OCCURRENCE OF MILLERITE AT MILWAUKEE, WISCONSIN

BENEDICT P. BAGROWSKI,
University of Kansas, Lawrence, Kansas.

Millerite, NiS, belongs to the rhombohedral class of the hexagonal system. The metallic crystals, brass- to bronze-yellow in color, are typically needle- or hair-like. They occur in radiating groups, or matted tufts, but fibrous coatings or crusts are common in some areas.

The mineral is scarce even though it has been reported from many localities. Milwaukee probably is the latest source of any appreciable amount of millerite.

HISTORY OF LOCALITY

Specimens of millerite from Milwaukee are included in scattered collections throughout the world. They are labelled as coming from Berthelet, North Milwaukee, Cementville, or Lindwurm (Lindwerm). Some are also labelled as coming from the Milwaukee Cement Quarry, Milwaukee River, Lincoln Park, Capitol Drive, Washington Street Bridge, or Humboldt Street Bridge in Milwaukee County. These names all refer to the same locality, which is now Estabrook Park, Milwaukee, Wisconsin.

The Milwaukee occurrence, though known for many years, has never been described in the literature. Hobbs (1), in a paper written in 1895, stated that specimens of millerite from the Milwaukee Cement Quarry were in the possession of a Mr. Howard Green of that city, but that he did not have an opportunity to study them. Cleland (2), in his paper on the Devonic of Wisconsin, mentioned millerite, but did not describe its occurrence, as his study was devoted primarily to the paleontology of that system. Dana (3) listed millerite from Milwaukee for the first time in the sixth edition of his *System of Mineralogy*, published in 1892. A short article by Wisniewski (4) reported another collection of millerite specimens that had been assembled by himself in recent years. The Thomas A. Greene library and collection, now in the Milwaukee-Downer College, contains records that millerite was known in 1884 when Thomas A. Greene exchanged millerite specimens with other collectors.

The millerite is found in the dolomitic limestone outcropping along the Milwaukee River in what is now Estabrook Park, in the northeastern part of the city. This park area was the scene of a cement-rock quarry during the early history of the city, but a flood caused abandonment of operations. Millerite was first obtained during this period during which quarrying took place.The river, after flooding the area, chose a new channel through the abandoned quarry, and the millerite-bearing rock was

thus made inaccessible. This condition prevailed for about thirty years, or until 1936, when governmental projects were instrumental in again making this mineral available. The millerite-bearing rock was exposed as a result of widening and deepening of the river channel. The writer, who made frequent visits to the area, relocated the millerite-bearing "zones" and began collecting the mineral for study. Now (1940) the stratum which bears the mineral is again under water. Efforts to trace this particular stratum elsewhere along the river so far have failed. The millerite-bearing bed, which is gently undulating with the rest of the strata, appeared above the surface of the water only at a small falls at the northwest end of the old quarry.

Geologic Occurrence

The limestone that outcrops here belongs to the Milwaukee formation. It is Devonian in age, classified by some writers as Hamilton (5, 6). Millerite is found at two different stratigraphic horizons in this formation. The best specimens are found in a somewhat hard layer of massive-bedded, dull to bluish-gray dolomite, a part of a unit referred to by Cleland (2) as "Zone B," but which has been called by Raasch (7) the Berthelet member. The stratum containing the millerite is about two feet thick and is found in the upper part of this rock member. It is characterized by numerous small cavities which are lined with calcite cystals. Some of these cavities are formed by the dissolution of lumpy colonial bryozoa. The millerite, along with pyrite, marcasite, and sphalerite, is associated with the calcite. A similar cavernous stratum containing asphaltum lies just below this millerite-bearing bed, but it contains no millerite.

