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SOME CENTRAL EUROPEAN GEOSCIENTISTS OF THE 18TH CENTURY AND THEIR INFLUENCE ON MOZART´S MUSIC

by

Alfred Whittaker

Honorary Research Associate
Kingsley Dunham Centre, Keyworth
Nottingham NG12 5GG, United Kingdom

Abstract

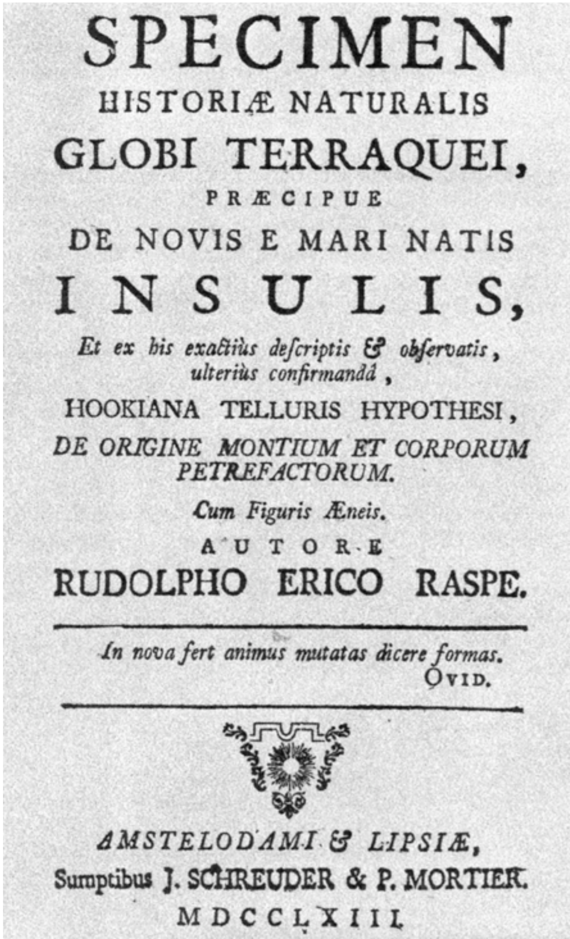
The lives and contributions of several geoscientists of the 18th Century are discussed, many of whom had close contact with the composer and musician Wolfgang Amadeus Mozart (1756-1791, Figure 1) by making contributions either directly or indirectly to some of his musical works, as well as making significant contributions to various aspects of geoscience and related technology which are still important today. Various individuals are discussed, plus the establishment of the Štiavnica Banska (Selmecbánya, Schemnitz) Mining Academy and its important contribution to geoscience and relation to technical mining matters and its particular importance at the time of the Industrial Revolution.
The discovery of the element tellurium and the relevance of the Academy to major scientific arguments of the day such as the position and status of the phlogiston theory and alchemy are also briefly discussed.

Figure 1
Wolfgang Amadeus Mozart (1756-1791). Image incorporating numerous masonic and alchemical symbols.

Rudolph Erich Raspe

One of the many memorable and relevant names among geoscientists in the 18^{th} Century, for various reasons discussed below, was Rudolph Erich Raspe (1736-94). His first major contribution to geoscience proper was a theory of the earth published in 1763, ultimately as a consequence of the great Lisbon earthquake of November 1^{st} (All Saints Day, 1755), which not only triggered much explanatory thought by earth scientists, but also gave the opportunity for intellectuals and philosophers to rethink how this apparently previously inexplicable phenomenon fitted in with contemporary ideas on philosophy in general.
Although probably best remembered for his very popular fictional work about Baron Münchausen's marvelous travels and campaigns in Russia, it is proper to remember that Raspe (Figure 2) was also seen at various times as a romantic poet, antiquary, embezzler, spy, and industrial chemist as well as a mineralogist, geologist and mining expert. His first and major contribution to geology was *Specimen Historiae Naturalis Globi Terraquei…* (Figure 3), a theory of the earth published in 1763. This work was considered at first as a fairly conventional description of the Englishman Robert Hooke's 1705 account of volcanoes and earthquakes, entitled 'Discourses of Earthquakes'.

Figure 2
Rudolph Erich Raspe (1736-1794) from the portrait medallion by J. Tassie Scottish National Portrait Gallery, Edinburgh, Scotland.



SPECIMEN
HISTORIÆ NATURALIS
GLOBI TERRAQUEI,
PRÆCIPUE
DE NOVIS E MARI NATIS
INSULIS,
Et ex his exactius descriptis & observatis, ulterius confirmanda,
HOOKIANA TELLURIS HYPOTHESI,
DE ORIGINE MONTIUM ET CORPORUM PETREFACTORUM.
Cum Figuris Æneis.
AUTORE
RUDOLPHO ERICO RASPE.
In nova fert animus mutatas dicere formas.
OVID.
AMSTELODAMI & LIPSIÆ,
Sumptibus J. SCHREUDER & P. MORTIER.
MDCCLXIII.

