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COPPER

BY

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Richardson—Economic Geology.
COPPER

By P. E. Joseph

Introduction:—The copper industry in the United States has enjoyed a year of unparalleled prosperity during 1915. It is needless to explain the conditions which have so greatly affected our copper market, as they are really self-evident, but I shall endeavor here to outline the possible conditions of the future copper market, which would be created by the termination of the European war.

The opinions regarding this question are many and greatly diversified, and many hold the belief that the termination of the war will result in a decline of the copper prices to a very low level. However, the consideration of the following facts will be of help in the formation of a more or less definite conception as to what the effect of the cessation of war might be upon the copper market.

1. War results in the destruction of wealth, which has to be replenished. History shows that all previous wars have been followed by long periods of great industrial activity.

2. The warring nations have practically exhausted their supply of copper, and are now using copper available in any form for the manufacture of ammunition, which copper is destroyed by the war and lost to the world.

3. Factories and railroads are now overtaxed with operations to such an extent that the amount of copper needed to rebuild their equipment may be larger than that used in the manufacture of war munitions.

4. The present rate of consumption is considerably in excess of the producing capacity of this country, and at the close of the war not only Europe will be bare of copper, but this country as well.

5. European manufacturers of copper and brass products will attempt to regain the foreign trade of which the war is depriving them, as well as to supply their own countries with all the copper and brass goods they use, and in order to do this, they will have to buy heavily of the American copper.

6. In all the buying countries of the world, with the exception of those at war, such financial conditions have been created by the war as to restrict their purchases of manufactured goods. The termination of the war will eliminate these abnormal conditions and thus create
greater market for the copper and brass products of European manufacturers.

Of course, a sudden cessation of war would cause the cancellation of war orders, and considerable copper which has been purchased for future delivery would be released; but the owners of this are American copper and brass manufacturers, who would be obliged to retain it to keep their own operations going.

From the above considerations, we may safely conclude that after the war there will be a stronger demand for copper than existed before, and probably than existed during the war.

ORES OF COPPER

Copper is a very common and widespread metal in nature, and it constitutes from about 0.01 to 0.005 per cent of the earth’s crust. It is a common constituent of sea water, and the green color of the sea has been attributed to its presence. It has also been obtained in the ashes of sea weeds and found in certain varieties of corals. Copper is easily oxidized and easily reduced as well, and it therefore is found both as native and in its many different compounds.

In addition to the minerals described below, copper is very frequently found in the iron sulphides from which it is extracted after burning for sulphuric acid.

COPPER—NATIVE COPPER

Composition:—Cu, often containing gold, silver, and sometimes mercury or bismuth.

General Description:—A soft, red, malleable metal. Usually in sheets or disseminated masses, varying from small grains to several hundred tons in weight. Sometimes in threads and wire and in distorted crystals and twisted groups.

Physical Characteristics:

Hardness (2.5 to 3), easily scratched by knife; Sp. Gr. very heavy (8.18 to 8.9).

Lustre, Metallic.

Opaque.

Streak, copper red.

Tenacity, brittle.

Color, copper red, tarnishing nearly black.

Qualitative Tests—Fuses easily to a malleable globule, often coated with a black oxide. In beads of borax or salt of phosphorous, it becomes green when hot, blue when cold in oxidizing flame; in reducing flame it becomes opaque red. In nitric acid it dissolves readily, with the evolution of a brown gas, yielding a green solution. If iron, steel, zinc or aluminum is immersed into this solu-
tion and the solution is allowed to stand, they will be coated with a layer of copper. On adding ammonia the solution becomes deep azure blue.

Native copper resembles nicolite and tarnished silver, from which it differs in its copper red streak.

**CHALCOCITE—COPPER GLANCE**

*Composition:*—Cuprous sulphide (Cu₂S) containing 79.8% copper and 20.2% sulphur.

*General Description:*—A black, heavy, metallic mineral, often coated with the green carbonate, malachite. Occurs in small tabular crystals of hexagonal outline; in granular or compact masses; or in nodules and pseudomorphs after wood.

