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Historia medicinae

St. Joachimstal : pitchblende, uranium and radon-induced lung cancer

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This article is based on a presentation [1] given at the 2005 annual meeting of the Radiological Society of North America. Without the mining of pitchblende at St. Joachimstal at the end of the 19th century, and its availability to the Curies, the discovery of radium would have been delayed. The uranium bearing ore carnotite in Colorado and Utah only became available after World War I and in any event this ore was far less uranium-rich than the St. Joachimstal pitchblende. Pitchblende deposits in the Belgian Congo (now Zaire), were only processed for radium by the Union Minière du Haut Katanga in the early 1920s. This article briefly describes the mining activities at St. Joachimstal. Uranium ore was first mined at the end of the 16th century although lead mining had occurred since the 12th century. By 1959 the mines were essentially depleted of pitchblende and in 1981 all but one, the Concordia mine which was then still open, were flooded. The miners' disease first recorded in the 16th century was eventually identified as radon-induced lung cancer. Finally, speculation is made with regard to who might have discovered radium if the Curies did not, because enough pitchblende was just not available to them in Paris in the late 1890s.

Key words: pitchblende, radium, St. Joachimstal

Introduction

St. Joachimstal

The village, later a town, of St. Joachimstal, came into being solely because of the mining activities which first began in the 12th century. The name means St. Joachim's valley after the father of the Virgin Mary (Figure 1). Today, St. Joachimstal which was originally in Bohemia is now in the Czech Republic and renamed Jáchymov. It is situated on the border with Germany (Saxony) and the ore mountains (Erzgebirge) span the border. The largest mining area on the German side of the mountains is Schneeberg. It is recorded in the Metske Museum in Jáchymov that Marie Curie visited the town in 1925 and there still exists a memorial to Marie and Pierre Curie in Jáchymov.

Pitchblende and radium

Without access to St. Joachimstal pitchblende (in the German language pech means pitch or bad luck), radium

Figure 1. A midwife handing the Virgin Mary to Saint Joachim after her first bath. Saint Anne, the mother of the Virgin Mary is in bed recovering from the birth. The lettering in this line engraving states 'Nativitas gloriosae Virginis Mariae' (Courtesy The Wellcome Library, London)

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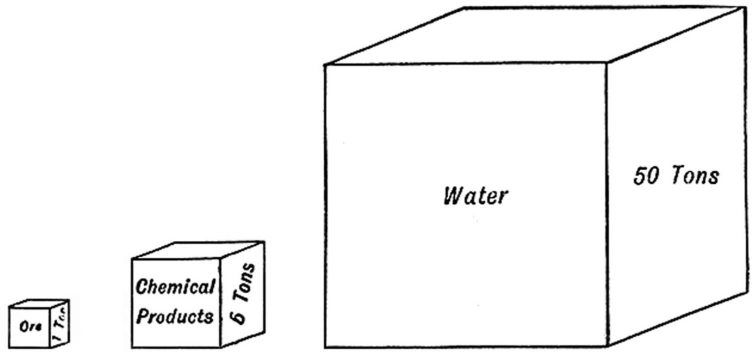

Figure 2. Schematic diagram in the first ever textbook devoted solely to radium therapy which shows the proportions of materials necessary to obtain 2-5 cg of pure radium bromide [2]

treatments would probably have been delayed by several years and radiation oncology would have relied solely on X-rays, perhaps until the early 1920s when pitchblende was found in the Belgian Congo (now Zaire), and was processed for radium by the Union Minière du Haut Katanga. This is a reasonable statement when it is considered that by 1910, in order to obtain 2-5 centigram of pure radium bromide it required 1 ton of pitchblende ore, (Figure 2) [2].

The Parisian physician authors of *Radiumtherapy* [2] Louis Wickham and Paul Degrais, describe the sources then available for pitchblende, in the following terms. 'The principal pitchblende workings are those at St. Joachimstal in Bohemia, in a mountainous region, 16

