STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

STRUCTURAL GEOLOGY AND OIL PRODUCTION OF NORTHERN GALLATIN COUNTY AND SOUTHERNMOST WHITE COUNTY, ILLINOIS

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HUBERT M. BRISTOL

ABSTRACT

Some key Mississippian and Pennsylvanian beds of northern Gallatin County and southernmost White County, Illinois, have been plotted, mainly from geophysical logs, to produce the series of structural maps presented here to assist in the location of faults and in the exploration for oil/gas and coal. Newly found faults and related structures in the study area have been delineated, and previously known faults have been redelineated. Most oil production occurs near, and is related to, structures that are adjacent to faults. Some pertinent statistical oil field data are presented for evaluating the part of the Wabash Valley Fault System just north of the Shawneetown Fault.

INTRODUCTION

This report provides a detailed interpretation of the structural geology of the southern part of the Wabash Valley Fault System; the interpretation is based almost entirely on the analysis of geophysical logs. The study area is at the southern edge of the Fairfield Basin. It includes southernmost White County and northern Gallatin County, Illinois (Tps. 7, 8, and 9 S., Rs. 8, 9, 10, and 11 E.), and a small part of Indiana extending into Illinois within meanders of the Wabash River (fig. 1).*

The study was undertaken to delineate the various structural features of the area as a guide to further exploration for oil/gas and coal.

Methods of Investigation

Geophysical logs on file at the Illinois State Geological Survey were examined, and the subsea elevations of three selected regional key horizons were determined. The three regional key horizons selected for structural mapping are:

1. Top of the Brereton Limestone Member (Pennsylvanian);
2. Base of the Negli Creek Member of the Kinkaid Limestone (Mississippian-Chesterian);
3. Base of the Beech Creek (Barlow) Limestone (Mississippian-Chesterian).

Figure 2 is a typical stratigraphic column for the study area.

The structure map of the Brereton Limestone Member was used to depict the major structural features of the area, as shown in figure 3. The structure maps of the Brereton, Negli

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*Data from Indiana were obtained from the Indiana Geological Survey. The traces of the faults shown in Indiana were confirmed by an unpublished structural map of the base of the Beech Creek Limestone furnished in 1973 by Dan Sullivan of the Indiana Geological Survey.

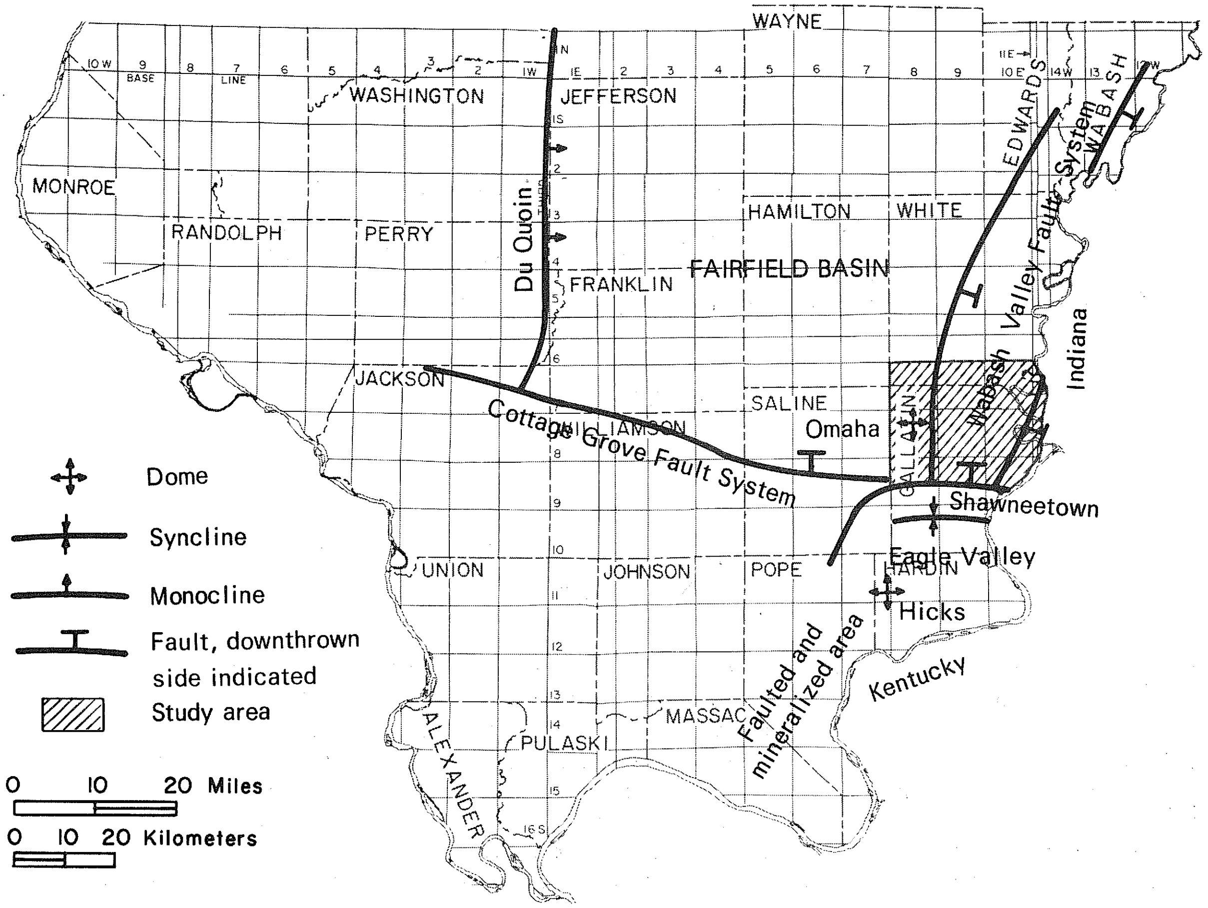


Fig. 1 - Location of the study area in relation to selected structural features.

Creek, and Beech Creek horizons are given in figures 4, 5, and 6.

In several small areas, other horizons were examined to pinpoint the location of faults. These horizons are:

1. Top of the Shoal Creek Limestone Member (Pennsylvanian);
2. Top of the West Franklin Limestone Member (Pennsylvanian);
3. Top of the Harrisburg (No. 5) Coal Member (Pennsylvanian);
4. Top of the Colchester (No. 2) Coal Member (Pennsylvanian);
5. Top of the Vienna Limestone (Mississippian);
6. Top of the Karnak Limestone Member of the Ste. Genevieve Limestone (Mississippian).

All of the named units are usually discernible on geophysical logs. Because of the lateral persistence of these units and the dense well control, there was little trouble with correlation.

The nature of the faults (normal or reverse) and the amount of displacement on them were determined by comparing the stratigraphic sequence in two adjacent wells, one of which cut through a fault and one of which did not. In the log of the well cut by the fault, certain beds are missing (normal fault) (fig. 7). (If beds were repeated, the fault would be a reverse fault.) The throw (displacement) of a normal fault is the amount of section missing, or the difference in elevation of a horizon at two adjacent locations separated by the fault.

STRUCTURE

The structure of the study area is characterized by high-angle northeast-southwest-trending normal faults (fig. 3). To the south,