Figure 3
Title page of Raspe's book 'Specimen' 1763.

Hooke (1635-1705), was best known as a chemist and physicist. His ideas on volcanoes and earthquakes suggested that these two phenomena were responsible in a major, if not unique, way for uplifting islands and continents. Raspe's book *Specimen* blended Hooke's ideas with those of the German geoscientist Johann Gottlob Lehmann (1719-67), who at one stage of his career propagated the idea that mineral deposits (veins) in the earth's crust were in fact the branches of a buried mineral tree. In addition to these direct individual contributions, Raspe was also in due course responsible, importantly, for the translation into English of Ignaz von Born's treatise on the amalgamation process of the precious metals, a microfiche copy of which from the British Library is in the author's possession.

However, as stated by IVERSEN & CAROTTI (1970) in their book about Raspe, "Raspe's feat of scientific acrobatics, like all his endeavours, shows originality and brilliant imagination, skillfully blended with shameless dishonesty." They also report that Raspe had played an important but little known role in the basalt controversy having introduced it to the volcanic origin of that rock in Germany. "On the basis of evidence around Cassel (Kassel), Raspe unfortunately reached the erroneous conclusion that prismatic basalt (see Figures 4, 5 and 6) represented submarine eruptions, and expanded it into the far-reaching concept that volcanism was the most important process in the shaping of the earth's crust." (see IVERSEN & CAROTTI, 1970).

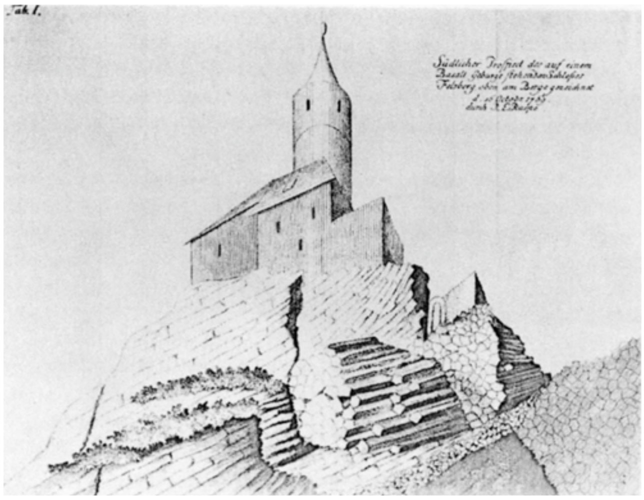


Figure 4
Sketch by Raspe of the prismatic basalts of the hill supporting the castle of Felsberg (Nachricht von einigen niederhessischen Basalten…1771).

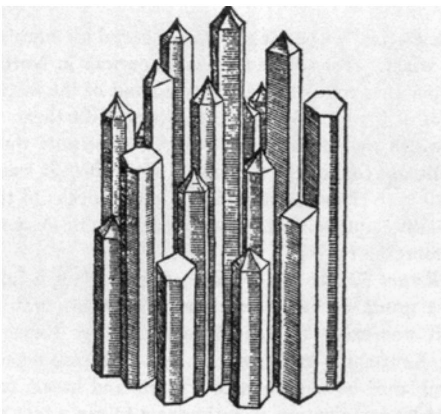


Figure 5
Columns of Basalt (from Gesner der Rerum Fossiliium…. Figuris (from Linnaeus, 1777) (Vollständiges Natursystem des Mineralreiches).

