AN ILLUSTRATED HISTORY OF METALLURGY*

by Fathi Habashi, Laval University, Quebec City, Quebec

THE SEVEN METALS OF ANTIQUITY

The ancient civilizations knew only seven metals: gold, silver, copper, iron, mercury, tin, and lead. They also knew seven celestial bodies: the sun, the moon, and the five planets — Venus, Mars, Mercury, Jupiter, and Saturn, which they thought all revolved around the earth. This coincidence apparently suggested a relationship between metals and the celestial bodies. Each metal was thus associated with one of the celestial bodies, and the symbols of these bodies also became the symbols of their respective metals. Thus, gold was denoted by the sun's symbol of a full circle (Fig. 1), which represents mathematical perfection, because as the sun was the dominant celestial body, gold had a similar ranking among metals. Gold was also associated with the sun by virtue of its bright yellow colour.

Silver, which ranked second in perfection and so was associated with the moon, was denoted by a half circle resembling the crescent moon (Fig. 2). The association of silver with the moon was reinforced by the metal's appearance. Because it was the warrior's metal, iron was associated with Mars, the planet of the god of war. The metal was therefore denoted with a shield and spear (Fig. 3). The symbols of the remaining metals incorporated a cross to signify the connection between alchemy and religion. In addition to a cross, copper was denoted by a full circle because of its red colour, which resembles gold more than the other metals. In this way the copper symbol came to resemble a hand mirror and was often called the looking glass of Venus (Fig. 4). It closely resembles the ancient Egyptian sign ankh ☥ which signifies the sun's gift of life to the earth and, as such, everlasting life.

As its name suggests, quicksilver moves quickly, so the metal was associated with Mercury, the planet of the messenger of the gods. This is also the origin of the modern term mercury. The quicksilver symbol also included a circle topped by the crescent of silver, to denote the close similarity in colour and brightness of the metals (Fig. 5). The symbols of tin (Fig. 6) and lead bore a close resemblance because they were often considered to be only variants of the same metal or a debased form of silver. This was the reason for the symbols' curved sections, reminiscent of the crescent of the moon. Tin was related to Jupiter. As lead was heavy and dull, it was the least valued of all metals and came under the influence of Saturn, which was the farthest from the earth of all known planets (Fig. 7).

1

2

3

4

5

6

7

All this information is shown on the seven stamps issued by the tiny Marshall Islands in the central Pacific Ocean. These 34 atolls and coral islands were discovered in 1526 by Spanish explorers and visited in 1788 by Captains Gilbert and Marshall. They were German protectorates from 1885 to 1914, occupied by Japan in 1914, then captured by U.S. forces in 1944. In 1947, they were included as a U.S. Territory of the Pacific Islands under United Nations trusteeship. One of the islands, the Bikini atoll, was the site of a U.S. atomic bomb test in 1946, that representatives from many foreign countries were invited to witness.

The Number Seven

There are seven metals, seven planets, seven days, the seven colours of the rainbow, and much more. The ancient Greeks recognized only seven wonders although many more were certainly known. It is attributed to Pythagoras (582-506 BC?) that the number seven is unique because it represents the sum of the angels of the two fundamental geometrical figures — the triangle and the square. In the Orient, there are celebrations seven days after a baby is born, at 14, when he is an adolescent, and at 21, when mature (all multiples of seven). In the Bible, the story of Joseph mentions seven lean and seven good years. In the Koran, the number seven is mentioned at least twenty-four times: seven heavens, seven cows, etc. The pilgrims to Mecca tour around the Kaaba seven times. Saint Ignatius of Loyola (1491-1556) mentioned the seven deadly sins in his Spiritual Exercises published in 1522. Even in modern times, the pH of a neutral solution is 7! But of course, God's Commandments to Moses were ten and the basic Christian doctrine is a trinity.

*Paper presented at the Conference of Metallurgists, Hamilton, Ontario, August 24, 2004.

METALS IN ANCIENT CIVILIZATIONS

Metals play an important role in modern life and archeological finds are a reminder that they were produced and used by the ancient people. Gold was the first metal used by man and was exploited on a large scale in ancient Egypt, for example, the gold mask of Tut Ankh Amoun (Fig. 8). Switzerland issued a number of stamps showing archeological finds. Some of the objects were made of gold, e.g. a bust of Emperor Marc Aurel (Fig. 9).

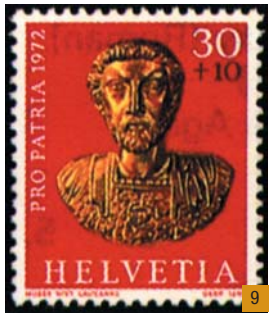
There are three gold museums in South America and one in Central America that preserved gold artifacts from the Inca and other ancient civilizations. They are located in Bogota (Colombia), Lima (Peru), La Paz (Bolivia), and San José (Costa Rica).

The first use of copper was around 4000 BC; the Bronze Age came few centuries later when it was discovered that adding tin or tin ore produced a metal of better quality and one that was easier to melt. The Romans actively exploited the copper mines in Cyprus and the name copper is derived from this Mediterranean island. Figure 10 shows a map of Cyprus, a copper ingot as produced in ancient times, and a sailing boat for shipping the product. Ancient Cypriot metal workers used bellows to raise the temperature of charcoal to reduce copper ore.

In the ancient civilizations of the Far East, bronze was also extensively used. Among the oldest surviving bronze is that found in China, dating back to the Shang dynasty (1766-1122 BC). In this period, some of the most distinctive metal objects ever made, bronzes of astonishing complexity, were produced.

