BIBLIOGRAPHY


Kemp, J. F.  Ore Deposits of the United States and Canada.

Lingren, W.  Mineral Deposits.
LEAD

BY P. E. JOSEPH

Lead is a soft, bluish white metal; its freshly cut surface has a bright metallic lustre, which, upon exposure, becomes coated with a film of the oxide. Unlike other metals, it is sufficiently soft to be scratched with the thumb nail. It is fashioned into foil or wire by rolling and pressing. It is readily soluble in nitric acid, but the other acids are without special solvent effect upon the metal at ordinary temperatures. It is heavy, having a specific gravity of 11.3. Its melting point is 327 degrees C. and its atomic weight, 207.10.

It is found in nature in small quantities in many localities and is always a secondary mineral, being formed by reduction from other lead minerals through volcanic action.

LEAD ORES

GALENA

Composition: Lead sulphite (PbS), containing 86.6% lead.

Usually contains silver, stibnite, bismuth, cadmium, etc.

General Description: A soft, heavy, lead-gray mineral, with metallic lustre and easy cubic cleavage. Sometimes in crystals; rarely fine-grained or fibrous.

Physical Characteristics:

- Hardness (2.5) easily scratched by knife.
- Sp. Gr. (7.4 to 7.6) heavy.
- Opaque.
- Lustre, metallic.
- Tenacity, brittle.
- Streak, lead-gray.
- Cleavage, cubic, very easy.
- Color, lead-gray.

Qualitative Tests: On charcoal it decrepitates and fuses easily, yielding in oxidizing flame a white sulphate coating, and in reducing flame, a yellow coating and a metallic button of lead. With soda yields malleable lead and sulphur test. Soluble in excess of hot hydrochloric acid, from which, on cooling, white lead chloride separates. Soluble also in strong nitric acid, with separation of sulphur and lead sulphate.
Occurrence: Galena is a primary ore of lead. It occurs with other sulphides, especially sphalerite, pyrite and chalcopyrite, less commonly with tetrahedrite, in a gangue of quartz, fluorite, barite or calcite. Often with ores of gold and silver.

ANGLESITE

Composition: Lead sulphate.
General Description: A very brittle, colorless or white mineral of adamantine lustre, occurring massive and in concentric layers around a core of unaltered galena.
Physical Characteristics:
Hardness (3) scratched by knife.
Lustre, adamantine to glassy.
Streak, white.
Color, colorless, white, gray, rarely blue or green.
Qualitative Tests: On charcoal decrepitates and fuses easily to a glossy globule, pearly white on cooling. In reducing flame yields a metallic globule and a yellow coating. With soda yields the sulphur test. Insoluble in hydrochloric acid, but is converted into chloride. Soluble slowly in nitric acid.
Occurrence: Anglesite is a secondary mineral formed by the oxidation of galena. It changes to cerussite by the interaction with calcium carbonate solutions.

PYROMORPHITE

Composition: Lead phosphate, containing some chloride. \( \text{Pb}_n\text{Cl} (\text{PO}_4)_3 \); often with some arsenic, iron or calcium.
General Description: A soft, heavy vari-colored mineral, occurring in hexagonal and tapering groups of prisms in parallel positions. Also in moss-like interlaced fibres and masses of imperfectly developed crystals. Less frequently in globular and reniform masses.
Physical Characteristics:
Hardness, 3.5 to 4.
Lustre, resinous.
Streak, white to pale yellow.
Color, green, gray, brown; also yellow, orange, white.
Qualitative Tests: On charcoal fuses to a globule which on cooling does not retain its globular form but crystallizes, showing plain faces. In reducing flame yields white coat at a distance
and yellow coat nearer the assay, and a brittle globule of lead. Soluble in nitric acid, and from the solution ammonium molybdate throws down a yellow precipitate.

**Remarks:** Probably formed from galenite, and occurs with other lead minerals found in the oxidized zone.

**Mimetite**

**Composition:** A complex lead arsenate, with chlorine, often with phosphorous or calcium.

**General Description:** A soft, heavy vari-colored mineral, occurring in hexagonal prisms or globular groups of crystals. Sometimes incrusting.

**Physical Characteristics:**
- Hardness: 3.5
- Lustre: resinous
- Sp. Gr.: 7 to 7.25 (heavy)

**Qualitative Tests:** On charcoal fuses easily and is reduced to metallic lead, coating the coal with white and yellow sublimates and yielding strong arsenical odor. Phosphorous, if present, and chlorine may be detected as in pyromorphite.

