

THE NEDA FORMATION IN NORTHEASTERN ILLINOIS¹L. E. WORKMAN²*Illinois State Geological Survey, Urbana*

In the vicinity of Mayville, Wisconsin, an "oolitic hematite" called "seed ore," "flaxseed ore," or "shot ore," was originally designated by Chamberlin³ as the "Clinton iron ore deposit." He described the grains of iron ore as "little lens-shaped concretions" composed of hydrated hematite averaging 1/25 inch (1 mm.) in diameter, but varying from 1/10 inch (2.5 mm.) to those that are very minute. Cross sections indicated that the ore occurs between the Cincinnati shale and the "Niagara limestone." He stated that, although a few fossils of Cincinnati age were reported to have been found in ore enclosed in a mass of glacial drift, an obvious unconformity at its base in outcrop and a less apparent break at the top indicate the deposit to be Silurian. He suggested that it was made in detached shallow basins over which the succeeding Silurian sea spread more widely. Figure 1 is a photograph of ore recently obtained at Mayville.

Thwaites⁴ further described the deposits of "Clinton" ore as occurring in eastern Wisconsin in broad lenses varying in thickness up to a known maximum of 55 feet. He pointed out that at many places where the iron ore is not present there are nevertheless beds of red rock at the same horizon, and pre-

sented a map (fig. 2) showing the known occurrences of iron ore and red rock. He reported also that in the Green Bay region the ore is interbedded with shale, and in an area



FIG. 1.—Neda Iron Ore from Mayville, Wisconsin (X6).

about 15 miles southeast of Mayville it appears from well cuttings to be broken up and mixed, or perhaps interstratified, with limestone.

Savage and Ross⁵ pointed out that the relations of the iron ore to formations both above and below are unconformable, but that fossils collected from the ore in place indicate it to be of Maquoketa (Cincinnati) age. They described the deposit as containing pebbles of shale, iron ore, and iron-oxide-replaced fossil fragments and suggested that the deposit is a formation laid down in local basins that, because of the presence of marine fossils, probably were connected and remained after the main portion of the normal marine Maquoketa sea had withdrawn from the greater part of the region

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³Chamberlin, T. C., *Geology of Wisconsin*, Wisconsin Geol. Sur., vol. 2, 1878, pp. 327-335.

⁴Thwaites, F. T., Recent discoveries of "Clinton" iron ore in eastern Wisconsin, U.S.G.S. Bull. 540, 1914, pp. 338-342.

⁵Savage, T. E., and Ross, C. S., The age of the iron ore in eastern Wisconsin, *Am. Jour. Sci.*, Fourth Series, vol. 41, 1916, pp. 187-193.

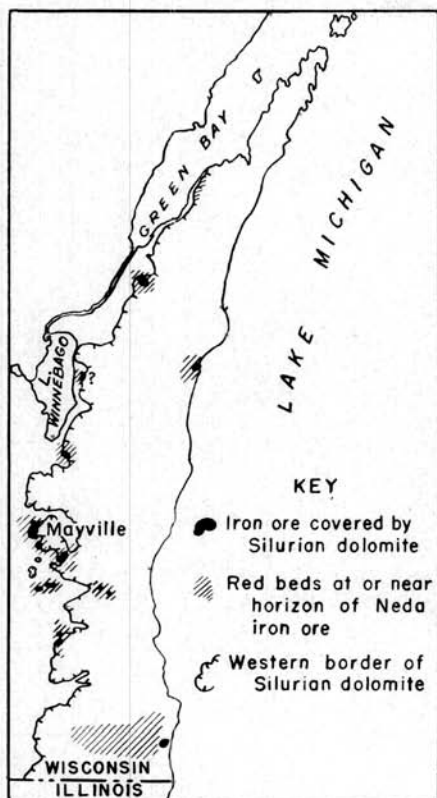


FIG. 2.—Locations of Neda Iron Ore in Wisconsin (after Thwaites).

farther south in the Mississippi valley. They named it the "Neda Iron Ore" formation.