*Physical Characteristics:*

- Hardness (2.5 to 3), easily scratched by knife. Sp. Gr. heavy (5.5 to 5.8).
- Lustre, metallic.
- opaque.
- Streak, grayish-black.
- Tenacity, brittle.
- Color, shining lead-gray, tarnishing fracture, conchoidal on exposure to dull black.

*Qualitative Tests:*—Bead reactions are same as described under native copper. On charcoal with soda it fuses to a malleable copper button if heated in the reducing flame, and also gives a very strong sulphur reaction. It is soluble in nitric acid, leaving a residue of sulphur. If moistened with hydrochloric acid, it colors the flame azure blue.

*Occurrence:*—Chalcocite is a secondary mineral produced by secondary (downward) sulphide enrichment. It is found in the enriched zone of copper veins, associated with bornite, chalcopyrite, enargite, malachite, pyrite, etc. In the ores of Virgilina district, Va., it is found to be of primary origin, or deposited from ascending solutions.

**BORNITE—PURPLE COPPER ORE—(HORSE FLESH ORE)**

*Composition:*—(Cu₉FeS₄). A copper-iron sulphide, containing 63.3% copper, 11.2% iron and 25.5% sulphur.

*General Description:*—On fresh fracture bornite is of a peculiar red-brown color and metallic lustre. It tarnished to deep blue and purple tints, often variegated. It is massive in texture, though cubes and other isometric crystals are found.

*Physical Characteristics:*
Arizona State Bureau of Mines

Hardness (3), easily scratched by knife. Sp. Gr. (4.9 to 5.4), heavy.
Lustre, metallic.
Opaque.
Streak, grayish black.
Tenacity, brittle.

Qualitative Tests:—When heated on charcoal it blackens, becomes red on cooling and finally fuses to a brittle, magnetic globule and evolves sulphur dioxide fumes. In oxidizing flame with borax or salt of phosphorous, gives green bead when hot, greenish blue when cold, and in reducing flame the bead is opaque red. Is soluble in nitric acid with separation of sulphur.

Occurrence:—Bornite is an important and widely occurring ore of copper, usually associated with other copper minerals and in subordinate amounts. It is mostly of primary origin (derived from ascending, hot, alkaline solutions) and is found in the enrichment zone as residual masses undergoing alteration. It is frequently associated with primary chalcopyrite and chalcocite. The other minerals with which it is associated are enargite, malachite, azurite, pyrite, etc.

CHALCOPYRITE—(COPPER PYRITES—YELLOW COPPER ORE)

Composition:—(CuFeS₂) a sulphide of copper and iron containing 34.5% copper, 30.5% iron, and 35.0% sulphur, with mechanically intermixed pyrite sometimes.

General Description:—A bright, brassy yellow mineral of metallic lustre, often with iridescent tarnish, resembling that of bornite. Usually massive, sometimes in crystals.

Physical Characteristics:
Hardness (3.5-4), scratched by knife. Sp. Gr. (4.1-4.3), heavy.
Lustre, metallic.
Opaque.
Streak, greenish black.
Tenacity, brittle.
Color, bright brass yellow, often tarnished blue, purple and black.

Qualitative Tests:—On charcoal fuses to a brittle magnetic globule. With soda yields metallic malleable red button and sulphur reaction as under chalcocite. In closed tube decrepitates, becomes dark and iridescent and may give deposit of sulphur. Bead and acid tests same as under bornite.

Occurrence:—The most common ore of copper and is found in association with the metallic sulphides and other copper ores, many of which have been formed by its alteration. Frequently carries gold
and silver. Often in subordinate amounts with large bodies of pyrite, constituting low-grade copper ores.

**ENARGITE**

*Composition:* \((\text{Cu}_4\text{AsS}_4)\), a sulph-arsenide of copper, containing
48.3% copper, 19.1% arsenic and 32.6% sulphur; sometimes the copper is replaced by zinc and iron, and the arsenic by antimony.

*General Description:* A black, brittle mineral of metallic lustre, occurring usually columnar or granular, but sometimes in crystals.