**Cerussite**

**Composition:** A lead carbonate, carrying PbO 83.5%, CO₂ 16.5%. Often carries silver.

**General Description:** A heavy, soft, very brittle mineral, occurring in silky, milk white masses of interlaced fibres; granular, translucent, gray masses and compact or earthy, opaque masses of yellow, brown, etc., colors.

**Physical Characteristics:**
- Hardness: 3 to 3.5
- Lustre: adamantine-silky
- Sp. Gr.: 6.46 to 6.51

**Qualitative Tests:** On charcoal decrepitates, fuses and gives a yellow coating, and finally a metallic globule. In closed tube turns yellow, then dark, and on cooling, is yellow. Effervesceses in acids, but with hydrochloric or sulphuric acid leaves a white residue.

**Remarks:** Cerussite is derived from galenite by the action of water containing carbon dioxide. It may also be produced from anglesite by action of a solution of calcium carbonate. Cerussite is one of the most important ores of lead.
CROCOITE

**Composition:** Lead chromate. PbO 68.9%; CrO 31.1%.

**General Description:** A relatively rare, soft, heavy mineral usually in monoclinic, prismatic crystals, but also granular and columnar.

**Physical Characteristics:**
- Hardness, 2.5 to 3.
- Lustre, adamantine.
- Streak, orange-yellow.
- Cleavage, prismatic.

**Qualitative Tests:** On charcoal fuses very easily, and is reduced to metallic lead with deflagration, the coal being coated with a yellow sublimate. In closed tube, decrepitates violently, becomes dark, but recovers color on cooling. With borax forms yellow glasses which are bright green, when cold. Soluble in nitric acid to a yellow solution.

VANADINITE

**Composition:** A lead vanadate containing chlorine, often with phosphorous or arsenic replacing vanadium. Pb₃Cl(VO₄)₃.

**General Description:** A soft, heavy, highly colored mineral, occurring in small sharp hexagonal groups and globular masses of crystals.

**Physical Characteristics:**
- Hardness, 3.
- Lustre, resinous.
- Streak, white to pale yellow.
- Color, deep red, bright red. yellow or brown.

**Qualitative Tests:** Fuses easily on charcoal to a black mass, yielding a yellow sublimate in the reducing flame. The residue gives a deep green bead with NaPO₄ in the reducing flame. With strong nitric acid the substance becomes deep red, then dissolves to a yellow solution.

**Remarks:** Is chief source of vanadium. Found in oxidized zones of lead bearing veins.

DESCLOIZITE

**Composition:** A lead-zinc vanadate. PbO, 55.4%; ZnO, 19.4%; V₂O₅, 22.4%; H₂O, 2.2%.

**General Description:** A soft, heavy mineral, much like vanadinite.

**Physical Characteristics:**
- Hardness, 3.5.
- Sp. Gr., 5.9 to 6.2.
Lustre, greasy.  
Streak, orange to brown.  

**Qualitative Tests:** On charcoal fuses to black mass, enclosing metal. In closed tube yields water. Vanadium reactions as in vanadinite.

**Remarks:** Associated with vanadinite in oxidized zones of lead-bearing veins.

**WULFENITE**

**Composition:** A lead molybdate, sometimes containing calcium, chromium, or vanadium.

**General Description:** A soft, heavy mineral, usually in thin, square, tabular crystals, less frequently in granular masses. Resinous lustre, and yellow, orange, or bright orange-red color.

**Physical Characteristics:**
- Hardness, 3.
- Sp. Gr., 6.7 to 7.
- Streak, white. Translucent.
- Cleavage, pyramidal. Tenacity, brittle.
- Color, wax yellow, bright
- Lustre, resinous to adamantine.

**Qualitative Tests:** Fuses easily on charcoal, giving yellow coat and finally a metallic globule. In salt of phosphorous dissolves to a bead, which is bright green in reducing flame. In borax, yields a colorless bead in oxidizing flame, which is made brown to black in reducing flame. Partially soluble in strong hydrochloric acid to a green liquid. If the solution is greatly diluted, cooled, and tin added, it becomes deep blue and finally brown. A similar test may be obtained either by boiling in porcelain with strong hydrochloric acid and adding alcohol, or by fusing in platinum with potassium sulphate, dissolving in water and boiling with tin or zinc.

