Copper ores in Pennsylvania

By

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Production.

Copper minerals have been found in many localities in Pennsylvania. Serious attempts to mine copper ores have been made at several places but in almost every case the attempts have been unsuccessful. Of the many "promotion schemes" which have been perpetrated, the promoters have been the only gainers financially. Notwithstanding this unpleasant aspect, the economic recovery of copper from Pennsylvania ores has been successfully practiced for many years.

Figures showing the production of copper from Pennsylvania ores cannot be published in complete form and are available for only a few years. The following tabulation gives the available figures:

<table>
<thead>
<tr>
<th>Year</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1908</td>
<td>196,869</td>
</tr>
<tr>
<td>1909</td>
<td>621,969</td>
</tr>
<tr>
<td>1910</td>
<td>927,360</td>
</tr>
<tr>
<td>1911</td>
<td>642,902</td>
</tr>
<tr>
<td>1912</td>
<td>473,060</td>
</tr>
<tr>
<td>1913</td>
<td>503,792</td>
</tr>
<tr>
<td>1914</td>
<td>646,016</td>
</tr>
</tbody>
</table>

Physical Properties.

The present universal familiarity of the public with copper wire and coins makes an exhaustive definition of metallic copper unnecessary. However, in order to crystallize the instinctive and perhaps indefinite or hazy ideas of the reader the following notes are offered.

The color of copper is so distinctive that the term "copper-red" brings to mind a definite visual sensation. The appearance of a copper wire just after it has been "skinned," or of a copper coin when new or just after it has been polished, gives an unmistakable copper color and typical metallic luster. Copper breaks with a "hackly" fracture and shows no signs of cleavage. If a copper wire be bent backward and forward rapidly by hand, the wire becomes hot for an inch or two each side of the bend and considerable flexing is necessary to break it. Such an attempt to weaken the wire shows the great ductility of the metal, and also how well it conducts heat. Results of scientific research show that the ductility is somewhat less than that of iron; and for conducting heat copper ranks next to gold. The universal use of copper for electric wires shows that it is an excellent conductor of electricity, and hammered copper ornaments and utensils indicate its malleability.

Copper crystallizes according to the isometric system, (3 axes of equal length at right angles to each other) although as it occurs in the "native" or metallic form in rocks it is commonly found in globules or masses, or in twisted or wire-like or irregular sheet-like forms.

Pure dry air has no effect on copper, but moist air quickly causes a corrosion of the exposed surface. This action is well illustrated by the numerous copper telephone and telegraph wires throughout the State. When first strung these wires have the typical and well-known copper-red, glistening aspect, but within a few weeks the wires become coated with a film of greenish material commonly called "verdigris." This film is a carbonate of copper, formed by the chemical union of the copper with carbon dioxide (CO₂) from the air. It is familiarly seen on copper utensils such as door-knockers, bell-pulls, signs, etc., and is easily removed by many chemicals, ammonia being the one usually employed for this purpose. In brass or bronze columns or statues the copper is affected by the weather in the same manner as wires, and frequently the staining of pavements near such statues is very noticeable.

The green color of this film is the typical color of the mineral malachite, which is a copper carbonate. As bright green is an unusual color for minerals, a mineral with this color attracts attention. Add to this the fact that a very small quantity of copper will form enough malachite to stain a large rock surface, and it can easily be seen why slight traces of copper form the basis for unwarranted excitement.
Copper Minerals.

There are several other minerals which contain notable amounts of copper. These other minerals are chemical combinations of copper with oxygen (O), silica (SiO\textsubscript{2}), or sulphur (S). A list of the common copper minerals follows.

List of the common copper minerals.

