COPPER

Cu

Native copper is easily the most famous of Michigan's minerals. As an ore mineral, native copper is very rare throughout the world, although minor occurrences are widespread. The greatest native copper deposits ever found and exploited are those of the Keweenaw Peninsula in Michigan's Northern Peninsula. Copper mineralization occurs along a narrow belt over 150 kilometers long, stretching southwestward through Keweenaw, Houghton, and Ontonagon Counties (Part I). There, native copper occurs in amygdaloids, conglomerates, and fissures ranging in size from microscopic grains up to masses 14 meters long and weighing 382 metric tons (Rickard, 1905). Similarly large masses of float copper have been found in glacial drift, particularly in the Northern Peninsula. (Rickard, 1905; Kraus, 1924), though native copper erratics are known in glacial drift in Wisconsin, Iowa, Illinois (Crook, 1929), Indiana, Ohio, Western New York, and Pennsylvania. While these large masses of copper

Figure 60: Native copper with cuprite (red) and tenorite (black) patina from the Central mine, Central, Keweenaw County. 4.5 x 12 cm. A. E. Seaman Mineral Museum specimen No. JTR 537, Jeffrey Scovil photograph.

are generally anhedral, euhedral crystals and crystal aggregates of copper occur relatively commonly in vugs.

Composition: Arsenic occurs in small amounts in all of Michigan's native copper deposits. Some of it occurs as copper arsenides (algodonite, domeykite), but the bulk of it is present in solid solution with the copper. The arsenic content varies from a few ten thousandths of a percent to over half a percent - a thousand-fold variation. Broderick (1929) has shown that in most mines the As:Cu ratio increases with depth and, in general, the higher the ratio the greater its rate of increase.

Alteration: Copper from many of the mines is coated by a patina of reddish cuprite or black tenorite, which, in some instances, may have formed after the mines were opened. However, in some deposits, particularly in higher levels, the

Figure 61: Native copper, wire copper with datolite from the Osceola mine, Calumet, Houghton County, field of view 7 cm, A. E. Seaman Mineral Museum specimen No. JTR 1671, Jeffrey Scovil photograph.

oxidation was pre-mining in origin (Butler and Burbank, 1929). Malachite forms similar coatings. Pseudomorphs of cuprite (q.v.) after copper are also known.

Habits: The aggregate forms assumed by copper are highly variable, and a number of distinctive types have been recognized:

1. Grains, blebs, pellets, and masses. Anhedral to subhedral.
2. Masses. The larger pieces commonly are very irregular with a hackly appearance.
3. Crystals and crystal groups.

4. Networks. Interconnecting irregular veinlets, sheets, plates, and aggregates.
5. Thin sheets. Formed in narrow fissures or fracture planes. An unusually fine specimen of sheet copper is in the University of Michigan collection. It measures 1.5 meters long, 0.3 to 0.6 meters wide, and about 5 mm thick and shows parallel striations.
6. Filiform or "wire."
7. Arborescent. Three-dimensional fernlike groups. Some variants are also described as "moss copper." An unusually fine and large specimen in the University of Michigan collection is a reticulated aggregate of distorted, elongate, semi-flattened crystals over a meter long, 15 to 30 cm wide, and 5 to8 cm thick.
8. Leaf. Dendritic aggregates flattened in one plane.
9. Brick. Massive, replacing sandstone.
10. Shell. Molds of boulders and cobbles. Also called "skull copper." An outstanding specimen is shown by Kemp (1980, page 260). It measures 17.5 x 11.5 x 14 cm, and is from the Calumet and Hecla mine, Houghton County.
11. Shot. Vesicle fillings.
12. Spike. Elongated vesicle fillings. An extraordinary spike is in the University of Michigan collection. Set in an altered basalt base, it is approximately a meter long and 5 to 15 cm in diameter, tapering upward, with a "flopped-over" point.
13. Pseudomorphs. Replacements of feldspar, calcite, or boulders.
14. Half-breeds. Intergrown masses of copper and silver.
15. Barrel. "Ponderous hackly masses" (Rominger, 1895).