**Occurrence:** Wulfenite occurs both as a primary and secondary mineral, in association with other lead minerals, especially vanadinite and pyromorphite; usually found in the oxidized zone as a secondary mineral.

**GEOLOGICAL OCCURRENCE AND ORIGIN**

According to their origin, lead ores may be divided into two types:

A. The lead deposits in sedimentary rocks, the origin of which is independent of igneous activity.

The best examples of this type are the lead and zinc deposits of the
Mississippi Valley, the largest of which are in Missouri. The ore consists of galena and zinc blende, accompanied by their products of oxidation, such as sulphates, carbonates and silicates, in association with some pyrite, marcasite and a little chalcopyrite. Cadmium is often present in the zinc. The gangue minerals are dolomite, with some quartz, barite and some carbonaceous matter. The ores are confined to zones of local brecciation, joints, or crevices, which have been enlarged by solution, giving rise to gash veins. Less commonly they occupy fault fissures. Sometimes they occur disseminated in limestone or dolomite, following closely certain sedimentary horizons.

The rocks in which the deposits are found are the Paleozoic limestones, especially the Cambro-Ordovician. These limestones are known to contain lead and zinc in small amounts as sedimentary syngenetic deposits, and the present deposits are believed to have been concentrated from the limestone formations by acidic to alkaline artesian waters.

B. Lead deposits in genetic connection with the eruption of igneous rocks.

(a) The silver lead veins: The most important deposits of this type are the galena-siderite veins of the Coeur d'Alene district in Idaho. The deposits occur as veins and replacements in sericitic quartzite, and shales, of pre-Cambrian age. These have been faulted, folded and intruded by monzonites enlarging downwards. Ore shoots are large and irregular. The ores consist of galena and sphalerite, and in places a little argentite rich in silver, with small amounts of chalcopyrite, pyrite and some pyrrhotite in gangue consisting largely of siderite, with some quartz. These deposits have been formed at intermediate depths by concentration from hot ascending solutions, which have probably derived their mineral content from the monzonite intrusions.

(b) The silver-lead replacement deposits in limestone: The most important deposits of this type are those of Leadville, Colorado. The rocks consist of Paleozoic sediments resting on granite and gneiss. These formations have been intruded by numerous sheets of porphyry, which mainly lie parallel to the bedding, but in places cut diagonally across it. The intrusions and the ore deposition were followed by considerable folding and faulting. The ore, consisting of argentiferous galena, sphalerite, and pyrite, oc-
curs chiefly in the blue limestone of lower carboniferous age.
These deposits have been formed at intermediate depths by ascending solutions of doubtful origin, but charged with emanations from the igneous intrusions.

**LEAD INDUSTRY IN 1915**

The lead industry in 1915 made good gains in output, both in mining and smelting. The lead content of ore mined in the United States was apparently over 600,000 short tons, compared with 522,864 tons in 1914, an increase of 78,000 tons, or 15 per cent. With the higher prices prevailing, the percentage of increase in value of the 1915 output was even greater as compared with other years.

During 1915 construction was begun on one lead smelter and plans were completed for another, both to treat ore from the Coeur d'Alene district of Idaho. The Hercules Mining Company purchased the copper smelter at Northport, Wash., and began the construction of two lead furnaces. This company is affiliated with the Pennsylvania Smelting Company of Pittsburg, Pa. The Bunker Hill and Sullivan Company of the Coeur d'Alene district also completed plans for a smelter, but the site is yet in abeyance. The National refinery of the American Smelting & Refining Company, at Chicago, was dismantled, and the Balbach Smelting & Refining Company abandoned its older lead plant at Newark, N. J.

The following estimates have been compiled by C. E. Siebenthal from reports to the United States Geological Survey by all the lead refineries and soft-lead smelters in operation during the year, except two smelters in the Joplin district, for which estimates have been made. These reports cover actual production for the first 10 or 11 months of the year, with an estimate for the remainder of the year, and from them the figures of production are made up without change. The statistics of imports, exports, and lead remaining in warehouse have been taken from the records of the Bureau of Foreign and Domestic Commerce for 10 months, the figures for November and December having been estimated.