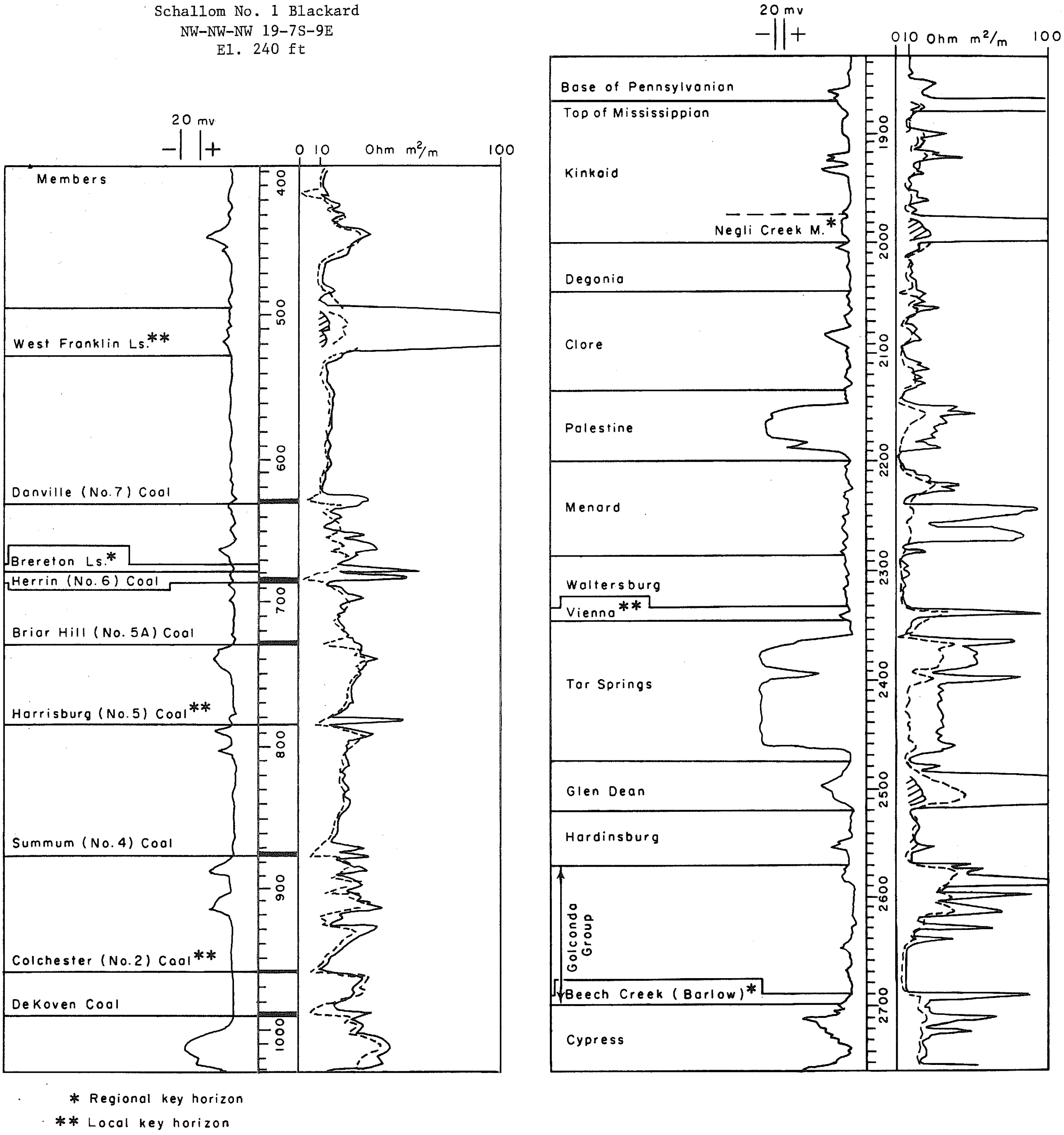


Fig. 2 - A geophysical log showing typical middle Pennsylvanian section and upper Chesterian section in Gallatin County.

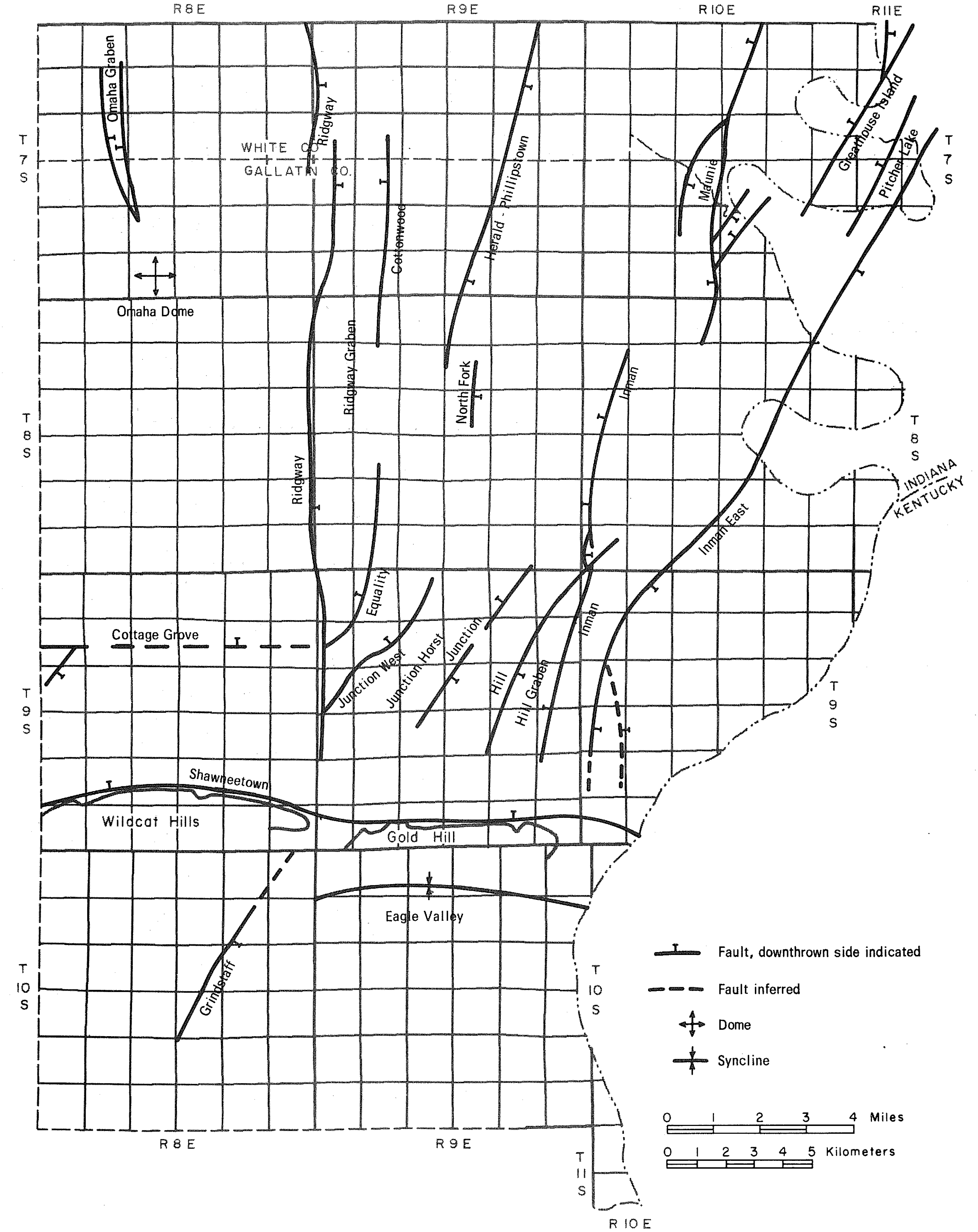


Fig. 3 - Major structural features of the study area as taken from the structure map of the Brereton Limestone Member (fig. 4).

Fig. 4 - Structure map of the top of the Brereton Limestone Member.

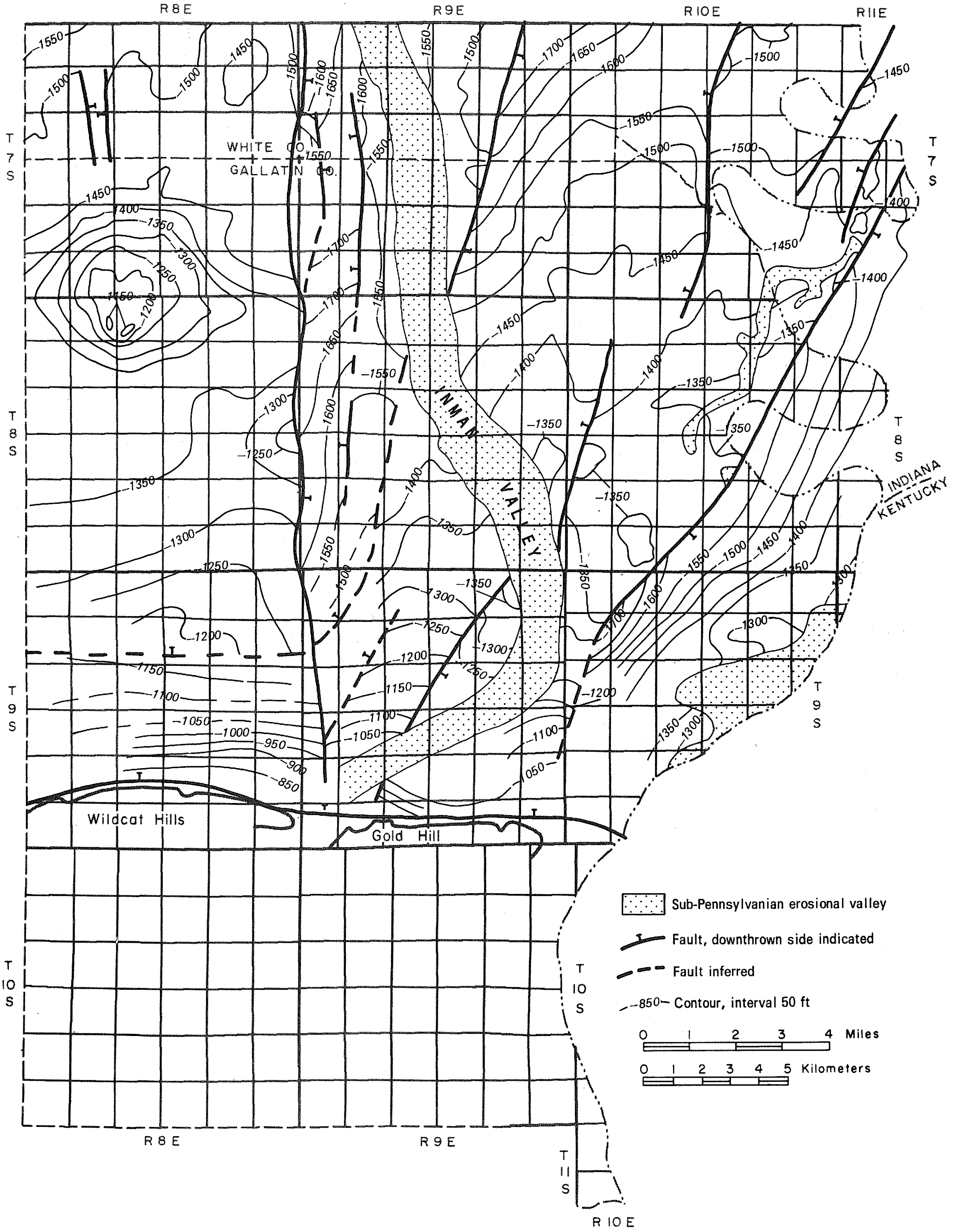


Fig. 5 - Structure map of the base of the Negli Creek Limestone Member (lower Kinkaid) (Mississippian-Chesterian).