Crystallography: The crystallography of Michigan native copper was studied in detail by Dana (1886), who identified the following forms:

Cube	{001}
Dodecahedron	{011}
Octahedron	{111}
Tetrahexahedrons	{014},{025}, {012}, {035}
Trapezohedrons	{113}, {112}
Hexoctahedrons	{5•10•18}, {1•6•11},{2•3•12}

The most common habit is tetrahexahedral, with {014} and {025} the most common forms. These may be combined with the cube, dodecahedron, or (rarely) octahedron. The cube alone is also relatively common, the dodecahedron less common, and the octahedral form alone much less common. Wilson and Dyl (1992) showed that crystal habit may be related to crystal size. In a preliminary study "of copper crystals 4 mm or less in diameter, in close association with prehnite and commonly also with quartz and calcite..nearly 70% of the copper crystals with identifiable forms proved to be the tetrahexahedron {057}, and half the remainder are this form modified to some extent by the dodecahedron." Larger crystals were found to have a higher proportion of other tetrahexahedron forms, along with the cube, octahedron, and dodecahedron. Figures 60 to 66 illustrate some of these forms.

Figure 62: Native copper, a rare, 2 cm, hexoctahedral copper crystal from the Osceola mine, Calumet, Houghton County, A. E. Seaman Mineral Museum specimen No. JTR 1672, Jeffrey Scovil photograph.

Distortions are widespread, giving rise to crystals with marked pseudosymmetry. Preferential elongation along a single crystal axis yields pseudotetragonal crystals. Examples of rhombohedral pseudosymmetry are also common. Some crystals may be skeletal, cavernous, or hollow. In some, the edges of the crystals project above deeply depressed faces. Also common are striations, pits, growth projections, and wavy surfaces.

Twinning on {111} is very common, giving rise to simple contact twins, a few penetration types, and less commonly repeated twinning (Dana, 1886).

X-ray powder diffraction data for copper (Calumet and Hecla mine) and for arsenian copper (Houghton County) are given by Berry and Thompson (1962, page 12).

Baraga County: Huron Islands: Dana (1892) reports "native copper in granite." Unconfirmed.

Dickinson County: **1.** Cyclops mine at Norway: Float copper in drift above the iron ore body. **2.** Reportedly the largest mass of float copper found in Dickinson County was uncovered in the early 1940s during excavation for a filling

Figure 63: Native copper, "Fern" copper from the Phoenix mine, Phoenix, Keweenaw County, 4.5 x 5.5 cm, A. E. Seaman Mineral Museum specimen No. JTR 1664, Jeffrey Scovil photograph.

Figure 64: Native copper, dendritic growth of cubic crystals from the Calumet and Hecla mine, Calumet, Houghton County, 5.5 x 8.5 cm, A. E. Seaman Mineral Museum specimen No. JTR 674, Jeffrey Scovil photograph.

Figure 65: Native copper, parallel growth of cubic crystals, Lake Superior copper district, 2.5 x 7.5 cm, A. E. Seaman Mineral Museum specimen No. GBR 569, Jeffrey Scovil photograph.

Figure 66: Native copper, twinned tetrahexahedrons from the Central mine, Central, Keweenaw County, 6 x 8 cm, A. E. Seaman Mineral Museum specimen No. DCG 1110, Jeffrey Scovil photograph.

station in Iron Mountain. It is estimated to have been about a meter across, 1 - 2 cm thick, and "only slightly oxidized" (B. J. Westman, written communication, 1983).

Gratiot County: Near Ithaca, T10N, R2W in Michigan Basin Deep Drill Hole in the altered upper basaltic-gabbroic unit. An accessory with bornite and digenite in albite-chlorite-calcite-epidote rock (McCallister et al., 1978).