*Physical Characteristics:*
- Lustre, metallic.
- Opaque.
- Streak, blackish-gray.
- Tenacity, brittle.
- Color, black or blackish-gray.

*Qualitative Tests:*—On charcoal fuses, yields white fumes with garlic odor (arsenic test). With soda yields malleable copper button and reaction for sulphur. In closed tube decrepitates, yields sulphur sublimate, then fuses and gives red sublimate of arsenic sulphide. Soluble in nitric acid.

*Occurrence:*—Enargite is a comparatively rare mineral found in association with other copper minerals, especially the arsenates derived from it.

**TETRAHEDRITE—GRAY COPPER ORE**

*Composition:* \((\text{Cu}_2\text{Sb}_2\text{S}_7)\), a sulph-antimonide of copper, containing
52.1% copper, 24.8% antimony and 23.1% sulphur. The copper is often replaced in varying amounts by iron, zinc, silver, mercury, lead, etc., and the antimony by arsenic.

*General Description:* A heavy, dark lead gray mineral, occurring in crystals; also massive and coarse to fine granular. Sometimes coated with yellow chalcopyrite.

*Physical Characteristics:*
- Hardness (3 to 4.5), scratched by knife. Sp. Gr. (4.5 to 5.1), heavy.
- Lustre, metallic.
- Opaque.
- Streak, black or reddish brown.
- Tenacity, brittle.
- Color, light steel to dark lead gray or iron black.
Qualitative Tests:—On charcoal fuses to a globule which may be slightly magnetic. Evolves heavy white fumes (antimony test) with sometimes a garlic odor, due to arsenic. The roasted residue gives bead and flame reactions for copper. Soluble in nitric acid to a green solution with white residue.

Remarks:—Resembles arsenopyrite and metallic cobalt ores from which it differs in softness and in that it does not yield a strongly magnetic residue on heating.

Occurrence:—Usually in metallic veins in association with the sulphides of lead, silver, copper, etc. May carry silver in sufficient amounts to become an ore of that metal.

CUPRITE—RED OXIDE—RUBY COPPER ORE

Composition:—(CuO), an oxide of copper containing 88.8% copper and 11.2% oxygen; sometimes intermixed with limonite.

General Description:—A heavy reddish mineral, occurring in fine-grained masses or in transparent crystals.

Physical Characteristics:
Hardness (3.5 to 4), scratched by knife. Sp. Gr. (5.85 to 6.15), heavy.
Lustre, adamantine to dull.
Transparent to opaque.
Streak, brownish red.
Tenacity, brittle.
Color, crimson, scarlet, vermilion.

Qualitative Tests:—On charcoal blackens and fuses easily to a malleable red button. Copper flame and bead tests. Soluble in nitric acid to a green solution. Soluble in strong hydrochloric acid to a brown solution, which, on dilution with water, gives a white precipitate.

Occurrence:—Cuprite is an important ore of copper of secondary origin, occurring in the oxidized portions of copper veins in association with other secondary minerals of copper, such as native copper, carbonates and silicates.

MALACHITE—GREEN CARBONATE OF COPPER

Composition:—Cu₂(OH)₂CO₃, a hydrated carbonate.

General Description:—A bright green massive mineral, often in crusts with a delicate, silky, fibrous structure or banded in lighter and darker shades of green. Frequently pseudomorphous after, and coating other copper minerals.

Physical Characteristics:
Hardness (3.5 to 4), scratched by knife. Sp. Gr. (3.9 to 4.03), moderately heavy.
Lustre, silky, adamantine or dull translucent to opaque.
Streak, pale green.
Tenacity, brittle.
Color, bright emerald to grass green and nearly black.

**Qualitative Tests:**—On charcoal decrepitates, blackens, fuses, and colors the flame green, leaving a globule of metallic copper. Heated in closed tubes, blackens, yields water and carbon dioxide. Soluble in acids with effervescence.

**Occurrence:**—A secondary mineral found in the copper oxidized zones and derived from other copper minerals by the action of carbonated waters.

