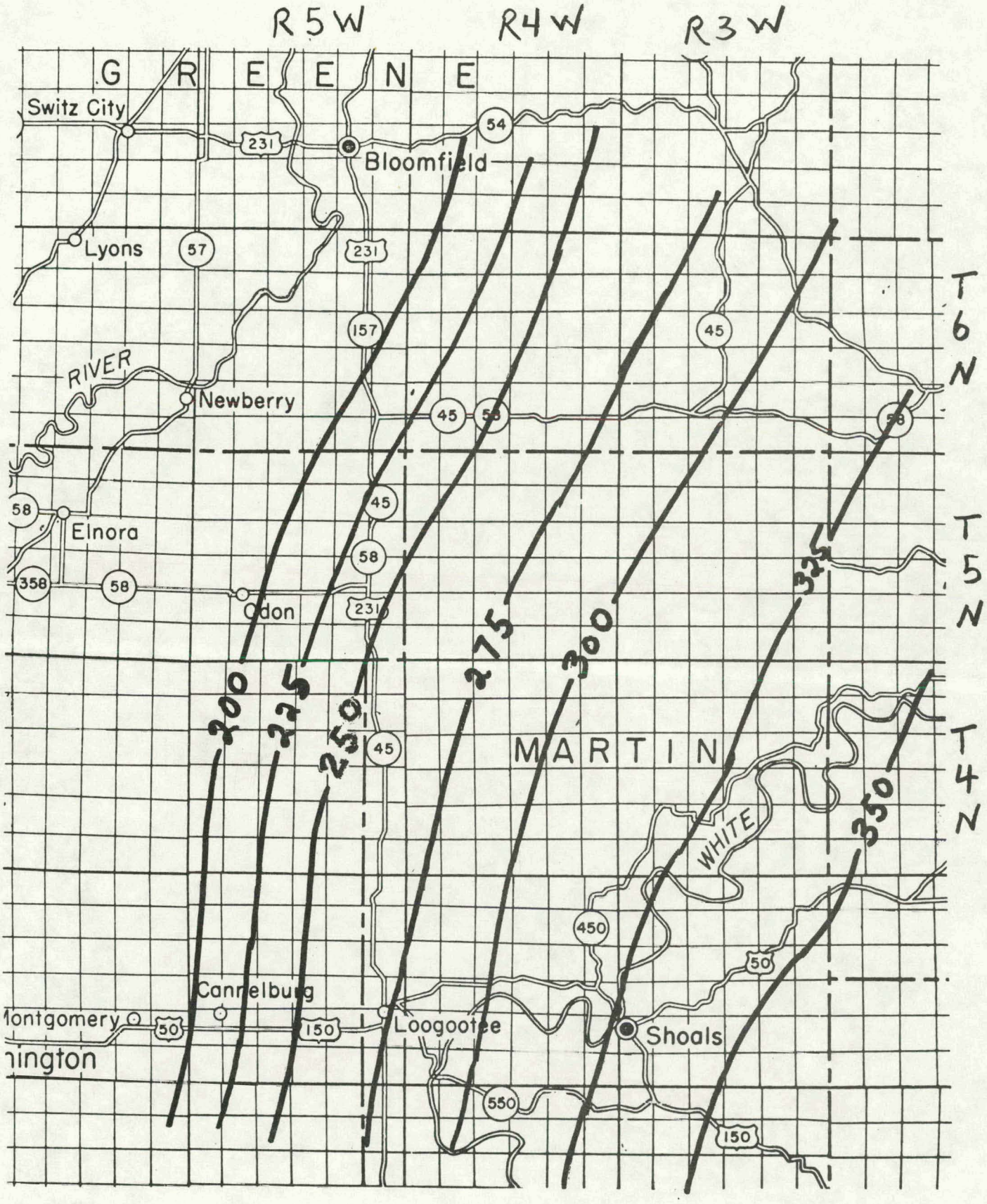


Figure 6. Map showing the thickness interval of the lower Maquoketa in the northern area. Thickness interval is 25 feet.

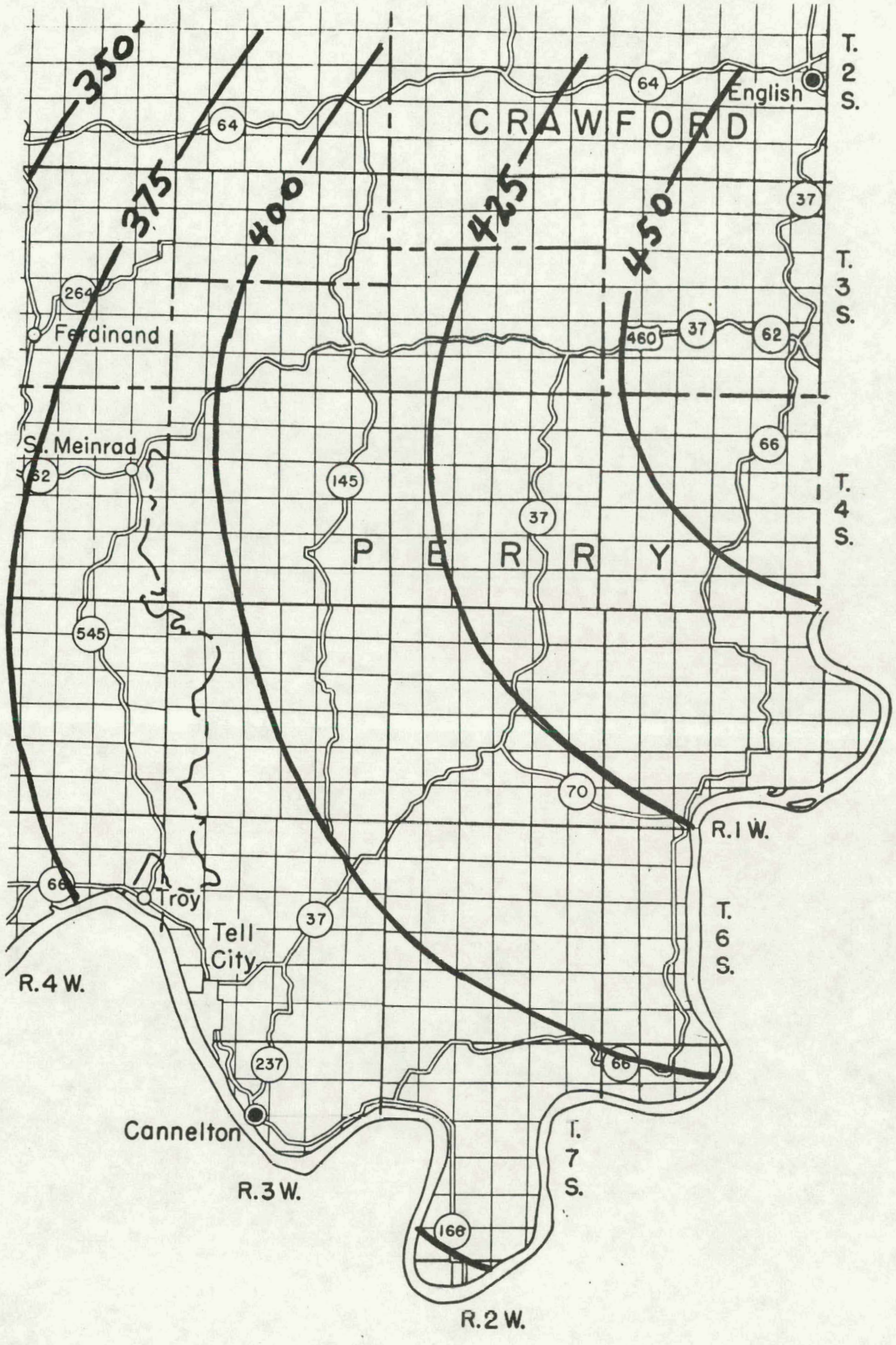


Figure 7. Map showing the thickness distribution of the lower Maquoketa in the southern area. Thickness is 25 feet.

