

A STRUCTURAL ANALYSIS OF THE NORTHWESTERN ILLINOIS ZINC-LEAD DISTRICT

J. C. BRADBURY

Illinois State Geological Survey, Urbana

GENERAL STRUCTURE

The northwestern Illinois zinc-lead district occupies essentially the northwestern one-third of Jo Daviess County. The district lies on the gently-dipping south slope of the Precambrian shield. The rocks are essentially flat-lying with a slight regional dip to the south-southwest of about 16 feet per mile.

Detailed structural contour mapping has revealed shallow synclines and elongate basins which have amplitudes ranging from 10 to 50 feet; the typical amplitude is about 25 feet. The synclines and basins may be grouped into three trends (Fig. 1)—a major northeast to east-northeast trend and subsidiary north-northwest and east trends. The northeast trend is characterized by broad, persistent synclines; the north-northwest and east trends are represented by narrow, sharp troughs or shallow, canoe-shaped basins.

Vertical and inclined joints are numerous throughout the district. The strike of the joints is variable, but there is generally a dominant direction in any specific area. Vertical east-west joints are the most common. They are prominent in nearly every outcrop and carry most of the shallow crevice deposits of the district.

STRUCTURAL CONTROL OF THE DEPOSITS

Structurally, the orebodies fall into two classes, which are characteristic of two different portions of the stratigraphic column. "Flat-and-pitch" orebodies, so-called because the ore occurs in "flats," or open bedding planes, and "pitches," or open inclined fractures, are associated with the thin-bedded limestones in the lower part of the ore-bearing section and the immediately overlying medium-bedded to massive dolomites. "Crevice" deposits are open-space fillings along vertical joints in massive dolomite in essentially the upper two-thirds of the section.

Flat-and-Pitch Deposits. The flat-and-pitch orebodies trend chiefly east-west and north-northwest and occur for the most part in definite belts which follow the synclines (Fig. 1). The main northeast synclines contain orebodies with a general east-west trend, arranged *en echelon*. The subsidiary north-northwest and east-west synclines contain orebodies parallel to their axial trends.

Considerable solution has taken place in the flat-and-pitch structures. Removal of up to 20 or more feet of limestone has resulted in the formation of solutional sag basins and the

opening up of bedding planes and inclined fractures to make the flats and pitches.

Because of this solution-induced sagging, it is difficult at most places to determine whether a syncline has been folded by tectonic forces or merely represents a fracture zone along which solution has occurred. Certain lines of evidence, however, indicate that a specific mode of origin can be assigned to the synclines of each of the three axial trends.

Data from studies in mines (Willman, 1945; Willman, Reynolds, and Herbert, 1946) and from prospect drilling indicate that the north-northwest-trending synclines are solutional structures. The amplitude of downwarping is approximately the same as the thickness of limestone strata removed by solution, and at the ends of the synclines folding and thinning die out concurrently. The east-trending synclines are structurally similar to the north-northwest synclines, that is, they are narrow and relatively straight, and may, likewise, be the result of solutional sag. In a paper on ore controls in the Illinois-Wisconsin district, Reynolds (1958) apparently assigns a tectonic origin to the east-trending synclines in the Shullsburg, Wisconsin, area but shows illustrations which suggest a solutional origin.

The major northeast-trending synclines, on the other hand, are generally thought to be tectonically folded because they are relatively broad structures and are more or less continuous across the district. Furthermore, in the nonmineralized portions of the synclines between the *en echelon* orebodies, the downfolds

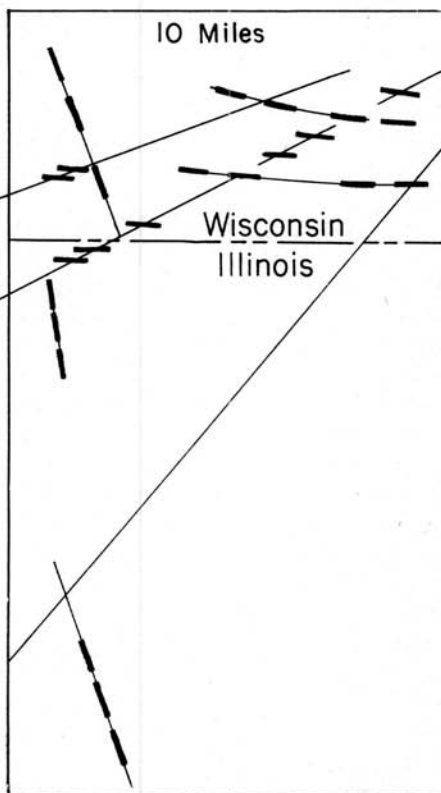


Fig. 1.—A portion of the Illinois-Wisconsin zinc-lead district, somewhat idealized, showing trends of flat-and-pitch orebodies and of the synclines in which they occur. The long light lines represent the synclines. Each short heavy mark represents an orebody, with the long dimension of the mark parallel to the strike of the orebody.

persist even though there may be no solutional thinning.

Structural Control of the Crevice Deposits. In contrast to the flat-and-pitch deposits, the crevice deposits exhibit no association with folds. The crevice deposits formed along vertical joints of great linear extent, as much as two miles in some places.

The great majority of these deposits have an east-west trend.

The crevices are interpreted as shear joints because of their great length and their characteristics and patterns in underground exposures. For example, in most deposits it is evident that the locus of deposition was in reality a zone of closely spaced fractures rather than a single clean break. Furthermore, brecciation of the rock is evident in many of the orebodies. In fact, some rather intense crushing is indicated in limited areas where angular rock fragments, one-half inch or less in diameter, are found cemented by ore minerals.

