An Example of Primary Sedimentological Control of Sulfur Distribution in Coal V in Sullivan County, Indiana

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Introduction

Since the advent of serious ecological concern over emission of sulfur oxides from combustion of coal, interest in sulfur distribution in coals has been growing. Pennsylvanian coals of the Western Interior Basin of Iowa, Missouri, Kansas, and Oklahoma are especially high in sulfur because of the dominance of marine conditions as evidenced by extensive limestone development. In contrast, the Appalachian Basin coals near source areas of Pennsylvanian sediments are low in sulfur. the sulfur content of the Illinois Basin coals on the average is intermediate to these extremes, but wide variations in sulfur content exist between seams and locally within seams depending upon conditions of deposition of the sediments.

A common Midwestern roof condition is that of a black shale and limestone marine association. The marine environment is responsible for a higher concentration of sulfate ions. The most important aspect to our discussion of the black shale environment is its reducing conditions which resulted in a concentration of sulfides. Zangerl and Richardson (1963) extensively studied the character and variability of some of the black shales in Indiana. This depositional situation has generated only high sulfur coals (>3% sulfur). Indiana coals IIIa (Colchester), IVa (Houchin Creek-Summum No. 4), V (Springfield), Va (Briar Hill), and many other seams in the Upper and lower Pennsylvanian commonly have the marine limestone and black shale roof.

Methods

The present investigation near Sullivan, Indiana (Fig. 1) is concerned with a clastic wedge (Fig. 2) from a "prograding" fluvial-deltaic crevasse splay deposit that has prevented sulfide contamination of Coal V from marine sulfate solutions associated with deposition of a "transgressing" unnamed black shale and the Alum Creek limestone (Fig. 3). The coal immediately surrounding the deposit averages 3.5-4.5% sulfur whereas the thick clastic wedge has maintained values of 0.5 to 1.0% sulfur in the underlying coal. This coal deposit contains some of the highest quality coal in the Midwest with respect to sulfur content, ash content, and coal thickness (USBM, 1927). Specific coal analyses with good map control are not available at this time, unfortunately. Most of the drill data was in the form of coal drilling logs made by one driller over about a 40-year period. Electric logs are rather limited for the study area and some begin deeper than the intervals under consideration. All log information was digitized for machine processing. CALCOMP plotted output was manually contoured for economy.

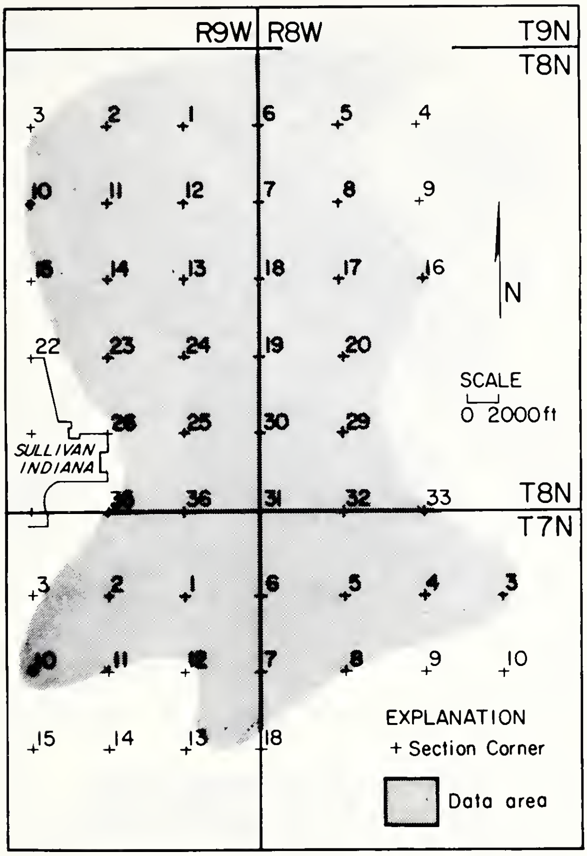

FIGURE 1. *Study Area Base Map*

Low Sulfur Association

Coal V is overlain at the extremities of the deposit by black shale and limestone. There is a clastic (sandstone and shale) wedge overlying Coal V in the center of the area. The wedge is asymmetric with respect to a coal absent channel area. The Alum Creek limestone (Fig. 3) and black shale rise up over the wedge, thin, and then pinch out as the clastic wedge (Fig. 2) thickens toward the channel. The distribution of the overlying Coal Va (Briar Hill?) has also been affected by the wedge. Indiana Coal VI and the underlying limestone (Providence-Brereton) and black shale (Anna) were not affected greatly by the presence of the clastic wedge. This would imply that the wedge had subsided to form a new "base level" by the time that the Anna shale was deposited.