Houghton County: **1.** Atlantic mine: Large masses. A large calcite vein transected the amygdaloid at which junction it contained nests and pockets of copper and silver (Rominger, 1895). **2.** *Baltic mine*: Fine crystals in lodes and "feeding fissures" (Broderick, 1931) with chalcocite. Groups of elongated, reticulated crystals. A fine group (specimen JTR 550), 19 cm across, is in the A. E. Seaman Mineral Museum (MacFall, 1983). **3.** *Calumet and Hecla mine*: Many varieties, including boulder cases, replacements of boulders, pseudomorphs after feldspar including one after a feldspar crystal 5 cm long (Harvard University collection, #85739), and "shot copper." Also "skulls" around rhyolite cobbles. **4.** *Centennial mine*: Brick copper replacing sandstone, fine microcrystals, excellent large crystals, "skulls", and leaf copper. **5.** John Gaspardo farm, 4 km northwest of Franklin mine: A large piece of float copper, showing glacial striations and evidence of partial working by Native Americans, weighing 220 kg and measuring 80x 105x 15 cm is now in the Mineralogical Collection of the University of Michigan (Kraus, 1924). **6.** *Hancock mine*: Very good crystals. **7.** Isle Royale mine: In lodes and feeding fissures (Broderick, 1931) and disseminated in epidote. **8.** *Kearsarge mine*: Fine crystals in lodes and fissures, sometimes associated with silver (Broderick, 1931). **9.** *Osceola mine*: Very fine crystals, wire (Number 13 shaft), and sheet copper. Wire copper in an intertwined cluster 10 cm high (specimen JTR 1670) is in the A. E. Seaman Mineral Museum (MacFall, 1983). Vugs with perfect small crystals. The famous sheets occurred in fissures in the diabase on the hangingwall of the Osceola amygdaloid (Rominger, 1895). **10.** *Quincy mine*: Fine crystals, many with dodecahedral habit, and microcrystals in amygdules. **11.** Tamarack mine: Sheet copper, shell copper (boulder casings), and pseudomorphs after calcite. **12.** *Winona mine*: Fine crystals. **13.** *Wolverine mine*: Excellent crystals, reticulated masses, and shot copper. **14.** Hancock: Ancient mine pits were uncovered in the south parts of sections 25, 26, and 27, T55N, R34W (Hinsdale, 1931). **15.** *Champion mine*: Arborescent crystal groups. **16.** Six Mile Hill, east slope; southwest of Houghton: Copper, calcite, and epidote in a network of veins. Copper in masses of 1 to 40 kilograms. Seams also contained considerable chalcocite and some prehnite and datolite (Rominger, 1895). **17.** *Pewabic mine*: As well-formed crystals and pseudomorphs of copper after laumontite and after quartz (Pumpelly, 1873). **18.** Other mines that have yielded fine specimens include: *Arcadian, Franklin, Laurium, and Trimountain*.

Iron County: **1.** Bengal (Cannon) iron mine: Thin post-ore foils in iron ore (James et al., 1968); also with schorl (T. M. Bee, personal communication, 1999). With manganese minerals in the oxidized zone of Young's iron ore body in the Riverton Formation (Kustra, 1961; Brower, 1968). Spectacular leaf copper in veinlets in several stopes. **2.** Great Western mine, 10th level, Crystal Falls: Similar occurrence in sheared hematite and a magnesium-rich neotocite-like mineral (A. E. Seaman Mineral Museum, specimen DM 1890).