The production and use of iron in ancient civilizations came much later than copper or bronze. Some of the reasons are the higher melting point of iron as compared to copper, and iron must be worked while red-hot while copper can be worked at room temperature. Not many iron objects were found by archeologists because of corrosion. The Delhi Iron Pillar is probably the most important iron object that survived nearly 1,500 years (Fig. 11). The pillar, which is composed of nearly pure iron, has a total height of 7.5 metres of which one meter is underground. The diameter at its largest point is 40 centimetres and it weighs seven tons. It dates back to the fourth century AD, during the reign of the Guptas, who united India and ruled from 320 AD to 480 AD. It is a masterwork of Indian metallurgists that could be simulated in Europe no less than one thousand years later.

8



9

10

11

12

13

The Catalan forge came into use about 700 AD in Andorra, in northeast Spain. The furnace had built up sides of stone forming a short shaft into which charcoal and iron ore were loaded. Air was forced into the charcoal by bellows through a nozzle at the bottom of the furnace. The air produced higher temperatures and allowed larger amounts of ore to be smelted at one time. However, the temperature was not high enough to melt the iron and the result was still wrought iron. Canada's first iron works, Les Forges du Saint Maurice, is located near Trois-Rivières in Québec. The site has been renovated and kept as a museum; it was recognized in 1996 by the Canadian Institute of Mining, Metallurgy and Petroleum as a National Heritage site. In 1988, on the occasion of its 250th anniversary, it was honoured by a stamp showing a smith at work (Fig. 12).

THE INDUSTRIAL AND CHEMICAL REVOLUTIONS

In 1709, the Englishman, Abraham Darby, succeeded in using coke (obtained by heating coal in a restricted air supply) to reduce the iron ore. Darby was able to build bigger furnaces because coke could support a larger load of iron ore than charcoal without crushing and extinguishing the fire. With iron ore and coal in abundance, iron production moved from the wooded districts of Sussex in southern England to the coalfields of the Midlands, South Wales, and Scotland and the industry entered a new era. Darby's factory was the first to use a Newcomen steam engine. Thus began the industrial revolution and manual labour gave way to machines driven by engines. By the 1750s, Darby's coke-based process was widespread. Darby's grandson, also named Abraham, was responsible for designing, casting, and constructing the world's first metal bridge from cast iron at Ironbridge,

MANY HISTORICAL FACTS, SOMETIMES OBSCURE, CAN BE FOUND ON STAMPS

over the River Severn, in Shropshire (Fig. 13). It used nearly 400 tons of iron and was opened in 1781.

The chemical revolution followed shortly after the Industrial Revolution. It was the French chemist Antoine Laurent Lavoisier (1743-1794) who, in 1777, explained the phenomenon of combustion and clarified the smelting process for producing metals from ores. Lavoisier was executed during the revolution because of his association with the hated tax-collecting system.

IRON AND STEEL

In 1961, the United States honoured Andrew Carnegie (1835-1919) the Scotch-American industrialist and philanthropist. By 1900, the Carnegie Steel Company produced one quarter of all U.S. steel. In 1901, it merged with the Federal Steel Company and others to form United States Steel, the largest corporation in the world.

Coke is an essential component for iron production in the blast furnace. It is produced by heating coal in special ovens in the absence of air. A stamp was issued for this operation by Bhutan in 1969 showing the old beehive ovens that were used at the beginning of the century and became obsolete a long time ago (Fig. 14). A Chinese stamp shows a large coke-making battery where coal is heated in retorts, then quenched when coming out (Fig. 15).

A modern iron blast furnace and the accompanying stoves is shown on a stamp from Belgium (Fig. 16). Bessemer's invention in 1856 was a revolutionary step in steelmaking that immediately displaced the puddling process. By blowing air through the molten pig iron, Bessemer was able to obtain steel in few minutes as compared to few days in the puddling process. In addition, no fuel was needed. This tremendous invention is shown on a stamp issued by Sweden showing one of Bessemer's first converters (Fig. 17). One hundred years later, a new technology was introduced at the Vöest plant in Linz, Austria, where a lance was used to introduce oxygen in the converter. The process became known as the LD process.

14

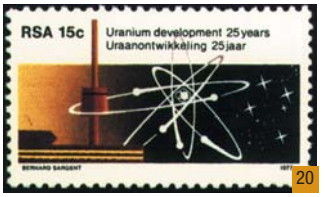

15

16

17

18

19



20

NONFERROUS METALS

Copper was the metal next to iron in terms of annual production until the 1960s when it was surpassed by aluminum. Many developing countries started light metal production, for example, Bahrain and Cameroun. Chile, at present the largest copper producer in the world, issued stamps on the occasion of nationalizing its industry. One in 1970 shows the Chilean star and a worker holding a copper ingot. Finland issued a stamp in 1983 depicting a flash smelting furnace in recognition of the innovation made by Outokumpu engineers to the copper industry (Fig. 18).

Nicaragua issued a stamp in 1983 entitled "Nationalization of the Mines," showing a technician pouring gold from a crucible in an assay lab (Fig. 19). South Africa issued a stamp in 1977 entitled "Uranium Development" to mark 25 years of nuclear power plants; the stamp shows atom symbol (Fig. 20).

EPILOGUE

Postage stamps are important means of communication and many countries have recorded important events, honoured worthy individuals, and described interesting facts through this medium. Many historical facts, sometimes obscure, can be found on stamps; some of these may not be easily located in a history or a science book. Stamps have artistic value, they are created by artists and are also a means for propagating culture: music, painting, sculpture, nature, etc. They are used every day and can be found everywhere. This history of metallurgy article is a selection of stamps that tell the story of metals, metallurgists, and metallurgical processes from ancient times to the present day.

REFERENCES

HABASHI, F., HENDRICKER, D., and GIGNAC, C., 1999. Mining and Metallurgy on Postage Stamps. Métallurgie Extractive Québec. Distributed by Laval University Bookstore Zone, 350 p.