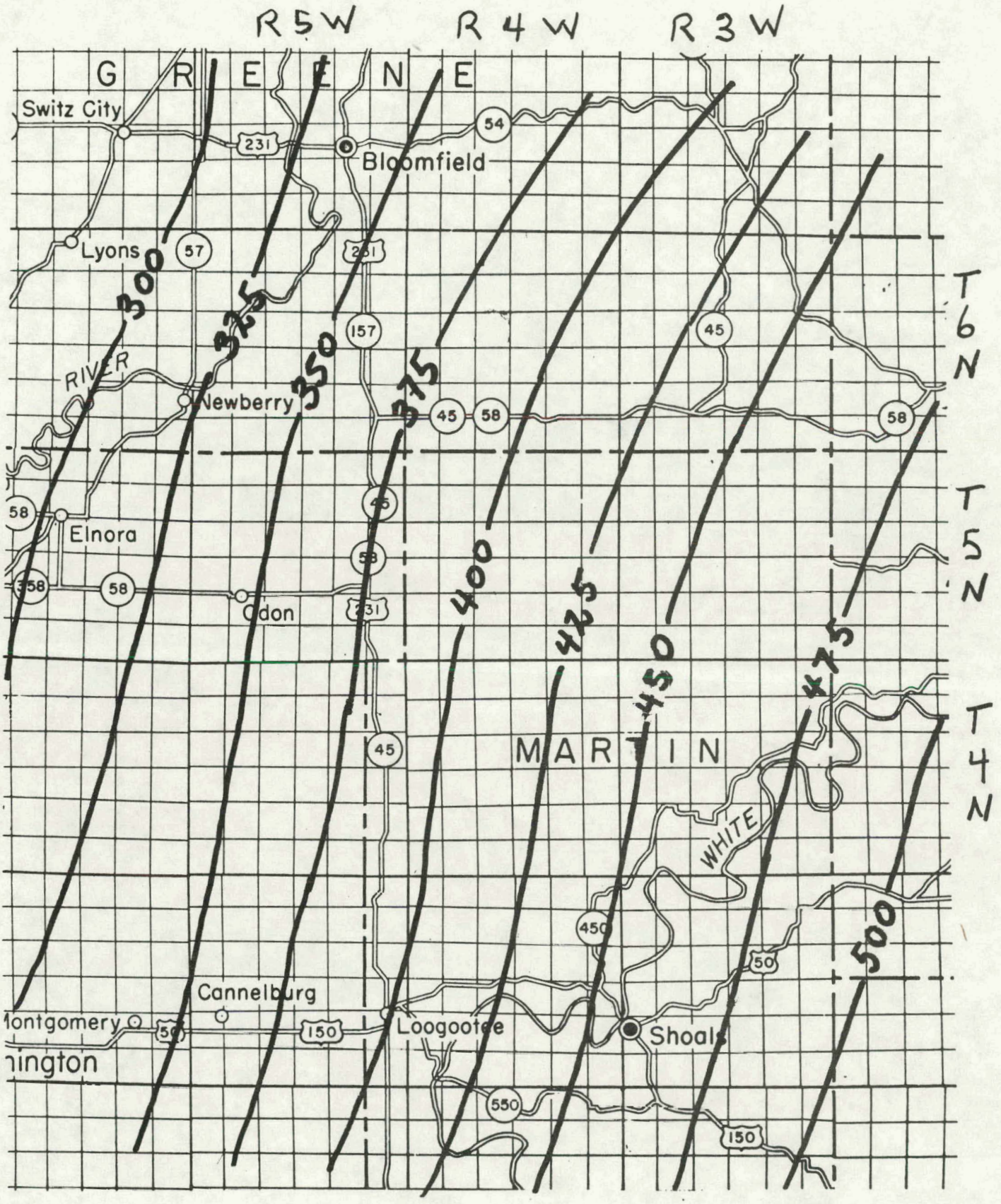


Figure 8. Map showing the thickness distribution of the Maquoketa Group in the northern area. Thickness interval is 25 feet.

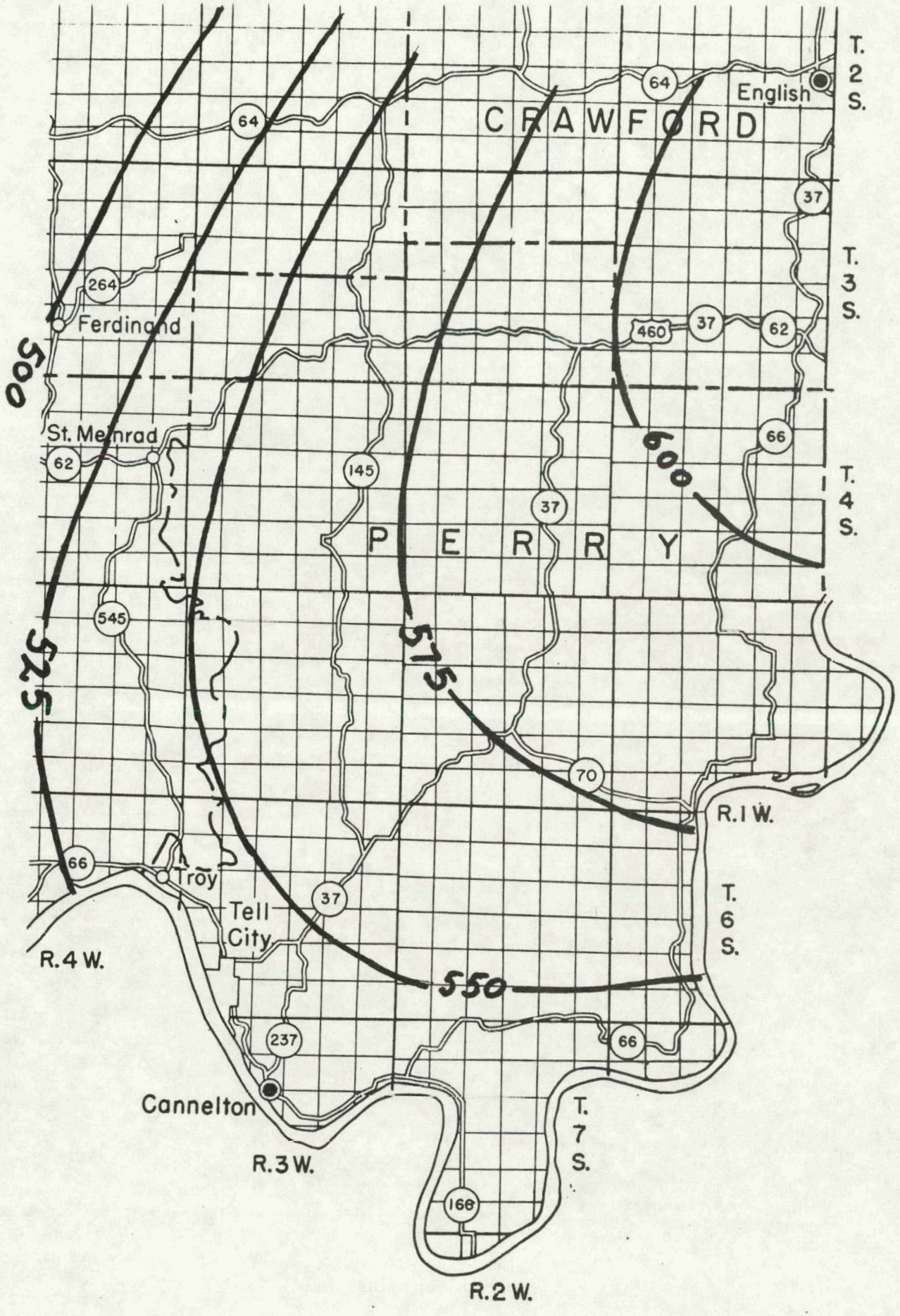


Figure 9. Map showing the thickness distribution of the Maquoketa Group in the southern area. Thickness interval is 25 feet.

are combined in this report into the lower Maquoketa. His unit C is designated upper Maquoketa and his unit D is not present in either study area. The lower Maquoketa is a thick shale and well suited for repository development. Figures 6 and 7 show excellent thickness in both areas. The upper Maquoketa contains interbedded shales and limestone and also may be suitable for repository development. The underground gas storage facility described earlier (Droste and Vitaliano, 1976) is developed in the upper Maquoketa. The total Maquoketa group thickness is given on Figures 8 and 9. The contact of the Maquoketa Group and the Trenton Limestone (below) is easily determined in well samples and on geophysical logs.