Another "zone" where millerite has been found, but in lesser amounts and usually somewhat weathered, lies in the Lindwurm member (7) which Cleland (2) called "Zone C." This stratigraphic unit overlies the Berthelet member (Zone B) and is made up of hard dull blue-gray shales interbedded with thin lenses of dolomite. The shales weather into a sticky gray mud, which contains numerous casts of fossil shells. Many of these casts are hollow and lined with calcite crystals; some of them contain millerite. Most common millerite-bearing fossils are *Atrypa reticularis* (Linnaeous), *Cyrtina hamiltonensis* (Hall), and *Cranaena iowensis* (Calvin).

Mineral Description

The writer has collected many beautiful well-crystallized specimens of millerite from this locality. They range in size from delicate hair-like forms to crystals as much as three inches long and 1/32 of an inch in thickness. Some radiating, almost solid masses also have been found. The

crystals, however, are for the most part individually radiating from a common point embedded in calcite. The lustre is metallic, and the crystals are extremely flexible.

The green nickel carbonate, zaratite, occurs where oxidation of the millerite has taken place. Very few specimens of zaratite have been seen by the writer, however.

Calcite is the most abundant mineral in the cavities. It occurs as colorless translucent crystals which are generally less than one-half inch in length. Most of the crystals contain both positive and negative rhombohedrons, but some crystals of minute size that are commonly attached to the millerite hairs exhibit a simple rhombohedron.

Sphalerite is the most abundant of the sulfide minerals in the cavities. It is dark-brown to black in color and occurs in subhedral crystals which commonly are twinned. The twinned crystals are as much as one inch in diameter.

Pyrite and marcasite are less common; of the two, marcasite is the rarer. The pyrite crystals are brilliant in luster and commonly exhibit cubes and octahedrons. Marcasite occurs as bright iridescent, bladed crystals, or as globular or concretionary forms.

Sequence of Crystallization

In the specimens studied, millerite was the first of the cavity minerals to form. Crystals of this mineral extend through those of all the other minerals lining the cavities. Sphalerite was second, followed by pyrite and marcasite. Crystals of pyrite in some specimens have grown partly around the crystals of sphalerite. Calcite was the last to crystallize. Crystals of calcite surround the marcasite and pyrite crystals as well as millerite and sphalerite.

Origin. The origin of the millerite is not easily explained. Marcasite, pyrite, calcite, and sphalerite are found in sedimentary rocks in greater or lesser amounts in many localities, owing to precipitation from circulating ground waters. Millerite, however is not common in sedimentary rocks.

The particular difficulty in determining the origin of the millerite lies in finding the source of the nickel. Howarth (8), in discussing the origin of millerite in the South Wales coal field, concludes that the nickel there was derived by circulating ground water from basic igneous rocks that outcrop in the Cornwall district southwest of the coal field. A similar source for the nickel of the millerite at Milwaukee, however, is very improbable. The nearest outcrop of igneous rocks is approximately 100 miles to the northwestward, and these are primarily acidic rocks. There are no known buried igneous intrusives in the vicinity of Milwaukee. Furthermore, if such a rock had been the source, there is no reason to

believe that millerite should not have been deposited in the underlying Silurian, Ordovician, and Cambrian rocks as well.

The possibility that the nickel may have been derived from seaweeds and other marine plants that lived in the Devonian seas is plausible. Both Clarke (9) and Lindgren (10) mention the occurrence of nickel in the ash of seaweeds and marine plants. Furthermore, fossil remains of marine plants are abundant in the Devonian rocks of this area. The very local occurrence of the millerite as compared with the wide occurrence of marine plant fossils discredits this hypothesis. Millerite is not associated with fossils of marine plants elsewhere. In addition, analyses of the dolomite do not show the presence of nickel.

Although no millerite occurs in the stratum containing the asphaltum, there may be a genetic relationship between the asphaltum deposit and the millerite in the overlying beds. Ellis (11) and Thomas (12) mention that nickel occurs in petroleum ash. The writer suggests that the nickel was derived from the asphaltum by circulating ground water and deposited as millerite in the more porous strata above.

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