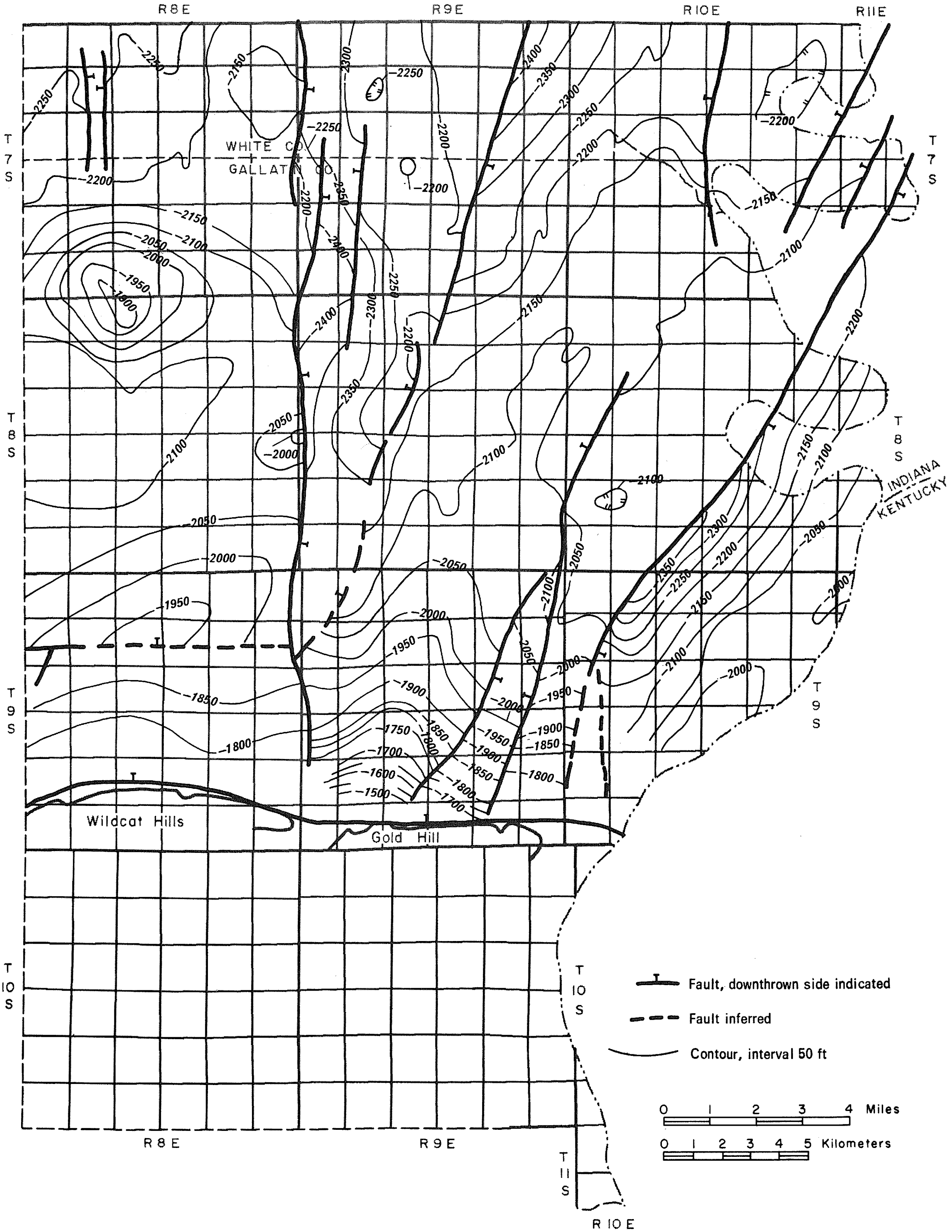


Fig. 6 - Structure map of the base of the Beech Creek Limestone (Barlow) (Mississippian-Chesterian).

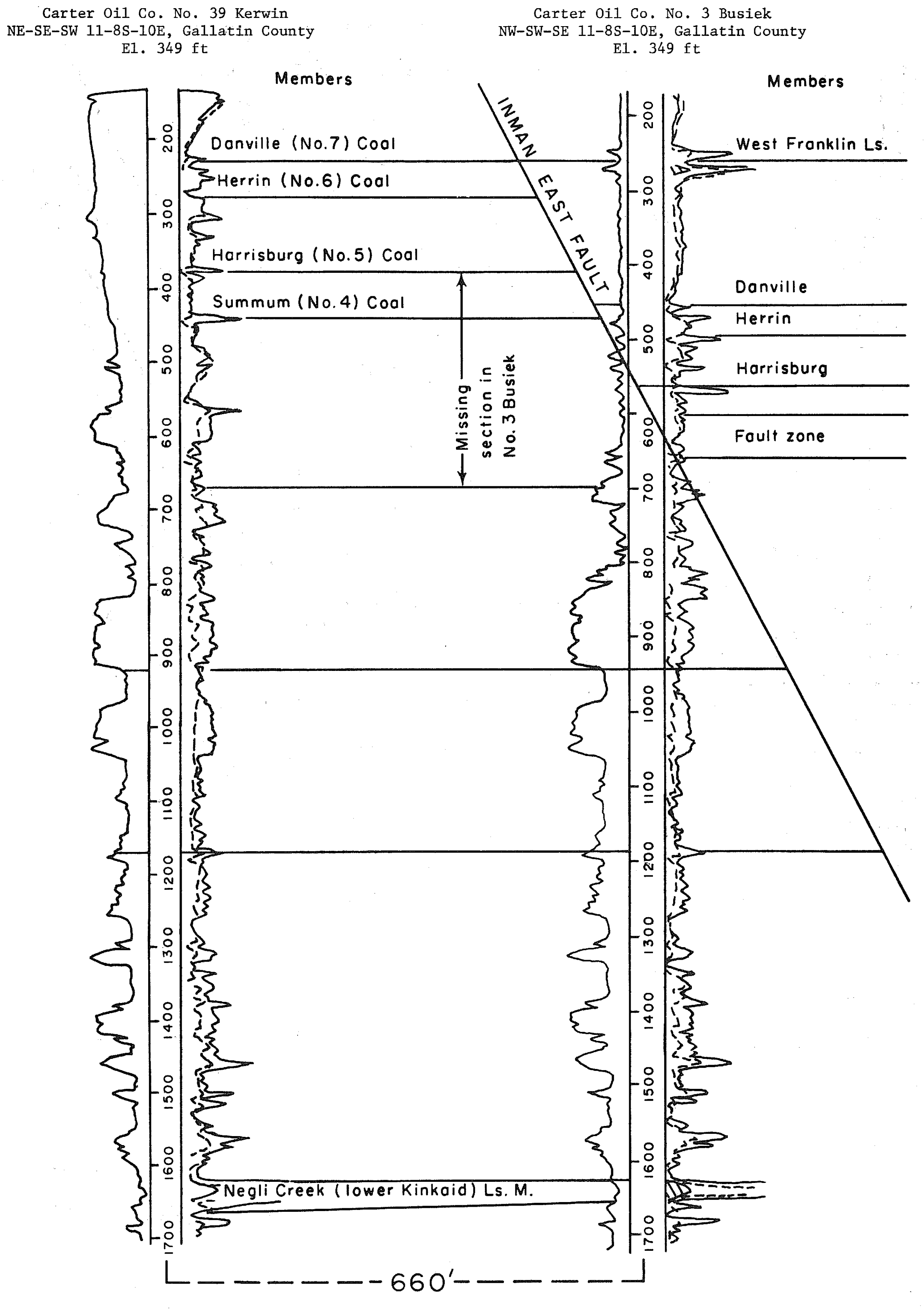


Fig. 7 - Graphic diagram of electric logs of two adjacent drill holes, one of which intersects a fault.

the major faults apparently terminate against, or just north of, the Shawneetown Fault; to the north, they extend into northern White County and beyond.

The existence of the major faults (Ridgway, Herald-Phillipstown, Inman East, Cottage Grove Fault System, Maunie, and Shawneetown) has been fairly well established (Harrison, 1951; Pullen, 1951). However, some modifications of their traces have been made in this report.

Several newly recognized features have been mapped and named. New faults (fig. 3) are:

1. Cottonwood - T. 7 S., R. 9 E.;
2. Inman - Tps. 8 and 9 S., Rs. 9 and 10 E.;
3. Junction - T. 9 S., R. 9 E.;
4. Junction West - T. 9 S., R. 9 E.;
5. Greathouse Island - T. 7 S., Rs. 10 and 11 E.;
6. Equality - T. 9 S., R. 9 E.;
7. North Fork - T. 8 S., R. 9 E.;
8. Hill - T. 9 S., R. 9 E.

Grabens and horsts newly mapped and named here (fig. 3) are:

1. Omaha Graben - T. 7 S., R. 8 E.;
2. Ridgway Graben - Tps. 7 and 8 S., R. 9 E.;
3. New Haven Fault Complex - T. 7 S., R. 10 E.;
4. Junction Horst - T. 9 S., R. 9 E.;
5. Hill Graben - T. 9 S., R. 9 E.