MULTISTORY REPOSITORY

Assuming a minimum shallow depth of 1000 feet for a repository level, a two-story repository may be envisioned. An upper level would be placed in the rocks of the Borden and New Albany and a lower level in the rocks of Maquoketa. The two levels could be separated by about 1000 feet of rocks.

The advantages of a multistory system are numerous. A greater life for the repository site is obvious. Land acquisition and the hassle that will be automatic from some individuals and organizations will be faced at only one location. Exploration and development expense will be needed only for one site. Even if only one zone is selected for the first repository, there is advantage of having a choice, upper or lower. One might start the repository at the lower level, fill it, "seal" it, and then move to the upper level. As the lower site is being used, the upper level can be developed initially for experimental purposes. As technology developes the upper level design could be modified.

NORTHERN AREA

Introduction

A large area of northern Martin County (Fig. 10) is occupied by the Crane Naval Ammunition Depot. The eastern boundary of Crane in Township 5 North adjoins the western boundary of the Hoosier National Forest in northwestern Lawrence County. The details of surface land use within Crane is not well documented in public literature. A lake, Lake Greenwood, about 4 miles long and about 1/3 mile wide, is located in the northwestern corner of T. 5 N. and R. 4 W. The following 7½ minute quadrangles show the topography of the area: Owensburg, 1957; Williams, 1957; Indian Springs, 1956; Shoals, 1960; Loogootee, 1956; Odon, 1950; Scotland, 1957; and Koleen, 1956.

In large areas where no cultural features are shown on these maps, unnatural patterns of contour lines indicate existence of roads, fills, cuts, storehouses, "ammunition lines", bunkers, etc. On the other hand large areas of the U.S. installation are "wild uplands" where deer hunters are permitted access to the Depot several days each fall. Conference with Department of Defense should produce designation of area(s)

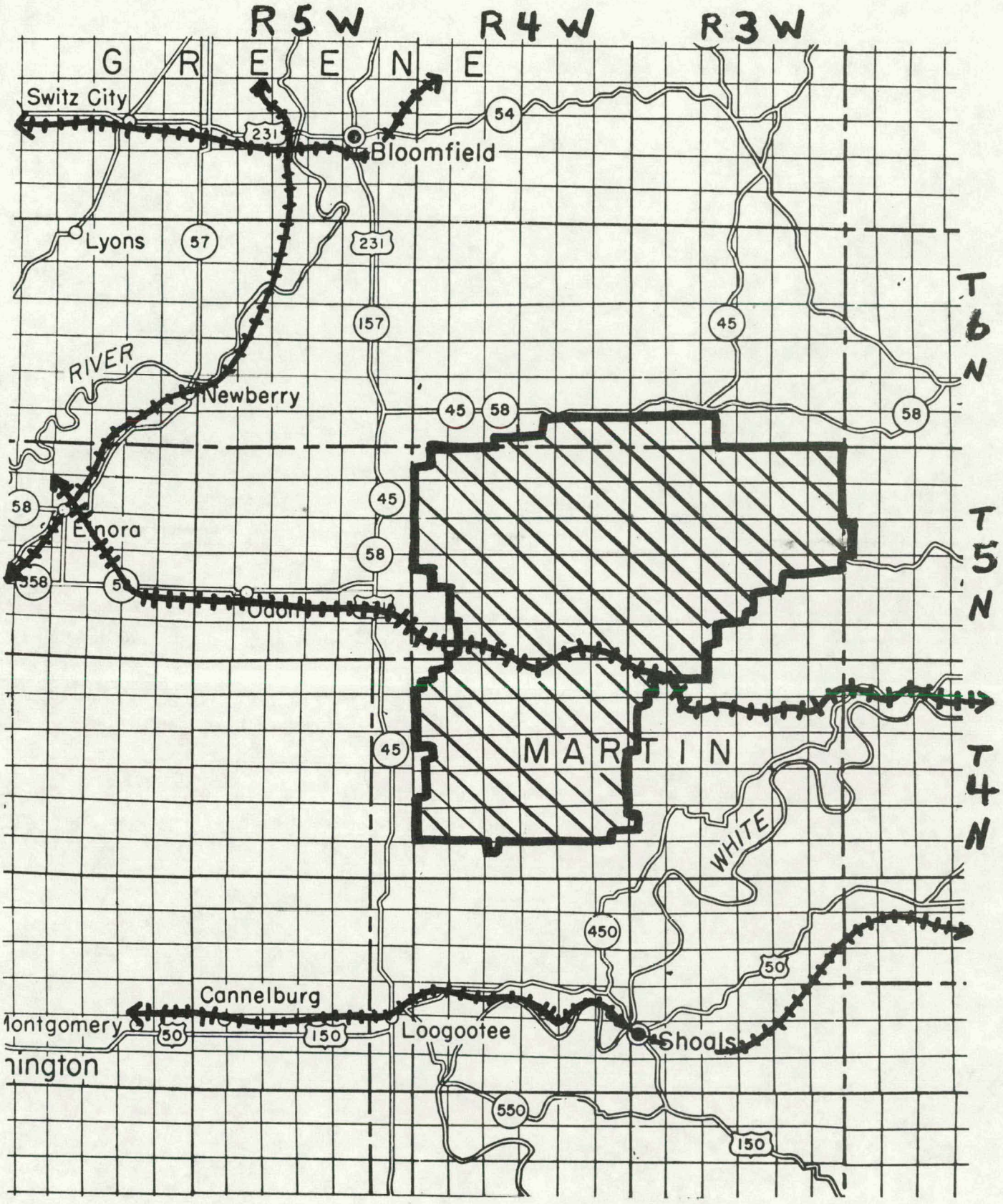


Figure 10. Map showing the general transportation routes of the northern area. The crossed ruled area is the Crane Ammunition Depot.

that will not interfere with military uses. The history of Crane is similar to most installations of this type. At the present time the Depot is "phased down or out" in many of the activities that were in operation during WWII, Korea, and Vietnam times. Without any question, the northern area offers the easiest land aquisition and greatest security.

The state and federal highways of the northern region are shown on Figure 10. The railroad crossing Crane is the Chicago, Milwaukee, St. Paul and Pacific line. About 12 miles east of the Crane boundary at Bedford, Indiana, the railroad crosses the north-south Monon R.R. line. West of Crane, at Elnora, this railroad crosses the Penn Central line and the Illinois Central Gulf line lies north of the area passing through Bloomfield. The Baltimore and Ohio Railroad passes through Loogootee and Shoals south of Crane NAD.

Geologic Summary

Subsurface Data. Only four wells within Crane NAD are recorded in the files of the Indiana Geological Survey. All these wells are shallow and total depths are: 736', 222', 225', and 313'. Moderately good well data are available outside the Crane boundary with respect to Mississippian data.

Enough wells cutting the entire Maquoketa are available so as to predict with confidence the thickness data presented on Figures 6 and 8.