Hawley and Beavan⁶ made a detailed analysis of the minerals of the Neda Iron Ore formation. They determined that nuclei observed in the oolites consist of: (a) fragments of reworked ore, (b) fossil fragments, (c) mineral or rock fragments, and (d) cross-shaped objects. They emphasized, however, that most of the oolites show no central nuclei. They showed that the spheroids are composed of at least 26 varieties of minerals, chief of which are goethite

($\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$), calcite, and halloysite ($\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot n\text{H}_2\text{O}$). Halloysite is a clay that was found to compose most of the insoluble residue after treatment with acid and that looked under the binocular microscope like finely granular unglazed porcelain, making up the fragile spheroidal shells of the spheroids. There are ten varieties of phosphates, and 50% of all phosphorus is contained in the outer shells of the spheroids. The non-oolitic portion of the ore is largely pore space. Crystalline hematite has grown from the spheroids into part of the space, and there are a number of sedimentary minerals such as quartz and materials from the weathering of igneous rock. The most abundant transported material consists of angular grains of scoriaeous lava largely altered to iron oxide. There are rounded fragments of reworked ore and nodules of calcite and dolomite. The authors state that the source of the predominant ore minerals is a baffling problem.

The Neda iron-bearing formation is reported in the same stratigraphic position in eastern Iowa⁷, eastern Kansas⁸, and northwestern Missouri⁹.

Athy¹⁰ very fully described the Neda deposit in Illinois but called it the Noix Oolite of basal Alexandrian (Silurian) age. The outcrops which he described, situated in sections 26, 27, and 35, T.32 N., R.10 E., Kankakee County, are the only ones known in Illinois. He reports the iron ore spheroids as occurring in a

⁷ Howell, J. V., An outlier of the so-called Clinton formation in Dubuque County, Iowa, Proc. Iowa Acad. Sci., Vol. XXIII, 1916, pp. 121-124.

⁸ Lee, Wallace, The stratigraphy and structural development of the Forest City Basin in Kansas, Geol. Sur. Kan., Bull. 51, 1943, p. 42.

⁹ Crane, G. W., The iron ores of Missouri, Missouri Bur. Geol. and Mines, 2nd Series, Vol. X, 1912, pp. 148-149.

¹⁰ Athy, L. F., Geology and mineral resources of the Hersher quadrangle, Ill. Geol. Sur. Bull. 55, 1928, pp. 33-38.

⁶ Hawley, J. E., and Beavan, A. P., Mineralogy and genesis of the Mayville iron ore of Wisconsin, Amer. Mineralogist, vol. 19, 1934, pp. 493-514.

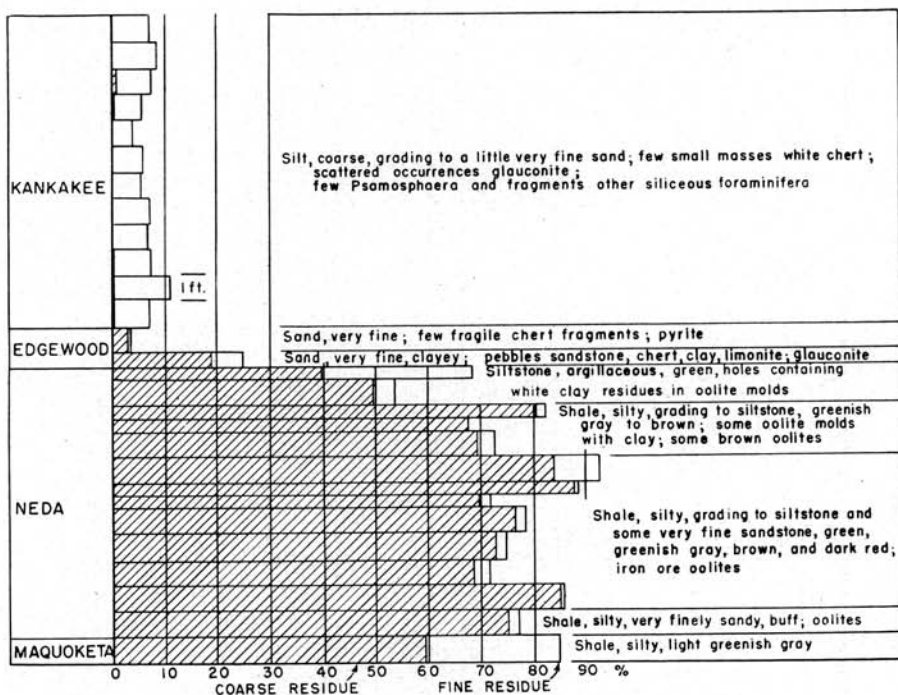


FIG. 3.—Graph of insoluble residues from Neda formation and associated strata in outcrop above spring in NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 27, T. 32 N., R. 10 E., Kankakee County, Illinois.

matrix of reddish brown, purplish, and green ferruginous shales and shaly dolomite reaching a thickness of 8 feet, 2 inches, and resting unconformably on olive-green Richmond (Maquoketa) shale. The spheroids are generally the size of fine to coarse sand averaging .5 mm. across. The shale was reported to contain much silt and fine quartz sand (up to .25 mm. diam.) and some medium sand (.25 to .50 mm.).

