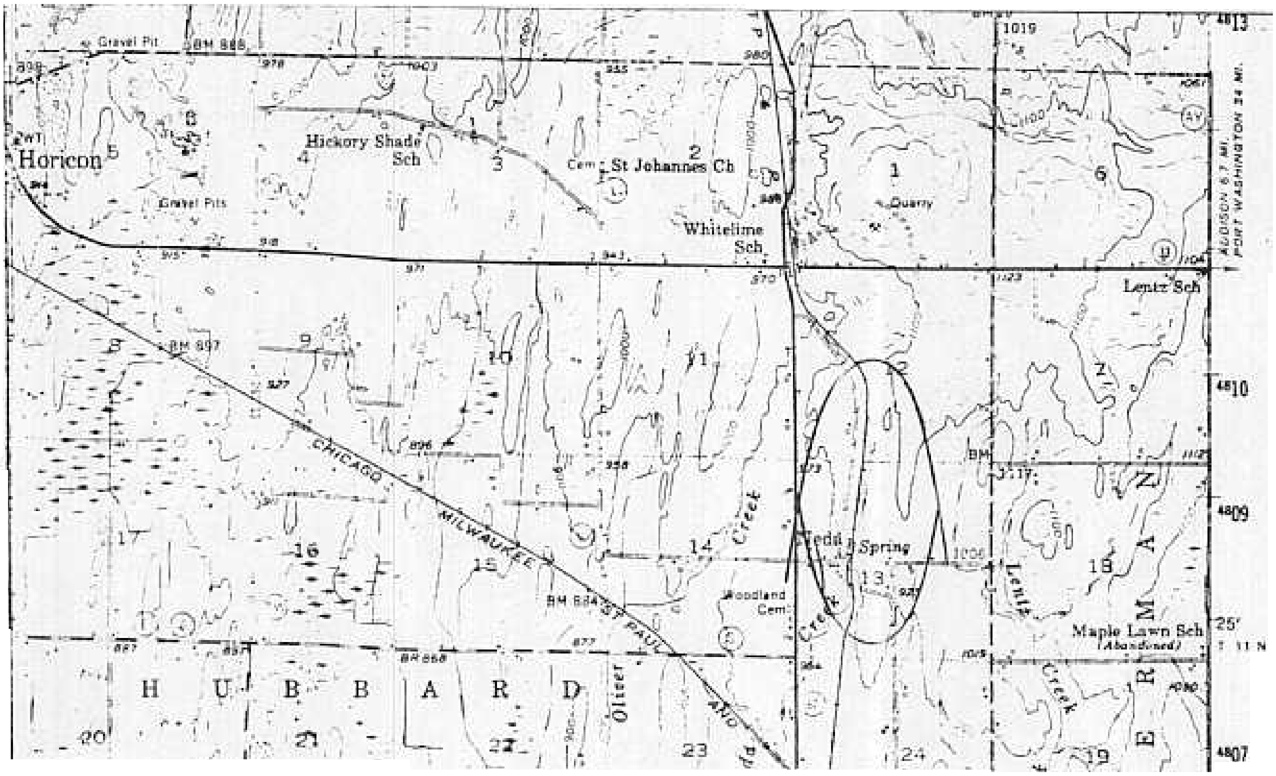
Title: Neda Iron Deposit

Location: Just east of Neda, Wisconsin. E½, NW¼, Sec. 1, T.11N., R.16E. (Horicon 15-Minute Quadrangle) Dodge Co.