**LARGEST PRODUCTION TO DATE**

The production of refined lead, desilverized and soft, from domestic and foreign ores in 1915 was approximately 565,000 short tons, worth at an average New York price $53,110,000, compared with 542,122 tons, worth $42,285,500, in 1914, and with 462,460 tons in 1913. The figures for 1915 do not include an estimated output of 20,500
tons of antimonial lead, worth $1,886,000, against 16,667 tons in 1914, and 16,665 tons in 1913. Of the total production, desilverized lead of domestic origin, exclusive of desilverized soft lead, is estimated at 306,682 tons, against 311,069 tons in 1914, and 250,578 tons in 1913; and desilverized lead of foreign origin at 49,318 tons, compared with 29,328 tons in 1914, and 50,582 tons in 1913. The production of soft lead, mainly from Mississippi Valley ores, is estimated at 210,000 tons, compared with 201,725 tons in 1914 and 161,300 tons in 1913. The total production of lead, desilverized and soft, from domestic ores, was thus about 516,682 tons, compared with 512,794 tons in 1914.

The final figures for the production of soft lead will show an increase of a few thousand tons over those here given, for the reason that the smelters and refiners of argentiferous lead undoubtedly treated more or less soft lead from the Mississippi Valley which is not distinguished from silver-lead ores in their preliminary estimates.

IMPORTS AND EXPORTS

The imports of lead are estimated at 9,625 short tons of lead in ore, valued at $653,000; 50,825 tons of lead in base bullion, valued at $3,496,000; and 400 tons of refined and old lead, valued at $28,000—a total of 60,850 tons, valued at $4,177,000, compared with 28,338 tons in 1914. Of the imports in 1915 about 58,000 tons came from Mexico, against 23,141 tons in 1914. These imports from Mexico are to be compared with an average of over 100,000 tons before the civil strife in that country. The remaining imports of lead came mostly from Chile.

The exports of lead of foreign origin smelted or refined in the United States again show an increase, being estimated at 43,000 tons, against 31,051 tons in 1914, and 54,301 tons in 1913. For the last two years, on the other hand, notable quantities of domestic lead have been exported to Europe, and the total for 1915 is estimated at 76,000 short tons, valued at $6,650,000, compared to 58,722 tons, valued at $4,501,674, in 1914.

LEAD AVAILABLE FOR CONSUMPTION

The amount of lead available for consumption during 1915 may be estimated by adding to the stock of foreign lead (domestic stocks are not known) in bonded warehouses at the beginning of the year (7,668 short tons) the imports (about 60,850 tons) the additions by liquidation (1,795 tons) and the domestic production (516,682 tons) making an apparent supply of 587,000 tons. From this are to be sub-
tracted the exports of foreign lead (about 43,000 tons) the exports of domestic lead (76,000 tons) and the stock in bonded warehouses, at the close of the year (assumed to be the same as at the close of October, 16,000 tons), leaving as available for consumption 452,000 tons, compared with 449,052 tons in 1914.

HIGH PRICES

Lead began the year at New York with a price of 3.8 cents per pound, nearly the minimum price of the year, and remained practically stationary until the middle of February. A gradual rise brought the price to 4.2 cents in April, and it remained there until the later part of May. A rapid rise next followed, and lead reached the maximum for the year at 7.56 cents on June 14. A sharp decline, followed by partial recovery and then by a more general decline, brought the price to 4.4 cents in the later part of August. After a slight recovery and another decline to 4.45 cents in September, the price gradually rose and closed the year at about 5.4 cents. The average New York price for the year was 4.7 cents a pound, compared with 3.9 cents in 1914 and 4.4 cents in 1913.

The London price of lead started at 4.1 cents a pound and rose until the later part of March, when it reached 5 cents a pound. From this point the price fell to 4.3 cents a pound, after which there was sharp ascent to 6.1 cents per pound at the middle of June. After several ups and downs the price dropped to 4.4 cents by the middle of August, and then a gradual rise carried it to 6.3 cents, and it closed the year at that figure. The London market was fairly parallel to the New York market, and except for the period of high prices in the United States during July and August, was uniformly higher than the American market.

LEAD INDUSTRY IN ARIZONA

Mohave County is the center of lead mining in Arizona, followed closely by Santa Cruz and Pima counties. It is also found scattered in many localities in Arizona, mostly as lead-silver veins.
The following table shows the production of lead in Arizona since 1894, in short tons:

