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ANVIL ROCK SANDSTONE AND CHANNEL CUTOUTS OF HERRIN (No. 6) COAL IN WEST-CENTRAL ILLINOIS

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ABSTRACT

The Anvil Rock Sandstone and related "cutouts," or "washouts," of Herrin (No. 6) Coal were mapped in subsurface in west-central Illinois. Maps were based on data from logs of more than 1200 drill holes from a 5400-square-mile area that includes Bond, Christian, Clinton, Macoupin, Madison, and Montgomery Counties and portions of Fayette, Marion, Sangamon, and Washington Counties.

One map depicts the occurrence and thickness of the Anvil Rock Sandstone in west-central Illinois, showing a typical linear, sinuous pattern. A second map shows the thickness of the interval from the base of the Piasa Limestone to the top of the Herrin (No. 6) Coal. Where No. 6 Coal has been eroded, the interval is extended to the base of the Anvil Rock Sandstone. This combined isopach-cutout map shows the relationship between maximum Anvil Rock Sandstone development and channel cutouts of No. 6 Coal as well as areas where the coal is split, thin, or absent adjacent to the major sandstone channel.

The cutouts are related to a stream drainage pattern of late Pennsylvanian age. The presence of the Anvil Rock Sandstone in the interval between the Piasa Limestone and the Herrin (No. 6) Coal and an increased thickness of this interval are guides for predicting coal cutouts in west-central Illinois.

INTRODUCTION

For this study the Anvil Rock Sandstone and related cutouts of the Herrin (No. 6) Coal in a 5400-square-mile area of west-central Illinois were mapped. The area includes Bond, Christian, Clinton, Macoupin, Madison, and Montgomery Counties and portions of Fayette, Marion, Sangamon, and Washington Counties and is part of the stable western shelf area of the Illinois Basin (fig. 1). The Anvil Rock Sandstone fills channels that had been cut into underlying sediments, including the No. 6 Coal in this area. The considerable amount of oil test drilling done during the past 15 years has made it possible to delineate more sharply than was formerly possible the areas where No. 6 Coal has been eroded.

Herrin (No. 6) Coal is the principal minable coal of Illinois and has been worked extensively in various parts of the area of this study. Although No. 6 Coal generally is thick and relatively uniform in distribution, elongate areas exist where the coal has been removed by Pennsylvanian erosion. Such areas generally have been called coal "cutouts," "channels," or "washouts" in geologic literature.

