

PUMPELLYITE GROUP

$$\text{Ca}_2\text{XY}_2(\text{SiO}_4)(\text{Si}_2\text{O}_7)(\text{OH})_2 \cdot \text{H}_2\text{O}$$

Closely related to the epidote group, the pumpellyite group comprises a series of mineral species defined by specific cations occupying structural sites represented by x and Y in the formula given above. Because multiple cations are involved, and because the same cation may occupy either site, it is impossible to say which species of pumpellyite is present without complete chemical and structural data. Based on the available analyses, most Michigan pumpellyites appear to be magnesium-dominant, intermediate solid solution series between pumpellyite-(Mg), pumpellyite-(Fe²⁺) and pumpellyite-(Fe³⁺).



Figure 109: A 0.8 mm aggregate of green pumpellyite crystals from the Cliff mine, Keweenaw County. Dan Behnke specimen and photograph.

Pumpellyite group minerals are widespread in low-grade metamorphic rocks (particularly in glaucophane schists), and also occur in hydrothermally altered mafic igneous rocks (e.g., basalts and diabases). Originally the mineral was described under the name “lotrite” from the southern Carpathian Mountains (Murgoci, 1901). Charles H. Palache, who in 1920 made the first systematic study of the secondary minerals in the altered copper lodes for the Calumet and Hecla Copper Mining Company, noted a green mineral which he believed to be a new mineral closely related to the zoisite-epidote family. Unaware of Murgoci’s earlier work, he submitted a manuscript to Calumet and Hecla describing the “new” mineral, proposing to call it “kearsargeite.” B. S. Butler didn’t like the name, and Palache changed the manuscript by crossing out

“kearsargeite” and penciling in “pumpellyite,” in honor of Raphael Pumpelly, the noted 19th century U.S. Geological Survey geologist who made many contributions to the knowledge and understanding of copper minerals and the copper deposits of the Keweenaw Peninsula.

“Chlorastrolite,” the State’s official gemstone (Figure 21), was first verified as a variety of pumpellyite at the University of Michigan in the late 1940s (W. B. Griffiths, personal communication). “Chlorastrolite” is found chiefly as small rounded beach pebbles showing a finely radiating or stellate pattern of slender green crystals. The pebbles are derived from vesicle fillings in the amygdaloidal basalts of the Copper Country, and were formerly found in relative abundance, particularly on Isle Royale beaches. Chlorastrolite was named the “official state gem” by the Seventy-sixth Legislature (Act 56, PA 1972, effective March 30, 1973). It is also called “greenstone” and “Isle Royale greenstone.” “Zonochlorite” is an obsolete name for impure pumpellyite-Mg, originally described by Foote (1873) from an amygdaloidal basalt from Nipigon Bay, Ontario, but to which Hawes (1875) subsequently referred as “chlorastrolite.” It is probably a mixture of pumpellyite-Mg and chlorite.

In general, pumpellyite is abundant in all amygdaloidal lodes and fissures. It is also present but not abundant in the conglomerate lodes and felsites. It forms in vugs and, with quartz, has replaced large volumes of the host rocks. It may occur in amygdules by itself, as needles in quartz, or associated with chlorite or epidote, from which it is not easily distinguished. Much of the pumpellyite is bluish-green in contrast to the epidote, which is yellow-green. Its most common occurrence is as a replacement of rock in flow tops, yielding a hard, dense, greenish-gray to bluish-green lode material that makes up a large part of the amygdaloid lode mined at the Isle Royale mine (Butler and Burbank, 1929; Stoiber and Davidson, 1959).

Keweenaw pumpellyite has the following habits: 1) radial stout prismatic, euhedral crystals usually enclosed by quartz; in fragmental amygdaloidal flows and in veins, 2) radial groups of needle-like crystals, either alone or with chlorite as amygdule fillings in “footy zones” of flows, 3) felt-like masses of cryptocrystalline grains replacing parts of

flow tops and ashy layers, with primary igneous textures preserved. Livnat (1983) recognized a number of parageneses. Northern Peninsula.

Houghton County: **1.** *Calumet and Hecla mine:* Material from the Kearsarge lode studied by Palache and Vassar (1925) came from a crosscut from the Red Jacket shaft on the 81st level. The bluish-green crystals were found in vugs. Pumpellyite from this mine also has been studied by Weege and Schillinger (1962). **2.** Centennial mine: Abundant. **3.** LaSalle mine. **4.** Baltic mine. **5.** *Quincy mine:* Abundant in the Pewabic lode. **6.** Hancock mine: Moore and Beger (1963) credit Sid Williams with identifying "lotrite" from the Hancock mine dump. It occurs as 0.5 mm prismatic, pale yellow-green crystals with prehnite in divergent groups on quartz in agatized amygdules in chloritized rock. **7.** Wolverine mine (Morris, 1983). **8.** *Laurium mine:* Abundant as tufted, pale gray-green microcrystals associated with quartz and epidote, filling vesicles in basalt. **9.** Osceola mine: As felt-like aggregates of dark green acicular microcrystals (Falster, 1978). **10.** Isle Royale mine: Material studied by Palache and Vassar (1925) revealed pumpellyite in vugs with calcite, epidote, and red microcline. Two periods of formation were recognized: 1) before the deposition of copper, quartz, and prehnite but after chlorite and epidote, and 2) more abundantly after feldspar and epidote with or after quartz, and before hematite, prehnite, calcite, and copper.

Keweenaw County: **1.** Clark mine: As honey-colored needles and greenish white botryoidal masses with calcite (Bee and Dagenhart, 1984). Reported by Morris (1983) and Behnke (1983) as "groups of dark greenish black, bladed crystals about 0.17 mm tall which under X-ray analysis, proved to be julgoldite." Analyses of pumpellyites from elsewhere in the Keweenaw (Palache and Vassar, 1925; Scofield, 1976; Livnat, 1983; Artioli et al., 1995) show none to have a Fe²⁺ and Fe³⁺ content even approaching that of julgoldite-(Fe²⁺). Because of similarities in X-ray powder diffraction patterns among members of the pumpellyite group, complete chemical and structural data are needed to verify the presence of julgoldite-(Fe²⁺). **2.** Ahmeek mine. **3.** *Isle Royale:* The variety "chlorastrolite" occurs as amygdule fillings in flows and as beach pebbles. It is also found on the south shore of Siskiwit Lake (Butler and Burbank, 1929; Dustin, 1931; Poindexter et al., 1939; Zeitner,

1960). **4.** *Smithwick and Mott Islands* off the shore of Isle Royale: Variety "chlorastrolite" (Poindexter et al., 1939). **5.** Delaware mine: Variety "chlorastrolite". **6.** Eagle River. **7.** *Central and Old Central Exploration mines:* Variety "chlorastrolite" filling amygdules. **8.** Copper Falls mines: "Chlorastrolite." **9.** Iroquois mine, Mohawk. **10.** Medora mine: "Chlorastrolite." **11.** *Northwestern mine:* "Chlorastrolite" filling amygdules. **12.** Seneca (Gratiot) mine (7-12, Morris, 1983). **13.** South of Eagle Harbor in drill cores: Analyses by Jolly and Smith (1972).

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