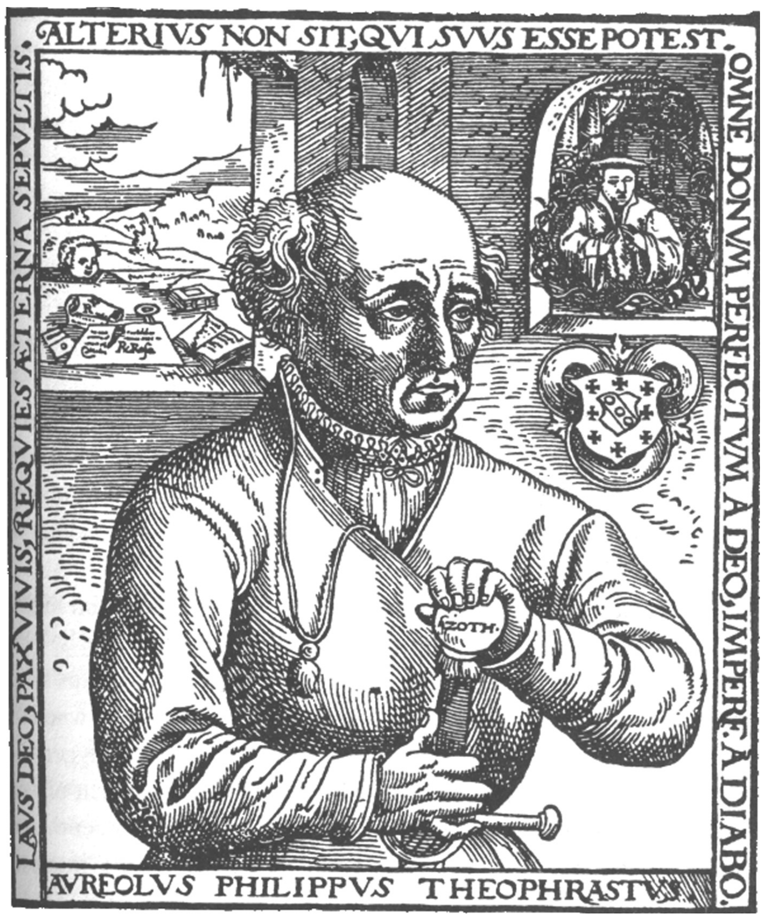

Figure 3. Paracelsus (1493-1541) a metallurgist turned physician. His real name was Theophrastus Phillipus Aureolus Bombastus von Hohenheim but he chose call himself Paracelsus. This means greater than Celsus (c. 25 BC – 50 AD), the famous physician of ancient Rome. Paracelsus made the statement that 'the true use of chemistry is not to make gold but to prepare medicine' and added greatly to the knowledge of compounds. He knew of ether and its narcotic action which he tested on chickens, and he used mercury as a diuretic

kilometres from Carlsbad, as the crow flies. There are many other pitchblende mines, the most important being in Bohemia, Hungary, Saxony, Turkey, Sweden, Canada, Colorado and Cornwall'.

When radioactivity was discovered by Antoine-Henri Becquerel in 1896 it is only recorded that he was working with 'uranium salts' and the source of these salts is not known. They were probably from the collection of minerals of his father Edmond Becquerel, whom he succeeded as Professor of Physics at the Muséum National d'Histoire Naturelle. However, it is known that the Muséum possessed a sample of pitchblende (uraninite-pechblende, UO_2 cubique) as one was loaned to Marie Curie in 1897 by the Muséum's Professor of Mineralogy, A. Lacroix [3]. Some of Marie Curie's experimental results are quoted by Sir Joseph Thomson, Director of the Cavendish Laboratory, Cambridge, in 1903 showing that she used four pitchblende sources which were from: Johanngeorgenstadt, Joachimstal, Priban and Cornwall [4]. St. Joachimstal (or Joachimsthal) was later named only Joachimstal and then still later, Jácymov: it is now in the Czech Republic.

Paracelsus, Agricola and Bergkrankenheit

The mountains of St. Joachimstal have been mined for centuries, initially c. 1100 AD for lead, and then for silver (c. 1470), uranium from 1789 (mainly for colouring glass) when this element was discovered by a Berlin apothecary, Martin Klaproth, and finally for radium after the discovery by Marie and Pierre Curie [5].

Also, as early as the 15th century, miners were reported as dying prematurely from a mysterious lung disease (Bergkrankenheit). Saxon folklore attributed the deaths to hobgoblins who lived under the mountains to protect their buried treasures. This lung disease was first described by Paracelsus (Figure 3) in 1533 and termed by him *mala metallorum*. Some 20 years later it was also described by the Saxon physician Agricola (Figure 4) in his book *De Re Metallica* (Figure 5) which was published posthumously in 1556.

Agricola also ascribed the disease to the inhalation of dust, and it was not until 1879 that Bergkrankenheit was correctly identified as lung cancer and not pulmonary tuberculosis or silicosis [6]. Agricola described improved methods of ventilating the mine shafts by the complex use of horse-powered and water-powered bellows rather than by the employment of men to continuously shake linen cloths along the passages. He also recommended the wearing of loose protective veils of fine netting, which the miners; women folk were taught to make [7]. However, it was only in the 1920s that radon gas was suspected as the causative agent.