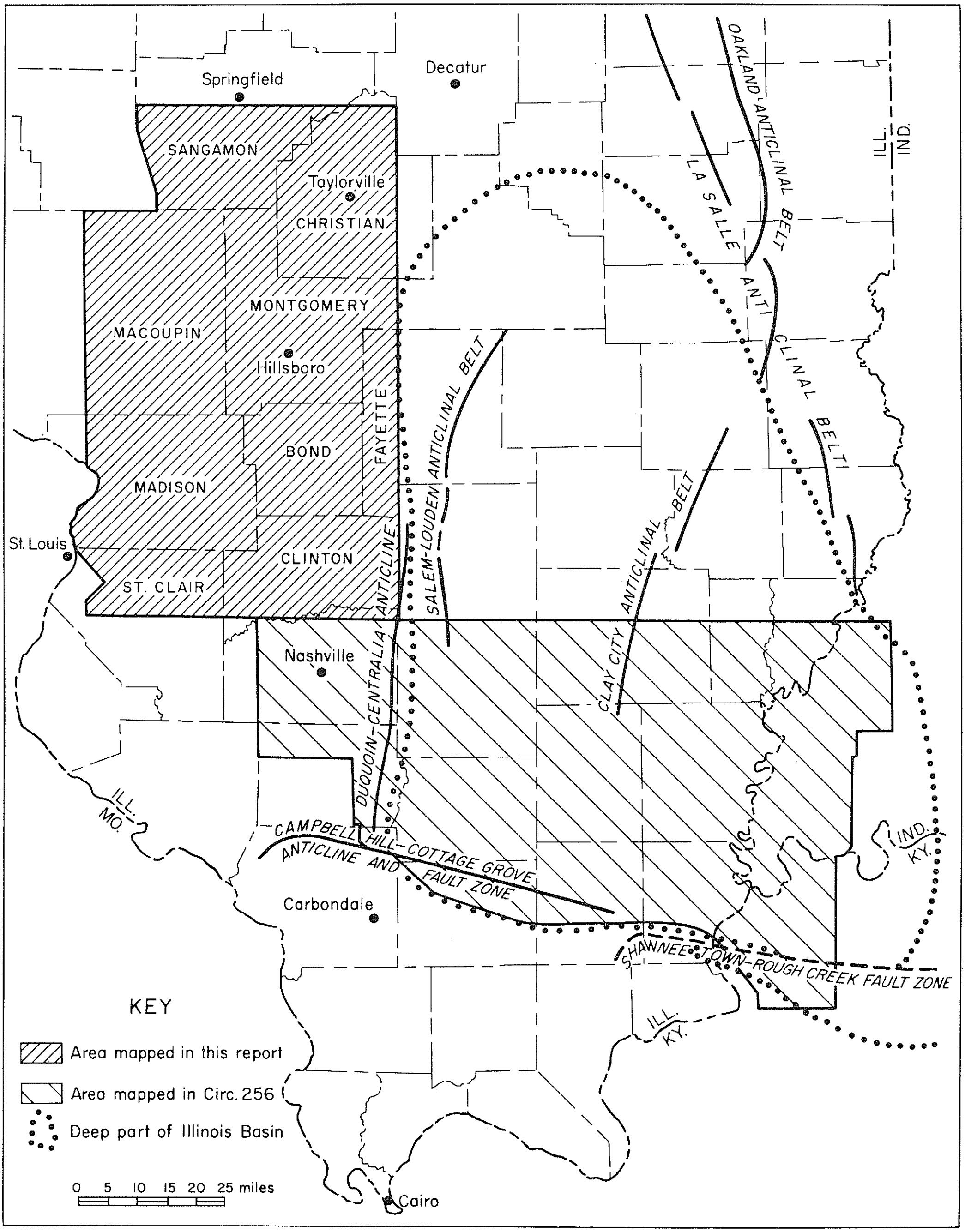

Fig. 1 - Index map showing area of Anvil Rock Sandstone studies.

Miners often call the features "faults," but inasmuch as they are related to erosion rather than to fracturing and vertical displacement of the coal seam that term is incorrect. Of all the names applied to this feature, "washout" is perhaps the most descriptive where development of channels has removed the coal, but "cutout" has been more generally used in Illinois.

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PREVIOUS WORK

The Anvil Rock Sandstone originally was named by Owen (1856, p. 45) for an exposure called Anvil Rock in Union County, Kentucky. In a report on coal resources and mining, Kay (1915) included a map indicating the trend of the principal area considered in this report where the sandstone cuts out the No. 6 Coal. Cutouts were recognized at that time in mines in Bond, Clinton, Christian, Macoupin, Madison, Montgomery, Washington, and Sangamon Counties.

Since 1940 a series of reports that included structure maps of No. 6 Coal have been published by the Survey. A number of these publications have indicated cutout areas where No. 6 Coal is missing. Reports by Payne and Cady (1944) and by Siever (1944) included the area of the large principal cutout mapped earlier by Kay (1915). Because more subsurface data were available by 1944, Payne and Cady and Siever were able to delineate the cutout more closely. Siever also mapped some additional relatively small cutouts. The report by Payne and Cady discussed and illustrated in detail a cutout in a Christian County coal mine.

Other cutout areas of No. 6 Coal have been reported by Harrison (1951), DuBois (1951), DuBois and Siever (1955), and Clegg (1959). Cady and others (1952, pl. 2) summarized the known extent of channel cutouts of No. 6 Coal for the entire state.

Hopkins (1958) mapped the Anvil Rock Sandstone across the southern part of the state, south and southeast of the area reported here. Because of the detailed character of his study and its bearing on the present investigation, his major conclusions are summarized below.

Hopkins found that the Anvil Rock Sandstone is present throughout much of the structurally deeper portion of the Illinois Basin (fig. 1), but that erosional channels filled with Anvil Rock Sandstone occur in a relatively small part of the total area. He termed the thick sections of the Anvil Rock Sandstone the "channel phase" and designated as "sheet phase" the relatively thin, widespread occurrence found in areas between channels. He noted that in the much more stable western shelf area west of the DuQuoin-Centralia Monocline (fig. 1) the Anvil Rock Sandstone generally appeared in only the channel phase. This relationship was confirmed in the present study.