Structure. Structural data are shown on maps for the base and top of the Maquoketa (Fig. 11 and 12), for the base of the New Albany (Fig. 13), and for the top of the Renault (Chester) Formation (Fig. 3). The structural map on the Renault was made because a large number of all wells drilled in the area at least penetrate this unit. The structures related to buried Silurian reefs are evident on this map; the structures around Odon and Elnora, for example, are produced by differential compaction and drape of overlying rocks in Silurian reef complexes below.

Lower Zone. Up to 325 feet of lower Maquoketa and 450 feet of total Maquoketa are present in the Crane area. Maquoketa Group rocks should provide excellent engineering properties for excavation.

Upper Zone. New Albany and Borden rocks range up to 600 feet in thickness in this area. The New Providence rocks should provide excellent properties for repository development.

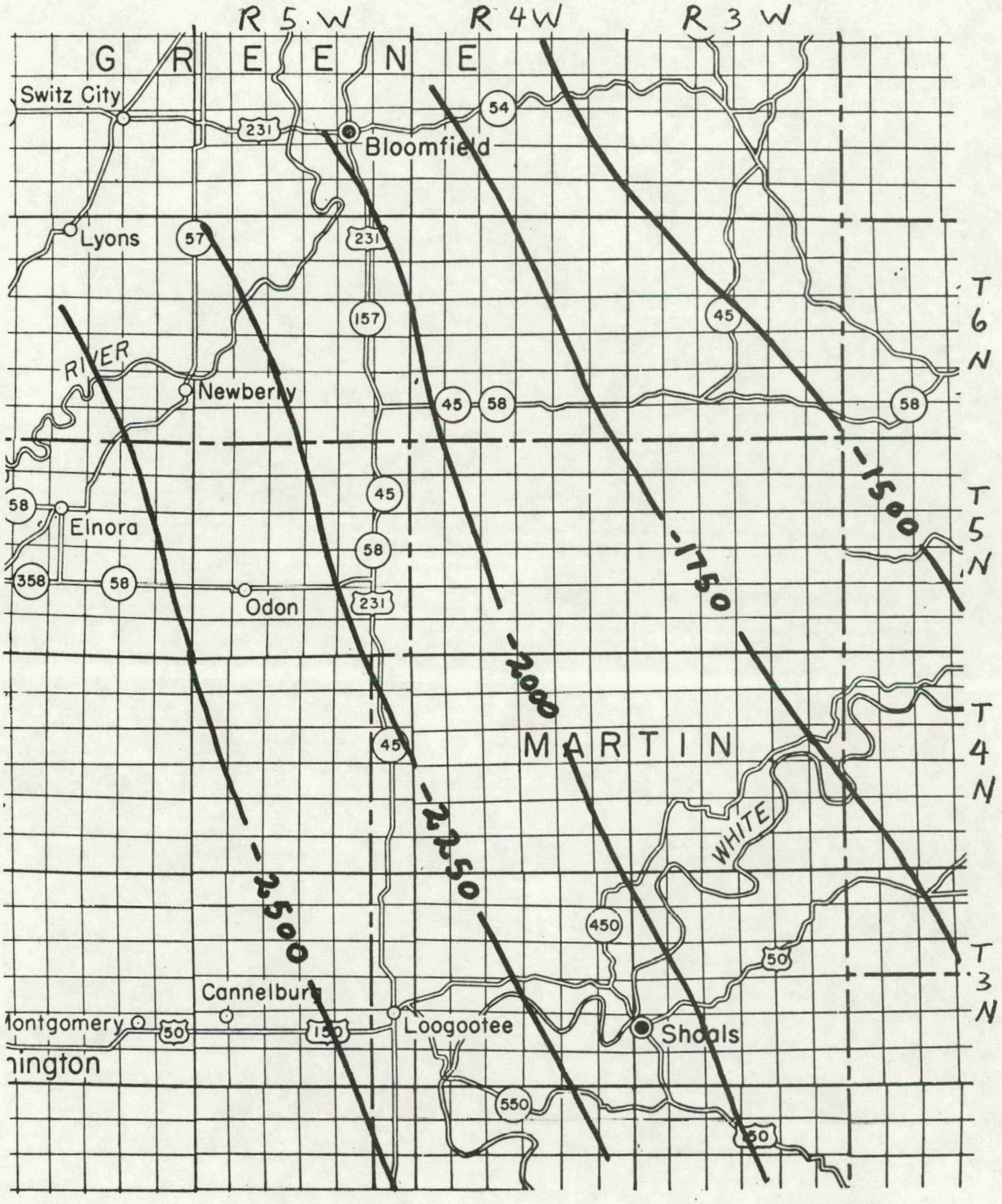


Figure 11. Map showing the structure on the base of the Maquoketa Group in the northern area. Contour interval is 250 feet.

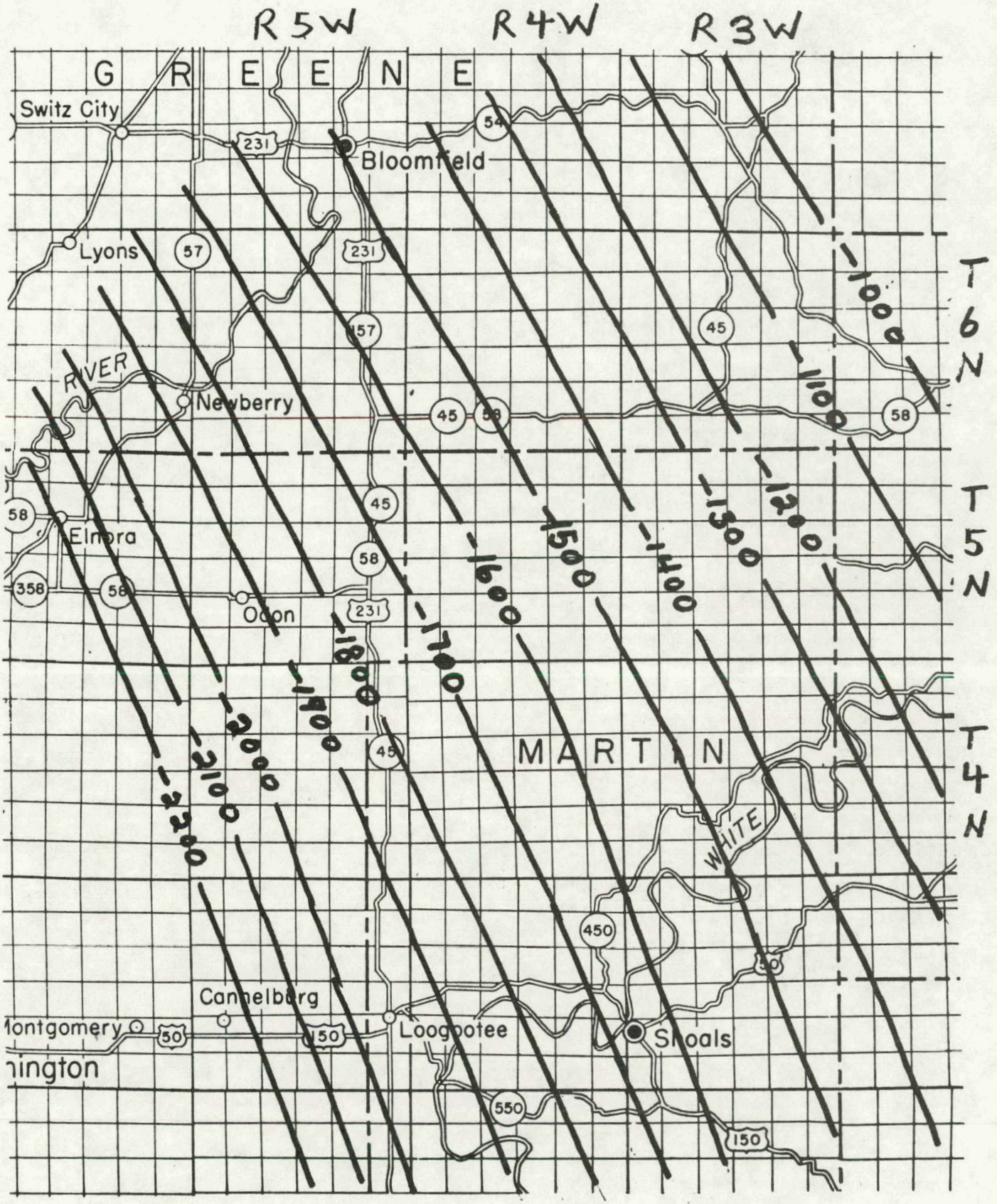


Figure 12. Map showing the structure on top of the Maquoketa Group in the northern area. Contour interval is 100 feet.