All of the faults in the Wabash Valley Fault System appear to be normal faults. The throw of these faults ranges from zero, in cases where the faults die out or scissor, to approximately 450 feet (Ridgway and Inman East). The throw of the Shawneetown Fault certainly exceeds 1,500 feet; it has been reported by Butts (1925) to be as much as 3,500 feet on the north end of Cave Hill (just west of the mapped area of the Wildcat Hills, fig. 3). In contrast to the normal faults of the Wabash Valley Fault System, the Shawneetown Fault is a high-angle reverse, or thrust, fault. In a reverse fault, the displacement (throw) is equal to the thickness of repeated section.

In the northeast-southwest-trending structure contours (fig. 4), the Omaha Dome has created a prominent anomaly that causes the contours to be diverted around the dome. Wildcat Hills and Gold Hill represent the upthrust side of the Shawneetown Fault and form part of the north flank of the Eagle Valley Syncline. Figure 8 is a diagrammatic sketch of the termination of the Fairfield Basin against the Shawneetown Fault and the Eagle Valley Syncline south of the area under study.

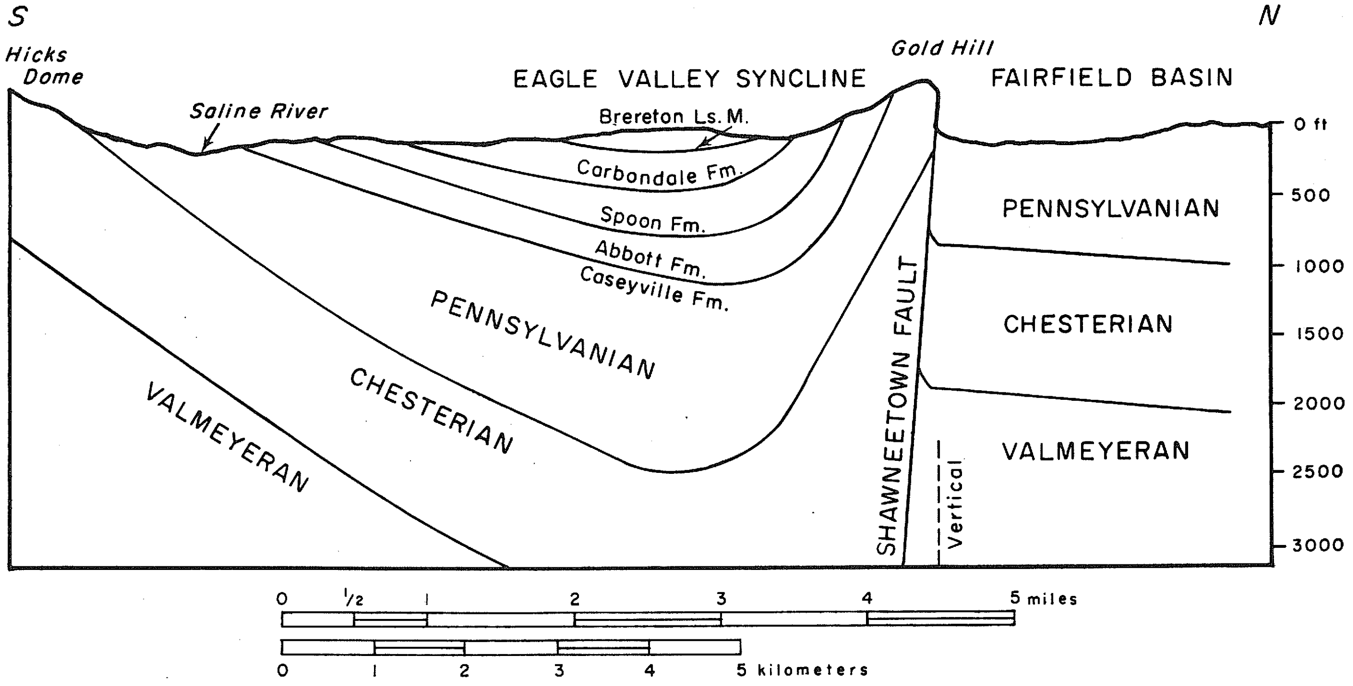


Fig. 8 - Diagrammatic sketch north-south across the Shawneetown Fault.

Individual Structures

A small graben in the northwest corner in figures 3 and 4, herein named Omaha Graben, is on the north flank of the Omaha Dome (English and Grogan, 1948). Maximum throw on either of the faults in secs. 8, 17, 20, 28, and 29, T. 7 S., R. 8 E., is 60 feet. Figure 9 is an interpretation of how the graben might look in the subsurface if the Pennsylvanian rock were stripped down to the Brereton Limestone. This graben was formed after the intrusion of a peridotite magma formed the Omaha Dome; this intrusion put the overlying rocks under tension, thus producing the two faults of the graben. Apparently the graben gradually dies out at depth, because it is difficult to detect in the Golconda.

The Ridgway Fault is shown here to have a slightly more complex course than that originally mapped by Pullen (1951). It extends southward, probably as a fault zone, downthrown to the east, to at least within a mile and a half of the Shawneetown Fault. The maximum throw plotted was 440 feet in sec. 7, T. 8 S., R. 9 E. (fig. 4).

In the study area, the Ridgway Fault and a newly mapped fault about $1\frac{1}{4}$ miles to the east have formed a graben. The newly found graben is called Ridgway Graben and the fault, Cottonwood Fault. Figure 10 is an interpretation of the north end of the graben. This graben may extend without interruption southward to sec. 7, T. 9 S., R. 9 E., where it is bounded on the east by the Equality Fault.

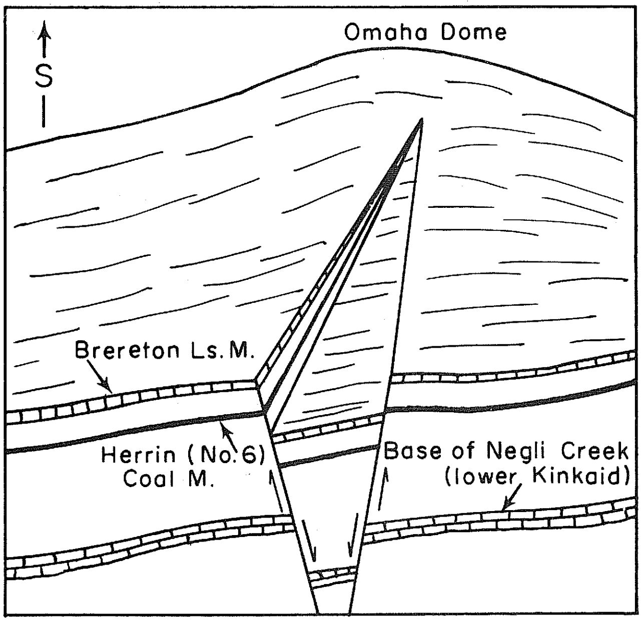


Fig. 9 - Block diagram of Omaha Graben on top of the Brereton Limestone Member. Overburden removed. (Secs. 8, 17, and 21, T. 7 S., R. 8 E., White and Gallatin Counties, Illinois.)

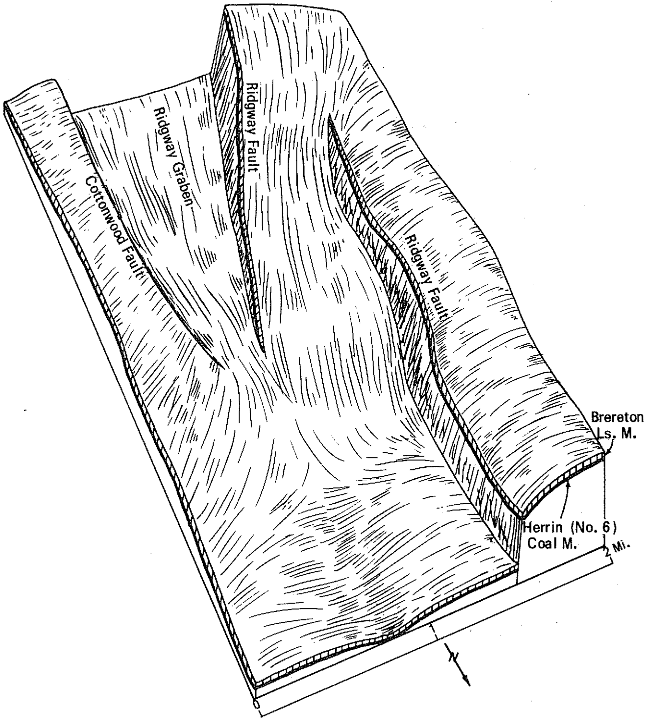


Fig. 10 - Block diagram showing present-day structure on top of the Brereton Limestone for a portion of the Ridgway Fault. Overburden removed. (T. 7 S., Rs. 8-9 E., Gallatin County, Illinois.)