Hopkins (1958) agreed with earlier workers that the channels commonly associated with the thick phase of Anvil Rock Sandstone deposition were erosional channels cut by ancient streams. He suggested that with a relative rise in sea level, these streams aggraded and the stream channels were filled chiefly with fluvial sands and shales. From the pattern of channel-phase deposition and from cross-bedding direction measured in outcrop, Hopkins concluded that this drainage pattern had a general southwestward orientation. Thus, an ancient Pennsylvanian

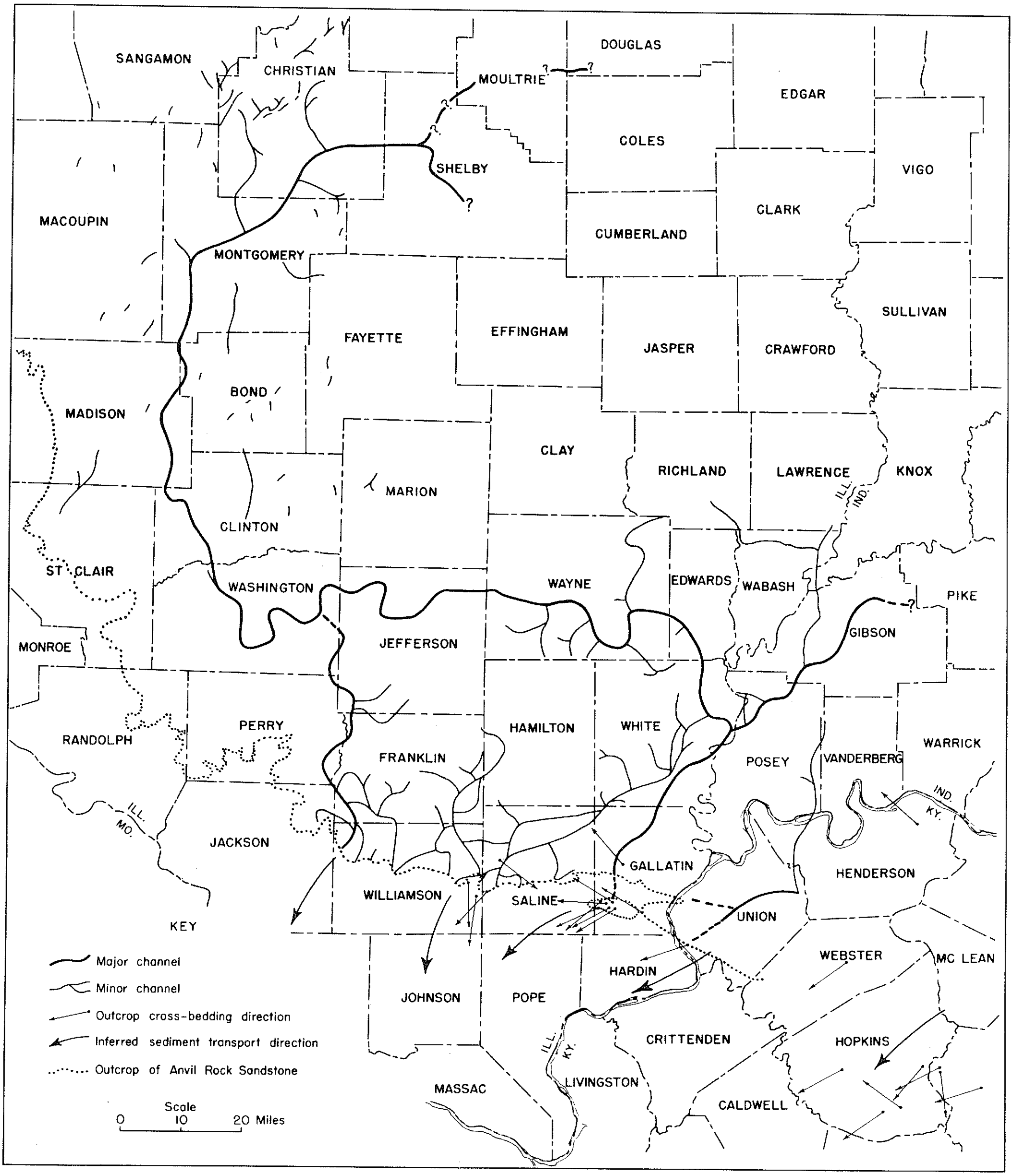

Fig. 2 - Generalized map of the known Anvil Rock Sandstone in Illinois.

stream pattern, generally flowing south and southwest, is considered to be the cause of the cutouts found in No. 6 Coal. Figure 2, adapted and extended from Hopkins, indicates this drainage pattern.