**AZURITE—BLUE CARBONATE OF COPPER**

**Composition:**—\( \text{Cu}_3(\text{OH})_2(\text{CO}_3)_2 \), a hydrated carbonate of copper.

**General Description:**—Dark blue, glassy crystals. Also massive, in which it may be glassy, velvety or dull and earthy. Also forming crusts on other copper minerals or filling cracks within them.

**Physical Characteristics:**
- Hardness (3.5 to 4), scratched by knife. Sp. Gr. (3.77 to 3.83), moderately heavy.
- Lustre, vitreous.
- Translucent to opaque.
- Streak, blue.
- Tenacity, brittle.
- Color, dark blue to azure.

**Qualitative Tests:**—Same as for malachite.

**Occurrence:**—As malachite.

**CHRYSOCOLLA**

**Composition:**—\( \text{(CuSiO}_3+\text{H}_2\text{O}) \), a hydrated silica; often very impure.

**General Description:**—A green to blue mineral, forming crust or seams, which resemble opal in texture. Also brown, like limonite, and in dull green earthy masses.

**Physical Characteristics:**
- Hardness (2 to 4), easily scratched by knife. Sp. Gr. (2 to 2.3), light.
- Lustre, glassy to dull.
- Translucent to opaque.
- Streak, white to pale blue.
- Tenacity, brittle.
- Color, green to light blue, brown when ferriferous.

**Qualitative Tests:**—Infusible but turns black, then brown and colors flame emerald green. In closed tube yields water. Decomposed
by hydrochloric acid, leaving a white residue of silica. Gives test for copper.

_Occurrence:_—A comparatively rare mineral, found in the oxidized zones of copper veins and is probably derived by the action of hot alkaline silicate solutions on other copper ores.

_Other minerals of copper are:_
- Tenorite—the black oxide of copper.
- Stalamicite—green hydrated oxychloride.
- Chalcanite—blue vitreol or sulphur.
- Brochantite—green sulphate.
- Liebethenite—olive green phosphate.
- Olivenite—olive green arsenate.
- Dioptase—emerald green orto-silicate.

**ORIGIN OF COPPER ORES**

According to their origin, the ores of copper may be divided into five groups:

1. Deposits formed by differentiation of the magma. These are irregular in shape, but are usually marginal with respect to the solidified magma from which they were derived. In the United States no workable deposits of this origin are known.

2. Deposits formed by ascending alkaline hot solutions depositing ores in fissures, pores, shear zone and brecciated zones, and by replacement of rocks.

3. Lens-shaped deposits in crystalline schists formed by concentration of the valuable material from a disseminated condition in the surrounding rock. These are usually of low grade.

4. Contact Deposits—These deposits are formed by contact metamorphism, or the reaction which takes place between an intrusive igneous rock and the country rock forming the wall rock of the intrusive. Both the country rock and, to a less degree, the intrusive are metamorphosed on the contact, the effects of metamorphism, being strongest on the contact and growing weaker away from the contact. Among the intrusives that are most commonly associated with contact deposits, and are thus considered to be most favorable for the formation of contact deposits, are the acid intrusive rocks high in silica, such as granites, syenites, diorites, and the intermediate types, monzonites, and granodiorites, are known to produce the largest zone. The wall rocks most susceptible to contact metamorphism and the formation of contact deposits are slate, shales and limestones, the limestones being most favorable.

The ore minerals are usually chalcopyrite and bornite associated with pyrite.
5. Disseminated Deposits.—These deposits usually occurring in igneous rocks or schists, are formed by the impregnation of the more or less fractured country rock with copper-bearing magmatic waters from which copper sulphides are precipitated.

The last two types constitute by far the most important deposits, especially in the Southwest. In each case the deposits usually suffer some change by oxidation and secondary enrichment. The ores within the zone of weathering partly undergo a chemical change, such as oxidation, carbonation, hydration, and partly are leached by the circulating surface acid waters and carried to lower levels to be there precipitated—giving rise to secondary enrichment.