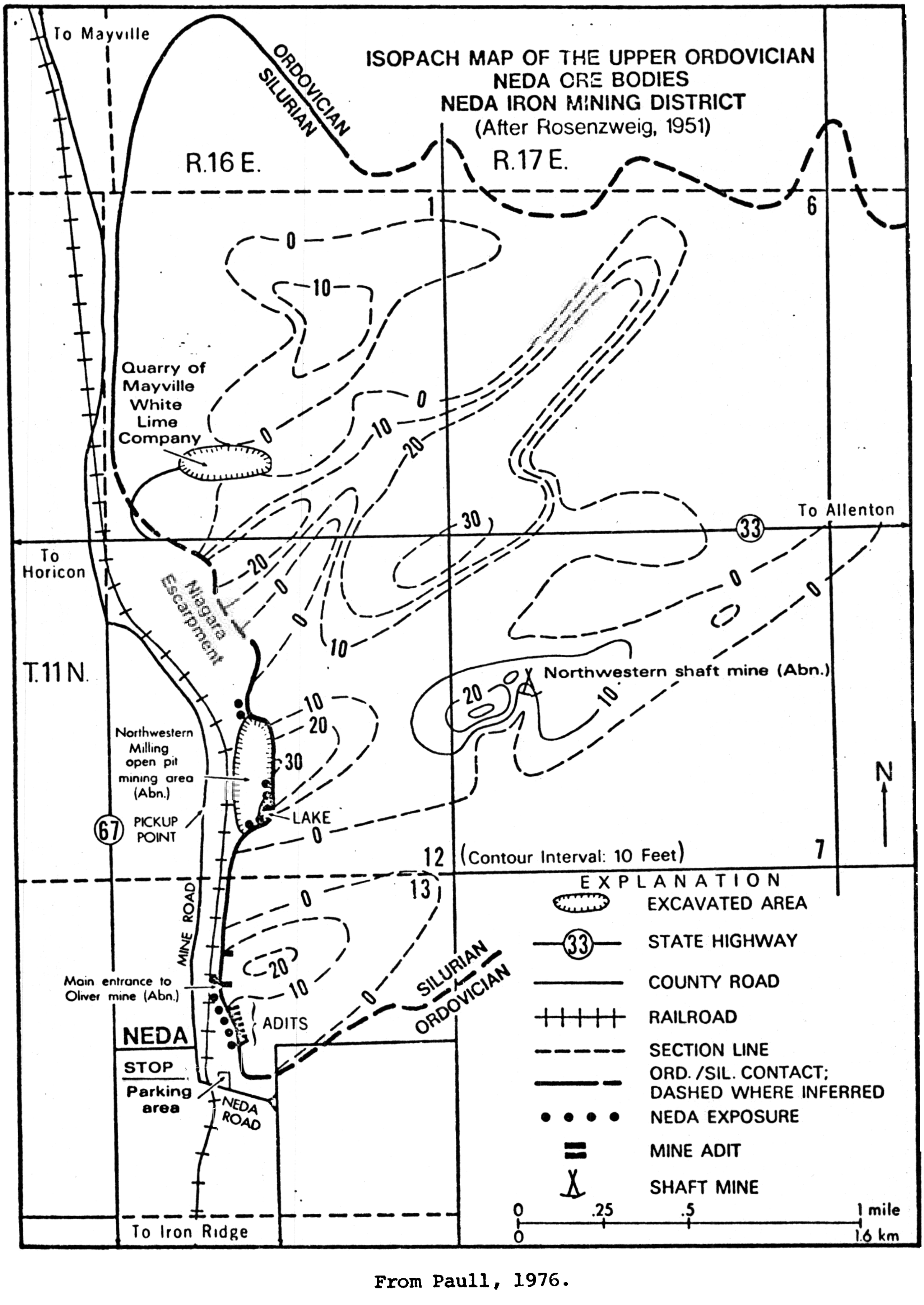


Author: Gene L. LaBerge (modified from Cunningham, Witt, and Palmer, 1976; Paull, 1977)

Description: The Neda Formation is an iron-rich sedimentary rock underlain by the Upper Ordovician Maquoketa Shale and overlain by the Lower Silurian Mayville Dolomite. It is a patchy deposit, present at only 8 known localities in eastern Wisconsin, and in a few places in Illinois, Iowa, Kansas and Missouri (Paull, 1977). The thickest known development of the Neda underlies Manitowoc, Wisconsin. At Neda the thickest orebody was 37 feet (Rosenzweig, 1951). The Neda consists of three "members": a lower shaly unit, a soft-ore unit, and an upper hard-ore unit.

The Maquoketa Shale, which underlies the Neda, is exposed in the road ditches on the hill just east of Neda. The Maquoketa is a greenish gray to bluish shale with dolomitic layers. It is quite fossiliferous here with abundant brachiopods, bryozoans and some corals and gastropods. The top of the Maquoketa exposed in the ditches along the road east of Neda is 20-30 feet higher than the base of the Mayville Dolomite exposed several hundred yards to the north, suggesting considerable relief on the top of the Maquoketa Shale.

The lower shaly unit consists of 2-3 feet of chocolate-colored shale with shiny Maquoketa shale pebbles covered by a film of iron oxides (Rosenzweig,



From Paull, 1976.

1951). Scattered iron-rich ooliths occur along bedding planes of the shale at the base of the unit (indeed, their presence defines the base) and become abundant upward until they constitute the bulk of the layers (Rosenzweig, 1951). Thus, the Maquoketa appears to grade upward into the Neda.

The soft-ore unit is a friable, reddish brown, thin to medium bedded, cross-bedded oolitic goethite-hematite, with some shaly interbeds. The ooliths have an average size of about 1 mm and are somewhat flattened. The long dimension of most ooliths is parallel to the bedding, but some are randomly oriented. Although most Recent oolites are composed of calcium carbonate, these oolites are composed mainly of goethite, which forms concentric layers around a nucleus. Rosenzweig (1951) recognizes four types of nuclei: 1) fossil fragments, 2) fragments of reworked ore, 3) mineral or rock fragments, and 4) cruciform specular hematite. All the nuclei are now hematite or goethite.

The hard ore unit is a dense compact layer of massive, dark red to purple hematite, generally less than a foot thick. Ooliths are present, but do not constitute a large part of the ore, and some thin interbeds and clasts of shale are present. Small pebbles of hematite are common, and appear to be an intraformational conglomerate. The hard ore appears to have formed by weathering and reworking of the soft (oolitic) ore.