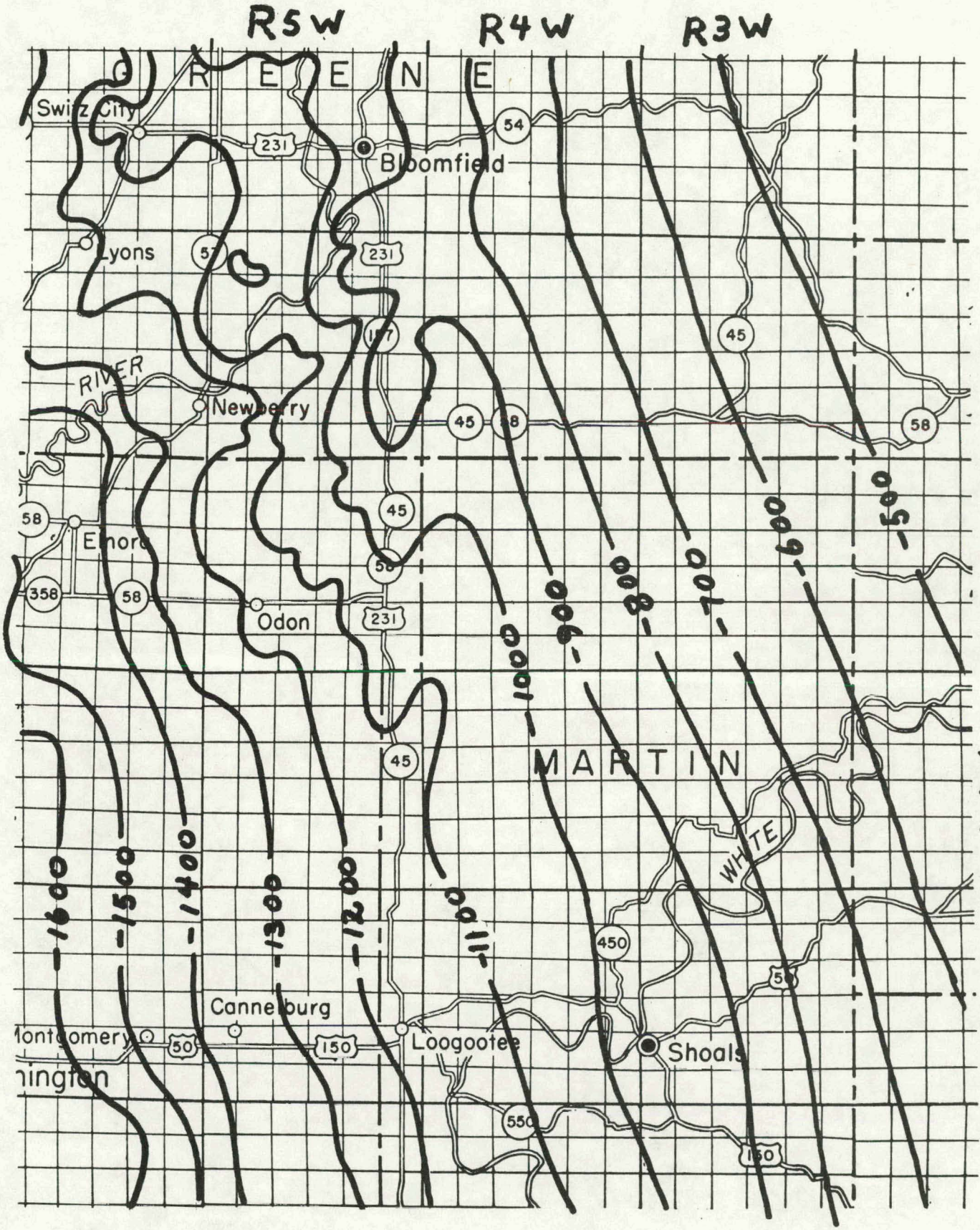


Figure 13. Map showing the structure on the bottom of the New Albany Shale in the northern area. Contour interval is 100 feet.

Typical well record. Martin County, Indiana.

Location: NE¼, SE¼, Sec. 20, T. 3 N., R. 4 W.

Company: McHale Farm: Joseph Hart #1

Elevation: GL = 459.1'; KB = 465.1'

Remarks: rotary well, completed 8/6/73, Birdwell Nuclear Log, samples available, casing set at 76'.

Pennsylvanian.

Sandstone, siltstone and shale, at bedrock surface.

Mississippian.

Chester Group. Sandstone, shale, limestone. 70' to 350'.

St. Genevieve Limestone. 350' to 590'.

St. Louis Limestone. 590' to 775'.

Salem Limestone. 775' to 920'.

Harrodsburg Limestone. 920' to 1030'.

Borden Group.

Limestone, fine to coarse, argillaceous, cherty 1030' to 1100'.

Interbedded argillaceous limestone and shale-siltstone, sporadic chert. 1100' to 1300'.

Siltstone and shale 1300' to 1460'.

Rockford Limestone. 1460' to 1470'.

Devonian.

New Albany Shale.

Interbedded siltstone and shale, dark gray to brownish black. 1470' to 1550'.

Shale, greenish gray. 1550' to 1560'.

Shale, black to brownish black. 1560' to 1585'.

North Vernon Limestone and Jeffersonville Limestone. 1585' to 1720'.

Silurian.

Wabash Formation. Limestone, cherty limestone, dolomite. 1720' to 2180'.

Louisville Limestone. 2180' to 2210'.

Salamonie Dolomite. 2210' to 2250'.

Sexton Creek Limestone. 2250' to 2280'.

Ordovician.

Maquoketa Group.

Shale and interbedded limestone. 2280' to 2410'

Shale. 2410' to 2702'.

Trenton Limestone. 2703' to T.D. at 2807'.

Typical well record. Martin County, Indiana.

Location: SE¼ SE¼ NE¼, Sec. 16, T. 4 N., R. 3 W.

Company: Wires & Wires Farm: Walter McBride #1

Elevation: 494'

Remarks: completed 10/6/48, no geophysical logs, samples available.

Mississippian at bedrock surface.

Chester Group. sandstone, limestone, shale. 0 to 80'.

St. Genevieve Limestone. 80' to 290'?

St. Louis Limestone. 290'? to 440'.

Salem Limestone. 440' to 570'.

Harrodsburg Limestone. 570' to 740'.

Borden Group.

Siltstone and shale with thin beds of limestone. 740' to 900'.

Shale and siltstone. 900' to 1160'.

Rockford Limestone. 1160' to 1170'.

Devonian.

New Albany Shale. Brownish black to black shale. 1170' to 1285'.

North Vernon Limestone and Jeffersonville Limestone. 1285' to 1420'.

Silurian.

Wabash Formation. Limestone and dolomite, partly cherty, interbedded with siltstone and shale. 1420' to 1690'.

Louisville Limestone. 1690' to 1725'.

Salamonie Dolomite. 1725' to 1785'.

Sexton Creek Limestone. 1785' to 1810'.

Ordovician.

Maquoketa Group.

Shale with interbedded thin limestone. 1810' to 2030'.

Shale. 2030' to 2275'.

Trenton Limestone. 2275' to T.D. at 2314'.

Typical well record. Martin County, Indiana.