The writer obtained insoluble residues from samples, taken at one-foot intervals or less from several of the outcrops along Kankakee River, by treating the rock samples with weak hydrochloric acid. The graph of the most complete section (fig. 3), taken at the locality figured by Athy on page 32 and described on page 33 (see footnote 10), shows

10½ feet of Neda ore-bearing material on top of the Maquoketa shale and under the Edgewood formation. The insoluble material of the Neda deposit consists of: (a) silty shales to siltstones variously colored brown, yellow, greenish, and purplish by iron oxide cement; (b) some very fine sand that grades in the middle of the deposit to very fine sandstone; (c) iron-ore spheroids scattered in variable proportions but nowhere composing most of the deposit as in Wisconsin. The total residue varies from 54 to 93 percent. These proportions are not essentially different from the proportions in the Maquoketa shale below, which in the single sample taken amounted to 85 percent. Neither is the silty shale to siltstone matrix greatly different, except for some sand content, from the

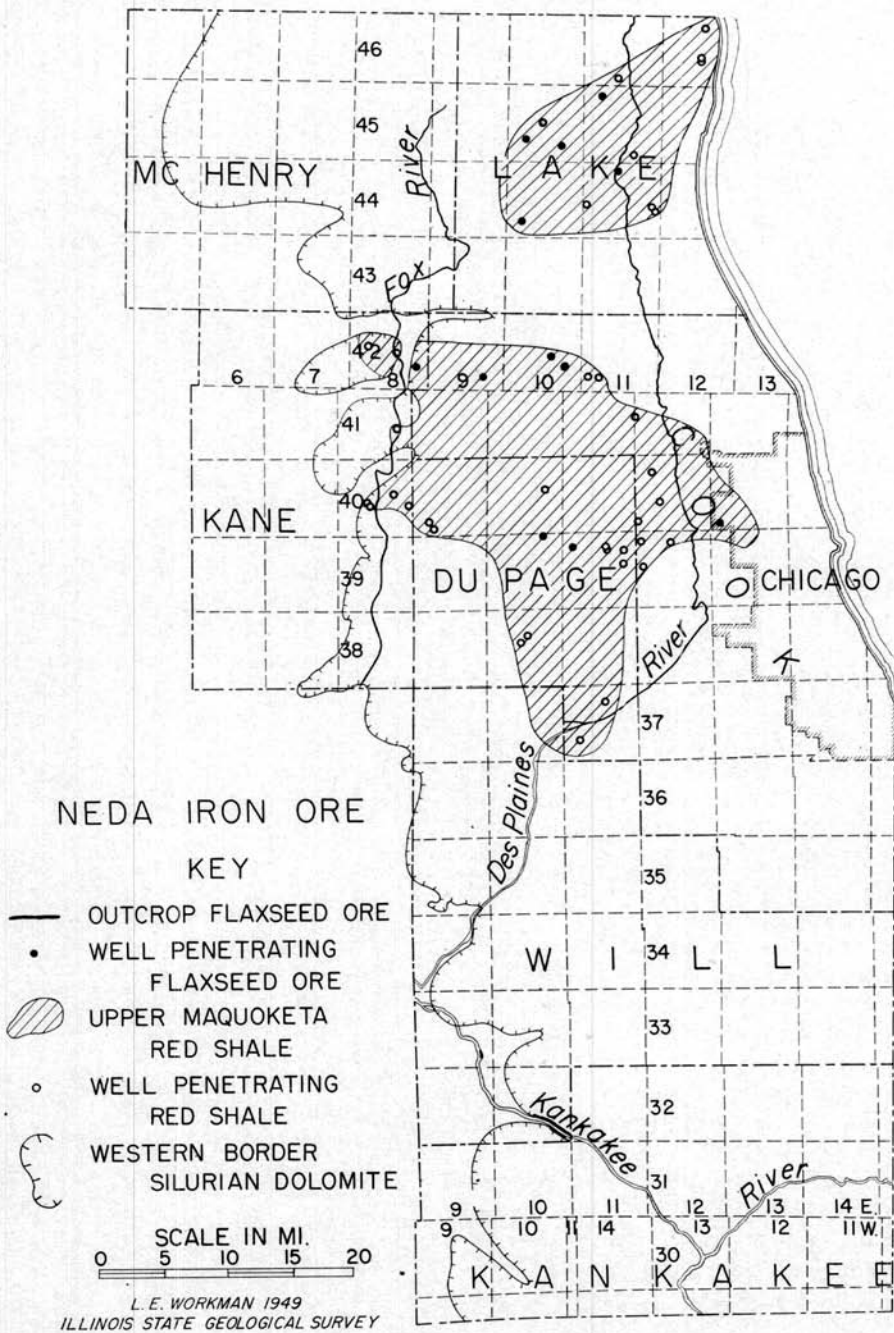


FIG. 4.

Maquoketa silty shale. On the other hand, the residue proportions are quite different from the 25 percent residue of the overlying Edgewood and there is an abrupt change from the silty sandy shale below to a sandy conglomeratic dolomite above. The pebbles of the conglomerate consist of grains of underlying shale and a few weathered iron ore spheroids. Were it not for the pebbles the proportion of insoluble residue of the lowest sample of Edgewood would be similar to that of the next sample above, that is, less than 10 percent.