The Cottonwood Fault (fig. 3) has a maximum observed throw of about 100 feet, with a downward displacement to the west. In the S. B. Griffith No. 1 Harvey-Blazier Comm. well (SE$\frac{1}{4}$NE$\frac{1}{4}$NW$\frac{1}{4}$, sec. 20, T. 7 S., R. 9 E.), the Vienna Limestone is 100 feet lower than in the S. B. Griffith No. 1 J. Hale well (SW$\frac{1}{4}$SW$\frac{1}{4}$NE$\frac{1}{4}$ of the same section). A 98-foot section of the Kinkaid and the lower part of the Pennsylvanian is missing in the B & G Oil Company No. 1 Grumley well, NE$\frac{1}{4}$SE$\frac{1}{4}$SW$\frac{1}{4}$ of sec. 20, an indication of the presence of a fault. The trace of this fault has been difficult to determine southward, although it may be present in sec. 5, T. 8 S., R. 8 E. As noted in the discussion of the Ridgway Graben, this fault could extend uninterrupted southward to join the Equality in T.

9 S., R. 9 E. Other faults or blocks may exist within the graben, but there is not enough information available to delineate them.

The next fault east of the Cottonwood Fault is the long Herald-Phillipstown Fault. This fault was originally called the Herald Fault by Pullen (1951); Harrison (1951) changed the name to Herald-Phillipstown. At the northern boundary of the study area, the fault has a throw of approximately 250 feet on the Negli Creek Limestone Member (Kinkaid) (fig. 5). Six miles to the south, in sec. 34, T. 7 S., R. 9 E., the throw is only 40 feet. South of sec. 34 the trace of the fault in the Negli Creek has been obliterated for about a mile where the Negli Creek has been removed in the sub-Pennsylvanian Inman Valley (fig. 5; and Bristol and Howard, 1971, fig. 4). However, in the Beech Creek (Barlow) horizon (fig. 6), the fault appears to die out immediately south of sec. 3, T. 8 S., R. 9 E. The trace of the fault in the Brereton Limestone (fig. 4) is almost completely absent within the study area, owing to removal of the Brereton Limestone by the Anvil Rock Channel.

Near the southern terminus of the Herald-Phillipstown Fault (fig. 3) is another small fault, North Fork Fault, apparently present only in the Pennsylvanian. This fault is in secs. 10 and 15, T. 8 S., R. 9 E., and has a maximum observed throw of only about 20 feet, with the downthrown side to the east.

The Maunie Fault is the next fault to the east. Where the fault enters the area, the throw is approximately 160 feet down to the west, and within 7 miles the fault cannot be detected. On the Brereton Limestone map (fig. 4), the south end of the Maunie Fault has been shown to bifurcate, whereas on the maps of the Negli Creek (fig. 5) and the Beech Creek (fig. 6), it extends to near the township line as a simple, single normal fault. Three figures (11, 12, and 13) illustrate the apparent structural configuration at the south end of the Maunie Fault, as shown by structure contours of the Brereton Limestone, the Negli Creek, and the base of the Beech Creek, respectively. The throw on the fault appears to diminish with depth.

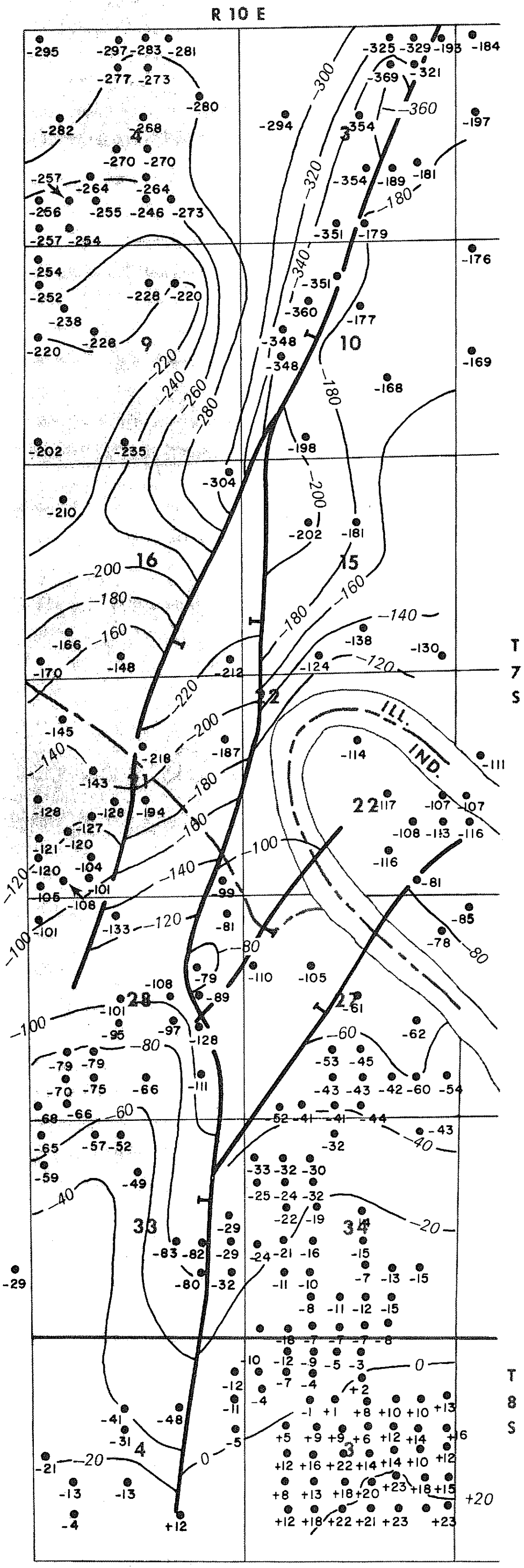
Farther east, a series of three faults is noted (fig. 3). The first two barely extend into Illinois. The most westerly of the three is a newly mapped fault called Greathouse Island Fault, which is downthrown to the west, with a maximum throw of 40 feet. The middle fault in this series was named the Pitcher Lake Fault by Harrison (1951). The maximum throw on this fault in this area is from 40 to 50 feet, with the downthrown side to the west. Harrison erroneously connected the Pitcher Lake Fault (named after Pitcher Lake in Posey County, Indiana) with a fault in sec. 22, T. 5 S., R. 14 W. (Indiana). The Pitcher Lake Fault and the Inman East Fault, the third in this series, where they parallel each other, form a small horst; the maximum throw of these faults is 40 to 50 feet in the horst.

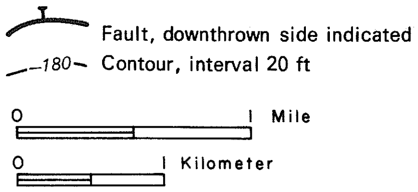
The Inman East Fault is one of the major faults of Gallatin County. It extends from sec. 5, T. 7 S., R. 14 W., in Indiana, southward to the Shawneetown Fault. The greatest magnitude of throw noted is approximately 450 feet (in sec. 33, T. 8 S., R. 10 E.), with the downthrown side to the east. It is quite likely that the southern end of the Inman East Fault bifurcates, forming a small splinter fault to the east. No name has been proposed for this splinter fault because there has not been enough drilling to substantiate its exact location. The Inman East Fault has been extensively drilled on the upthrown side in Tps. 7 and 8 S., but not nearly so extensively in T. 9 S. (fig. 18).

It is apparent that faults increase in number or complexity, or both, as they approach the Shawneetown Fault. Because of a general lack of data, these faults have not been mapped to the Shawneetown Fault; however, they probably do terminate against it.

The newly named Inman Fault, downthrown to the west and extending from sec. 7, T. 8 S., R. 10 E., southward, perhaps even to the Shawneetown Fault (fig. 3), is the major fault of a complex centered in sec. 31, T. 9 S., R. 9 E. (figs. 14 and 15). At a focal point in sec. 31, another fault, named Hill Fault, intercepts, and perhaps crosses, the Inman Fault, thus creating a graben, named Hill Graben, between the two. The Hill Fault is displaced downward to the east. The displacement on the Inman and Hill Faults increases to the south, where nearly 300 feet of throw is noted. Because the Inman Valley cuts out the Kinkaid Limestone over the juncture of the faults (fig. 5), a map had to be drawn of the top of the Vienna Limestone (fig. 15).

