MAGNETITE

$Fe^{2+}Fe^{3+}{}_2O_4$

A very widespread and common iron oxide mineral. Magnetite occurs as an accessory species in most igneous rocks (from peridotites to granites and their extrusive counterparts), and in some hydrothermal veins. It is also found as a detrital mineral in sands, sandstones, and in placer accumulations. Magnetite is present in many metamorphic rocks as a common accessory and concentrated in several types of iron formation, some of which are mineable or amenable to beneficiation (e.g., taconite). Occasionally, magnetite may alter to hematite, forming pseudomorphs known as "martite." Chiefly Northern Peninsula but also Southern Peninsula.

Figure 97: Octahedral magnetite crystals in chlorite schist from the Cleveland mine, Ishpeming, Marquette County. Crystals average 3 mm. A. E. Seaman Mineral Museum specimen No. DM 5953, Jeffrey Scovil photograph.

Baraga County: Spurr mine, Imperial Heights, with grunerite (Morris, 1983).

Dickinson County: **1.** Metronite quarry, 4 km east-northeast of Felch: In an aplite-pegmatite dike (Heinrich, 1962b). **2.** Menominee district: A basal unit of the Vulcan Iron Formation contains magnetite-chert rock. Some magnetite-rich layers occur in the lower and middle units of the formation. The upper unit is bedded magnetite-rich rock with some distinct iron silicate bands. Notable exposures are in section 5, T41N, R30W and SE ¼ section 33, T42N, R28W (James et al., 1961; Bayley et al., 1966; Dutton and Zimmer, 1968). **3.** Groveland mine: In upper Vulcan Iron Formation (Cumberlidge and Stone, 1964). **4.** Chapin mine, Iron Mountain. **5.** Penn mine, Norway. **6.** Pewabic mine, Iron Mountain (4 to 6, Hawke, 1976). **7.** Three serpentinite bodies were recorded by Rominger (1881, p.216) near the mouth of the Sturgeon River. One "contains magnetite granules in considerable quantity and gives with the blowpipe reaction of chrome."

Gogebic County: Gogebic iron range: Occurs in small amounts throughout the iron formation, most abundantly in the ferruginous slates (Hotchkiss, 1919). It is the "wavy-bedded iron formation" in the Plymouth and Norrie members of the Ironwood Formation. These rocks contain darker bands of magnetite and carbonate, lighter bands of chert and carbonate, and some minnesotaite in lighter-colored layers (James, 1954).

Houghton and Keweenaw Counties: **1.** Jacobsville Sandstone: Detrital (Denning, 1949). **2.** Keweenawan lava flows: Titanian magnetite ("titanomagnetite") is a widespread accessory mineral, often altered to hematite or titanite-rutile-hematite mixtures, near tops of flows (Butler and Burbank, 1929) and is locally intergrown with ilmenite (Cornwall, 1951a). **3.** Kearsarge amygdaloid: In "short-circuiting fissures" (Broderick, 1931). **4.** Copper Harbor Conglomerate: Found as detrital grains. **5.** Mount Bohemia: As octahedral crystals to 4 mm in calcite veins. **6.** Isle Royale mine, Houghton: Massive, rounded blebs to 1 cm in quartz veins. Rare.

Iron County: **1.** Hiawatha mine, Menominee iron range: Small, drusy crystals (Brower, 1968). **2.** Iron River district: Found in the "magnetic ironstone" unit (youngest Huronian), a magnetite-siderite-chlorite-chert rock (James, 1961). **3.** *Bengal (Cannon) mine*, Stambaugh: As unusual groups of octahedral aggregates to 4 mm, which in turn are composed of stacked cubo-dodecahedral crystals. **4.** NW ¼ section 12, T43N, R32W: Magnetite-rich zones in the upper part of the west Kiernan metagabbro sill contain rounded 0.2 to 3 mm grains in clusters comprising up to 50% of the rock. It is also found in altered plagioclase and uralitized pyroxene, some of which is titaniferous and altered to titanite or "leucoxene." Other associated minerals are chlorite, biotite, apatite, epidote, pyrite, and unspecified carbonates (Wier, 1967).

Marquette County: **1.** Marquette iron range, general: Soft ores have hematite, "martite," and locally some magnetite. Hard ores consist of specular hematite and magnetite or "martite" (Anderson, 1968). The middle part of the Negaunee Formation contains banded magnetite with some minnesotaite (James, 1954). **2.** Empire mine: Magnetitic taconite ore occurs in the Negaunee Iron Formation. Magnetite grains range from 0.037 to 0.019 mm in magnetite-chert, magnetite-chert-carbonate, magnetite-chert-silicate, and magnetite-chert-silicate-carbonate rocks (Anderson, 1968). Magnetite metacrysts in quartz also are found (Schwartz, 1936). **3.** *Republic mine*: In magnetite-chert and magnetite-grunerite-chert rocks, and as rich, large masses of pure magnetite (Anderson, 1968). **4.** Near Humboldt: Exposures of magnetite iron formation. **5.** *Beacon mine*: Octahedra in chlorite schist (Mandarino, 1950). **6.** *Champion mine*: Excellent collecting area (Spiroff, 1940; Markert, 1960). Large, massive blocks as well as crystals in vugs with siderite crusts may be found here. **7.** Magnetic mine: Rich, massive specimens with garnet, grunerite, and amphibole (Lamey, 1934). **8.** Lake Michigamme: Metacrysts with inclusions of hematite (Schwartz, 1936). **9.** Ishpeming: Metacrysts altered to "martite" in soft red hematite matrix (Schwartz, 1936). **10.** Washington mine: Disseminated in banded magnetite-chert iron formation of Negaunee age with garnet and actinolite (Rominger, 1881). Some of the magnetite is iridescent (Brooks, 1873). **11.** Republic area: Marginal to the magnetite ores were unusual rocks of quartz-magnetite, too lean to be ores, called "black-ore jasper" (Van Hise and Bayley, 1897). **12.** Greenwood mine, Greenwood, with grunerite. **13.** Michigan mine: Also with grunerite. **14.** Ogden mine, Ishpeming (12-14, Morris, 1983). **15.** *Cleveland mine*, Ishpeming: As sharp, octahedral crystals to 5 mm, partially altered to "martite" in chlorite schist. **16.** *Michigamme mine*: As rich, pure masses and small octahedral crystals in chlorite schist similar to those from the Cleveland mine. Also in an unusual botryoidal habit, possibly pseudomorphous after reniform hematite. **17.** Yellow Dog peridotite, sections 11 and 12, T50N, R29W: As a major accessory mineral along with ilmenite (q.v.), chromite, rutile, and numerous sulfides (Klasner et al., 1979). Both primary and secondary magnetite are present, the former as grains interstital to silicates (olivine, augite, enstatite), and as rounded to angular inclusions up to 0.5 mm across in orthopyroxene. Serpentinization of olivine and pyroxene produced secondary magnetite as thin (5 to 10 mm) stringers between relict olivine and as single grains or grain clusters within or surrounding altered pyroxene. Some ilmenite grains show fine (<3 mm wide), oriented, exsolved lamellae of titanian magnetite intergrown with chalcopyrite (q.v.).

Ontonagon County: White Pine: As a detrital mineral in the Nonesuch Shale (Doane, 1956).

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