Structural Relations of Flat-and-Pitch to Crevice Deposits. As the crevice deposits and many of the flat-and-pitch deposits have an east-west trend, it is reasonable to assume that the fracture zones which controlled these deposits had the same origin. The difference in distribution between the two classes of deposits can be related to intensity of fracturing and the width of the individual fracture zones. The flat-and-pitch orebodies formed in fracture zones about 50 or more feet wide where there was opportunity for the solutions to leach the carbonates over a considerable width and develop the sagging which caused the flat-and-pitch structures. The stratigraphically higher crevice orebodies formed along narrow fracture zones (typically 10 feet wide) in which conditions for extensive carbonate leaching were less favorable, and flat-and-pitch structures could not form.

Because the formation of flat-and-pitch structures required more in-

tense fracturing, the flat-and-pitch orebodies tend to occur in specific belts, whereas the crevice deposits, which did not require such special conditions, are much more scattered. The occurrence of belts of flat-and-pitch orebodies along the major northeast-trending synclines is probably the result of a concentration of stresses and fracturing along these folded structures.

There is one trend of flat-and-pitch orebodies, however, which does not relate easily to the east-trending crevice deposits. The north-northwest-trending orebodies appear to be a special case in that they are prominent only in the western part of the district where they form a north-south belt of *en echelon* deposits. As this belt is unique in the district, it must have been formed by forces that operated only locally. These will be discussed more fully in a later paragraph.

STRUCTURAL DEVELOPMENT OF DISTRICT

The major elements of structure to be accounted for in the structural development of the district are north-east-trending synclines, east-trending fracture zones of probable shear origin, and a single north-south belt of *en echelon* north-northwest-trending ore-bearing fracture zones. These elements are illustrated diagrammatically in Figure 2. A Mohr diagram shows the proposed orientation of stresses.

Disregarding temporarily the unique belt of *en echelon* orebodies, the structural pattern appears to be one which can be created by north-west-southeast compression — the

northeast trending synclines strike normal to the axis of compression and the east-trending fracture zones occupy a principal shear plane. However, because of relations which are found in other parts of the Wisconsin-Illinois-Iowa zinc-lead district, the east-trending shear joints should be regarded as part of a joint system that pre-dated the northeast-trending folding. During the period of folding, the shearing component of the northwest-southeast compressive stress would tend to be dissipated

along pre-existing joints that most nearly paralleled a major shear plane. In this way, east-west vertical joints in the Illinois area acquired the characteristics of shear joints and, because of this additional fracturing along them, became favored channelways for the leaching and mineralizing solutions.

The unique belt of *en echelon* northwest-trending orebodies could have been caused by movement along a north-trending strike-slip fault in the basement rocks (Fig. 2). Strike-slip movement in the basement rocks, if it did not create a like fault in the overlying sedimentary rocks, would initiate a couple and cause *en echelon* tension fractures in the sedimentary rocks in a belt overlying and parallel to the fault. Such a fault would be parallel to one of the shearing components of the northwest-southeast compression and is, thus, feasible.

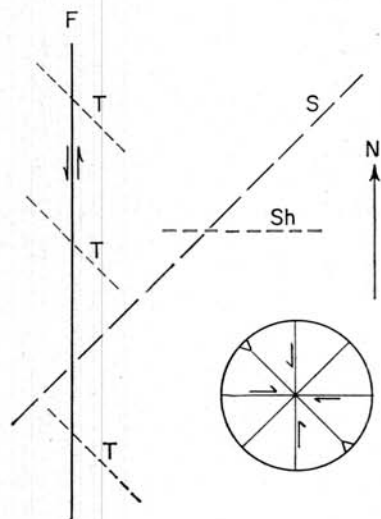


Fig. 2.—Diagrammatic representation of structural elements of northwestern Illinois zinc-lead district. S = northeast-trending synclines, Sh = east-trending fracture zones of probable shear origin, F = strike-slip fault in the basement rocks, T = *en echelon* tension fractures. In the Mohr diagram, the northwest-trending line represents the axis of greatest compression, the line normal to it the direction of greatest tension. The other two lines, at right angles to one another, represent the principal shear planes, with arrows showing directions of relative movement.

SUMMARY

Mineralized structures within the northwestern Illinois zinc-lead district are shallow synclines and basins that have a major northeast trend and subsidiary east and north-northwest trends, and joints which strike mainly east-west. Studies based on observations in mines and on drilling data suggest that the northeast-trending synclines were formed by compressional folding but that the north-northwest and possibly the east-trending synclines are solutional sag structures.

It is postulated that the northeast-trending synclines were formed during the main period of diastrophism by a northwest-southeast compressive

force that dissipated its shearing component along the east-west joints of a pre-existing joint system, thereby creating fracture zones favorable for ore deposition. The north-north-west-trending orebodies form a north-south belt of *en echelon* deposits at the west edge of the district. This unique belt must be the result of a special localized set of forces such as might be created by a strike-slip fault in the basement rocks.

LITERATURE CITED

- REYNOLDS, R. R. 1958. Factors controlling the localization of ore deposits in the Shullsburg area, Wisconsin-Illinois zinc-lead district. *Econ. Geol.*, 53: 141-163.
- WILLMAN, H. B. 1945. (Abstract) Structure of the zinc-lead deposits of northwestern Illinois. *Econ. Geol.*, 40: 96.
- WILLMAN, H. B., R. R. REYNOLDS, and PAUL HERBERT, JR. 1946. Geological aspects of prospecting and areas for prospecting in the zinc-lead district of northwestern Illinois. *Ill. St. Geol. Surv., Rept. Invest. no. 116.* 48 pp.

Manuscript received June 4, 1959.