Most shale splits in the coal have limited distribution and are associated with a coal absent sandstone channel area. Because the splits are within the coal, it is thought that the channel existed concurrently with coal deposition.

In many areas there are two horizons of the Alum Cave with a light colored claystone or laminated shale between. Usually there is an unnamed black shale underneath the limestone. Frequently the limestone, black shale, and light colored shale are intercalated so that various vertical sequences of the beds exist. It appears that either there may have been some reef-like thickening of the limestone on the edge of the clastic wedge or the limestone was thickened by dilution with argillaceous clastics. It is evident that the limestone distribution was controlled by the clastic wedge.

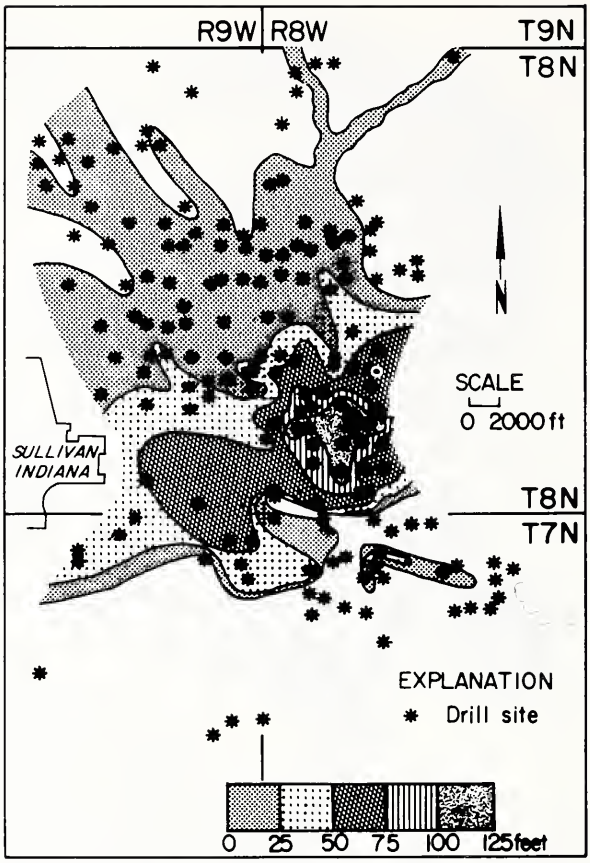

FIGURE 2. *Thickness Map of Clastic Wedge over Coal V*

(Fig. 2) shows the distribution and thickness of light colored clastics between Coal V and either the Alum Cave limestone, associated black shale, Coal Va, or Anna Shale, whichever was first encountered above. Other sand units exist overlying the Alum Cave and Coal Va. In some cases it is not possible to absolutely distinguish these units from the clastic wedge. However, the clastic wedge continued to be deposited subsequent to cessation of Coal V accumulation. It is possible to consider the clastic deposition as a semi-static "prograding" deltaic finger. On a regional scale this crevasse splay deposit is a very localized radial form. However, the contour lines indicate that the full extent of the wedge has not been mapped because of limited data. In other known areas each splay deposit is only a part of a much larger fluvial-deltaic system. Overall the stratigraphy is similar to the model described by Gluskoter and Hopkins (1970).

Another aspect of the clastic wedge noted on drillers' logs, which is not detected on available electric logs, is the presence of a thin "rash" or black shale between the coal and the light colored clastic wedge. Apparently this black shale originated in quite a different environment than the black shale below the Alum Cave limestone. Donald Eggert of the Indiana Geological Survey (oral communication, 1977) has located what may be a similar "rash" condition over a relatively low-sulfur coal at the Park Coal Company surface mine in Pike County, Indiana. There terrestrial plants and vertical tree trunks are associated with the rash. Also, there is a split in the coal, inferred to be a levee overbank