Cutouts have been reported in other minable coal beds in the state. Other channel systems may have been as large and some were certainly larger than those which removed the No. 6 Coal. However, because the No. 6 is the coal most extensively mined in Illinois, more instances of cutouts are known in this coal than in any other.

Channel sandstones such as are described in this report are known to occur prominently in other coal fields in the United States and throughout other coal fields in the world, and they have been reported frequently in geologic and mining literature. References by Raistrick and Marshall (1939), Stutzer and Noé (1940), Thiadens and Haites (1944), and Trueman (1954) give detailed accounts of washouts outside the United States. The report by Thiadens and Haites contains an extensive bibliography on this subject.

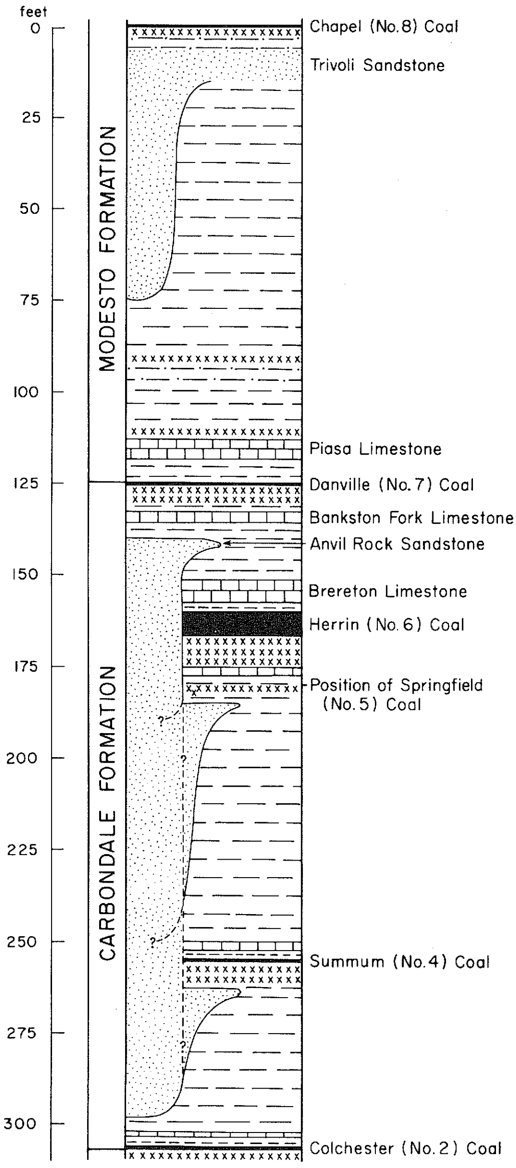

Fig. 3 - Generalized stratigraphic section of the Carbondale Formation and the lower part of the Modesto Formation in west-central Illinois.

STRATIGRAPHIC RELATIONSHIPS

Details of the sequence of strata above No. 6 Coal are well known for much of the area from diamond drill core records, particularly in the coal mining areas. A generalized normal sequence and the "abnormal" sequence resulting from channel cutout of the coal are shown in figure 3. The Piasa Limestone indicated in figure 3 is one of the most persistent, recognizable units and generally can be recognized in the channel areas even though as much as 200 feet of the underlying sequence may be variable. This limestone is a particularly valuable marker unit in exploration because of its relative persistence and because it is normally associated with red, yellow, green, brown, and gray variegated shale or clay. Such variegated shales are associated with other members but normally do not appear in any other stratigraphic position close to the Piasa Limestone.

Lithologic and electric logs (pl. 1) show the stratigraphic relationships in the channel, near the channel in areas of thin and split coal, and in the normal sequence of nonchannel areas.

MAPPING PROCEDURE

The objective of the mapping was to delineate the areas where No. 6 Coal had been eroded, areas where No. 6 Coal was either thin or split near the principal cutout, and areas where the Anvil Rock Sandstone was present.