<table>
<thead>
<tr>
<th>Name</th>
<th>Color</th>
<th>Formula</th>
<th>Cu</th>
<th>O</th>
<th>CO\textsubscript{2}</th>
<th>H\textsubscript{2}O</th>
<th>SiO\textsubscript{2}</th>
<th>S</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper (native)</td>
<td>copper (metal)</td>
<td>Cu</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuprite</td>
<td>red to black</td>
<td>Cu\textsubscript{2}O</td>
<td>86.8</td>
<td>11.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tenorite</td>
<td>black</td>
<td>CuO</td>
<td>79.9</td>
<td>20.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malachite</td>
<td>green</td>
<td>2CuO, CO\textsubscript{2}H\textsubscript{2}O</td>
<td>57.4</td>
<td>14.5</td>
<td>19.9</td>
<td>8.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azurite</td>
<td>azure blue</td>
<td>3CuO, 2CO\textsubscript{2}H\textsubscript{2}O</td>
<td>55.3</td>
<td>13.9</td>
<td>25.6</td>
<td>5.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrysocolla</td>
<td>green to blue</td>
<td>CuSiO\textsubscript{3} + 2H\textsubscript{2}O</td>
<td>36.1</td>
<td>9.1</td>
<td>2.05</td>
<td>34.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Callopyrite</td>
<td>brass yellow</td>
<td>Cu\textsubscript{2}S, Fe\textsubscript{2}S\textsubscript{3}</td>
<td>34.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35.0</td>
<td>30.5</td>
</tr>
<tr>
<td>Bornite</td>
<td>brownish iridescent</td>
<td>3Cu\textsubscript{2}S, Fe\textsubscript{2}S\textsubscript{3}</td>
<td>58.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23.1</td>
<td>16.4</td>
</tr>
<tr>
<td>Callopyrite</td>
<td>blackish gray</td>
<td>Cu\textsubscript{2}S</td>
<td>79.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20.2</td>
</tr>
</tbody>
</table>

Occurrence.

The copper minerals commonly found in Pennsylvania are native copper, malachite, chrysocolla, and callopyrite. The other copper minerals are much less common. Malachite and chrysocolla are the minerals seen most frequently. Their unusual and often brilliant appearance seldom fails to evoke great interest.
Copper minerals as found in Pennsylvania occur in either of two general relations: (a) copper minerals predominant, there being little or none other important metallic mineral present in the same deposit, and (b) copper minerals subordinate to other metallic minerals such as iron, nickel, lead, or zinc.

In the deposits which copper minerals predominate have attracted much attention at many places in Pennsylvania. The well-known deposits of the South Mountain region of Adams and Franklin counties belong in this category, as do also most of the numerous "traces" of copper minerals which are found in the sedimentary rocks, schists, and gneisses (particularly the red shales of the Triassic and Catskill) of the State.

In the deposits where copper occurs with other metallic minerals the amount of copper present is so proportionately small that its presence is frequently overlooked or its value is greatly discounted. However, for many years deposits of this character have been furnishing Pennsylvania's entire production of copper.

Copper Minerals Predominating.

South Mountain region: In the South Mountain district of Franklin-Adams counties the rocks are of igneous origin. Owing to their very great age (pre-Cambrian) and to the earth-movements and tremendous pressures to which they have been subjected the rocks have been so changed that their original characteristics are not readily recognizable.

The similarity between these rocks and those of the Keweenaw Peninsula (Michigan) was perceived many years ago. Furthermore, the presence of metallic copper and of other minerals in the South Mountain district occurring in forms similar to those in the Michigan deposits led to the hope that the South Mountain rocks would contain the copper minerals in amounts comparable with the Michigan deposits.

All the mines in this district are idle and have been so for years. The large waste-dumps show that considerable work was done and much money was spent in vain endeavors to develop paying ore bodies. History thus teaches the futility of attempting to work these deposits.

Triassic area: The Triassic rocks lie between well-defined boundaries, and extend in a broad belt across the State in a northeasterly direction from the Maryland to the New Jersey State line. This belt includes portions of the following counties: York, Adams, Lancaster, Dauphin, Lebanon, Berks, Chester, Montgomery, and Bucks. The Triassic area exhibits several characteristics, chief of which are: (1) the sandstones and shales are typically red, (2) northwesterly dips prevail, (3) almost all the diabase (basic igneous) extrusions in the State occur within the Triassic area.

