PYRITE

FeS_2

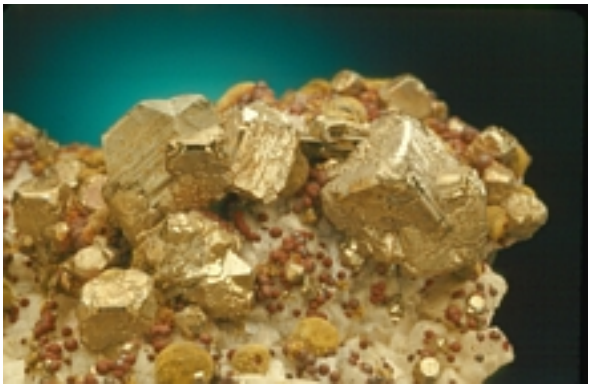

Figure 110: Cubic crystals of pyrite to 8 mm with twinned marcasite crystals, goethite, and hematite on dolomite from the Imperial mine, near Michigamme, Baraga County. A. E. Seaman Mineral Museum specimen No. DM 496, Jeffrey Scovil photograph.

Dimorphous with marcasite (q.v.), pyrite is one of the most widely distributed iron species and the most common iron sulfide. "Bravoite" is a nickel-rich variety. Pyrite occurs in a great diversity of rocks and deposits. The main types of Michigan occurrences include: 1) sedimentary rocks - in vugs and fractures in sandy dolostone and limestone, as concretions and disseminated grains in shale or coal, as tiny disseminated crystals in halite (evaporites), and as pyrite microbiota in phosphorite; 2) metamorphic rocks - as disseminations and veins in iron formation, graphitic slate, and breccia, and in marble pyrometasomatically altered by pegmatite dikes; and 3) in hydrothermal veins and related deposits. Northern and Southern Peninsulas.

Alger County: Sault Point and Grand Marais: In large vugs, some of which are completely filled, in the sandy, dolomitic Aux Train Formation (Middle Ordovician) (Hamblin, 1958).

Alpena County: **1.** Squaw Bay, south of Alpena: Concretions of pyrite, marcasite, and dolomite (variety "anthraconite") in the Antrim Shale (Devonian) (Dorr and Eschman, 1970). **2.** LaFarge Corporation, Great Lakes Region (formerly National Gypsum Company) quarry, Alpena: With calcite, dolomite, barite, sphalerite, marcasite, and rare chalcopyrite and strontianite (Morris, 1983). **3.** Paxton quarry at Paxton: As crystallized nodules several centimeters across in shale; with calcite, dolomite, chalcopyrite, marcasite, sphalerite, and quartz (Morris, 1983). **4.** Sulfur Island, near Alpena: In small nodules.

Antrim County: Norwood, 0.8 km south along Lake Michigan shore: Thin, drusy crusts in concretions in Antrim Shale (Devonian), associated with marcasite, dolomite, and chert (Dorr and Eschman, 1970).

Baraga County: **1.** Taylor mine 3.2 km north of Alberta, just off old U.S. 41: With graphite, pyrolusite, and manganite (Mihelcic, 1954). **2.** Ohio mines (Imperial and Webster mines) Imperial Heights (near Michigamme): With other sulfides, hematite, goethite, carbonates, graphite, grunerite, and palygorskite (Morris, 1983). **3.** In outcrops near the Imperial Heights road: Tiny octahedral crystals. **4.** Pyrite microbiota have been found by Cloud and Morrison (1979) in basal Michigamme beds in thin phosphatic layers at Big Eric's crossing of the Huron River. They take the form of strongly curvate pyritic chains and filaments averaging ~6 μ in diameter.

Branch County: Old shale quarries southeast of Coldwater: Clay ironstone concretions with pyrite, galena, sphalerite, and siderite in the Coldwater Shale (Mississippian) (Dorr and Eschman, 1970).

Calhoun County: Limestone pits 16 km north of Battle Creek on west side of the Battle Creek River: 1 to 2.5 cm bands in northeast-trending fractures with marcasite and calcite crystals (*Rocks and Minerals*, **28**, page 248, 1953).

Clare County: Cuttings from McKay Number 1 well, Grant township, section 3, T17N, R4W from 1,040 to 1,060 feet: In dolomitic siltstone of the lower part of the Hemlock Lake Formation (Pennsylvanian). Pyrite may constitute as much as 40% of the cuttings (Vugrinovich, 1984).

Delta County: Limestone quarry south of Bark River: As cubo-octahedral crystals to 4 mm in calcite veins in limestone (M. J. Elder, personal communication, 2003).