The interval from the base of the Piasa Limestone to the top of No. 6 Coal was mapped (pl. 2). Where the coal was eroded, the base of the Anvil Rock Sandstone was used as the base of the interval. In the cutout areas indicated on the map, the sandstone base occasionally was difficult to determine accurately from electric logs.

Over 1200 electric, diamond drill, and cable tool logs were sources of information for the mapping. Diamond drill records were used to help interpret electric logs, many of which might not otherwise have been interpretable.

On the electric logs, thickness of the sandstone (fig. 4) was estimated by establishing the self potential of the average shale and measuring all units more than 10 millivolts to the left as sandstone. By this standard most siltstones were considered as shales. For consistency, the siltstones of diamond drill core descriptions also were tabulated as shales, even though some siltstones appeared more closely related to the sandstones.

An attempt was made to select at least one drill hole record per section. In areas proximal to the major channel of the Anvil Rock Sandstone, all available records were used.

Contouring

In drawing the contour, based on datum points, we were guided by studies of the Anvil Rock and other Pennsylvanian sandstones in areas of dense control. These studies demonstrate that the Pennsylvanian channel sandstones in the Illinois Basin are similar in having meandering map patterns and very sharp, abrupt boundaries. Where the Anvil Rock Sandstone passes through areas of the most dense control, it shows these characteristics fully. We therefore have contoured both the thickness and the coal cutout as a relatively narrow, sinuous pattern even in areas of relatively poor drill hole control such as portions of Christian and Montgomery Counties (pl. 2). Thus, we believe this interpretative contouring, rather than conventional arithmetic contour spacing, best displays the relationships between the Anvil Rock channel cutout and the adjacent sediments.

Where relatively close control exists, as in T. 5 N., R. 5 W., and T. 6 N., R. 5 W., the cutout boundary probably is accurate to within 1000 to 2000 feet. Uncertainty about the location of the cutout is indicated on plate 2 by question marks along its possible boundary.

DISTRIBUTION OF ANVIL ROCK SANDSTONE

The Anvil Rock Sandstone in west-central Illinois generally occurs in relatively narrow, elongate, linear belts (fig. 4). This contrasts with its occurrence in the more rapidly subsiding and now structurally deeper portion of the Illinois Basin (fig. 1) where Hopkins (1958, pl. 1) found thin, widespread development of the sandstone between the channel areas. The principal channel sandstone of