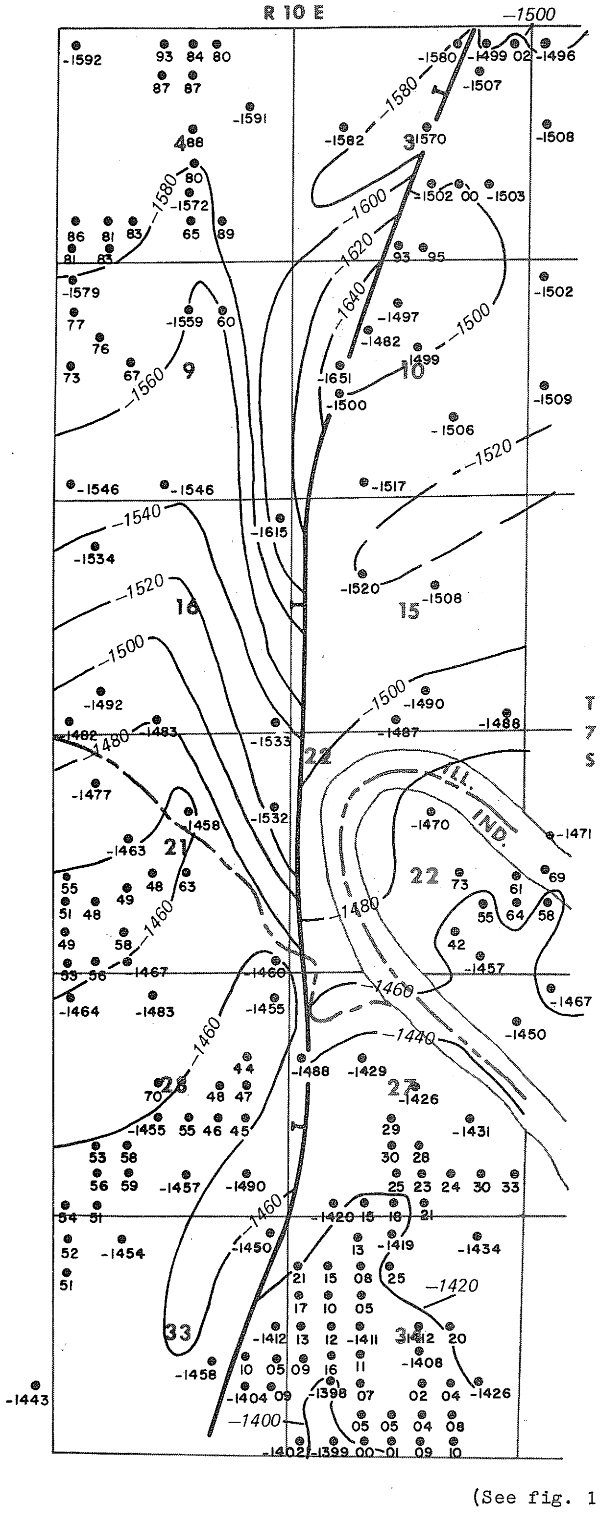
West from the Inman and Hill Faults, three newly named northeast-southwest-trending faults (Junction, Junction West, and Equality) are shown (fig. 3); although information is rather meager, enough deep tests have been drilled

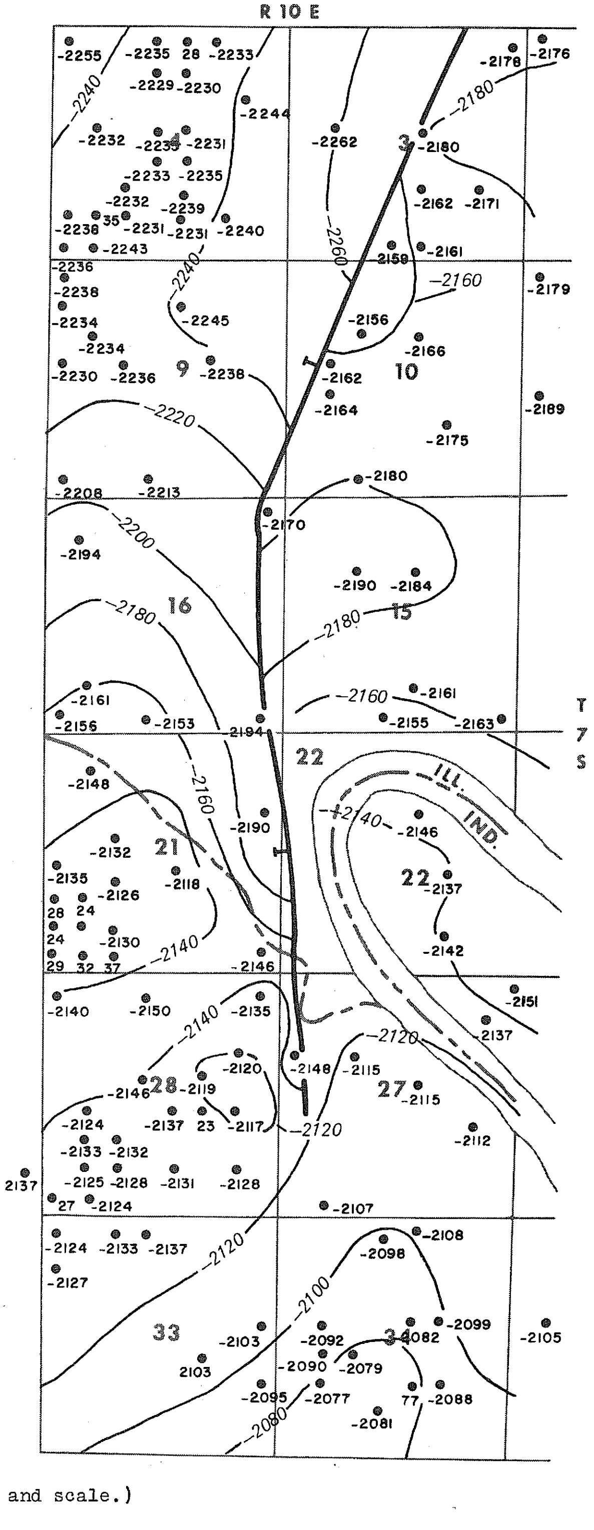




Key and scale for figs. 11, 12, and 13.

Fig. 11 - Detailed structure map of the top of the Brereton Limestone Member for the complex south end of the Maunie Fault.





(See fig. 11 for key and scale.)

Fig. 12 - Detailed structure map of the base of the Negli Creek Limestone Member (lower Kinkaid) for the complex south end of the Maunie Fault.

Fig. 13 - Detailed structure map of the base of the Beech Creek Limestone (Barlow) for the complex south end of the Maunie Fault.

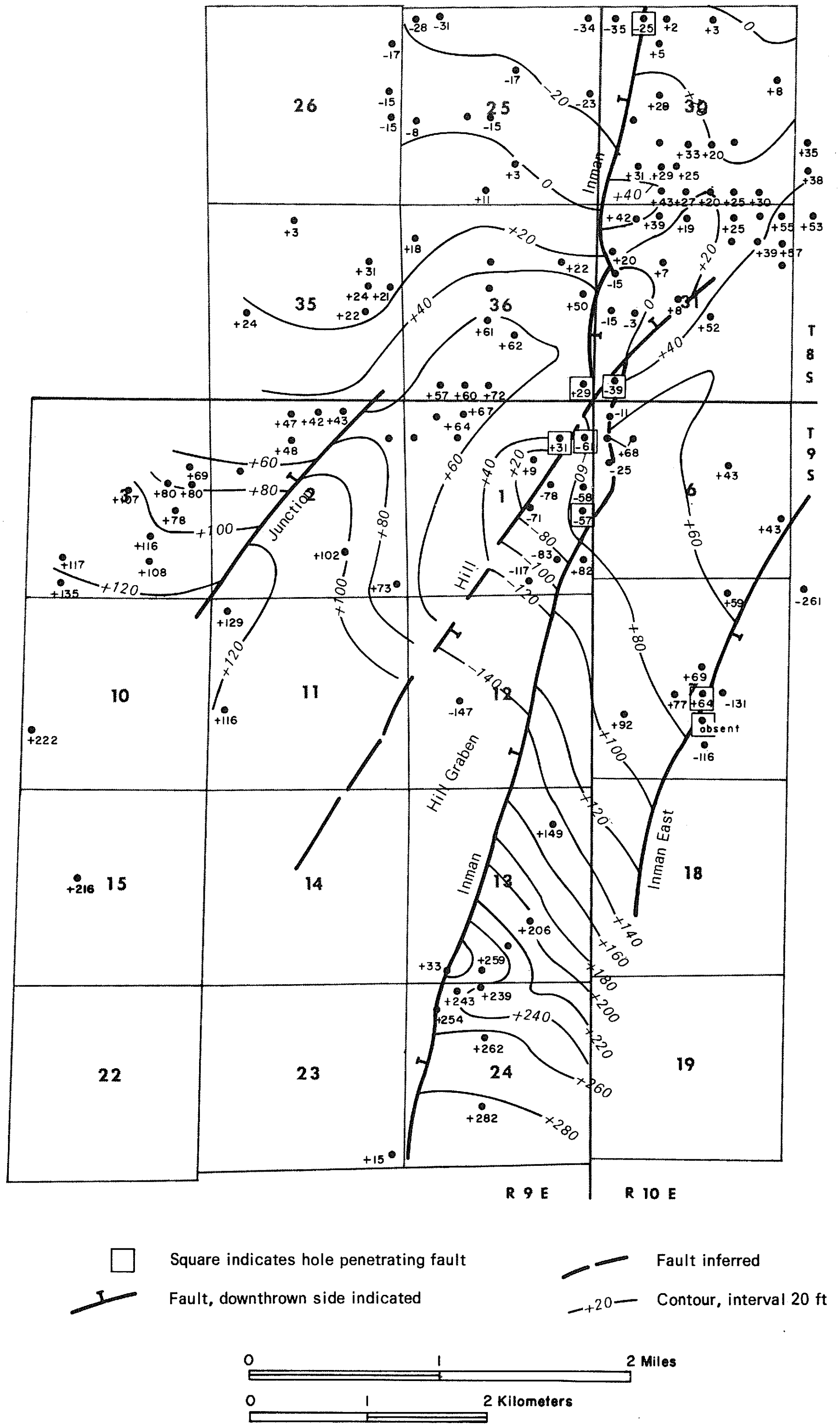


Fig. 14 - Detailed structure map of the base of the Brereton Limestone Member for the complex area surrounding the juncture of the Inman and Hill Faults.

to assure that faulting has occurred at depth. On the Beech Creek (Barlow) map (fig. 6), the two Junction Faults have not been drawn because the information is too sparse, but the general Brereton map (fig. 3) and the detailed Brereton maps (figs. 14 and 16) present interpretations of this area. Of the Junction, Hill, and Inman Faults, the Junction Fault is the best understood. The Junction Fault appears to scissor between secs. 10 and 2 (fig. 16), with the southern part downthrown to the east and the northern part downthrown to the west. The locations of the Junction West and Equality Faults are not well established at this time. The Junction West Fault and the Junction Fault border a horst-like area, herein named Junction Horst. The complexity of this area will be unraveled as more holes are drilled and more coal information becomes available.