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity</th>
<th>Year</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1894</td>
<td>1480</td>
<td>1905</td>
<td>2091</td>
</tr>
<tr>
<td>1895</td>
<td>2053</td>
<td>1906</td>
<td>2884</td>
</tr>
<tr>
<td>1896</td>
<td>1165</td>
<td>1907</td>
<td>2418</td>
</tr>
<tr>
<td>1897</td>
<td>2184</td>
<td>1908</td>
<td>1464</td>
</tr>
<tr>
<td>1898</td>
<td>2224</td>
<td>1909</td>
<td>1507</td>
</tr>
<tr>
<td>1899</td>
<td>3377</td>
<td>1910</td>
<td>948</td>
</tr>
<tr>
<td>1900</td>
<td>....</td>
<td>1911</td>
<td>3428</td>
</tr>
<tr>
<td>1901</td>
<td>4045</td>
<td>1912</td>
<td>3891</td>
</tr>
<tr>
<td>1902</td>
<td>599</td>
<td>1913</td>
<td>4901</td>
</tr>
<tr>
<td>1903</td>
<td>1493</td>
<td>1914</td>
<td>5602</td>
</tr>
<tr>
<td>1904</td>
<td>1499</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PRICES**

The prices of lead during 1915 were taken up above. The following table shows the highest and lowest monthly prices of lead at New York in cents per pound:
<table>
<thead>
<tr>
<th>Year</th>
<th>January Highest</th>
<th>January Lowest</th>
<th>February Highest</th>
<th>February Lowest</th>
<th>March Highest</th>
<th>March Lowest</th>
<th>April Highest</th>
<th>April Lowest</th>
<th>May Highest</th>
<th>May Lowest</th>
<th>June Highest</th>
<th>June Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1901</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
</tr>
<tr>
<td>1902</td>
<td>4.10</td>
<td>4.00</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
</tr>
<tr>
<td>1903</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
</tr>
<tr>
<td>1904</td>
<td>4.50</td>
<td>4.45</td>
<td>4.50</td>
<td>4.40</td>
<td>4.60</td>
<td>4.50</td>
<td>4.60</td>
<td>4.50</td>
<td>4.60</td>
<td>4.50</td>
<td>4.60</td>
<td>4.50</td>
</tr>
<tr>
<td>1905</td>
<td>4.60</td>
<td>4.45</td>
<td>4.50</td>
<td>4.45</td>
<td>4.50</td>
<td>4.45</td>
<td>4.50</td>
<td>4.45</td>
<td>4.50</td>
<td>4.45</td>
<td>4.50</td>
<td>4.45</td>
</tr>
<tr>
<td>1906</td>
<td>5.60</td>
<td>5.60</td>
<td>5.60</td>
<td>5.35</td>
<td>5.50</td>
<td>5.35</td>
<td>5.50</td>
<td>5.35</td>
<td>5.50</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
</tr>
<tr>
<td>1907</td>
<td>6.00</td>
<td>6.00</td>
<td>6.10</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>1908</td>
<td>3.80</td>
<td>3.55</td>
<td>3.75</td>
<td>3.70</td>
<td>4.00</td>
<td>3.65</td>
<td>4.10</td>
<td>3.90</td>
<td>4.37,2</td>
<td>4.00</td>
<td>4.52,2</td>
<td>4.32,2</td>
</tr>
<tr>
<td>1909</td>
<td>4.22,2</td>
<td>4.12,2</td>
<td>4.15</td>
<td>3.92,2</td>
<td>4.10</td>
<td>3.92,2</td>
<td>4.25</td>
<td>4.10</td>
<td>4.35</td>
<td>4.20</td>
<td>4.35</td>
<td>4.35</td>
</tr>
<tr>
<td>1910</td>
<td>4.30</td>
<td>4.70</td>
<td>4.70</td>
<td>4.52,2</td>
<td>4.60</td>
<td>4.35</td>
<td>4.40</td>
<td>4.35</td>
<td>4.37,2</td>
<td>4.25</td>
<td>4.40</td>
<td>4.30</td>
</tr>
<tr>
<td>1912</td>
<td>4.50</td>
<td>4.25</td>
<td>4.35</td>
<td>4.05</td>
<td>4.25</td>
<td>4.05</td>
<td>4.25</td>
<td>4.05</td>
<td>4.20</td>
<td>4.15</td>
<td>4.50</td>
<td>4.20</td>
</tr>
<tr>
<td>1913</td>
<td>4.37,2</td>
<td>4.35</td>
<td>4.40</td>
<td>4.35</td>
<td>4.40</td>
<td>4.35</td>
<td>4.40</td>
<td>4.35</td>
<td>4.50</td>
<td>4.35</td>
<td>4.40</td>
<td>4.35</td>
</tr>
<tr>
<td>1914</td>
<td>4.20</td>
<td>4.10</td>
<td>4.20</td>
<td>4.00</td>
<td>4.00</td>
<td>3.80</td>
<td>3.95</td>
<td>2.80</td>
<td>3.95</td>
<td>2.90</td>
<td>3.90</td>
<td>2.90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>July Highest</th>
<th>July Lowest</th>
<th>August Highest</th>
<th>August Lowest</th>
<th>September Highest</th>
<th>September Lowest</th>
<th>October Highest</th>
<th>October Lowest</th>
<th>November Highest</th>
<th>November Lowest</th>
<th>December Highest</th>
<th>December Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1901</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
<td>4.37,2</td>
</tr>
<tr>
<td>1902</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
</tr>
<tr>
<td>1903</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
<td>4.10</td>
<td>4.05</td>
</tr>
<tr>
<td>1904</td>
<td>4.30</td>
<td>4.10</td>
<td>4.20</td>
<td>4.10</td>
<td>4.20</td>
<td>4.20</td>
<td>4.20</td>
<td>4.20</td>
<td>4.20</td>
<td>4.20</td>
<td>4.20</td>
<td>4.20</td>
</tr>
<tr>
<td>1906</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
<td>5.75</td>
</tr>
<tr>
<td>1907</td>
<td>5.75</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>4.75</td>
<td>4.75</td>
<td>4.75</td>
<td>4.75</td>
<td>4.75</td>
<td>4.75</td>
</tr>
<tr>
<td>1908</td>
<td>4.52,2</td>
<td>4.40</td>
<td>4.62,2</td>
<td>4.47,2</td>
<td>4.60</td>
<td>4.52,2</td>
<td>4.75</td>
<td>4.20</td>
<td>4.40</td>
<td>4.25</td>
<td>4.50</td>
<td>4.12,2</td>
</tr>
<tr>
<td>1911</td>
<td>4.60</td>
<td>4.50</td>
<td>4.60</td>
<td>4.55</td>
<td>4.55</td>
<td>4.50</td>
<td>4.50</td>
<td>4.25</td>
<td>4.50</td>
<td>4.25</td>
<td>4.50</td>
<td>4.50</td>
</tr>
<tr>
<td>1912</td>
<td>4.75</td>
<td>4.50</td>
<td>4.85</td>
<td>4.47,2</td>
<td>5.12,2</td>
<td>4.80</td>
<td>5.15</td>
<td>5.00</td>
<td>5.00</td>
<td>4.50</td>
<td>4.50</td>
<td>4.37,2</td>
</tr>
<tr>
<td>1913</td>
<td>3.90</td>
<td>3.90</td>
<td>3.90</td>
<td>3.90</td>
<td>3.90</td>
<td>3.75</td>
<td>3.70</td>
<td>3.50</td>
<td>3.95</td>
<td>3.85</td>
<td>3.85</td>
<td>3.80</td>
</tr>
</tbody>
</table>
A complete discussion of the metallurgy of lead is not within the scope of this paper. The following are the principles utilized in the extraction of lead from its ores:

1. **The reduction process:** this is applicable to the oxides which are reduced to the metallic state by carbon, as shown by the equation
\[ \text{PbO} + \text{C} \rightarrow \text{Pb} + \text{CO}. \]

2. **The roast-reaction process:** the sulphide ore is oxidized in a reverberatory furnace to the sulphate, as shown by the equation
\[ \text{PbS} + 2 \text{O}_2 \rightarrow \text{PbSO}_4. \] The oxygen acting upon the sulphate formed in the presence of a new charge of ore reduces the sulphate to the oxide. The interaction between the oxide and a new charge of the sulphide ore results in the reduction of metallic lead as shown by the equation
\[ 2 \text{PbO} + \text{PbS} \rightarrow 3 \text{Pb} + \text{SO}_2. \] This process is applicable to galena free from the sulphides of the heavy metals.

3. **The smelting or precipitation process:** The ore is first given an oxidizing roast. The oxide is then smelted with suitable fluxes in a blast furnace, and metallic lead is produced. This lead is impure and has to be refined.

4. **The lime-roasting process:** This method depends upon the treatment of galena with lime or gypsum under conditions favorable for oxidation.

**USES OF LEAD**

The properties of lead are such as to make it one of the most useful metals. Its chief use is in the manufacture of sheet lead for various purposes; it is extensively used for lead pipes, for lining of acid containers, for paint, for lead shot, etc.