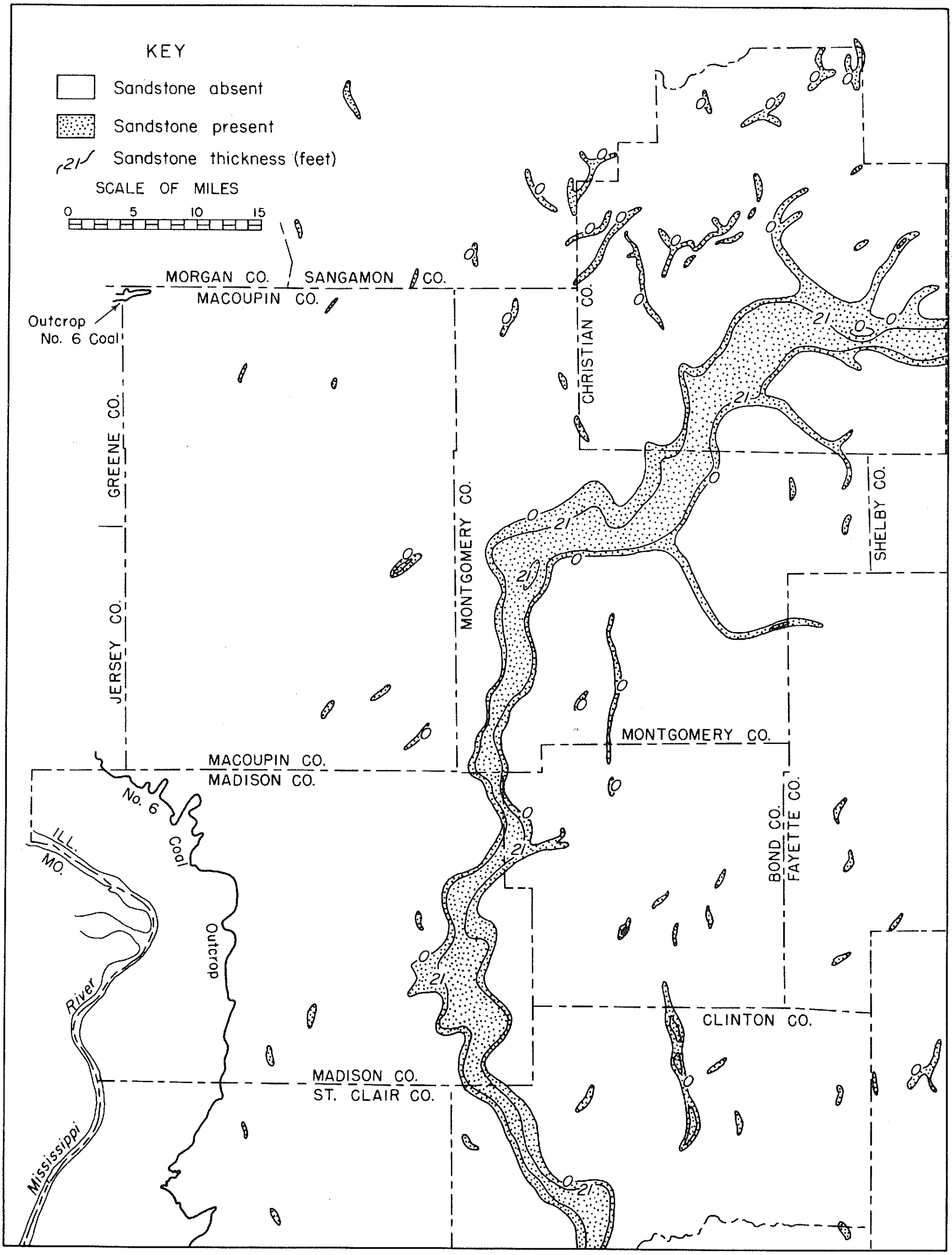

Fig. 4 - Thickness and distribution of Anvil Rock Sandstone in west-central Illinois.

the area studied extends from the eastern boundary of Christian County southwestward to Montgomery County and continues southward to Washington County. This principal channel is continuous with the main channel trend mapped by Hopkins (1958, fig. 4). The 21-foot isopach in figure 4 delineates this major sandstone channel. Thicknesses of Anvil Rock Sandstone in excess of 100 feet are not uncommon. Several test holes appeared to have more than 150 feet of Anvil Rock Sandstone, although such thicknesses probably represent Anvil Rock superimposed on one or more lower sandstones.

As the map shows, the main channel of the Anvil Rock Sandstone generally is 2 to 3 miles wide and has a meandering outline. Additional data probably would indicate areas where the major channel consists of a series of anastomosing, narrow channels containing blocks or "islands" of uneroded No. 6 Coal.

Subsurface data indicate that only where the sandstone thickness exceeds about 10 feet has there been much erosion at its base, and although exceptions do exist, in the area of this study erosion of the Brereton Limestone and No. 6 Coal commonly occurs only where the Anvil Rock Sandstone is more than 21 feet thick.

The scattered, relatively small, isolated, lenticular sandstone bodies are the second significant feature of the map (fig. 4). They are best known in the northern part of the area of this study where mining and more detailed drilling have disclosed their presence, but they probably are present throughout the area. These apparently isolated sand bodies commonly are less than 21 feet thick and have been traced for distances of 4 or more miles. They probably are part of an interconnected system. The width of many of these small sandstone channels is undoubtedly less than is shown on figure 4. Many of the minor channels are known to be a few hundred feet or less wide and most are probably less than one-fourth mile wide. Where these minor channels are indicated by two or more wells, they most often appear to have a southerly trend. In some places the minor channels have cut out the No. 6 Coal, but this is not commonly the case. Recognition of the minor channels is very important in exploratory drilling, however, because a water-bearing sandstone body within a few feet of the top of the coal may adversely affect mining.

Additional drilling probably will reveal many more minor sandstone bodies and also will improve understanding of the relationships between the minor sandstone channels and the major cutout.

CUTOUTS OF NO. 6 COAL

The stippled areas of plate 2 show where No. 6 Coal has been eroded. The interval shown on plate 2 extends from the base of the Piasa Limestone to the top of No. 6 Coal or, if the coal has been eroded, to the base of the Anvil Rock Sandstone. Having thickness and coal cutouts indicated on one map should prove helpful in exploration near the major Anvil Rock Sandstone channel.