Relation of Structure to Oil Production

The heavily faulted portion of the Fairfield Basin described in this report contains highly productive oil fields. It appears that, at least through Pennsylvanian time, Gallatin County was the site of major deposition of Paleozoic sediments. The Texaco No. 1 Walters well, sec. 29, T. 9 S., R. 9 E., penetrated 7,600 feet of Paleozoic sediments; the Paleozoic section is probably at least 10,000 feet thick. To date, most of the oil has come from the Chesterian beds at a depth of less than 3,000 feet. Only three Devonian or deeper tests have been drilled in Gallatin County north of the Shawneetown Fault; therefore, no consideration has been given to the oil potential below the Valmeyeran (middle Mississippian).

Most of the large accumulations of oil are related to the faults. The faults have acted as traps, with the oil generally on the upthrown side. On the other hand, the Omaha field is on a large dome not associated with a fault system. As the Shawneetown Fault is approached, the complexity of the faults increases, breaking up the large structures; the sands here become slightly quartzitic because of the proximity to the large subsurface intrusive to the south (Hicks Dome, fig. 1). As a result of these factors, the pools are less productive.

PAST OIL PRODUCTION AND FUTURE OIL PROSPECTS

Since oil was first found in Gallatin County in 1939, the county has produced (to the end of 1972) about 48 million barrels of oil from fields that have produced a total of 108,274,000 barrels (see table 1). The Illinois State Geological Survey recognizes 19 oil fields, of which 16 are located entirely within the county and 3 extend into White County, Illinois, or into Indiana (fig. 17). Peak productions were obtained in 1949 and again in 1956, when slightly more than 3 million barrels of oil were produced. The peak in 1956 was made possible by secondary recovery waterfloods. Since 1951, when waterflooding was begun in the county, about 50 waterflood operations have been installed.

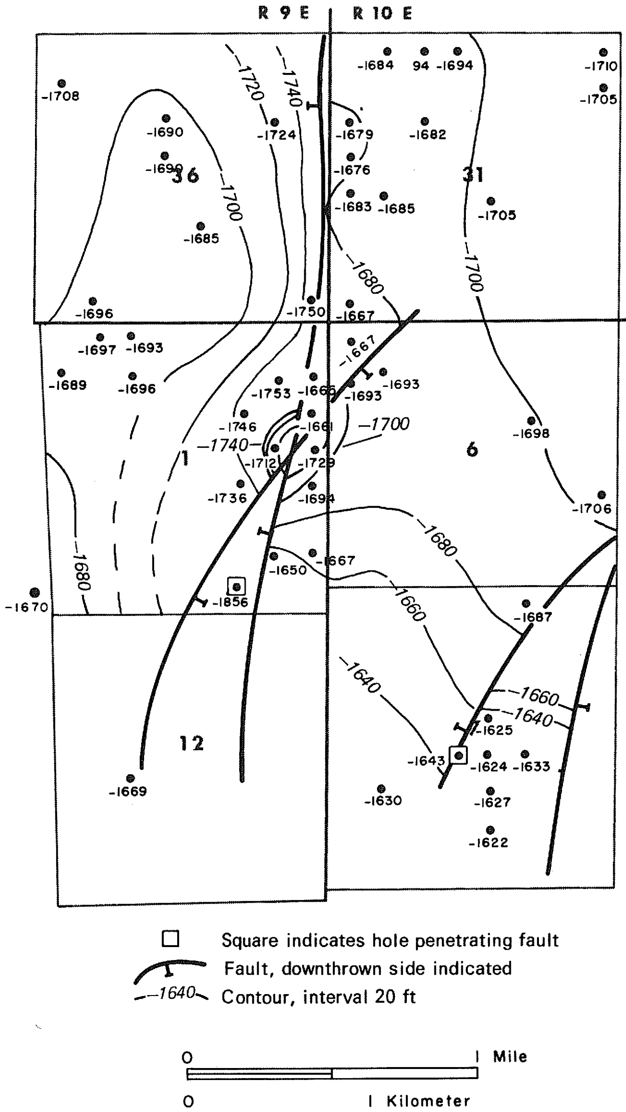


Fig. 15 - Detailed structure map of the top of the Vienna Limestone for the complex juncture of the Inman and Hill Faults.

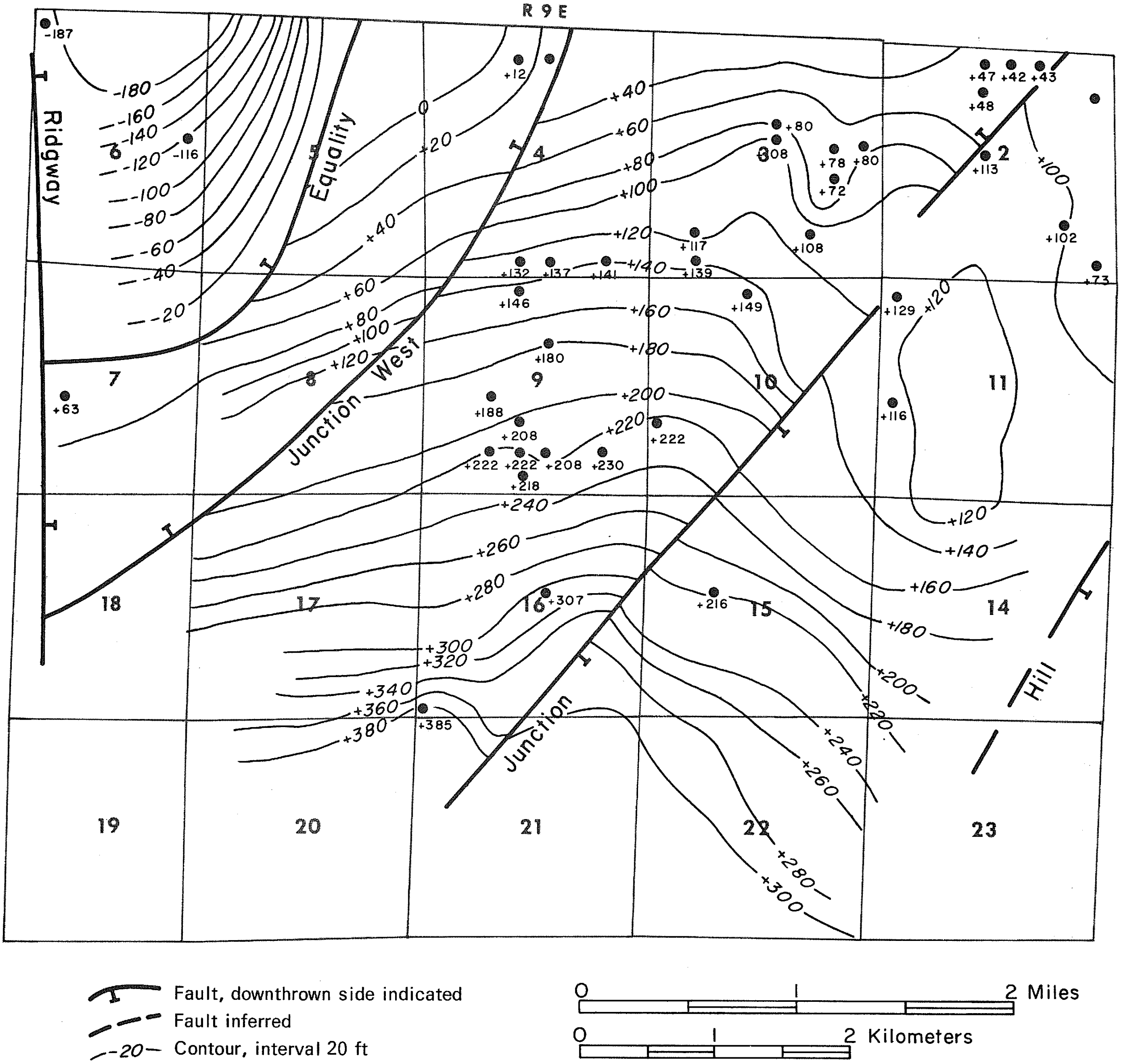


Fig. 16 - Detailed structure map of the top of the Brereton Limestone Member for the Equality, Junction, and Junction West Faults.

About 2,500 oil test holes have been drilled, with 1948 being the peak year of activity (fig. 18).

Oil prospects are favorable on the upthrown side of the faults, especially in T. 9 S. and probably on the Ridgway Fault in Tps. 8 and 9 S. It is possible to have oil in grabens or on the downthrown side of faults if the beds are tipped up toward the faults. These three kinds of traps probably have oil potential in this area, despite the low porosities of the rocks. (See fig. 17 for the location of oil fields in relation to faults.) Potential for oil deposits also exists where the sub-Pennsylvanian channels, like the Inman Valley (fig. 5), cross or parallel the faults (Bristol and Howard, 1971); under these conditions the oil could be trapped against a fault in valley-fill sediments.