Dickinson County: **1.** Metronite quarry, 4 km east-northeast of Felch: In marble (Randville Dolomite) adjacent to pegmatite dikes (Heinrich, 1962b). **2.** Rian's quarry, southeast of Felch. Similar occurrence (Pratt, 1954). **3.** Menominee

iron range. Disseminated in graphitic slate as crystals along faults. Not common (Brower, 1968). **4.** *Groveland iron mine*, near Randville: In groups of cubic crystals to 2 cm. Zimmer (1966) found beautiful epitactic overgrowths of pyrite crystals on calcite, in which the {110} planes of the pyrite are parallel with the negative rhombohedron of the calcite. **5.** *Vulcan and West Vulcan iron mines*: As fine cubo-octahedral crystals up to 3 cm with dolomite and calcite. Cherty pyrite-rich rock is cut by veinlets of chlorite, calcite, dolomite, pyrite, and pyrite-quartz. Some phases contain massive aggregates of pyrite granules (Bayley, 1904). **6.** Chapin mine, Iron Mountain: Nodules of crystallized pyrite several centimeters across occur in hematitic iron formation. Similar specimens also are known from the Penn iron mine, near Norway. **7.** *Loretto mine*, Loretto: in fine crystals with calcite, similar to those from the Vulcan mine. **8.** Felch: Small octahedral crystals of pyrite associated with marcasite (both partially replaced by goethite) occur in cavities in marble exposed by a road cut on highway 69 near the west end of the village. **9.** Millie mine, Iron Mountain: Complex diploidal crystals to 5 mm modified by the octahedral faces occur on drusy quartz coating fractures in iron formation. **10.** Briar Hill mine: small crystals with calcite.

Eaton County: **1.** *Cheney limestone quarry* at Bellevue, NW ¼ NW ¼ section 28, T1N, R6W: In Bayport Limestone (Mississippian) with both brown and white calcite crystals and marcasite (Rexin, 1961; *Rocks and Minerals*, **37**, page 378, 1962; Squire, 1972); cubo-octahedral crystals to 1 cm. Some crystals are perched on calcite scalenohedra. Naski (1982) reported the first occurrence of vivianite from Michigan from the pyrite-rich collapse shale breccia in the Bayport Limestone exposed in the quarry. **2.** Holden quarry, Bellevue: Similar occurrence.

Gogebic County: **1.** Gogebic iron range: Disseminated in graphitic and slaty rocks and in or near veins cutting iron formation (Mann, 1953). **2.** Eureka mine near Ramsey, sections 12 and 13, T47N, R46W: In quartz veins at a granite-slate contact with gold and chalcopyrite (Dickey and Young, 1938). **3.** Gogebic area: Pyritiferous hornblende-rich dike-like rocks are common in older Precambrian rocks. The sulfide content is generally in the range from 0.2 to 0.4%. Analyses show that copper (up to 500 ppm), nickel (up to 150 ppm), cobalt, and silver values are too low for the bodies to be of economic interest (Schmidt and Trent, 1969). **4.** Copp's mine, 9.7 km north of Marenisco: With galena, sphalerite, chalcopyrite, and dolomite (Dana, 1892). **5.** Cloud and Morrison (1979) report an abundant, diverse procaryotic microflora in the Tyler Formation along the Black River south of U.S. Highway 2 near Bessemer. They consist of pyrite in the form of filamentous, spheroidal, and radiate taxa, ranging in size from 2 to 40 μm in siliceous clasts in pyritic chert.

Gratiot County: Near Ithaca, T10N, R2W in Michigan Basin Deep Drill Hole: As an accessory with chalcopyrite in altered basalt of the lower unit in albite-epidote-actinolite-chlorite-augite (relict) rock. Also in veinlets of albite-quartz-actinolite-pyrite (Heinrich and Pollack, 1978; McCallister et al., 1978).

Houghton County: **1.** Several copper mines: In feeding fissures in the Isle Royale and Baltic lodes (Broderick, 1931). **2.** Isle Royale mine. **3.** Turunen Brothers limestone quarry, near Pelkie: Found rarely as octahedral crystals up to 5 mm associated with colorless calcite lining small vugs in a hydrocarbon-bearing stratum.

Huron County: **1.** Wallace Stone Company between Bay Port and Pigeon: In limestone with calcite crystals, and in small quartz geodes along with calcite, dolomite, millerite, and other minor sulfide minerals. **2.** Fairhaven township, Tarry well in section 15: Pyritiferous shale with galena at 40 to 45 feet in a pyrite-galena vein. **3.** Fairhaven township, section 22: In a pyrite-galena vein in a well between 40 and 50 feet. **4.** Sebewaing township, Bauer well in section 8: With siderite and sphalerite. **5.** Michigan Standard Coal Company mines at Sebewaing: Numerous nodules of pyrite in black shale overlying the coal (2-5, Lane, 1900).

