Lead between the lines

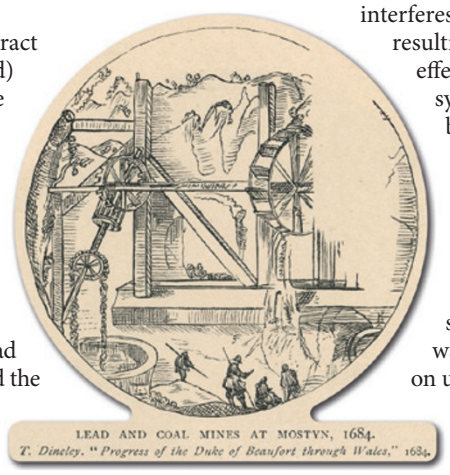
Somobrata Acharya explores the history, properties and uses of lead — an ancient metal that is still very relevant to today's technologies, but should be used with caution.

Lead was one of the first metals known to man. The history of element 82 can be traced back to as early as 6,400 BC from the Neolithic settlement Çatalhöyük (situated in the central part of modern day Turkey). The *opheret* of the Hebrews and *molybdos* of the ancient Greeks was referred to as 'lead' in the Old Testament[1]. Commonly used throughout the Antiquity, it is also believed to have been used in the 'Hanging Gardens' of Babylon, as sheets to retain moisture. Widespread applications — for example for water pipes throughout the Roman Empire — arose from the fact that this flexible and malleable heavy metal is abundant and easy to use; furthermore, its properties can be tuned by alloying it with other metals, such as copper or antimony. It played a crucial role during the Industrial Revolution.

Lead's symbol Pb originates from its Latin name, *plumbum* — which actually used to refer to soft metals more generally. In fact, lead and tin were not clearly distinguished until the sixteenth century, when lead was referred to as *plumbum nigrum* (black lead) and tin as *plumbum candidum* or *album* (bright lead). The Latin root name has persisted in other languages — for example it is 'plomb' in French — and in English through the words 'plumber' and 'plumbing', as lead was a popular material for pipes owing to its high corrosion resistance.

Pure lead is bluish-white in colour with a bright lustre, and crystallizes in a face-centred-cubic structure, with no known allotropic modifications[2]. On exposure to moisture this lustre is lost through the formation of an oxide coating that protects the underlying metal. Lead is found in nature, rarely in pure form but in ores with other metals — the most abundant one in the Earth's crust being galena (PbS). Natural formation of lead occurs by radioactive decay of uranium and thorium through radon (^{222}Rn). Four stable isotopes are known, ^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb, the first three of which are used for estimating the ages of rocks. Lead compounds exist mainly in +2 or +4 oxidation states, the former being more common.

An early route to extract lead from ores (pictured) involved roasting an ore in air, which converts its lead sulfide to oxide and sulfate forms, and subsequently smelting those with limestone and coke to obtain crude lead. Today about half of the annual production of lead comes from mining, and the rest from recycling.



LEAD AND COAL MINES AT MOSTYN, 1684.
T. Dineley. "Progress of the Duke of Beaufort through Wales," 1684.

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Lead compounds are associated with several significant discoveries crucial to modern technologies. Rectifying properties were discovered at metal–galena point contacts by F. Braun in 1874[3]. In 1901 J. C. Bose detected an electromagnetic wave using galena — a key event for the development of the radio[4]. Infrared detectors based on lead chalcogenides (that is, sulfides, selenides and tellurides) represented a major advance in infrared technology, for example for night vision and for the spectroscopic analytical techniques that are now available to chemists. Lead chalcogenides are also characterized by low direct-bandgaps, which change depending on the sizes of the crystallites and cover a broad spectral range — a phenomenon called the quantum confinement effect, which forms the basis for devices such as field-effect transistors, solar cells and photodetectors.

The widespread production and consumption of lead continued until the twentieth century, through uses in petrol, lead-acid batteries, paint, radiation shielding and in the polyvinyl plastic industry as a stabilizer. However, humans are susceptible to lead poisoning by either acute or, more often, chronic exposure.

Lead accumulates in the body and interferes with various processes, resulting in neurotoxic effects with a variety of symptoms. Even as far back as the Roman period maladies were correlated with lead, through the use of 'lead sugar' (lead acetate) beverages and pipes for water supply. Yet these early warnings were not acted on until the mid-twentieth century, from which point the use of lead started being closely monitored in many countries — resulting in measures such as bans from petrol and paint.

Fortunately, lead poisoning can now be treated with chelating agents (typically ethylene diamine tetraacetate), using their greater affinity to the heavy metal to form complexes that can be expelled from the body. Sadly it is estimated that, at current use rates, the metal we've relied on for thousands of years will run out in about four decades. A more positive side of this situation is that these developments are generating renewed interest in recycling and thoughtful progress in fuel-cell technology. ❐

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