Unconformably overlying the hard ore is the Middle Silurian Mayville Dolomite, a gray, medium to thick bedded cherty dolomite that forms a resistant cover on the softer Maquoketa shale and Neda formation in this area. A quarry in the Mayville Dolomite operated by the Mayville White Lime Company is located 2 miles north of Neda. The geological map of the Neda area shows the relationship of the Neda formation to the overlying Mayville Dolomite; the Neda is preserved only where it was protected by the Mayville.

Significance: The Neda iron deposit was mined almost continuously from 1849-1928, and provided an important resource for this part of Wisconsin. Some of the ore was smelted in Mayville, and was the basis for a modest local steel industry. Although much ore remains in the deposit, the relatively high phosphorous content, patch distribution, and "soft" nature of the ore as well as the necessity of utilizing underground mining methods make this deposit non-profitable to mine in the foreseeable future.

The origin of the Neda has been debated for nearly 100 years, and the geological setting in which the ore formed is still not agreed upon. Paull (1977) presented an excellent summary of the ideas on the origin of the Neda, and included his interpretation of the depositional environment. A number of factors must be considered in explaining the deposit: 1) the relief on the top of the Maquoketa suggests an erosion surface; 2) the elongate lens-like shape of the orebodies may indicate its development in channels, or perhaps in shoals (mounds) on the sea floor; 3) the increase upward in the abundance of ooliths in the lower member suggests that the Neda is gradational from the Maquoketa; 4) oolites generally form in shallow agitated waters; 5) all Recent oolites are calcareous; 6) because the iron is chemically precipitated, it is virtually impossible to indicate its source, except that it must have come from the overlying sea water; 7) the hard-ore layer on top of the Neda has the appearance of a "reworked" ore, or perhaps a weathered zone formed by exposure of the ore; 8) the Mayville Dolomite uncomforably overlies the deposit with much of the Lower Silurian (Alexandrian) missing, indicating a significant hiatus; 9) the lack of detrital sedimentary rocks above the unconformity suggests the lack of any nearby landmass of significant size.

Paull (1977) concludes that the Neda originated as a calcareous oolite similar to the present day Bahama Banks that developed on the Maquoketa. He suggests that the carbonate ooliths were replaced by iron oxides in a weathering environment during a regression of the Late Ordovician sea, and prior to the transgression in Lower Silurian time. He cites fossils replaced by iron oxides and the fact that modern day oolites are calcareous to indicate a secondary origin for the deposit. Do replaced fossils prove a secondary origin for the entire deposit, or are they replaced by iron oxides because they are in an iron deposit?

An alternative explanation might be that the deposit developed in a shallow marine environment during an upwarp of the Maquoketa Shale. The ooliths may originally have been chamosite (an iron-aluminum layer silicate) as is the case in a number of other Phanerozoic sedimentary iron deposits (e.g. Devonian deposits in Libya (Khaled Hangari, personal comm., 1977), the Silurian Wabana deposits of Newfoundland (Hayes, 1915, 1929), Ordovician in France (Cayeux, 1922; Chauvel, 1962). The ooliths may, in part, be formed by reworking of the Maquoketa Shale in the shallow-water environment. Iron was introduced, perhaps by bacterial action extracting iron from the overlying waters and accumulating primary ferruginous ooliths. Chamosite ooliths are commonly flattened and occur in a matrix of siderite. This iron-rich deposit may then be oxidized to hematite/goethite with a further uplift of the Maquoketa (or lowering of sea level, or may be oxidized at some later date. The iron is subject to change whenever oxidizing conditions develop. The ultimate <u>source</u> of the iron may be almost impossible to locate and is not necessarily germaine to the <u>deposition</u> of the deposit.

The presence of a massive carbonate (the Mayville Dolomite) immediately above an erosion surface seems to preclude the presence of a large landmass. It seems more likely that the Neda developed in a shallow water, but off-shore environment. Later transgression (or deepening) of the sea over the area initiated the deposition of carbonate on the eroded Maquoketa-Neda surface

References

Cayeux, Lucien, 1922, les minerais de fer oolithique de France, II. Minerais de fer secondaires: Minist. Trar. Publices, Etudes gites minerais de la France. 1052 p.

Chauvel, J. J., 1962, Les Minerais de fer amoricains: Composition mineralogique et structure de la couche de minerai silurien reconnue par sondages entre Bain-de-Bretagne (I-et-v) Penn. Ar. Bed. vol. 3, pp. 205-212.

Cunningham, K., Witt, R., and Palmer, E., 1976, "The Neda Iron Deposit": Guidebook for 8th Annual UW-System Geology Field Conference, Oshkosh

Hayes, A. O., 1915, Wabana Iron Ore of Newfoundland: Geol. Survey of Canada Memoir 78.

Hayes, A. O., 1929, Further Studies on the Origin of the Wabana Iron Ore of Newfoundland, Econ. Geol., Vol. 24.

Paull, R. A., 1977, "The Upper Ordovician Neda Formation of Eastern Wisconsin": Guidebook, 41st Annual Tri-State Field Conference, Milwaukee.

Rosenzweig, A., 1951, Neda Iron Ore in Eastern Wisconsin, Unpublished M.S. Thesis, U.W., 57 p.