Iron County: **1.** Iron River-Crystal Falls iron district: In pyritic slate breccia (39.7% pyrite). In graphitic-pyritic slate (Wauseca pyritic member of Riverton Iron Formation) (38% pyrite) (James et al., 1968). As complex clusters of twinned pyritohedra in vugs with scalenohedral calcite crystals up to 2.5 cm long, and in flattened groups along fractures. **2.** *Hiawatha* and several other iron mines in Iron River area: Abundant as coatings of small crystals in vugs and irregular post-ore veins. At Hiawatha, botryoidal 10 cm masses with barite

also were found (James et al., 1968). **3.** *Bengal (Cannon) mine*, Stambaugh: With hematite, manganese minerals, carbonates, and sussexite; octahedral crystals to 5 mm with calcite and goethite. **4.** Bristol mine: With hematite, goethite, and manganite. **5.** Buck mine, Gaastra: With other sulfides, hematite, and uranium minerals. **6.** Homer-Wauseca mine, Iron River: Small, etched octahedral crystals on botryoidal calcite (3-6, Morris, 1983). **7.** Mansfield iron mine, near Mansfield: In pyritic slate as 2.5 cm aggregates of subhedral, flattened cubes.

Jackson County: 1. Jackson (Dana, 1892). **2.** John C. Jeffrey quarry, Parma: With marcasite, goethite, glauconite, and several carbonates (Morris, 1983).

Keweenaw County: 1. South Cliff copper mine: Very rare occurrence in a small fissure with galena and sphalerite (Butler and Burbank, 1929). **2.** Mount Bohemia: In copper-sulfide veinlets. **3.** Gratiot Lake chalcocite deposit, sections 6 and 7, T57N, R30W and sections 1 and 12, T57N, R31W: As a minor constituent associated with chalcocite, and lesser amounts of bornite and covellite in brecciated amygdaloid flow tops in the Portage Lake Volcanics (Maki, 1999).

Marquette County: 1. Marquette iron range generally: In some graphitic and slaty rocks and in or near veins cutting iron formation (Mann, 1953). **2.** Beacon mine: Cubes and some dodecahedra (Mandarino, 1950). **3.** Cliffs Shaft mine: Spheroidal masses of crystals in quartz in veins in upper part of Negaunee Iron Formation (Reed, 1967a, b). Also massive with chalcopyrite. **4.** *Champion mine*: Cubes to 1 cm on edge in quartz veins with manganese-bearing minerals in the Negaunee Iron Formation. Also, cubo-octahedral crystals with almandine, pyrrhotite, chalcopyrite, and quartz (Babcock, 1966a, b). **5.** Presque Isle: In veins in serpentinite with galena, pyrrhotite, and chalcopyrite (Snelgrove et al., 1944). **6.** Michigan gold mine: In quartz veins (Broderick, 1945). **7.** Ropes gold mine: In quartz veins and altered wall rock (Snelgrove et al., 1944). In 1987, a fracture zone encountered on the 1,548' level near a contact between the ore body and peridotite produced crystals of calcite coated with brilliant, drusy microcrystals of pyrite. The nickel-bearing variety "bravoite" has been reported by Bornhorst et al. (1999). **8.** Grummet gold prospects in the NW ¼ section 36, T48N, R28W: Cubic crystals in quartz vein (Snelgrove et al., 1944). **9.** Marquette River: In copper sulfide-bearing veins cutting Kona Dolomite (Reed, 1965). **10.** Wheat mine (Dana, 1892). **11.** Republic iron mine (Morris, 1983). **12.** Sections 26 and 35, T49N, R26W: Pyrite-rich zones (up to 20%) in Compeau Creek Gneiss (Puffet, 1974). **13.** A minor accessory with eight other Fe and Cu sulfides in the Yellow Dog peridotite, sections 11 and 12, T50N, R29W (Klasner et al., 1979). **14.** Clark Creek region: The dominant sulfide in veinlets and disseminated mineralization in meta-basalt of the Ishpeming Greenstone Belt with arsenopyrite (q.v.), chalcopyrite (q.v.), pyrrhotite, and local galena (q.v.) and sphalerite (Baxter et al., 1987). **15.** Hill's Lakes area: With pyrrhotite (q.v.) associated with quartz veins in altered basalt. Other sulfides are chalcopyrite, galena, sphalerite, and arsenopyrite (Johnson et al., 1987). **16.** *Imperial mine*, Michigamme: As lustrous cubic crystals to nearly a centimeter across, modified by octahedral and pyritohedral faces. Some crystals epitactically overgrow twinned marcasite crystals and are associated with dolomite, calcite, hematite, and goethite (Figure 110). **17.** *Cleveland mine*: In aggregates of small crystals to 10 cm. **18.** Lucy mine, Negaunee: Small crystals with calcite. **19.** Dalliba mine: Small crystals on dolomite. **20.** *Bessie mine*, Humboldt: Cubo-octahedral crystals with calcite. **21.** *Kloman (Columbia mine):* As striated cubic crystals to 4 cm, from an unspecified occurrence southwest of the Kloman mine (specimen DM 3819, A. E. Seaman Mineral Museum, Michigan Technological University).