PRODUCTION OF COPPER IN THE UNITED STATES

Table Showing Production of Copper in the United States, 1910-1915, by States in Pounds.

<table>
<thead>
<tr>
<th>State</th>
<th>1910</th>
<th>1911</th>
<th>1912</th>
<th>1913</th>
<th>1914</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>4,311,056</td>
<td>22,058,889</td>
<td>31,936,209</td>
<td>27,324,070</td>
<td>24,985,897</td>
</tr>
<tr>
<td>Arizona</td>
<td>297,269,536</td>
<td>302,202,832</td>
<td>359,322,296</td>
<td>404,278,809</td>
<td>382,449,922</td>
</tr>
<tr>
<td>California</td>
<td>4,780,200</td>
<td>35,538,651</td>
<td>31,515,471</td>
<td>32,492,265</td>
<td>29,784,173</td>
</tr>
<tr>
<td>Colorado</td>
<td>9,307,497</td>
<td>9,761,861</td>
<td>7,663,520</td>
<td>9,055,104</td>
<td>7,316,066</td>
</tr>
<tr>
<td>Idaho</td>
<td>6,677,515</td>
<td>4,514,116</td>
<td>7,182,185</td>
<td>8,711,490</td>
<td>5,875,205</td>
</tr>
<tr>
<td>Michigan</td>
<td>221,462,984</td>
<td>218,135,306</td>
<td>234,112,258</td>
<td>155,710,286</td>
<td>158,092,748</td>
</tr>
<tr>
<td>Montana</td>
<td>283,075,473</td>
<td>271,814,491</td>
<td>306,770,326</td>
<td>255,719,918</td>
<td>236,805,845</td>
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<tr>
<td>New Mexico</td>
<td>3,784,609</td>
<td>2,860,400</td>
<td>29,170,400</td>
<td>50,196,881</td>
<td>64,204,703</td>
</tr>
<tr>
<td>Nevada</td>
<td>64,494,649</td>
<td>65,561,015</td>
<td>85,413,900</td>
<td>85,290,536</td>
<td>69,122,994</td>
</tr>
<tr>
<td>Oregon</td>
<td>23,022</td>
<td>125,983</td>
<td>311,860</td>
<td>79,812</td>
<td>5,599</td>
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<tr>
<td>So. Dakota</td>
<td>43</td>
<td>1,607</td>
<td>22,657</td>
<td>4,549</td>
<td></td>
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<tr>
<td>Utah</td>
<td>125,185,456</td>
<td>142,340,215</td>
<td>122,150,520</td>
<td>148,057,450</td>
<td>160,580,660</td>
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<tr>
<td>Washington</td>
<td>68,021</td>
<td>196,008</td>
<td>1,068,035</td>
<td>123,742</td>
<td>683,602</td>
</tr>
<tr>
<td>Wyoming</td>
<td>217,127</td>
<td>130,499</td>
<td>25,080</td>
<td>362,235</td>
<td>17,082</td>
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<tr>
<td>Eastern States</td>
<td>18,342,359</td>
<td>20,538,791</td>
<td>19,310,298</td>
<td>20,449,951</td>
<td>19,286,836</td>
</tr>
</tbody>
</table>

Total         | 1,089,159,509| 1,097,232,749| 1,243,268,720| 1,224,484,098| 1,364,618,500

COPPER INDUSTRY IN ARIZONA

The United States is the leading copper producing country of the world. About 75% of the total production is furnished by the states of Arizona, Michigan and Montana, with Arizona yielding about one-third of the total production in 1914 and 1915. In fact, if the present high prices will continue, in the course of a very short time, a sufficient number of copper properties might be developed in Arizona to easily double its already enormous production.

The steady output of copper from Arizona began in 1875 with the earliest record of production being for 1862. Since 1880 the growth of the industry has been steady and very rapid, and at the close of 1914 Arizona had produced 4,649,437 pounds of copper, or 23.24% of the total output of the country.
DESCRIPTION OF THE COPPER DISTRICTS OF ARIZONA

In describing the districts only such features are noted which may be helpful in learning the geological occurrence of copper deposits in Arizona, the knowledge of which is of unquestionable importance to the prospector.

