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Review

Gregorius Agricola memorial lecture: Lung cancer—A work-related disease for 500 years, as predicted by Agricola

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ABSTRACT

In the early 16th century Gregorius Agricola reported on Bergsucht (miner's consumption) in mine workers in the Erzgebirge. About 350 years later, Härting and Hesse reported on large numbers of lung cancers among the mine-workers in the same mine district, thus confirming that *Bergsucht* primarily was *lung cancer*, but could also have been pnumoconiosis or tuberculosis or a combination of both. Mining for bismuth continued another 75 years – through World War II. Bismuth mining was replaced by large scale uranium mining from the late 1940 through 1989, employing some 400–450,000 workers, resulting in the major local epidemic of work-related cancer larger than anywhere in the world, so far amounting to ±14–15,000 cases. Had the mine developers listened to the warnings by Agricola and Härting and Hesse, the epidemic could have been prevented.

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Introduction

Gregorius Agricola – a Saxonian scholar and scientist – was born at Glauchau on March 24th, 1494 and he passed away in Zwickau, Saxony on November 21, 1555. His birth-name was Georg Pawer (*Bauer* in modern German), but he Latinized his name to Agricola, by which he was known throughout his entire adult life. He is known as "the father of mineralogy" and his most well known textbook in this field is *De Re Metallica* (Zurich and Deventer, 1556), in which he also reported on a work-related disease that later has proven to be lung cancer.

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Education and early career

Agricola was gifted with a precocious intellect. He early threw himself with great success into the pursuit of the "new learning". Aged 24 he was appointed *Rector extraordinarius* of the Greek School of Zwickau, where he started as a writer on philosophy. At the time in the years before the Lutheran reformation Zwickau was in a state of religious controversies. A religious rebel of Thuringia – Thomas Münster – turned up in Zwickau in 1520 to become a Lutheran agitator when preaching in the St. Mary Church.

After 2 years Agricola gave up his appointment at the Greek School of Zwickau to pursue his studies at Leipzig, where he received support and encouragements from the professor of classics, Peter Mosellanus (1493–1525), a famous humanist of the time, with whom he had already corresponded. In Leipzig he also devoted himself to the study of *medicine*, *physics*, and *chemistry*. After Mosellanus passed away, Agricola went to *Padua*, Italy, where he completed his medical education during 1524–1526.

Agricola and mineralogy

Agricola returned to Zwickau in 1527 and was soon chosen as town physician at Joachimsthal a center of mining (currently in the Czech republic). His intention was to scrutinize and revise what had been written about mineralogy through careful observation of ores and the methods of their treatment. His education in philosophy appeared to be useful to enable him in developing – from his observations of minerals – a logical system which he established from 1528 an onwards. Agricola's textbook "*Bermannus, sive de re metallica dialogus*" (1530) [*Bermannus; or a dialog on metallurgy*], reflecting his first attempts to reduce to scientific order the knowledge won by practical work. His work that resulted in this textbook also brought Agricola in contact with *Erasmus van Rotterdam* who wrote an approving letter at the beginning of the book.

As of 1530 *prince Maurice* of Saxony appointed Agricola historiographer with an annual allowance and he accordingly moved back to Chemnitz, the center of the mining industry in the kingdom of Saxony, to expand the range of his observations. The citizens of Chemnitz showed their appreciation by appointing him to town physician in 1533. In that year he also published a book about Greek and Roman weights and measures, *De Mensuis et Ponderibus*.

Agricola's De Re Metallica

He completed this immense textbook comprising 12 volumes in 1550, but it was not printed before 1556 – in Zurich and Deventer. He described many mining-methods that are now obsolete, e.g. fire-setting, a method involved building fires against hard rock faces, subsequently quenching the hot rock with water, which gave a thermal shock cracking the rock-face sufficiently for manual removal. Due to the toxic gases from the fires the method was hazardous when used underground. In spite of that it was applied for hundreds of years until made redundant when replaced by powder and later by dynamite. In an appendix to the textbook the German equivalents for the technical terms used in the Latin text was listed. Modern words that derive from the Agricola's textbook include *fluorspar* (from which was later named fluorine) and bismuth.