Copper minerals have been found at many places in this area, and
numerous samples of such material have been sent to this Survey for identification and information. Many copper deposits in the Triassic sandstone and shales are malachite occurring as lumps ranging in size from a pea to a piano, or malachite or chrysocolla in very thin coatings upon the surface of the rocks. These deposits have been formed by the precipitation of the copper from surface and shallow subsurface waters. Nowhere in Pennsylvania has a deposit of this type contained a paying quantity of copper ore.

Another class of copper deposits in the Triassic belt occurs in the sandstones or shales at or near their contact with diabase dikes and also in the dikes themselves. Such deposits are numerous in Bucks and northern Chester counties. The copper probably came from the same magma as the dikes. Crystals of chalcopyrite occur in portions of the diabase, and as other mineral deposits (e.g. magnetite) associated with the diabase dikes contain copper minerals, it is certain that the magma which furnished the material for some of the dikes also contained copper.

Some of these deposits are undoubtedly due to the leaching action of groundwaters upon the chalcopyrite and the subsequent precipitation of the copper minerals in the position and form as now found. The occurrence of copper deposits along fault-planes presents the possibility that they were deposited by ascending waters or vapors which had leached the copper from underlying rocks or which had been given off from some deep-seated magma.*

Other Sedimentary Areas: Similar to the occurrences in the Triassic shales not connected with the diabase dikes are those deposits in Somerset, Clinton, Northumberland, Montour, Columbia, Luzerne, Lackawanna, Susquehanna, Wayne, Pike, Monroe, and other counties. In these counties surface waters have leached from large quantities of surrounding rocks the copper that occurs in nearly all rocks in minute amounts, and have re-deposited it as concentrations in the positions where it is now found. These deposits are interesting from a mineralogical standpoint, but none of them presents commercial possibilities.

Copper Minerals Subordinate.

Copper occurs in minor quantity in deposits of other minerals in Pennsylvania. The deposits may be worked principally for the other minerals, and the copper may or may not be recovered.

With Magnetite: Several magnetite deposits of the Cornwall type** have been reported to contain various copper minerals. In these deposits copper forms only a minute portion of the ore; usually the quantity present is merely a fraction of 1 per cent. However, in

preparing the ore for furnace treatment the magnetite can be separated more or less completely from the other minerals. As the residue contains all of the copper which the untreated ore contained, the proportion of copper present is increased. Further treatment may profitably recover the copper. This method is practiced, and, as shown by the table, page 1, a surprisingly large saving of copper is made. The most abundant copper minerals in deposits of this type are chalcopyrite, malachite, copper-bearing pyrite, and native copper. Many others have been recognized, but they occur only as occasional specimens.

With Nickel: The Gap mines in Bart township, Lancaster County, developed one of the few places in Pennsylvania where nickel is found, and the only place in Pennsylvania where nickel ore has been successfully mined. The ore occurs intimately mixed with a "dark colored highly crystalline hornblende."* "The ore contains from 1 to 3 per cent of nickel; it also contains cobalt, about one-twentieth, and copper, about one-third as much as the nickel."

The dark crystalline hornblende is a very basic dike which has been intruded into the surrounding rock, now a micro-schist. At the time the intrusion occurred the hornblende was in a molten condition. It contained copper, nickel, and iron sulphides in solution. As the mass cooled the sulphides crystallized first; the hornblende later. During the process of crystallization the sulphide particles formed large masses or local concentrations. This type of deposit is known as magmatic segregation. These mines have not been operated for many years. The deposits** discovered in 1718, were at first worked for copper. In 1852 the predominance of nickel was recognized and from 1863 to 1888 these mines were the only "working nickel mines in the North American continent."***

It is probable that a greenish mineral (malachite or morenosite), appearing on the surface, first attracted attention to this deposit. As operations proceeded, sulphide ores were discovered.