Location: NW¼ SE¼ SE¼ Sec. 34, T. 4 N., R. 4 W.

Company: Lyons Farm: Lee Haines #1

Elevation: 650' -

Remarks: Cable tool well, completed 4/12/51, no geophysical record, samples available.

No samples from 0 to 500'. Pennsylvanian probably at bedrock surface.

Mississippian.

Chester - no samples.

St. Genevieve Limestone. 500' to 690'?

St. Louis Limestone. 690'? to 850'.

Salem Limestone. 850' to 1000'?

Harrodsburg Limestone 1000'? to 1300'.

Borden Group

Limestone with interbedded thin shale. 1300' to 1350'.

Siltstone and shale with interbedded thin limestone. 1350' to 1410'.

Siltstone and shale. 1410' to 1570'.

Rockford Limestone. 1570' to 1575'.

Devonian.

New Albany Shale. Brownish black to black shale. 1575' to 1705'.

North Vernon Limestone and Jeffersonville Limestone. 1705' to 1840'.

Silurian?

Wabash or Backbone Limestone. 1840' to 1930'.

Silurian.

Wabash Formation. Dolomite and limestone with interbedded thin shales. 1930' to 2200'.

Louisville Limestone. 2200' to 2250'.

Waldron Formation. 2250' to 2255'.

Salamonie Dolomite. 2255' to 2290'.

Sexton Creek Limestone. 2290' to 2320'.

Ordovician.

Maquoketa Group.

Interbedded shale and limestone. 2320' to 2400'.

Shale, rare thin limestone beds. 2400' to 2755'.

Trenton Limestone. 2755' to T.D. at 2809'.

SOUTHERN AREA

Introduction

Perry County and part of southern Crawford County, Indiana mark the area recommended for consideration to be developed into a repository. Figure 14 shows the highway system of the area. Interstate 64 (just completed, September, 1976), not shown on the map, crosses the area east-west parallel to and just north of Indiana Highway 62 and U. S. Highway 460. The Southern Railroad is the only rail line crossing the region.

The entire area is within the boundaries of the Hoosier National Forest. The actual land now under public (Forest Service) control is highly variable and ranges from large and nearly continuous acreage over many square miles to partial Sections here and there. Three locations are shown on Figure 14 within the southern area, one or more Sections are designated by placing the number(s) of the Section(s) on the map. The numbered Sections are located so as to be least interfering with surface land usage by the public.

The area in the vicinity of the numbered Sections is rugged upland with hilltop elevation exceeding 850 feet and deep valleys cut to near 400 feet above sea level.

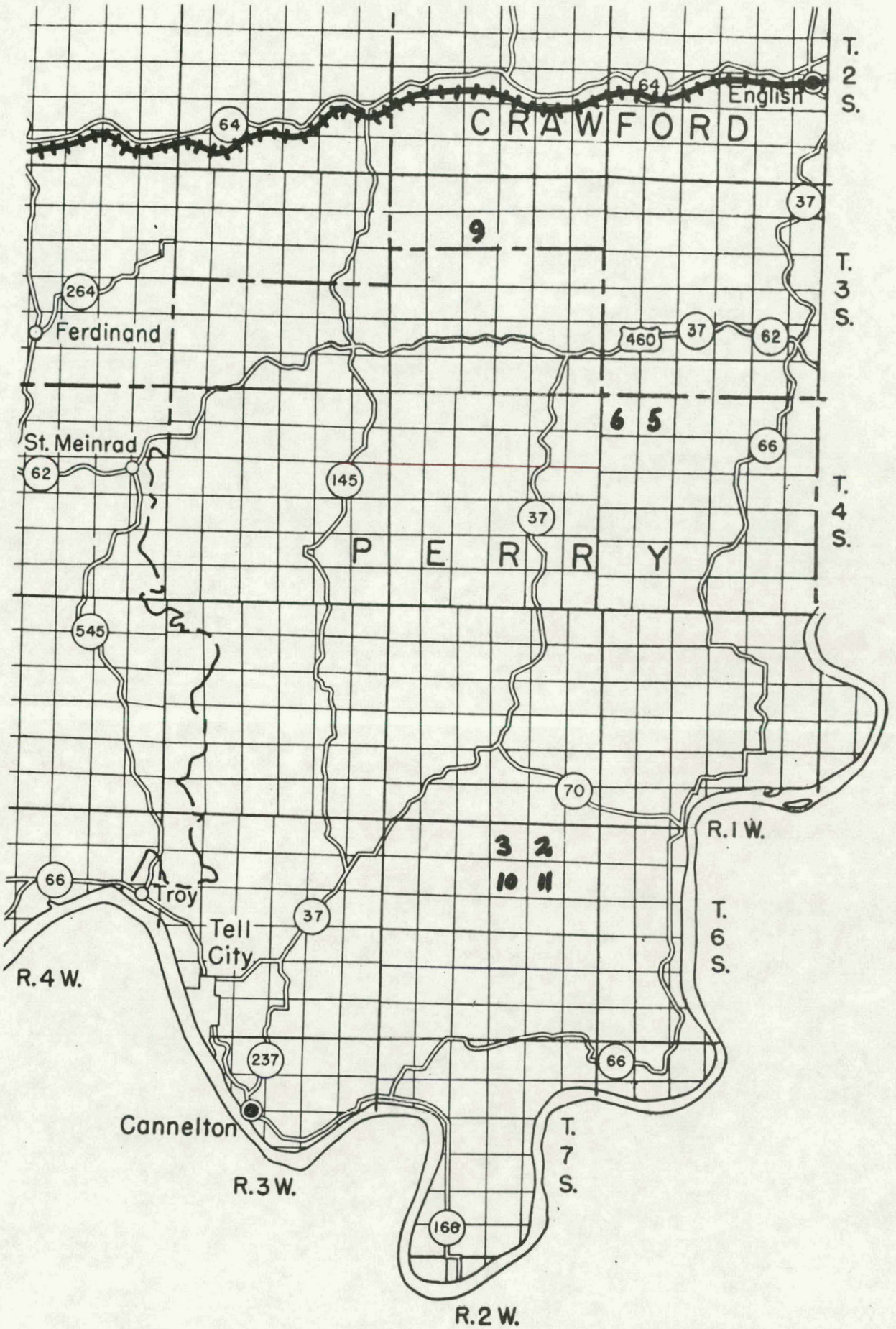


Figure 14. Map showing general transportation routes of the southern area. Numbered Sections are referred to in the text.

Geologic Summary

Subsurface Data. Numerous shallow (less than 1000 feet deep) wells are located generally over the region and enough deep well data are available to show with confidence the thickness distribution seen on Figure 7 and 9.

Structure. The structure on the base and top of the Maquoketa Group is given on Figure 15 and 16. The structure on the base of the New Albany is given on Figure 17. In order to use data from almost all wells in the area, a structural map on the contact between Barlow and Cypress (Chester) Formations (Fig. 2) is given. The structure induced by drape over Silurian reefs can be seen in the Bristol area (southwestern T. 4 S. and R. 2 W.) for example. The faulting shown in southern Perry County on Figure 2 is not well understood. Using only subsurface data from Indiana, one could easily show slight steepening in folds to explain the structure. Surface study of the faulting is not known, or, at least, not published. These faults appear on various geologic maps of areas in Kentucky, and the strike of the faulting in south Perry County is an extension of data from Kentucky.

Lower Zone. Between 400' to 450' of lower Maquoketa is present and up to 600' of Maquoketa Group should provide rock with excellent engineering properties for excavation.