The interval from the Piasa Limestone to the top of No. 6 Coal thickens, in the area in general, from west to east. Although data are limited, this interval seems to be less than 25 feet thick in western Macoupin County. In eastern Clinton, Fayette, Montgomery, and Christian Counties the interval commonly is close to 50 feet thick. This gradual eastward thickening, as indicated by the isopachs, is abruptly interrupted where No. 6 Coal has been eroded, and the mapped interval is extended to the base of the sandstone. The abrupt change in thickness of the interval indicates both the main Anvil Rock Sandstone trend and the associated coal cutout.

As shown on plate 2, No. 6 Coal generally has been eroded where the mapped interval exceeds 75 feet. An abrupt thickening of more than 60 feet in the interval between the Piasa Limestone and the No. 6 Coal can be considered good evidence of proximity to the major cutout.

Proximity also is indicated by atypical development of some lithologic units that normally occur between No. 6 Coal and the Piasa Limestone (pl. 1). The presence of sandstone, increase of siltstone and shale, and decrease in limestone are characteristic of proximal sections. The occurrence of sandstone in the interval is particularly significant because on this stable shelf area the Anvil Rock Sandstone normally occurs only in or near channels.

When the diamond drill is used in exploration for No. 6 Coal, core should be obtained at least from Piasa Limestone through No. 6 Coal, particularly if the presence of sandstone channels appears likely. The association of variegated shale with the Piasa Limestone permits its ready recognition throughout most of the area.

Relatively small coal cutouts have been mapped in several parts of the area. The minor cutouts mapped in some detail in the Peabody Coal Company mines in Christian County might be traceable to the main cutout if more data were available. The minor cutout that trends south between Hillsboro and Taylor Springs has been encountered in mines nearby and has been interpreted as a tributary to the main channel (Payne and Cady, 1944), but additional data do not support this interpretation to the extent that the connection can be shown as definite. Other known minor cutouts trend southwest, south, or southeastward in some of the mines. In the Virden Coal Company mine at Virden, Macoupin County, cross-bedding in the Anvil Rock Sandstone in a minor channel cutting out the coal indicates that the transport direction of sediments was southwestward. Inability to relate more clearly the minor to major cutouts is largely due to inadequate data,as neither mining nor close diamond core drilling has been carried on close enough to the cutout areas.

Future drilling probably will indicate the presence of additional minor sandstone channels and will modify the width now assigned to the major cutout. As shown on plate 2, the width of the major cutout is appreciably smaller than that shown in earlier publications (Payne, 1941; Payne and Cady, 1944; Cady and others, 1952).

AREAS OF THIN AND "SPLIT" NO. 6 COAL

In a portion of Franklin, Perry, and Jefferson Counties, a so-called "split coal" area occurs (Cady, 1938) in which benches of silty shale and siltstone of varying thickness are interbedded with the coal. This area trends north-south, lying just east of and nearly parallel to the DuQuoin Monocline. In the central part of the split coal area is a major channel of the Anvil Rock Sandstone (Hopkins, 1958) that has removed the split coal. This channel appears to be an extension of the main channel of the area of the present study. Although the "split" material in the coal is older than the sandstone filling the channels and is not directly related to the sandstone, it appears probable that the greater subsidence implied by the coal split may have persisted and later influenced the course of a channel-cutting stream.

In this study it has not been practical to indicate clearly the areas of split coal, although limited data reveal that in much of the area immediately adjacent to the major channel the coal is split to varying degrees. There are also large areas adjacent to the major channel in which the coal appears to be thin or absent. Available records do not permit clear differentiation between the two types of occurrence, particularly where only electric logs of oil test holes are available.

Areas adjacent to the major cutout in which the No. 6 Coal is thought to be split, thin, or absent have been indicated on plate 2. Undoubtedly such areas exist along other parts of the major channel although not now so indicated on the map because of lack of reliable data. This is particularly true on the east side of the major channel where there has been little diamond drill core testing. The No. 6 Coal appears to average nearly 7 feet thick over much of the area. No. 6 Coal that is less than 4 feet thick near the channel was included in the thin coal area. Areas where No. 6 Coal is less than 4 feet thick are shown on plate 2 only if near the main washout.

