XL. SOME FEATURES OF ORE-BODIES FORMED IN SYNCLINES BY METEORIC WATERS.

H. C. George, School of Petroleum Engineering, University of Oklahoma.

The Wisconsin Lead and Zinc District is located in the southwest corner of Wisconsin in Grant, Iowa and Lafayette counties, and extends a few miles into Iowa to the west and Illinois to the south. It lies within that area which is known geologically as the non-glaciated island of the upper Mississippi Valley .

For about a hundred years, this district has been a producer of galena (lead sulphide), which in most cases has been mined above ground water level, within sixty feet of the surface. About fifty years ago, the mining of zinc was begun. At that time the zinc ore mined was smithsonite (zinc carbonate), commonly known as "dry bone." This ore was frequently associated with galena and was generally found above ground water level. However the mining of sphalerite (zinc sulphide) from the larger ore-bodies found below ground water level did not attain importance until the year 1904. This paper deals with the zinc sulphide ore-bodies, which in most cases have been found and developed since that time.

The geology of the Wisconsin Zinc District has been described by Chamberlin[1], Bain[2], Cox[3] and others[4]. Briefly the region is one of slightly disturbed sedimentary rocks of Paleozoic Age. Neither igneous or metamorhic rocks outcrop in the region, nor have been encountered in mining. some deep water wells have penetrated granite at 1700 to 2000 feet below the surface. A general section of the rocks outcropping within the mining area may be tabulated as follows:

System.	Formation.	Character.	Thickness.
Silurian	Niagara	Dolomite	150′
Ordovician	Mequoketa	Shale	160′
Ordovician	Galena	Dolomite	240′
Ordovician	Trenton	Limestone and Dolomite	60′
Ordovician	St. Peter	Sandstone	80′

[1]T. C. Chamberlin, Geology of Wisconsin, Vol. IV, Pages 377-571.

[2]Bain, H. Foster, Zinc and lead deposits of the Upper Mississippi Valley, Geol. Survey Bull. No. 294, 1906.

[3]Cox, G. H., Lead and Zinc Deposits of Northwestern Illinois, Illinois State Geol. Survey Bull. No. 21, 1914.

[4]George, H. C., The Wisconsin Zinc District, Trans. Amer. Inst. Mining Eng., 1918.

The major zinc ore-bodies of the region are found in the lower part of the Galena dolomite and the upper part of the Trenton limestone below ground water level and at depths ranging from one hundred to two hundred and fifty feet below the surface.

The rock formations of the district dip to the south-southwest about twenty feet to the mile. The strata also have been slightly compressed and folded, resulting in a series of structural synclines and anticlines or basins and domes. The main axis of most of these structures approximate an east and west line. Frequently one side or one end of these structures will show much steeper dips than the other parts of the structure. The ore-bodies are generally found near the base of the Galena dolomite in the bottom of the synclines and basins near the side which shows the steepest dip.

There are two general types of ore-bodies; (1) the long and narrow type which generally is located around the bottom rim of large structural basins or in the bottom of extensive synclines in close proximity to the base of the steeper dipping leg; (2) the short, compact type which generally is located in the bottom of a small structural basin near the side or end having the steepest dip. Type (1) is illustrated in Fig. 1, Plate VI, which shows the ore-bodies at Platteville, Wisconsin. Type (2) is illustrated in Fig. 2, which shows some of the ore-bodies at New Diggings, Wisconsin.

Fig. 1 shows at (1) the Hodge Mine, at (2) the Enterprise Mine, at (3) the Empire Mine, at (4) the Homestead Mine, at (5) the Royal Mine and at (6) the Acme Mine. The structural basin is practically flat between mines 1) and (2), between (3) and (4) and between (4) and (5). The strata dip from the north and south about forty feet to the mile for a distance of about a mile north and south of the group of ore-bodies. Prospect-drilling between (4) and (5) and between (5) and (6) has shown that the mineralization contineus between these points. However this mineralization is mostly marcasite and calcite instead of sphalerite so that mining operations for the recovery of the zinc content has not been warranted commercially.

In prospecting for ore-bodies of the type shown in Fig 1, surface geology is first studied in order to secure evidence of mineralization and synclinal structural conditions. If the locality is considered favorable, prospect drill holes are then spaced 400 to 500 feet apart at right angles to the major axis, until the bottom of the basin is found; Then by closer spacing of the prospect drill holes, the bottom rim is located. If an ore-body is present it will usually be found near this point and can be sufficiently developed by further prospect drilling to determine whether or not the mineralization is sufficient or of such a character as to warrant mining operations.