Keweenaw County: **1.** *Ahmeek mine*: Fine crystals and groups including copper inclusion phantoms in calcite crystals. **2.** *Central mine*: Fine crystals in vugs and shot copper. Also masses, some many tons in weight (Rominger, 1895). Groups of fine dodecahedral crystals. One specimen (JTR 526), 10 cm across, is in the A. E. Seaman Mineral Museum (MacFall, 1983). **3.** *Cliff mine*: Superb crystals. Whitney (1859) notes this locality as producing the finest quality single crystals. They were mainly of tetrahexahedral habit. Many were twinned. Microcrystals from the Cliff far surpass all others. Single crystals occur as complex cubes, tetrahexahedrons, octahedrons, or dodecahedrons. The copper is closely associated with prehnite. Wire copper, moss copper, and arborescent masses are also found. Williams (1966) reports good crystals "abundant everywhere along the vein." The majority is dominated by {124}, modified by {001}, {011}, and {111}. Many distorted crystals are triangular plates on {111}, bounded by various hexoctahedra. **4.** *Copper Falls* mine: Whitney (1859) states (page 11), "no other (locality) has furnished any specimens to compare with those found here." Many of the superb crystals range in size from a few millimeters to about 2.5 cm. The dodecahedron is the predominant form in groups of crystals, but the octahedron is also found. A large 73 metric ton mass of copper came from this mine. Some spike copper is found. **5.** *Mohawk mine*: High-arsenic copper (Stoiber and Davidson, 1959). **6.** *Phoenix mine*: Excellent crystals, leaf copper, moss copper with analcime, and arborescent groups. **7.** Seneca mine: Fine microcrystals in amygdules (Moore and Beger, 1963) plus arsenian copper (Stoiber and Davidson, 1959). **8.** Drill hole Delaware 77, T58N, R30W: Disseminated in unaltered layers in a flow above the Kearsarge Conglomerate (Cornwall, 1951a). **9.** Isle Royale: Prospectors reaching the island in the late 1840s found that all the major copper lodes on the island gave evidence of prehistoric mining in the form of pits as much as 9 meters across and as deep as 18 meters. Rock-copper masses as heavy as 2,700 kg were found to have been raised by cribwork. The excavating and mining were accomplished by means of hammerstones or mauls along with fracturing of the rock by fire-heating and quenching with water (Drier and DuTemple, 1961). A completely different occurrence of native copper has been noted by Sukow (1987, 1990), who described inclusions of copper in agate from Isle Royale beaches. **10.** Stromatolite limestone beds in the Copper Harbor Conglomerate in the vicinity of Copper Harbor: Microscopic native copper has been found in stromatolites near Dan's Point, Horseshoe Harbor, and 1 km east of Horseshoe Harbor, where the Copper Harbor Conglomerate is cross cut by the "Lakeshore veins," which contain laumontite, chalcocite, barite, chlorite, calcite, and fluorite. The copper occurs in vugs in the stromatolites and associated oolite-oncolite beds (Nishioka et al., 1984). **11.** *Eagle Harbor*: In 1971 Don Pearce of Calumet collected many hundred kilograms of well-crystallized copper from an underwater vein in Lake Superior near Eagle Harbor, known locally as "Grand Marais," or "Gull Rock." The herringbone to arborescent crystal groups were enclosed in calcite. One specimen weighing about 45 kg consists of a face half a meter across of fine herringbone copper with large blocky crystals on the opposite side (Wilson, 1983b). **12.** *Point prospect*: Some of the world's largest crystals of native copper came from a small fissure vein exposed during road construction approximately 10 km southeast of Copper Harbor, known locally as "Point prospect." The crystals have an overall dodecahedral aspect, often in combination with an unidentified tetrahexahedron form. Crystals up to 6.4 kg are known (Rosemeyer and Carlson, 2000). **13.** Other mines that produced native copper in excellent specimens include: Allouez, Clark (Copper Harbor), Delaware, Iroquois, Kingston, Medora, Northwestern, *Ojibway*, and Star. Also found at Five and Seven Mile Points at Eagle River and at Hays Point at Copper Harbor.

Marquette County: **1.** Dead River: In quartz-carbonate-sulfide veins (Puffet, 1966). Also in small seams in quartz at the Fire Centre gold mine, section 35, T49N, R27W (M. P. Basal, personal communication, 1999). **2.** Eastern Marquette iron range, NE ¼ NW ¼ section 1, T47N, R25W: In fractures and interstitial grains replacing quartz grain boundaries in red quartzite (Reed, 1967a, b).