The lack of sufficient diamond core drilling limits the accuracy of delineation of the thin and split coal areas of plate 2. Definitive evaluation of No. 6 Coal thickness in most of these areas also must await more diamond drill core data. The outer boundaries of the thin and split coal areas are particularly subject to appreciable modification in some areas.

No thin coal or split coal appears, in general, to be adjacent to the minor channels, except locally where the channels have partially removed the upper part of the coal. In a number of reported occurrences in mines, the coal has been at full, normal thickness immediately adjacent to minor cutouts.

CHARACTER OF CHANNEL SANDSTONE DEPOSITS

Channel sandstone deposits, though referred to collectively as the Anvil Rock Sandstone, consist of a number of types of rock, as observation of cutouts in several coal mines makes apparent. The channel fill contains shale, silty shale, and siltstone as well as sandstone. The channel sandstone deposits are commonly fine grained, but may range to coarse grained. Locally derived conglomerates composed of irregular fragments and rounded pebbles of shale, coal, clay ironstone concretions, and limestone in a sandstone matrix are present in the fill. Locally, conglomerates consisting only of shale and coal have been reported in channel cutouts. In the mine of Breese-Trenton Mining Company near Breese, Clinton County, a conglomerate consisting of varicolored kaolinite fragments and coal filled a channel cutout in No. 6 Coal.

Channel cutouts encountered in mining operations exhibit both steep and gently inclined unconformable basal contacts. In some instances the channel cuts across the relatively flat-lying coal bed at a high angle or nearly vertically. The face of a mine entry may appear to be blocked by an abrupt sandstone "wall." This type of occurrence often resembles a true displacement fault, even to the presence of slickensided surfaces that have resulted from differential compaction. Throughout most of the west-central Illinois area, however, such features are generally the result of cutouts rather than displacement faults. In other instances the contact between the coal and the channel is irregular, with the coal thinning as the bottom of the channel cuts across it at a low angle. Removal of the coal may be either complete or partial.

A most useful indication of possible presence of a cutout in a mine is the presence of sandstone roof at the top or near the top of No. 6 Coal.

As suggested previously, split coal may indicate proximity of the major channel in a mine. Peabody Coal Company No. 58 mine near Taylorville is the only mine known to have approached the major channel in the area of this study and to have encountered split coal as the channel was approached. (Compare Peabody Coal Company No. 1 and Peabody Coal Company No. 2 drill holes on plate 1). Drill records, however, indicate that occurrence of split coal areas adjacent to the major channel is common.

ECONOMIC SIGNIFICANCE OF CUTOUTS

The relationships of the Anvil Rock Sandstone, and the associated channels filled by this sandstone, to the exploration and exploitation of No. 6 Coal have been discussed above, and much of the information concerning the sandstone-filled channels has been summarized from earlier reports, field notes, unpublished studies, and some mine maps. Most mines from which sandstone channels or sandstone roof have been reported are no longer operating, thus limiting possibilities of further detailed study.

Plate 2 shows the location of coal mines that have reported some sandstone roof and, locally, partial or complete cutout of No. 6 Coal by Anvil Rock Sandstone channels. There are undoubtedly additional mines that encountered these conditions. Although there is some concentration of minor cutouts in the northern part of the area, mines throughout the region have encountered minor cutouts. Undoubtedly additional ones will be discovered as mining is extended. The mine near Nashville, Washington County, in the area previously mapped by Hopkins (1958), is the only mine known to have encountered what is believed to be the major sandstone channel and coal cutout that extends through the west-central Illinois area.

An understanding of the nature of the size, trend, and composition of channel deposits is important in evaluating the feasibility of driving across a channel cutout for recovery of coal on the opposite side. Although prediction of channel direction may be possible from an entry exposure, it may be seen from the minor channels mapped in some detail that the channels may meander considerably across a mine property.

Recognition of a channel near an active or projected mining operation is important because the sandstone fill may serve as an aquifer and introduce water to an otherwise dry mine. Excess water has deleterious effects on most mine roofs and floors and, if sufficiently saline, as is the case in most of the deeper mines in west-central Illinois, it tends to corrode equipment. Adequate information concerning the occurrence of the sandstone bodies will permit planning for problems created by their presence. Recognition of the Anvil Rock Sandstone in drill core exploration may require more closely spaced drilling than would normally be employed. In underground operations, evaluation of sandstone channels may be vital to the projected plans for continued operation of the mine.

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