In the northern half of the Wisconsin zinc district at Platteville, Livingston, Rewey, Linden, Monford and Highland ore-bodies of the type shown in Fig. 1 predominate. The length of some of the synclines and basins containing this type of ore-body has not yet been determined. About five miles south of Platteville, a series of ore-bodies has been proven and mined along the south rim of a structural syncline for a distance of five or six miles without having reached the east end of the structure.

Fig. 2 shows at (1) the Meloy Mine, at (2) the Sally Water Mine, at (3) the Hoskins Mine, at (4) the Winrock Mine, at (5) the Lake Superior Mine, at 6 the Booty Mine, at (7) and (8) the Winskell Mines, at (9) theIndian Mound Mine, at (10) and (11) the C. A. T. Mines, at (12) and (14) the Peni-Benton Mines, at (13) the Lucky Twelve Mine, at (15) the Longhorn Mine, at (16) the Champion-Church Prospect, at (17) the Blackstone Mine, at (18) the Longhorn Prospect, at (19) the Fields Mine and at (20) the Crawhall and Thompson Mines, all located in what is known at the New Diggings Mining District.

The ore-bodies of the New Diggings District, because of their shape, are called the "horse-shoe tpye". This type is best illustrated by means of Numbers 3, 6, 7, 9, 13 and 15 in Fig. 2. Each of the mines of this type is located in a small synclinal basin. For illustration, the contour of the base of the Galena dolomite between mines (9) and (13) and between mines (9) and (10) shows folding with the creast of the folds about ten feet higher than the bottom of the basins in which the ore-bodies occur.

In prospecting for ore-bodies of the type shown in Fig 2, the relative position and distance between ore-bodies already discovered is taken into consideration. For illustration, the probable location of ore-body No. (6) was made on the surface with reference to mines numbers (7), (9) and (19) which had been previously discovered. At ore-body No. (6) the 17th prospect drill hole discovered the ore-body. Other similar locations such as Numbers (16) and (18) were drilled on the "interval" basis, and although a mineralized zone was discovered in each case, the major part was calcite and marcasite instead of sphalerite, so that mining operations were not warranted.

The early discovery of ore in this district like the early discovery of oil in many oil fields, frequently has been made by chance.

However some of the old ore-bodies were found by noting the yellow character of the soil along certain lines, which stood out by contrast with the usually black soil. This yellow color is due to the oxidation above ground water level, of the marcasite usually contained with the lead and zinc and zinc minerals in the average ore-body of the district.

Five or six feet of brown, carbonaceous shale known as the "oil rock" and six inches to two feet of blue clay known as the "clay bed" are found at the base of the Galena dolomite. These strata in many cases act as a seal and prevent water migration from the Galena dolomite into the underlying "glass rock" member of the Trenton limestone or from the Trenton limestone into the Galena dolomite. Frequently the water in the Trenton limestone occurs under much greater hydrostatic head than the water in the Galena dolomite, as shown by observations made when the Trenton limestone is penetrated in prospect-drilling and mining operations.

Even in the same mine, the zinc ore found in the Trenton limestone generally differs considerably from that found in the Galena limestone in the amount of marcasite associated with the sphalerite. In the Galena dolomite, these two minerals are generally found in about the same proportions, whereas in the Trenton limestone often only a trace of marcasite is found. This observation regarding the relative amounts of sphalerite and marcasite in the zinc ores of the Galena dolomite and the Trenton limestone is further confirmed by a comparison of the mines in different parts of the District. In the northern and northeastern part of the District at Highland, Mifflin and Linden, where the top of the Trenton limestone is within a hundred feet of the surface, most of the zinc ore-bodies are found in the "glass rock" member of the Trenton limestone and in most cases produce a zinc concentrate practically free from marcasite. Whereas in the central and southern part of the District, where the top of the Trenton limestone is from 150 to 250 feet below the surface, most of the zinc ore-bodies are found in the Galena dolomite, and produce a concentrate containing about equal amounts of sphalerite and marcasite.