GEORG BAUER *(AGRICOLA)*

[1494–1555]

Figure 4. Agricola (1494-1555) whose given name was Georg Bauer, practised medicine in St. Joachimstal 1527-1531 and was also known to have visited the town for a month in 1550. His book *De Re Metallica* was a treatise on prospecting, mining, assaying, smelting and other topics. The first English translation was in 1912 by the mining engineer Herbert Hoover, who became President of the USA 1929-1933 and who in 1929 invited Marie Curie to the White House to receive the second 1 gram of radium from America

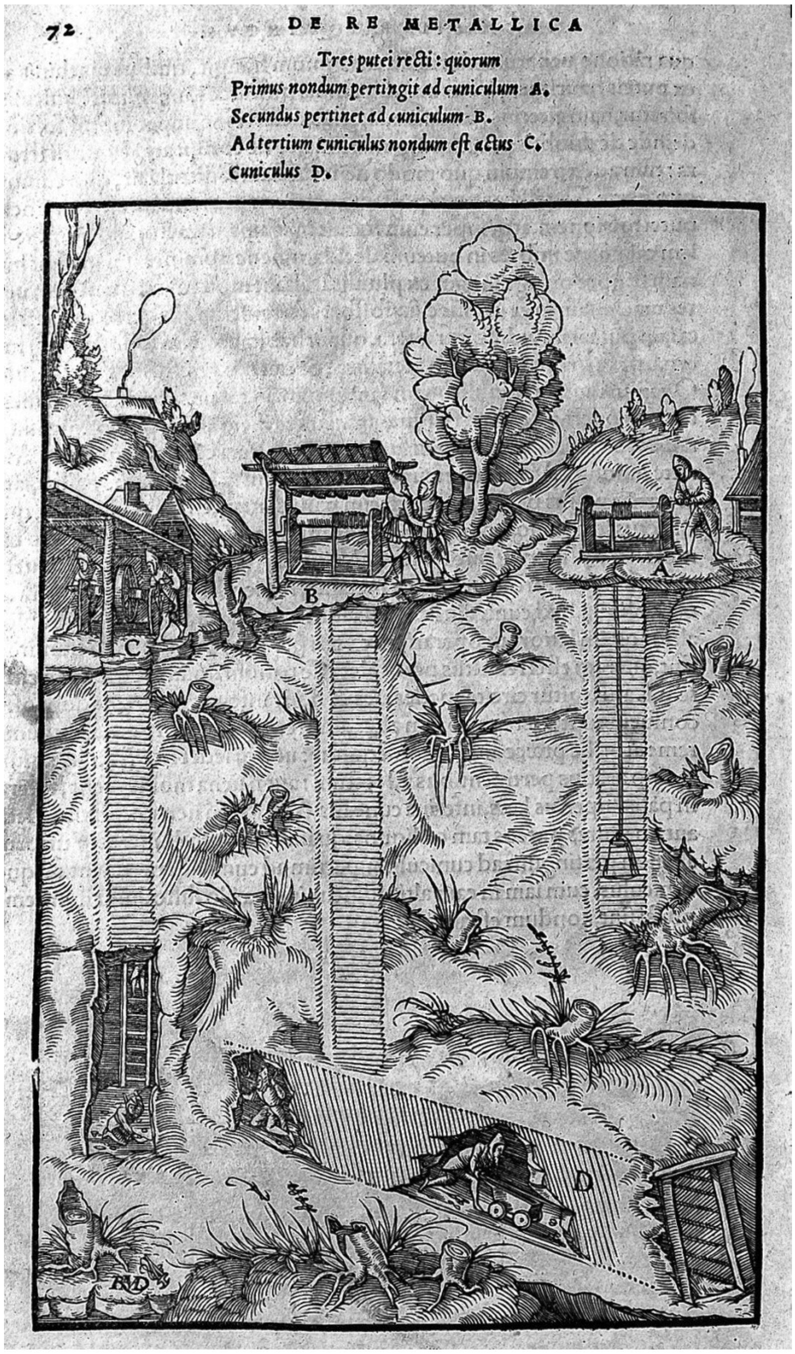

Figure 5. A mining scene from the *De Re Metallica* by Agricola which was published in 1556 by H. Froben & N. Bischoff of Basle (Courtesy The Wellcome Library, London). Agricola described improved methods of ventilating the mine shafts by the complex use of horse-powered and water-powered bellows rather than by the employment of men to continuously shake linen cloths along the passages. He also recommended the wearing of loose protective veils of fine netting, which the miners' women folk were taught to make

Compensation claims by pitchblende miners

By 1926 Saxon miners could claim compensation for their occupational illness. In 1932 Czech miners could also make claims. Then in 1939 Nazi Germany officially recognised the radon aetiology and the danger. However, in the USA it was not until 1991 that a Radiation Exposure Compensation Act was passed by Congress.