In the subsurface of the Chicago region (fig. 4) the spheroids of iron ore are found in a variety of sediments. Like those along Kankakee River, they occur in silty shales having various iron-oxide colors. As in the Wisconsin outcrops, they occur as spheroids loosely cemented with crystalline hematite, though the beds are so thin that only a relatively small part of a 5-foot well sample consists of such material. They are commonly associated with red to green weak silty clay that contains small pebbles and grains of weathered Maquoketa dolomite. In some samples they appear to occur in a yellowish brown silty clay which has a starch-like fracture and contains brown flakes, suggesting a soil zone. In one sample the spheroids occur in a very fine sandstone containing grains of dolomite, hematite, and a hematite-replaced spicule. All occurrences are in the midst of more extensive areas where the top of the Maquoketa is represented by red clay shale containing weathered dolomite fragments. Such red shale areas are present only where the Maquoketa reaches its maximum thickness of 190 to 250 feet, as may be noted by comparison with Du-

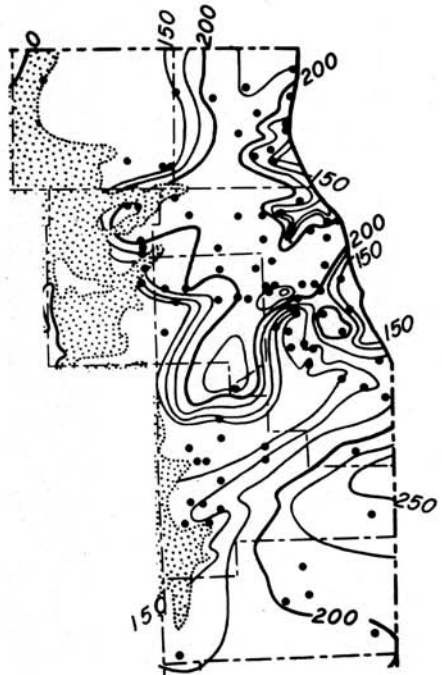


FIG. 5.—Thickness of Maquoketa formation in the Chicago region; isopach interval 25 feet (after DuBois).

Bois¹¹ isopach map of the Maquoketa (fig. 5).

Elsewhere in Illinois Neda spheroids have been noted in two wells in eastern Whiteside County and in another in eastern Peoria County where the Maquoketa thickness is near a maximum for the region of a little more than 200 feet. All these conditions are interpreted as indicating that the Neda was deposited on a relatively flat surface of the Maquoketa and was eroded widely along with the Maquoketa formation in an interval previous to Edgewood deposition.

The iron-oxide spheroids in the matrix of silty shale of the Neda de-

¹¹ DuBois, E. P., Subsurface relations of the Maquoketa and "Trenton" formations in Illinois, Illinois Geol. Survey Rept. Inv. 105, fig. 1, p. 8, 1945.



FIG. 6.—(Left) Thin section of Neda iron oxide spheroids in matrix of silty shale from Illinois (X18).



FIG. 7.—(Middle) Broken surface of Neda silty shale showing spheroids altered to clay (X18).