Lung diseases in miners

In this textbook Agricola also reported on the hazards of "foul air", cold and wet conditions, toxic effects of heavy metal, as well as on how to prevent accidents in mines. He reported on respiratory diseases among miners, which he attributed to exposure to dust; quoting Agricola verbatim: it "*..penetrates into the windpipe and lungs, and produces difficulty in breathing, and the disease which the Greeks call* ἄσθμα" (Bergsucht), and further: "*.. it eats away the lungs, and plants consumption in the body*" [1]. Agricola made no mention of having performed autopsies on deceased miners, but it seems likely that he did so, otherwise he would not have discovered that whatever disease he was describing that "eats away the lungs" as well as *pneumoconiosis*, the latter along with tuberculosis, both traditional diseases of miners.

In accord with Hoover and Hoover [1], there are no reports in the textbook pointing directly to detection of lung cancer – a localized disease that does not "*eat away the lungs*". *Tuberculosis* is an infectious disease caused by the bacterium *Mycobacterium tuberculosis* that causes liquefaction of lung tissue and subsequent cavities, thus it "*eats away the lungs*".

Elements in the Erzgebirge and toxic effects to the environment

In 12 volume books *De Re Metallica* Agricola attributed and extensive deaths of fish in rivers to pollution by metals and minerals. He also pointed at cutting down of forests for mine construction and for ore smelting, lead to eradication of birds in Saxony. Many other mineral resources are available in the same deposits, i.e. Sn, W, Zn, Fe, Cu, Bi, Co, Ni, Ag, As, In, Cd, Nb; Ta, phosphate, barite, fluorite. In total 251,510 tons of uranium was mined at Wismut AG 1946–1990.

Trace elements and healthiness

As of 1660 a well with mineral-rich water was detected in Ronneburg. Soon after, this will was used as site for alleged healing – in particular for rheumatoid diseases. The claimed healing effect of the water was attributed to high content of acid iron carbonate. Duke *Friedrich III* of Saxony-Gotha ordered construction of a temple-like building on the top of the well and from 1769 and onwards the duke spent weeks each year at the well site for his health. Ronneburg was at the time one of the most significant bath- and healing sites in the German area and from 1666 to 1935 the official name of the town was *Bad Ronneburg*.

The detection of uranium and related health hazards

On August 18th, 1785 Johann Wolfgang von Göthe traveled from *Karlsbad* to *Johanngeorgenstadt* to collect rock samples. In one of the mines ("Georg Wagsfort") in this village (currently in the Czech republic), JW von Göthe collected a piece of mineral named "Pechblende" that he called the "Joachimsthaler Suite" and he added the sample to his mineral collection. Four years after Göthe's visit in Johanngeorgenstadt a sample of Pechblende from the same mine was sent to the pharmacist Martin H. Klaproth in Berlin for analyses. In this sample Klaproth found a new element that he gave the name *Uran* – after the planet *Uranus* – which had been detected by Friedrich W. Herschel just 8 years earlier. The planet had been named after the Greek God *Uranos* (Greek, *uranos = heven*).

Mining in the Schneeberg for six centuries

Mining for *copper*, *silver* and *iron* started in the Schneeberg mountains about 1410 [5]. Over the years many shafts were sunk in the district and *cobalt*, *nickel* and *manganese* were also identified and mined. The recovery of and processing of uranium ores for glass manufacture and for luminescent material began in 1820. By the late 19th century there was a complex of six mines employing on average some 650 miners who extracted ore largely for the production of nickel, cobalt and bismuth. After World War II these mine-area became the source of uranium for the Soviet Union's military and energy purposes.