Silver dollars

In 1516 it was the discovery of silver that created the necessity for St. Joachimstal and during the period to 1540 a total of some 3,000,000 ounces of pure silver were mined per year. The silver coins of the Austro-Hungarian empire (of which Bohemia was part) were called Talers (the origin of the name Dollar) and were originally designed as a substitute for gold Florins. Other countries struck similar coins which in the Netherlands

Figure 6. A silver taler: the figure on the coin is St. Joachim [8]

were Rijksdaalders, in Denmark Rigsdaler, in Italy Tallero, in Poland Talar, in France Jocandale, in Russia Jefimok (Figure 6). Until the discovery of the extensive silver deposits in Mexico and Latin America, the mint with the largest output of silver coins remained St. Joachimstal.

Uranium fission

With the discovery of uranium fission in 1938 by Otto Hahn and Fritz Strassmann [9] and the start of World War II in 1939, uranium mining in the Sudetenland (which was annexed by Germany) assumed new importance. Prisoners of war and slave labour were used to work the St. Joachimstal (and other) mines for their weapons programme. By the end of the war in 1945 a two-stage intercontinental ballistic missile containing nuclear waste had been planned, the A 9/10 'New Yorker' and was to have been launched from silos in France [10, 11]. After the defeat of Germany, the Sudetenland came under Soviet Russian control and German prisoners of war and Soviet dissidents were drafted as miners until 1981 when the mines were flooded and abandoned. As a footnote, J. Robert Oppenheimer who played such an important role in the development of the nuclear bombs which were dropped on Hiroshima and Nagasaki, wrote his American prep school thesis on the St. Joachimstal mines [12, 13].

Radon spa

Early on in the 20th century a radium spa was developed at St. Joachimstal and a hotel built with 300 rooms with radon gas piped from the basement into the bedrooms [14] and radon baths available (Figure 7) [15] as well as radon inhalation devices, similar to what are now available in hospitals, but for breathing oxygen rather than radon. The hotel, called the Radiumkurhaus was advertised in *The Times* newspaper in London with a grand opening of this 'Radium Cure Establishment' on 15 May 1912. Also in 1912, St. Joachimstal opened a State Sanatorium for the treatment of various ailments: this was called the Radium Palace and appears to have been attached to the hotel (Figure 8) [8].

Prior to the building of the hotel, wooden baths were set up in cabins in the house of the St. Joachimstal village baker who was supplied with water from the mine in 40 litre containers carried on the backs of the miners. The district doctor reported marked medical results among those who had bathed in the water, and still more remarkable results when the water was drunk. When the water was analysed by two Viennese physicists in 1905 the expected high concentration of radioactivity was confirmed. In 1906 Austrian government permission was granted for a spa to be opened [8].

Friedrich Giesel or Marie and Pierre Curie?

It is perhaps interesting to speculate on what would have occurred if the Curies had not received their vast amounts of pitchblende ore in 1898, because without such amounts of the ore, it would have been impossible to obtain radium. This is because radium is present in pitchblende in extremely small quantities, about 0.3 gram of radium per ton of pitchblende [8]. What was necessary for the discovery was not only scientific brilliance (such as Marie and Pierre Curie possessed) and pitchblende ore but also chemical expertise in the separation and fractionation processes necessary.