One peculiarity of underground water movement in the mines of the Wisconsin Zinc District is that after mining and pumping operations are begun, springs located along the strike of the ore-body being mined ,two or three miles distant, are frequently drained, whereas springs located only a short distance to one side of the ore-body are not affected. This condition probably results due to drainage through the numerous crevices which exist in the Galena dolomite, parallel to the crests of the major folds and to which the major axes of the ore-bodies are generally parallel. In this connection it might not be out of place to state that the crevices above mentioned in the Galena dolomite have usually been the repositories from which were secured most of the galena (cog-lead) and smithsonite (dry-bone) mined in the District previous to 1904.

The Wisconsin lead and zinc ore-bodies have been formed by the deposition of lead and zinc sulphides on the walls of underground water channels. The crevices and openings in which the ore occurs may have been produced in several ways. The lateral pressure and resulting folding may have produced them, or the dolomite beds for several feet immediately above the impervious oil rock may have been dissolved-out along channels in the structural basins, producing slump of the overlying strata; or, as suggested by H. Foster Bain, the oil rock layer, containing much organic matter, and being much thicker in certain parts of the structural basins, in the changes which the bed has undergone, has decreased in thickness to a considerable degree, in the same manner that coal beds have decreased in thickness, producing a slump in the overlying formations at points where the oil rock is the thickest.

In 1912 the writer and several other mining Engineers examined the Black Jack mine at Galena, Illinois, when it was unwatered after having been abandoned for 12 or 15 years, with the steel mine rails and cars left in the mine. All members of the party were surprised to note that the mine rails and cars were incrusted with a deposition of marcasite, galena and sphalerite from one eighth inch to one quarter inch thick. However similar incrustations have been noted on pieces of steel in the mines of the Joplin District of Missouri.

At times, when in the course of mining operations, large solution cavities have been encountered. These cavities have usually been lined with varying relative amounts of beautifully crystalline calcite, galena, marcasite and sphalerite. Some of these cavities extend for several hundred feet with a width ranging from ten to fifty feet and heighth ranging from two to ten feet. Within these cavities are sometimes found the peculiar form of stalactitic marcasite described in a paper by the writer before the Oklahoma Academy of Science in 1924, as well as the less common forms of galena such as cubo-octohedrons, octohedrons, skeleton crystals and the reticulated and tabular forms.

Similar mineral deposits may occur in the Trenton limestone at other places several hundred miles from the Wisconsin Zinc District. Several years ago, the writer when at Findlay, Ohio, saw sludgings from oil wells drilled into and producing from the Trenton limestone in the Lima oil field of northwest Ohio, which contained large amounts of crystalline marcasite and sphalerite. Undoubtedly the water channels formed in the Trenton limestone in Ohio, at some stage subsequent to their formation, contained circulating water from which sphalerite and marcasite were deposited on the walls of the openings. Later the water in these openings was replaced by oil and the Lima oil field resulted. Mr. Alexander Johnston, Production Superintendent of the Ohio Oil Company at Findlay, Ohio, stated to the writer that it had been their experience that the big oil production from the Trenton limestone came from those places where drilling had shown that the Trenton limestone was full of cavities and openings.

PLATE VI

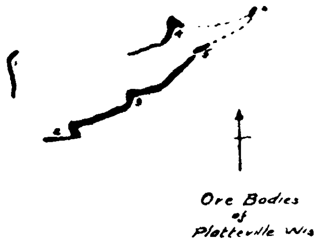

Fig. 1

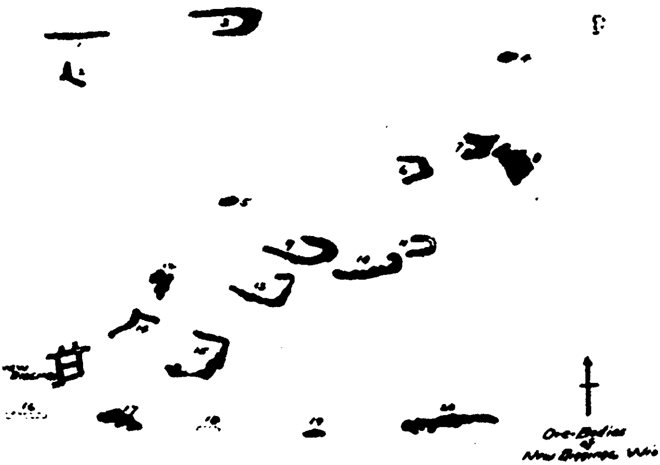

Fig. 2