THE BISBEE DISTRICT

According to Ransome, the oldest formation in the Bisbee district is the Pinal schist, which has been intruded by granite, probably of pre-Cambrian age. These form the complex basement upon which the Paleozoic sediments, chiefly limestones with quartzite at base, have been deposited. In the Mesozoic time, these sediments have been intruded by stocks, sills and dikes of granite porphyry. Then followed a period of erosion, after which the Cretaceous sediments were deposited, which have since been removed from the producing area.

The primary ores, which are chiefly pyrite and chalcopyrite, were deposited during and after the intrusion of the Mesozoic granite porphyry, and their association with contact metamorphism minerals, such as garnet, diopside, tremolite, etc., has led to the belief that the ores are contact deposits.

The primary ores, however, have been oxidized and enriched by surface solutions, and a large part of the ore extracted was in the form of secondary sulphides, oxides, and carbonates. Most of the ore bodies are irregular in shape, and have no definite arrangement, making the cost of prospecting rather high.

This district, which is situated in southern Cochise county, is one of the oldest and biggest producers, ranking third among the copper districts of the country in total and present output.

MORENCI-METCALF DISTRICT

The deposits of this district are at Morenci and Metcalf, in Greenlee county. The district lies in a basin six to ten miles across, surrounded by hills of Paleozoic, probably carboniferous limestone, resting on sandstones underlain by granites. The basin consists of a mass of porphyry with frequent limestone inclusions. Felsite and porphyry dikes are also present in the surrounding sedimentary or granite rocks. Several miles to the east there is an outflow of trachyte and evidence of recent volcanic action. The ores may be classified as follows:

1. Contact deposits. These ores occur in the limestone along the intrusive porphyries, and in a zone of highly kaolinized porphyry, along the contact with the limestone.

Some deposits have been formed in outlying bodies of limestone which have been mineralized by ore channels from the contact. The
ores, originally pyrite and chalcopyrite, have later been oxidized and secondarily enriched, giving rise to malachite, azurite, cuprite, some metallic copper, and melaconite. The ores are associated with limonite, some wad, and clay of a residual character.

2. Disseminated deposits. These deposits form sheets and pockets in the highly altered porphyry near the fissure veins and impregnate the solid rock itself. The ores have been largely leached on the surface and deposited as chalcocite on the pyrite lower down. The gangue material is a kaolinized porphyry.

3. Vein deposits of the Coronado type. These are true fissure veins, cutting across a quartz porphyry dike. On the surface the ore is chalcocite which has resulted from enrichment of the chalcopyrite below. These deposits have been found to extend in depth below the general level of the ore zone. The average content of the ores is about 1.95% copper, and small amounts of gold and silver, but in as much as the copper is not refined electrolytically, the precious metals are not recovered.

The district is one of the oldest copper producers in the state. Its total production has yielded about 6% of the output of the country since 1845 and about 25% of the copper output of the state.

GLOBE DISTRICT

The geology of this district may be summarized as follows:

Paleozoic sediments, consisting of conglomerates, quartzites, shales, and schists, have been laid down unconformably on pre-Cambrian schist (Pinal schist) and intruded granites. Later these sediments were intruded by diabasic and still later by granitic rocks. After a period of erosion, the area was buried beneath Tertiary volcanic and sedimentary rocks, which have since been partly eroded.

In the Miami end of the district, the ore bodies occur chiefly in small veins of quartz and sulphide in the shear zone near the granite and schist contact. The ores near the surface have been leached and redeposited as chalcocite on the sulphides below. The commercial ore consists of grains of pyrite and chalcopyrite, partly or wholly replaced by chalcocite disseminated through the schist and granite along the contact.

In the Globe end of the district the deposits form lenticular replacements, in the limestone and fissure zones of quartz and sulphides in the diabase. Most of the commercial ores have been oxidized and enriched, though some primary ores of commercial grade have been developed.