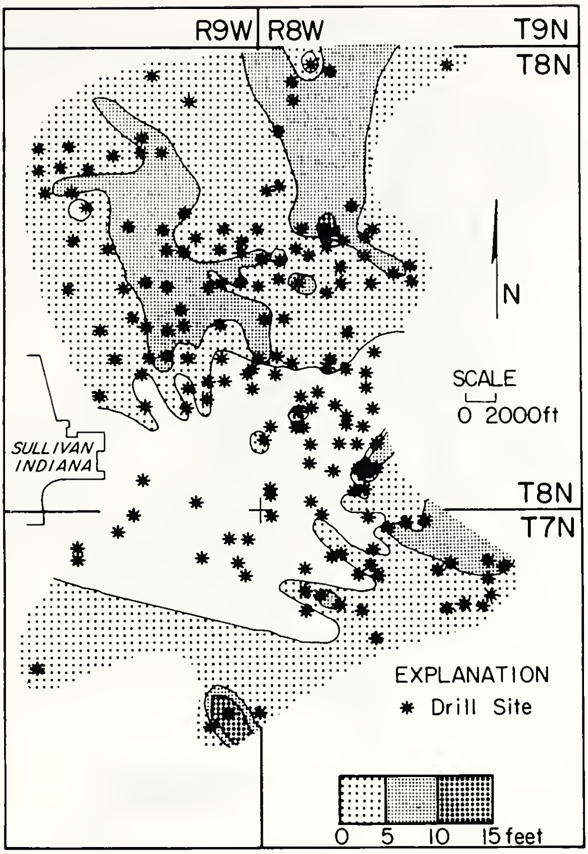

FIGURE 3. *Thickness Map of Lower Alum Cave Limestone*

deposit, which widens to 25 feet on the high wall face. No such overlying "rash" occurrences have been noted in other Illinois Basin studies.

Facies Analysis

A digital facies analysis was made of drillers' and electric logs for the interval between coals V and VI. On an isopach map separation between these two coals varied from 31 feet to 137 feet. Maximum separation coincides with the area of maximum clastic wedge thickness. Contoured percent sand in the V to VI interval (not illustrated) suggests a dentritic pattern with sand occurring in channels and subsiding pockets and low shaly areas occurring between the sandy areas as interdistributary bays. Additional facies analysis was done at other intervals and horizons.

Coal Thickness

The area of maximum Coal V thickness (Fig. 4) corresponds with the area of maximum clastic wedge deposition. In some localities the coal gradually thins toward the channel area but in others the coal first thickens in a ridge form near the channel then abruptly thins. This is probably related to levee patterns of the channel complex. On cross sections there are several instances where Coal V thins over thick sediment intervals between coals V and IVa. The area of maximum Coal V thickness also corresponds with an elevation low (syncline) relative to the surrounding coal elevation surface.

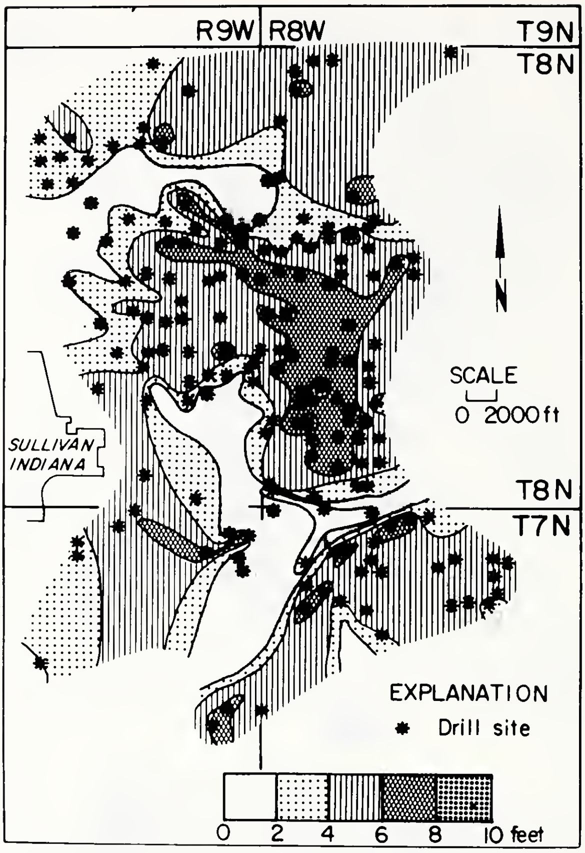

FIGURE 4. Thickness Map of Indiana Coal V

Coal thickness maps were also made for overlying coals VI and VII. In both cases clastic wedge and V thickness maps indicate little influence upon succeeding coal thickness. This would imply loading subsidence of Coal V and the clastic wedge before Anna Shale deposion. Coal VI thicknesses are erratic in contrast to the rather broad contour spacing for Coal VII thickness.

Conclusions

The low-sulfur coal occurrence in the Indiana coal V seam near Sullivan, Indiana originated by virtue of a synchronous and subsequent accumulation of fluvial-deltaic crevasse splay clastics within and over the coal bed. The clastic blanket isolated the coal locality from marine sulfate contamination. The clastic wedge had a notable effect on the separation between coal V and the overlying coals, but had little effect on the thickness of those coals. The overall depositional pattern is similar to some of those found in Illinois with the exception of noting a black shale "rash" associated with part of the low sulfur coal area. Further studies of roof characteristics of Indiana coal seams probably will define additional low-sulfur coal resources.

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