Bog Ore in Early Vermont

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Figure 1

Hematite ore mined from a mine in Iran. This ore contains approximately 62 percent iron. (Image taken from www.alibaba.com)

Geologic Background of iron

Iron, which makes up 34.8% of the earth, is the most abundant element. However, the majority of this iron is concentrated in the core of the earth. Iron only makes up 5.8% of the earth's crust (Chernicoff and Whitney, 2007). In an oxygen free environment, such that existed about 2.5 billion years ago, iron is soluble in water. During that time, iron molecules floated around in the water completely dissolved. These dissolved iron molecules were Fe2+. However, about 2 billion years ago the first living organisms appeared on earth and started producing oxygen as a bi-product of cellular respiration. The iron that was dissolved in the oceans bonded with this oxygen to become iron oxide (Fe2O3). The iron oxide, which is insoluble in water, then sank to the bottom of the ocean where it condensed (www.columbia.edu). While on the bottom of the ocean, this iron oxide combined with other minerals and rocks to form iron ore. Iron ore is defined as the rocks and minerals from which metallic iron can be economically extracted (Wikipedia.com). The rocks and minerals that combined with the iron determine what kind of iron ore is produced. The most common iron ore is hematite (Figure 1), which is the mineral form of iron oxide. Hematite usually has about 65% iron (www.unisbm.com).

Eventually, due to the movement of plate tectonics these sedimentary iron ore deposits found themselves onto continental landmasses in the form of "banded iron formations" (Chernicoff and Whitney, 2007). Humans mine this iron ore from deep within the ground and through the smelting process are able to rid the iron of impurities to produce relatively pure iron, which can be used to make a number of items ranging from swards to wheels to fences.

Figure 2

Here lies a pile of mined bog ore. This bog ore is was extracted from New Jersey's Pine Barrens. The ore extracted from here was used in the revolutionary war to make cannon balls and iron wheels. This Photo was taken by Carolyn Foote Edelmann. This photo was taken from http://www.packetinsider.com/blog/nature/?p=394#comments

Figure 3

Here is a spring in Saratoga, New York sputtering water onto the ground. Looking closely at the water droplets in mid-air you will see that they are clear. However, when they land they are making the ground red. This is because initially the iron within the water is not oxidized. After the water lands and the iron has had enough time to bond with the oxygen, the iron within the water turns a dark red color. If this iron rich spring was producing more water, bog ore would form. Photo taken from http://saratogawoodswaters.blogspot.com

Geologic Background of Bog Iron Ore.

Bog iron ore is iron ore that forms in low-lying swamps or bogs. It is generally a "soft, spongy, and porous deposit of impure hydrous iron oxides" (U.S. Bureau of Mines, 1996) (Figure 2). It has high phosphorous content and vegetation fragments which contribute to its impurity (Drake et al. 2012). Bog ore usually appears in the mineral form of limonite and goethite. These minerals' chemical structure is FeO(OH) or a close variation of this. A high iron limonite is said to have more than 47.69% iron (www.unisbm.com).

There are contradicting views on how bog ore forms in such different conditions than normal iron ore. Some, such as Victor Rolando and Hitchcock et al. suggest that bog ore formed primarily by iron that has dissolved out of older, decomposed iron ore and then washed downhill due to the erosion of the higher, older elevations to settle and collect in marshes. However other, more scientific and recent articles suggest that water rich in dissolved iron emerges from groundwater within a bog or marsh where it oxidizes and forms iron ore. (Kaczork and Sommer 2003) and (Bricker et al. 2004). Figure 3 shows this process in action on a small scale. It is likely that both of these contribute to the formation of bog ore with the latter being most influential. There is also evidence from U.S. Bureau of Mines Dictionary of Mining, Mineral, and Related Terms suggesting that iron bacteria such as Gallionella and Leptothrix can contribute to the formation of iron oxides from dissolved iron in water through their metabolic processes (figure 4). Bog ore can be extracted from bogs and smelted into raw iron.

Figure 4

Iron bacteria produce a slimy iron rich coating and the "breakdown of the bacteria produces a natural oil discharge that makes a sheen on the water" (Bellacoolablog.com). Photo taken from www.panoramio.com

Figure 5

The towns that had bog ore deposites. The majority of these deposites are located within the Champaign Valley.

Bog Iron Ore's Contribution to Vermont's Early Settlers.

Little is known about bog iron in Vermont or even America for that matter. There have been 144 ironworks sites/remains located in Vermont (Rolando 1992). The many bogs and low-lying marshes in Vermont provide good locations for bog ore to be exploited and mined. One of bog ore's most important features is its ease of extraction. Mining for bog ore consists of using a pick and shovel to extract the ore and then drying it out. While this is no doubt a challenging task, it requires much less labor, effort, and risk than underground mining. At the time (late 18th early 19th century) it was the best option for extracting iron ore from the ground. Another beneficial aspect of bog ore is that is a relatively renewable resource. "Deposits which were once exhausted are again workable after an interval of a few years" (Bricker et al. 2004). According to Hitchcock et al. bog ore was found in the following Vermont towns: Colchester, Milton, Bristol, Huntington, Ripton, Starksboro, Warren, Wallingford, Highgate, Swanton, Guilford, Bennington, Bennington, Manchester, Pittsford, Brandon, Chittenden, and Strafford (see figure 5). Many forges were built for the specific reason of extracting iron metal from the bog iron ore. One historical reference states that, "Ira Allen in 1783 was contracting the construction of forges along the Winooski River to exploit Bog ore beds at Colchester" (Rolando 1992).

The smelting process involves heating the bog iron to about 1500°C. This melts off many of the impurities that come with the ore to produce a metallic iron. The environment inside a furnace pulls the oxygen atoms of the iron oxide leaving raw metal. However, in the case of bog iron ore, there are so many other impurities such as phosphorous and plant material in the ore that the final quality of the metal is relatively poor. Also, smelting technology back in the early 19th and late 18th centuries could not remove all the carbon. Thus the metal obtained from bog ore is too brittle to be used for wire or materials where "toughness is required" (Hitchcock et al. 1861). Thus the ore from bogs could not "produce iron enough to pay the expense, nor of a quality valuable for smelting" (Smith and Rann 1886). However, "considerable quantities of it were made into cast iron…before 1800, and it is said to have made good castings" (Goodhue 1861). Because of its low quality, once people were able to extract better ore from the ground, they began to phase out the use of bog iron ore. Soon bog iron ore was history, but for early Vermonters, it was their only source for iron.

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