Monroe County: 1. Plum Creek quarry near Monroe: In limestone as seams and crusts of small, tarnished octahedra associated with calcite, dolomite, celestine, and strontianite (Sherzer, 1900). **2.** Enrico Fermi Atomic Energy Plant quarry at Pointe aux Peaux, near Monroe: Associated with celestine and calcite. **3.** France Stone Company quarry, Monroe: Similar paragenesis. **4.** France Stone Company (Ida) quarry at Grape. Same paragenesis, plus quartz. **5.** Woolmith quarry (Michigan Stone and Supply Company), Maybee: Same paragenesis; also gypsum, strontianite, and sulfur. **6.** Abandoned quarry, I-275 and Newport road: Calcite-celestine mineralization along with fluorite and quartz (2-6, Morris, 1983).

Newaygo County: Turner Petroleum Corporation (Sun Oil Company) Number 4 Glen Bradley well: Cores from the Salina Group revealed euhedral to subhedral pyritohedra, irregular masses, and radiating needles generally in anhydrite-dolomite laminae but also less commonly in halite. Largest masses generally less than 0.5 mm across (Dellwig, 1955).

Ogemaw County: Brazos-Su-Superior Number 1 State Foster well: In the Munising Formation (Cambrian) with anhydrite in numerous beds between 11,710 and 12,996 feet (anhydrite, Ogemaw County).

Ontonagon County: White Pine: In Nonesuch Shale in barren zone above cupriferous zone. Euhedra 5 to 10 microns in size, as framboidal aggregates in chlorite. Also in veinlets with chalcopyrite (Doane, 1956; Carpenter, 1963; Brown, 1966, 1968), and less commonly as small, euhedral cubo-octahedral crystals with calcite.

Presque Isle County: South and west of Rogers City: Concretions in Bell Shale (Devonian) (Dorr and Eschman, 1970).

Saginaw County: **1.** Coal beds in the Saginaw area generally: Nodules in coal, known locally as "coal brasses" (Allen, 1920). **2.** Consolidated Coal Company, Saginaw: Waste pile of the coal washery contained several thousand tons of lump pyrite. It was investigated as a possible source of sulfur during World War I (Smith, 1918).

Washtenaw County: Martin Marietta Cement Company quarry near Milan: Beautiful groups of pyrite cubes with curved faces in subspherical clusters, plus single cubes modified by octahedral faces. Minute twinned crystals also are found.

Wayne County: International Salt Company mine at Detroit: Minute crystals and aggregates (0.5 mm or less) in anhydrite-dolomite rock. Occurs less commonly in halite (Briggs, 1960).

FROM: Robinson, G.W., 2004 Mineralogy of Michigan by E.W. Heinrich updated and revised: published by A.E. Seaman Mineral Museum, Houghton, MI, 252p.

UPDATE

A 9 x 10 cm nodule of pyrite crystals showing partial replacement by goethite from near Iron Mountain, Dickinson County. A. E. Seaman Mineral Museum specimen DM 28553, George Robinson photograph.

Charlevoix County: St. Mary's Cement Co. quarry (shale pit) at Charlevoix, Michigan, NW ¼ section 5, T33N, R8W: As irregular nodules or concretions from 2 – 15 cm in diameter in a shale layer of the Devonian Gravel Point Formation (A. Blaske, personal communication, 2007).

Dickinson County: Pyrite nodules up to 10 cm across occur in Randville Dolomite exposed in a small quarry east of Iron Mountain near the center of the SW ¼ section 33, T40N, R30W. The crystals comprising the nodules are simple cubes with small octahedron faces, and are partially altered to goethite on their exteriors.

Menominee County: See Part IV.

Presque Isle County: Lafarge Presque Isle Quarry (Stoneport), section 2 and surrounding area, T33N, R8E: Small (~1 mm) pyrite crystals occur on fracture surfaces in the middle Devonian Rogers City Limestone (A. Blaske, personal communication, 2007).

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