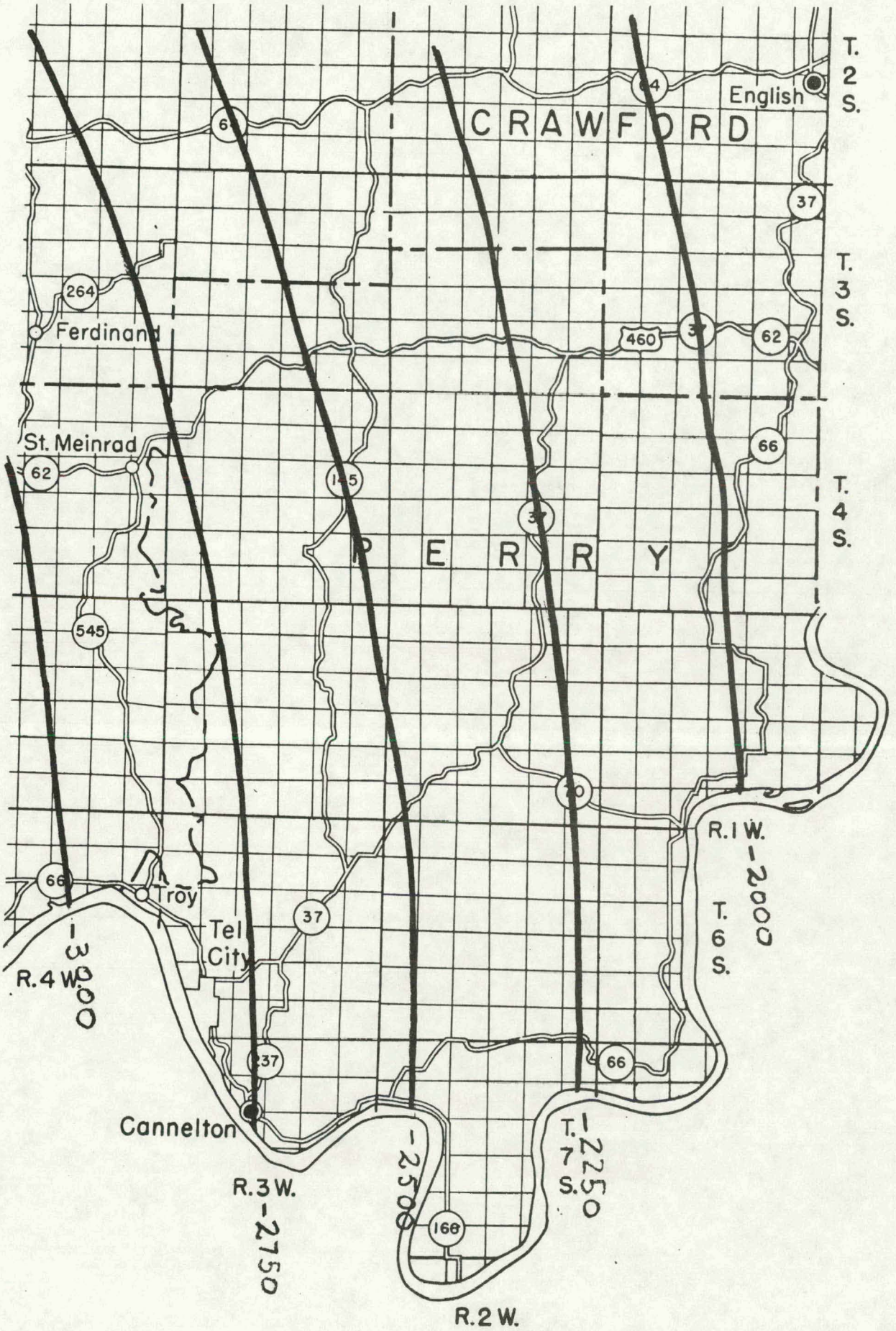


Figure 15. Map showing the structure on the base of the Maquoketa Group in the southern area. Contour interval is 250 feet.

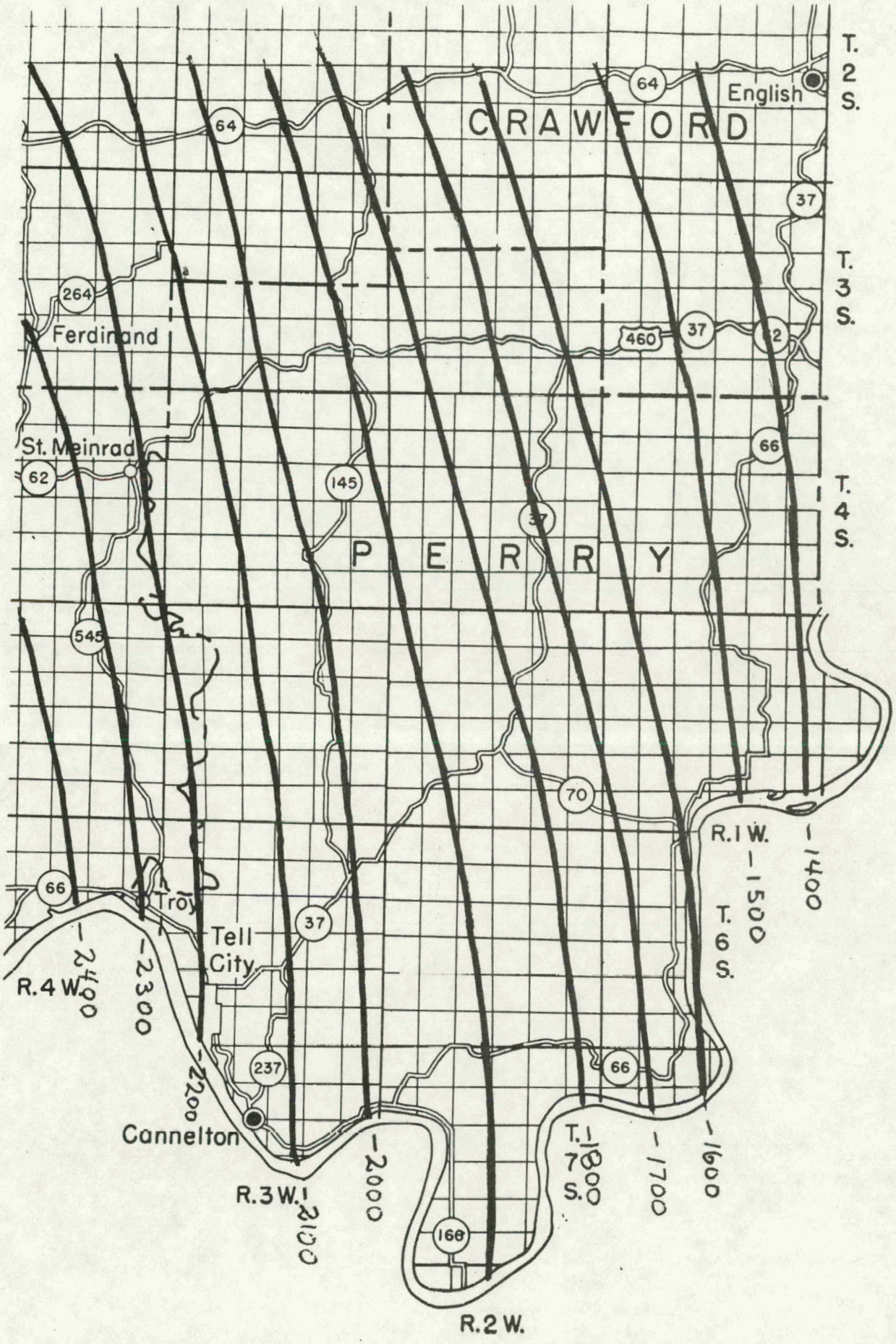


Figure 16. Map showing structure on the top of the Maquoketa Group in the southern area. Contour interval is 100 feet.