With Lead and Zinc: Copper minerals have been found in deposits of lead and zinc ores. That ore from the Bamford zinc mine.**** East Hempfield township, Lancaster County, contained minute amounts of copper is inferred from analyses of the spelter which show minute quantities of copper. The copper mineral is not known; it was probably a sulphide. This was not recovered during the operations of 40 years ago.

With the lead and zinc ores of the Phoenixville district copper occurred in various amounts. Although some of these deposits were

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*This and the following statement are from Frazer, Persifor, Jr., Second Pennsylvania Geol. Survey, Vol. CCC, Lancaster County, page 165, Harrisburg, 1880.
***Brown, Amos P., and Ehrenfeld, Frederick. Topographic and Geol. Survey of Pennsylvania No. 9, p. 113; 1913.
almost barren of copper minerals others were so predominately copper-bearing that they were worked largely or solely for that metal. More than a dozen copper minerals have been reported from these deposits, but chalcopyrite, chalcocite, and malachite probably form the largest bulk of these. Dr. B. L. Miller, Associate Geologist of this Survey, had the opportunity of visiting some of these mines four or five years ago when they were being operated. His conclusions are therefore very valuable. Concerning the origin of these deposits he says:*

"The lead, zinc, and copper lodes of Chester and Montgomery counties are of hydrothermal origin. They have been formed by deposition from heated solutions probably given off from some deep-seated igneous masses. They are fissure veins and may follow faults wholly or in part. In the Chester County lode the foot-wall is prominently slickensided and in places the hanging wall also shows slickensides. In the Wheatley mine the vein cuts three trap dikes that have been displaced several feet. On the mine dumps one also finds occasional pieces of slickensided rocks. However, one cannot say whether faulting preceded the deposition of the lodes or not. The shattered character of the gangue and ore minerals and the presence of clay gouge and open quartz-lined fissures indicate that there has been at least some displacement following the formation of the lodes.

"The lodes are of Triassic or post-Triassic age as proved by the fact that they cut the Triassic shales of the Stockton formation and the trap dikes that are so commonly found as intrusives of the Triassic rocks of the State.

"In every case the lodes have undergone secondary changes through the agency of downward percolating waters. The goaen and cavernous quartz of the outcrops, the secondary minerals such as pyromorphite, cerussite, anglesite, calamine, etc., some of which are found at considerable depths, furnish evidence of the extensive alteration which the lodes have undergone.

"The abundance of pyromorphite is difficult to explain as there is now no evidence of the source of the phosphoric acid. It is possible that there were some phosphatic beds in the overlying Triassic strata now removed by erosion, but this is only a conjecture.

"It seems that Rogers probably over-emphasized the distinctions between the lodes lying within the gneisses and those found in the shale areas although he was correct in pointing out general differences. Undoubtedly the shales tended to cause the deposition of the primary chalcopyrite to a greater degree than did the gneisses and vice versa. The gneisses had a selective reaction on the solutions causing greater deposition of the galena than is found in the veins enclosed by the Triassic shales."

Near New Galena, Bucks County, some mining work has been done in several attempts to develop lead and zinc deposits. Specimens of chloropyrite are to be found in the waste-camps, and if these mines become productive copper minerals may possibly be saved as a by-product.

Summary. There is no large known deposit of (solely) copper-bearing minerals in Pennsylvania. There are numerous very small deposits of copper minerals, but none of them are of sufficient size to warrant any attempt to work them for the copper content alone.

Those who are solicited for subscriptions to mining ventures should remember that mining is as distinctly a specialized business as is medicine or law. In all cases a banker, the local chambers of commerce, and the State Geologist should be consulted, either by a personal visit or by correspondence.

**Average price of copper in cents per pound, 1850 - 1921.**

*Chart plotted from figures in Mineral Resources of U.S., pt. I, 1921.*

*For a discussion of these deposits see Miller, B. L., "Lead and Zinc Deposits of Bucks County." Pennsylvania Geological Survey Bulletin 69.*