The content of the ores varies from 1.26% to 7.18% copper, with an average yield of about 2.4% copper and some gold and silver.
Production of copper began here in 1881, though before this it was known as a silver producer. For several years subsequent to 1881 the production was intermittent. But since 1889, when a railroad reached the camp, it has become an important producer of copper, having yielded 2.92% of the output of the country since 1845 and 12.5% of that of the output of the state.

In Miami important production began in 1911, and this end of the district will continue to grow in importance.

THE JEROME OR VERDE DISTRICT

Here the deposits occur in pre-Cambrian schistose rocks which have resulted from metamorphism of dioritic, rhyolitic and possibly sedimentary rocks.

The ores, consisting chiefly of chalcopyrite, with varying amounts of pyrite and sphalerite, occur partly in small irregular fractures, and along planes of schistosity, but to a large extent as metasomatic replacements of the schist, particularly the fine grained sericitic variety. The sulphides are primary and were all deposited in the pre-Cambrian era.

The most important producer in this district is the United Verde Copper Company. This district ranks sixth among the copper districts of the country and third in Arizona.

MINERAL CREEK OR RAY DISTRICT

In geology this district is very similar to the Globe district described above. The ore deposits are of two types, namely those formed in the sedimentary rocks near the faults and fissures, and the disseminated deposits in the schist and granite. The ores of both types are believed to have been introduced at the time of and closely following the granitic intrusion.

TURQUOISE DISTRICT

The rocks in this district, which is situated in Cochise county, consist of Paleozoic sediments, chiefly limestone, extensively faulted and intruded by monzonitic porphyries. The ore bodies here occur as replacements and veins in the intrusive monzonites.

SILVER BELL DISTRICT, PIMA COUNTY

Here the rocks consist of Paleozoic sediments cut by granite porphyry. The district has yielded about 40,800,000 pounds of copper.

AJO DISTRICT, PIMA COUNTY

The rocks of this district consist of a series of lavas, breccias, and tuff, which have been cut by stocks of quartz monzonite porphyries
and similar rocks. The original copper deposits consist of small veins, containing chalcopyrite and bornite mostly, in the intrusive rocks, but also in the extrusives.

Other districts of the state making important production are the Big Bug, Yavapai county; Cochise, Cochise county; Palmetto and Patagonia, Santa Cruz county; Pioneer and Bunker Hill, Pinal county; Pima, Pima county; Bentley, Mohave county; and the Borner, Gila county. There are at least 140 mining districts in Arizona with copper in almost all of them, but for the most these lack sufficient development and could not be considered as producers.

GRADES OF AMERICAN COPPER

There are four grades of copper on the American market:

1. Lake copper: Tough and ductile copper, obtained from the Lake Superior mines. It contains 99.8% copper, small amounts of arsenic and silver, and is sold in form of ingots, slabs and cakes.

2. Electrolytic copper: Electrolytically refined copper of highest purity and conductivity. Contains 99.9% copper and is sold in form of ingots, slabs, cakes and wire bars.

3. Standard or Pig copper: This is a medium grade copper suitable for brass and bronze alloys and is sold in form of ingots.

4. Casting copper: A low grade copper suitable for casting only. It is made by melting and casting scrap copper, has a low conductivity and is sold in form of ingots.

METALLURGY OF COPPER

Copper may be extracted from its ores in three different ways:

1. Smelting.
2. Leaching.
3. Electrically.

For further information regarding this subject, see Bulletin No. 36, Arizona State Bureau of Mines, which may be obtained by writing Charles F. Willis, Director, Tucson.

USES

The properties of copper, such as its conductivity, malleability, etc., make it one of the most useful metals known. In fact, the uses are so numerous and for the most part well known to all, that the writer does not think it necessary to describe them on these pages.

PRICES

The following table shows the average monthly prices at New York per pound of electrolytic copper in cents.
## Price of Electrolytic Copper in Cents

<table>
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<tr>
<th>Months</th>
<th>1912</th>
<th>1913</th>
<th>1914</th>
<th>1915</th>
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<td>14.34</td>
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<td>May</td>
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<td>18.71</td>
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