Ontonagon County: **1.** *Adventure mine*: Fine crystals. **2.** *Minesota mine*: Crystals, leaf copper, and large masses. **3.** *Victoria mine*: Fine crystals. **4.** *White Pine mine*: In the Nonesuch Shale as disseminated grains and as thin sheets along fractures in the lower part of the ore zone associated with chalcocite and native silver, the

latter commonly forming rims on the copper (Doane, 1956; Carpenter, 1963; Brown, 1966, 1968; Rosemeyer, 1999). It also occurs disseminated and in veinlets in the chloritic facies of the Copper Harbor Conglomerate (Hamilton, 1967). **5.** Ontonagon Boulder: This float boulder of native copper, (Figure 3) destined to become famous in American history and also in the annals of the Copper Country ("The Great Copper Rock"), was found half buried in the muddy bank of the west branch of the Ontonagon River. Reportedly, French explorers had hacked off souvenir pieces as early as 1664. Alexander Henry, who visited the area in 1760, examined it in the side of the stream bed about 32 kilometers above the mouth of the river and chopped off a 45-kilogram portion with an axe. The locality is given as that now occupied by the Victoria Dam, which is in section 31, T50N, R39W. Details on the legendary peregrinations of the Ontonagon Boulder are presented by Pantell (1976). **6.** Another famous float boulder of copper found near the mouth of the Ontonagon River was described by Catlin (1835) as weighing 62 kilograms and showing "rudiments of crystals with triangular faces" as well as incrustations of a "green carbonate of copper." The copper boulder was donated by Mr. Catlin to Yale University. **7.** Numerous prehistoric excavations for copper, including a shaft 7.5 meters deep, were found from Mass City to Victoria, and halfway between Victoria and Bergland (Hinsdale, 1931). **8.** Porcupine Mountains: Veinlets of calcite, quartz, epidote, and traces of native copper. **9.** Ridge mine: Pseudomorphs after quartz crystals. **10.** Bohemian mine: A magnificent distorted tetrahexahedral crystal 1 cm across (MacFall, 1983, Figure 66). **11.** Other mines well known for fine specimens during their periods of activity are Algomah, *Caledonia*, *Indiana*, *Lake*, *Mass*, *Michigan*, Morris, and *National*.

Tuscola County: Southern Tuscola County; a float mass weighing 29 kilograms was plowed up and placed on exhibit in a Mayville hotel for many years.

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

Alger County: Approximately 7 kilometers east of Grand Marais: As microscopic flakes with gold and rare platinum (q.v.) in black sands in sand dunes (M. J. Elder, personal communication, 2006). Verified by energy dispersion X-ray spectrometry.

Baraga County: The Huron River uran-ium prospect, NW ¼ NW ¼ section 1, T51N, R30W: As rare thin sheets and dendritic growths along fracture surfaces with cuprite (Carlson et al., 2007a).

Houghton County: 1. Houghton: Cubic crystals of native copper have been found in a calcite vein exposed in a small traprock quarry operated by Moyle Construction Company. **2.** Copper occurs as bands in agate amygdules at the Wolverine No. 2 mine, Kearsarge, the Calumet & Hecla No. 21 shaft in Calumet and the Saint Louis mine in Laurium. The amygdules vary in size from 1-10 cm (though most are ~ 2-3 cm), and from gray to beige or pink in color, with small agate "eyes" developed along their outer edges. Paragenetically, the agate appears to have preceded the copper, which in turn appears to have selectively replaced certain bands in the agate (Rosemeyer, 2012). Though small, these unique agates are quite attractive, and are popular with both lapidaries and mineral collectors.

UPDATE FROM: Robinson, G.W., and Carlson, S.M., 2013, Mineralogy of Michigan Update: published online by A.E. Seaman Mineral Museum, Houghton, MI, 46p.

Copper replacing bands of agate in a 3-cm amygdule from the Wolverine No. 2 mine, Houghton County. A. E. Seaman Mineral Museum specimen DM 30339, George Robinson photograph.

A 7 cm branching aggregate of cubic copper crystals from the Moyle Construction Quarry in Houghton, Houghton County; A. E. Seaman Mineral Museum specimen DM 28332, George Robinson photograph.