TABLE 1 — OIL PRODUCTION FROM FIELDS IN GALLATIN COUNTY, ILLINOIS*

Field	Year discovered	Production through 1972 (bbl of oil)
1. Ab Lake	1957	104,100
2. Ab Lake South	1959	3,800
3. Ab Lake West	1950	526,100
4. Elba	1955	25,000
5. Fehrer Lake	1963	4,700
6. Herald Consol. (White)	1939	15,903,800
7. Inman East Consol. (White-Ind.)	1940	21,643,700
8. Inman West Consol.	1940	8,300,600
9. Junction	1939	679,500
10. Junction East	1953	81,900
11. Junction North	1946	230,300
12. Omaha	1940	5,459,300
13. Omaha East	1946	61,200
14. Omaha South	1951	89,500
15. Ridgway	1946	100
16. Roland Consolidated (White)	1940	55,020,300
17. Shawneetown	1945	16,900
18. Shawneetown East	1952	18,300
19. Shawneetown North	1948	104,900
		TOTAL 108,274,000*

* From 19 oil fields, 48,000,000 barrels are attributed to Gallatin County.

Source: Van Den Berg and Lawry, 1973.

In T. 9 S., R. 8 E., the Cottage Grove Fault System may continue eastward from the western border of the area to the Ridgway Fault (fig. 5). The change in contour pattern south of this possible extension of the Cottage Grove System indicates that at least some deformation extends east of the western border of the area. If the fault does continue to the Ridgway Fault, the upthrown side has some oil potential.

Farther east, the location of the Equality Fault is somewhat conjectural. Further drilling is warranted to delineate it.

Figure 18 shows the well-control density for the study area; the sparsely drilled areas are worthy of further exploration.

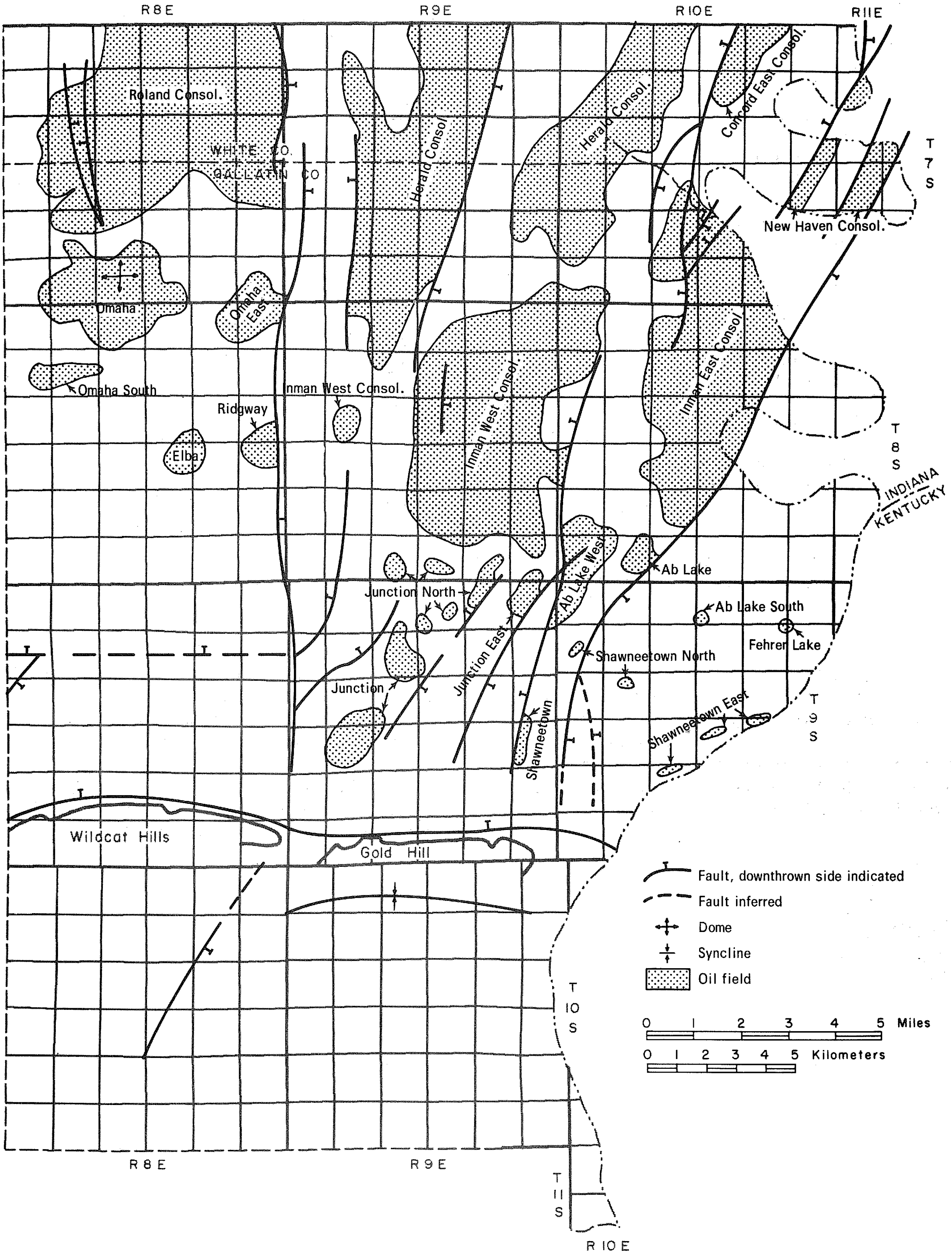


Fig. 17 - Location of oil fields in relation to structures.

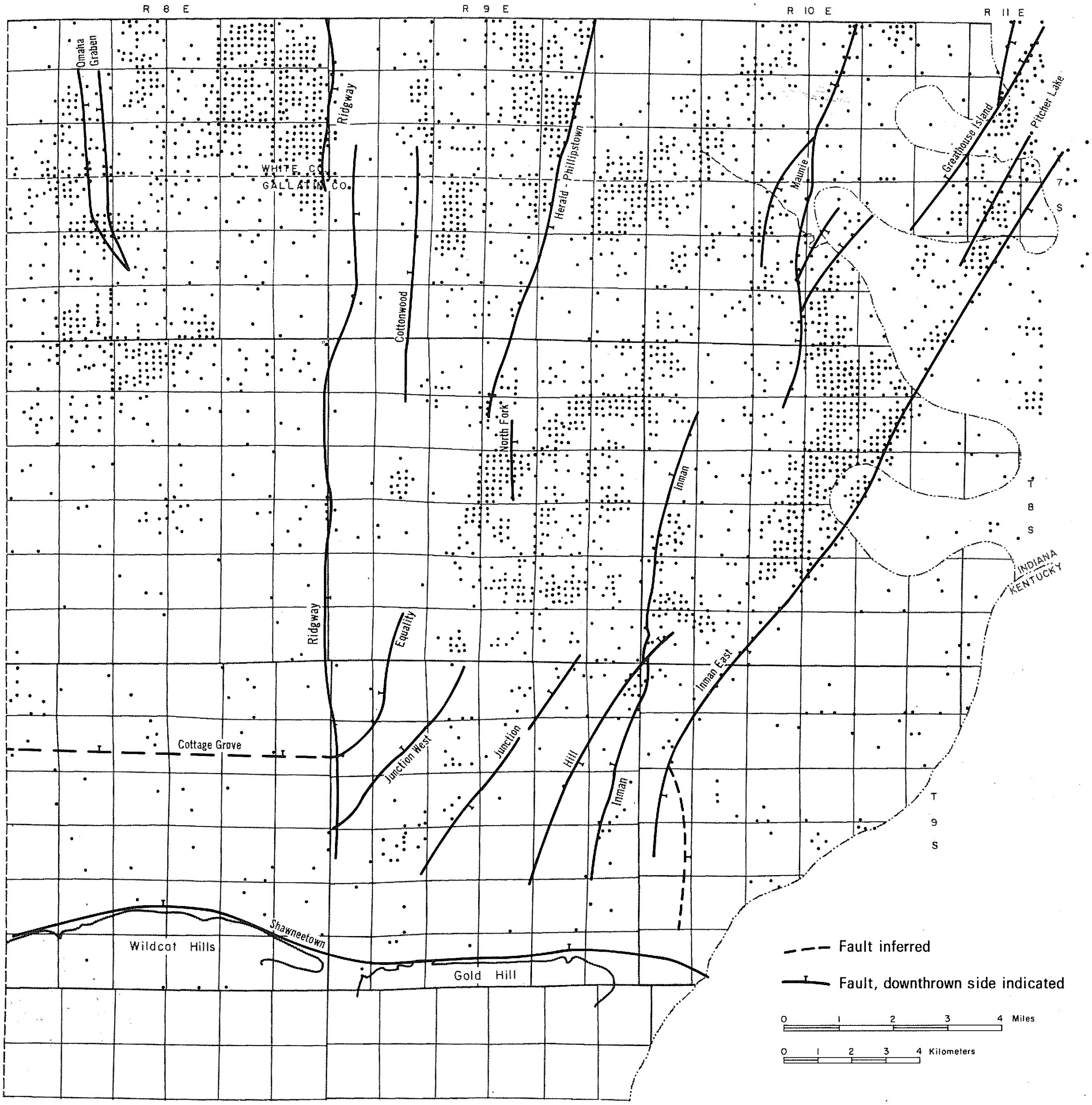


Fig. 18 - Map showing datum points and faults.

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