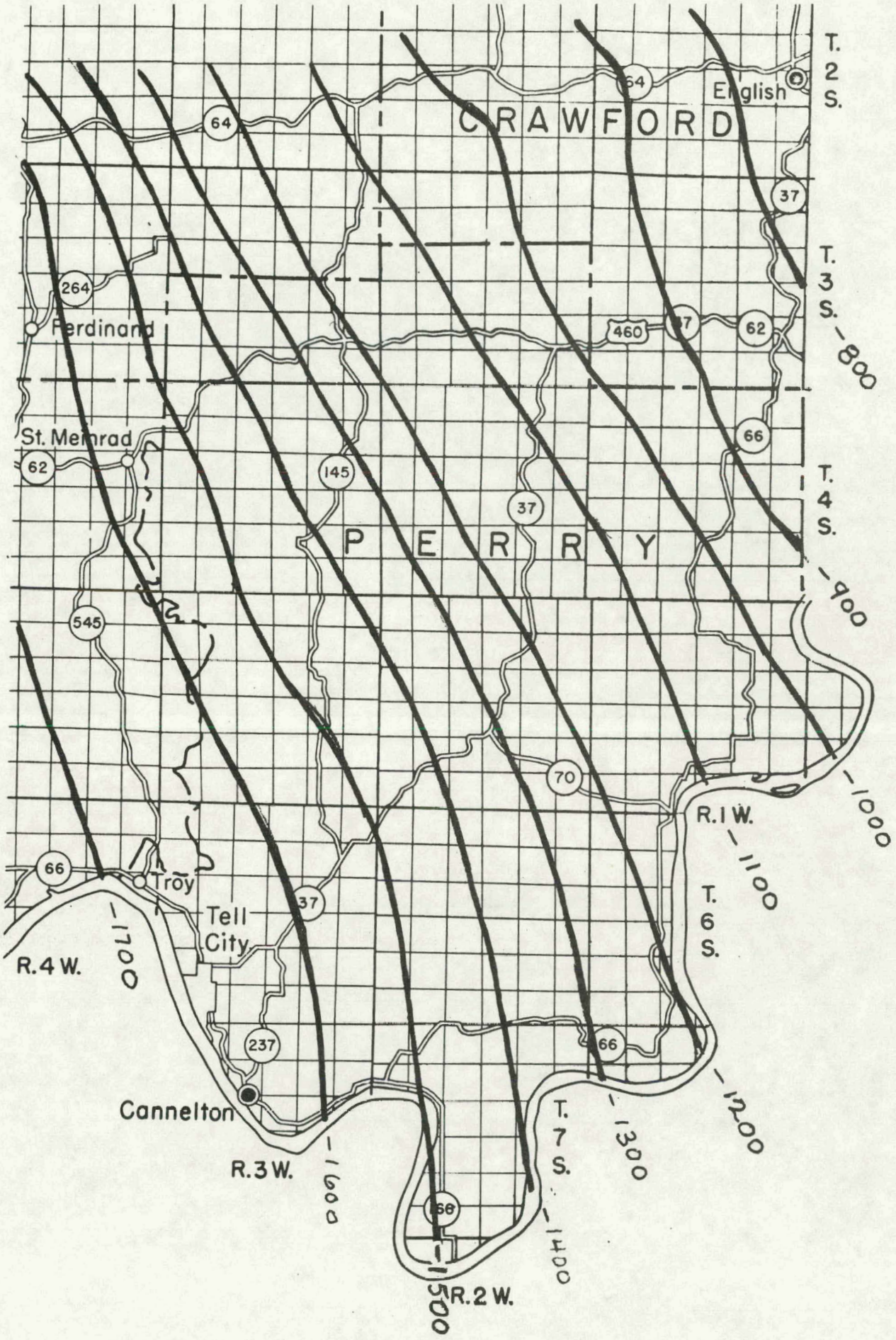


Figure 17. Map showing the structure on base of the New Albany Shale in the southern area. Contour interval is 100 feet.

Upper Zone. New Albany and Borden rocks range up to 450' thick in the southern area. New Providence shale and siltstone should be thick enough to be the locus of repository development.

Typical well record. Perry County, Indiana.

Location: SE¼ SE¼ SE¼ Sec. 17, T. 4 S., R. 1 W.

Company: Sun Oil Farm: Victor Gibson #1

Elevation: 748'

Remarks: Completed 2/14/45, casing set at 65', no geophysical records, samples available, Mississippian at bedrock surface.

Mississippian.

Chester Group. Sandstone, shale, limestone. 65' to 520'.

St. Genevieve Limestone. 520' to 690'.

St. Louis Limestone. 690' to 1110'?

Salem Limestone. 1110'? to 1200'.

Harrodsburg Limestone. 1200' to 1290'.

Borden Group.

Limestone, fine to medium, argillaceous, cherty. 1290' to 1390'.

Interbedded limestone as above and thin shale-siltstone beds. 1390' to 1460'.

Interbedded shale and siltstone with a few thin limestone beds. 1460' to 1510'.

Shale and siltstone. 1510' to 1640'.

Devonian.

New Albany Shale.

Shale, dark gray to brownish black. 1640' to 1755'.

North Vernon Limestone and

Jeffersonville Limestone. 1755' to 1860'.

Silurian.

Wabash Formation.

Liston Creek Limestone Member. 1860' to 1940'.

Mississinewa Shale Member. 1940' to 2120'.

Louisville Limestone. 2120' to 2185'.

Waldron Formation. 2185' to 2190'.

Salamonie Dolomite. 2190' to 2240'.

Sexton Creek Limestone. 2240' to 2260'.

Ordovician.

Maquoketa Group.

Shale with interbedded thin limestone. 2260' to 2470'.

Shale. 2470' to 2860'.

Trenton Limestone. 2860' to 2870'.

Black River Limestone. 2870' to 3400'.

(TD in Knox Limestone at 3534')

Typical well record. Crawford County, Indiana.

Location: SE¼ SE¼ Sec. 11, T. 2 S., R. 2 W.

Company: Roggenkamp. Farm: Perry Smith #1.

Elevation: 546'.

Remarks: Cable tool well, completed 5/28/52, casing set at 100', no geophysical records, samples available.

Mississippian

Chester Group. Sandstone, shale, limestone. 100' to 250'.

St. Genevieve Limestone. 250' to 425'.

St. Louis Limestone, 425' to 665'.

Salem Limestone. 665' to 810'.

Harrodsburg Limestone. 810' to 970'.

Borden Group.

Interbedded fine to medium, cherty, argillaceous limestone and shale. 970' to 1120'.

Interbedded shale and siltstone. 1120' to 1330'.

Devonian

New Albany Shale.

Shale and siltstone, dark brownish gray to black. 1330' to 1455'.

North Vernon Limestone and Jeffersonville Limestone. 1455' to 1580'.

Silurian.

Wabash Formation

Liston Creek Limestone Member. 1580' to 1660'.

Mississinewa Shale Member. 1660' to 1900'.

Louisville Limestone. 1900' to 1935'.

Waldron Formation. 1935' to 1940'.

Salamonie Dolomite. 1940' to 1990'.

Sexton Creek Limestone. 1990' to 2005'.

Ordovician

Maquoketa Group

Shale with thin interbedded limestone. 2005' to 2225'.

Shale. 2225' to 2585'.

Trenton Limestone. 2585' to 2620'.

Black River Limestone. 2620' to T.D. at 2740'.

CONCLUSIONS

Both areas will provide two rock zones, an upper (Borden-New Albany) interval and a lower (Maquoketa) interval, with suitable geological and engineering properties to permit development of repository facilities for underground waste disposal. The major advantage of the northern area is that the land is now federally owned and secured as the Crane Naval Ammunition Depot. All other things being equal, an eastern location in Crane would be more desirable. Reefs with associated oil reservoirs should become less abundant eastward. The Maquoketa Group also thickens in an easterly direction.

The locations in the southern area must be nearly centered on the Sections seen on Figure 14. Control over a 25 square mile area around any of these locations will put the facility boundary adjacent to high surface use areas in the Hoosier National Forest.

At least one core from the surface to the Trenton Limestone should be taken in each area before either area is selected for more extensive study.

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