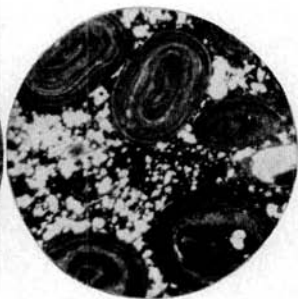


FIG. 8.—(Right) Thin section of Neda deposit showing spheroids replaced by calcite (X18).

posit in Illinois are generally smaller than those in Wisconsin, ranging up to 1 mm. in larger diameters, only a few reaching 1.25 mm. diameter, and averaging .75 mm. or less. They are similar in appearance to those in Wisconsin, being generally spheroidal and having smooth surfaces not only on the outsides of grains but on secondary surfaces made by breaking off the oolitic shells. Many of the spheroids in thin section show no nuclei, but the most common nuclei observed are fragments of other spheroids, especially fragments of the outer shells (fig. 6). A few were observed that were fragments of the matrix of silty shale, and a very few contained single silt grains or other material at the center. Most of them show a slightly darker brown outer hull.

Some observations of interest in considering the composition and geologic history of the oolites are as follows:

1. In the upper portions of outcropping Neda beds, varying in observed thickness from a few inches to as much as eight feet, the former oolites which were subjected to weathering previous to Edgewood

deposition lost their iron-oxide content, leaving a residuum of clay (fig. 7). This clay has been identified by Grim¹² as illite. Usually its texture is dense and porcelaneous, showing only faintly or not at all the former concentric rings of the oolites. The dull olive-green color disappears on treatment of the sample with acid, leaving the clay almost white. These clay masses appear slightly smaller than the average iron-ore spheroid, and the shapes of the cavities in which they occur, though roughly spheroidal, are somewhat distorted, indicating that the sediments have been somewhat compacted to fill partly or entirely the former oolite spaces. However, it becomes evident that, because of the large amount of residual clay, some original spheroids were not highly iron-bearing. Some clay masses are soft and porous, and occupy proportionately less space than the dense variety in the cavity left by solution of the iron oxide. Some consist only of flat round blebs of green clay in sizes typical of the oolites. Evidently these last formerly contained high

¹² Grim, Ralph E., personal communication.

proportions of iron oxide before the iron was dissolved and the sediments collapsed.

2. Some of the former oolites contain partial replacements of gray crystalline calcite (fig. 8). The cleavage faces of the calcite are so oriented as to indicate that each oolite replacement developed as a single crystal. Surrounding the crystal mass is the residual clay. Some of the calcite masses occupy practically all the former oolites except the outer hulls, whereas others are smaller and the residual clay masses seem to be larger accordingly. It is suggested that calcite formation took place only after the cavities had been left by iron-oxide solution and that the sizes of the crystals were governed by the available space. Thus it would appear that the calcite deposited after the beginning of Edgewood time, possibly long after that time.

3. Some of the residual material enclosing the calcite grains has the appearance of perfect fragments of outer hulls of iron-ore spheroids except that they are dark brown to black, suggesting the presence of organic material. Kosanke¹³ examined some of these and reported that they show no cellular structure but appear rather to be composed of amorphous material. Upon being heated in a test tube the black color disappears, leaving light-brown amorphous clay suggestive of that described by Hawley and Beavan as halloysite in the hulls of oolites in Wisconsin and of a somewhat different chemical character

than the materials making up the remainder of the oolite.

The considerable variety of sedimentary materials in which the iron-ore spheroids are found, the occurrence of the spheroids in northeastern Illinois and elsewhere only where the Maquoketa is thickest, and recognition of the same type of iron-ore spheroids at about the same geologic horizon in widely separated areas from Kansas to Wisconsin and Illinois, suggest that the Neda formation was a widespread deposit of variable character lying upon known Maquoketa (Cincinnati) shale, and was to a great extent eroded away during pre-Edgewood (pre-Lower Alexandrian) uplift. It appears significant for considerations of correlation that the Neda type of oolite occurs elsewhere in the eastern half of the United States in Silurian strata only, that is, the Red Mountain formation of Upper Alexandrian and Lower Niagaran ages in the Birmingham District, and the Clinton group of Lower Niagaran age in New York.

There is no difficulty in assuming that conditions of deposition favorable to the formation of Neda oolite recurred at intervals from late Cincinnati to early Niagaran times, but in order to be sure that these conditions prevailed across the Ordovician-Silurian boundary the possibility should be examined that the Maquoketa fossils found in the Neda in both Wisconsin and Iowa may have attained their position by being reworked by an early Silurian sea.

¹³ Kosanke, R. M., personal communication.