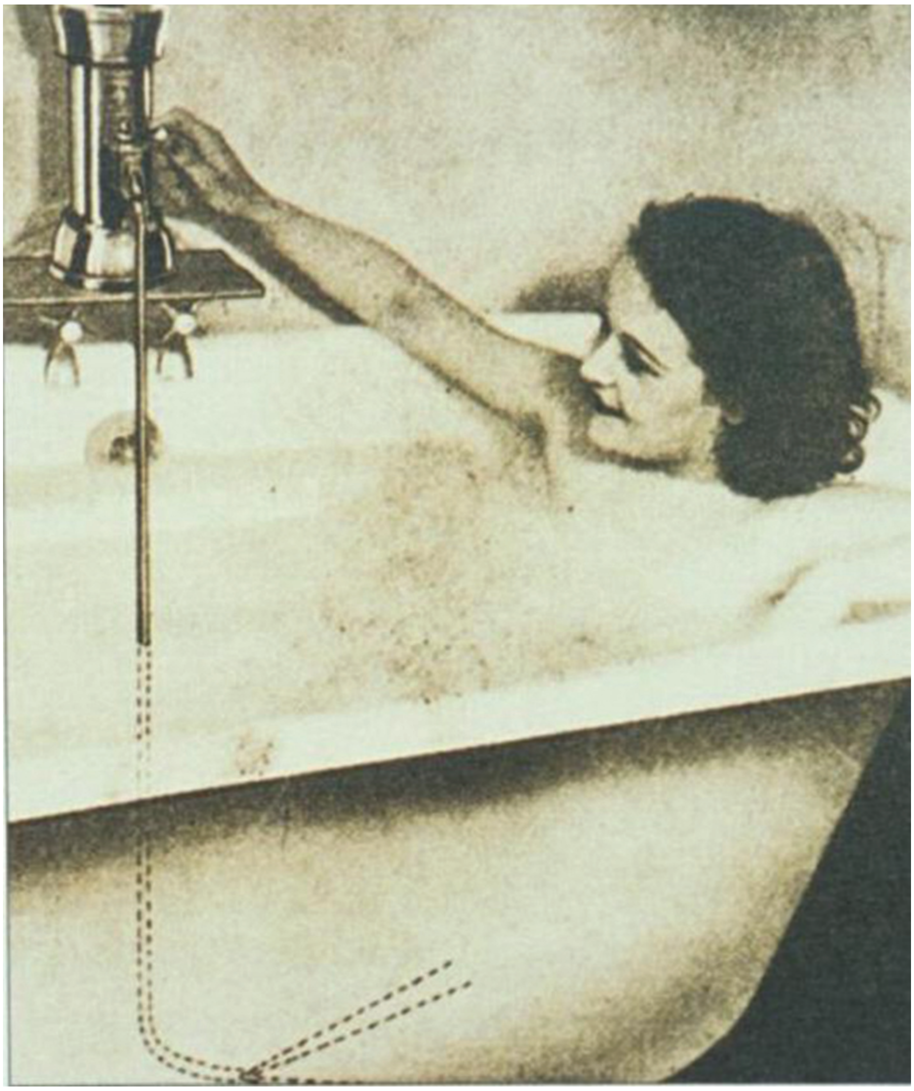

Figure 7. A radon bath of the type which was very popular until the 1930s. The radon Emanator (or Revigorator or radon generator: there were probably more than 10 types of such device, with different commercial names, containing small amounts of radium) is clearly seen. A tap is used to deposit 'radon water' into the bath. (Courtesy Professor Jean-Marc Cosset)

Figure 8. Luggage tag from the Radium Palace Hotel in St. Joachimstal (Courtesy Dr Jesse Aronowitz)

This last factor was available to those with expertise in quinine production, such as Armet de Lisle in Paris and Friedrich Giesel who was a chemist employed by the Buchler Company of Brunswick. For several years in the early part of the 20th century, before the carnotite deposits were worked in the USA, there were only two sources of commercially available radium: referred to as German radium and French radium. Sources of German radium, also obtained from St. Joachimstal pitchblende, was sold by the Buchler company as early as 1899 and with Germany closer to Austria-Hungary than France, in terms of geographical location and politics, pitchblende ore was relatively easily available to Buchler: at a price.

We can therefore speculate that Giesel could have been the first to process radium. However, there is a problem with this speculation in that Giesel's early work was influenced by that of the Curies and post-dates their first communication [5]. So we cannot really answer the question of who, after the discovery of radioactivity by Becquerel in 1896, might have beaten the Curies to the discovery of radium. It was the *ideas* of the Curies which were responsible for the discovery of radium (and polonium) and the enormous supplies of pitchblende from St. Joachimstal which made the processing a *practical* proposition and makes St. Joachimstal worthy of not being forgotten in the medical history of radium.

Friedrich Giesel deserves remembrance for being the first to sell radium (on behalf of the Buchler Company) and also for being one of the earliest, in 1900, to make self-exposure experiments with radium. These predate by some 12 months the self-exposure experiments of Henri Becquerel and Pierre Curie [16-18].

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