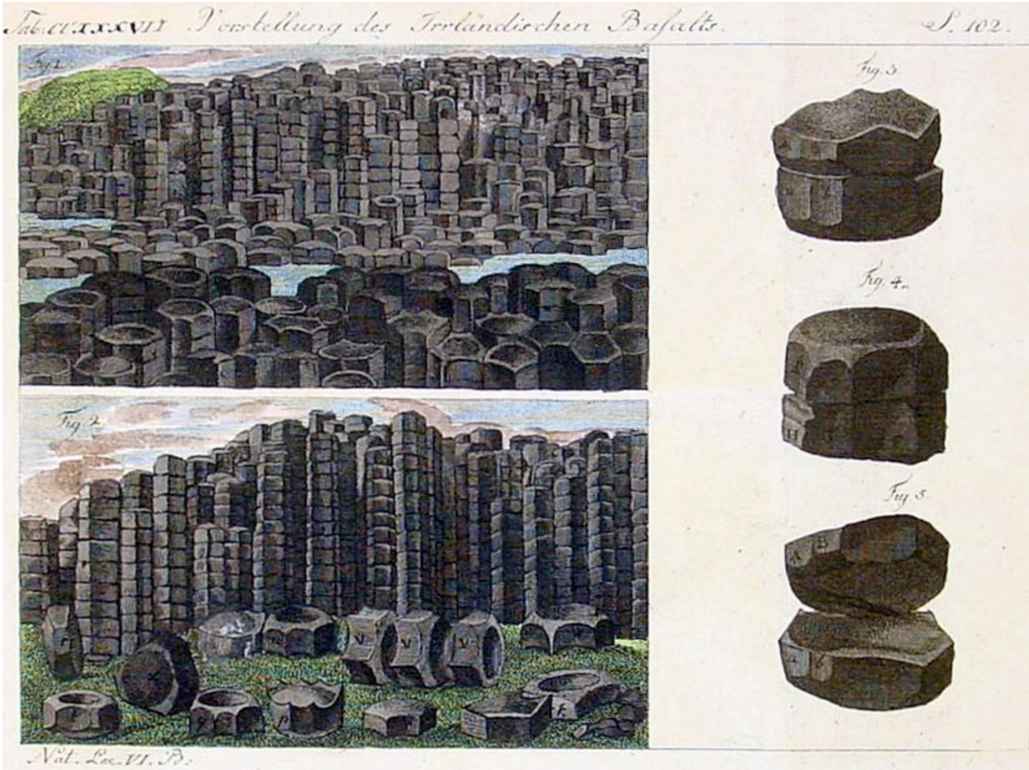


Figure 6
Andrew Nicholls (1804-1880), Irish artist, drawings of the prismatic basalts of the Giants' Causeway, Northern Ireland, UK.

Despite his extravagant, erratic, and often 'dodgy' or unethical behaviour, Raspe remains an important literary and scientific figure of the 18th Century; he had many important well-established contacts in mineralogy and geology including John Hawkins (1761-1841), Ignaz von Born (1742-1791), and J. J. Ferber (1743-1790), {Prussian Oberbergrath or Senior Mining Advisor}, all of whom had attended the famous first meeting of the newly-founded Mining Society at Schemnitz (and Skleno) in the year 1735, the oldest such Society in the world.

By the age of 30 in 1767, Raspe had already enjoyed great success in science, philosophy and literature. He carried on an extended correspondence with many of the well-known scientists of his day, for example he became very friendly with the American scientist Benjamin Franklin (1706-1790) with whom he had a long correspondence. Franklin, of course, eventually made several important contributions to the understanding of the geosciences in North America during his lifetime, utilizing the new knowledge he had acquired in Central Europe.

At this time Raspe was also enjoying his reputation as a poet particularly when his younger contemporaries were presenting their work to him for criticism and comment. But in this year (1767) an even greater honour awaited him when he was offered the post of Curator of the collections owned by the Landgrave of Hesse-Cassel, plus the Chair of Antiquity at Cassel University, and a seat on the Hessian Privy Council. After stealing or pilfering some collections of gemstones in his care he eventually had to flee the court of Landgrave Frederick II of Hessen-Cassel (Hessen-Kassel) for England in 1775. In England he was initially employed by Matthew Boulton (1728-1809), a man deeply involved in the establishment of the steam engine and the British Industrial Revolution, and who came from the English midland area of Birmingham. He was also involved in the workings of several of the Cornish metal mines in south west England.

It is also of great importance to remember that this period of time also saw the evolution of mineralogy into geology (see LAUDAN, 1987), alchemy into chemistry, numerology into mathematics, astrology into astronomy and the change from the classical to the Romantic Movement in the arts. Also at about this time Europe was experiencing the development of the Enlightenment with associated political changes such as the French Revolution and the discovery of numerous overseas territories, potentially of especial importance to Europe, because of extremely valuable mineral wealth likely to be useful in the development of new types of industry and in the fighting of wars. At about the same time Raspe also wrote various books on geology and the history of art. He also worked for the important English publisher John Nichols in various projects.

In 1791 Raspe moved to Scotland and after a mining swindle there (in which he 'salted' a Scottish mine with Cornish minerals) he left there and finally moved to Ireland where he managed a copper mine on the Herbert Estate in Killarney. Raspe's further activities in Great Britain are described in 1917 by Sir Archibald Geikie (1835-1924) and in GEIKIE (1917). As if to enhance and advertise his colourful reputation, Raspe was clearly taken as the model by Sir Walter Scott for the important character Hermann Dousterswivel (the surname broadly means 'swerving divining rod') in his popular novel 'The Antiquary'. Raspe died in Killarney of typhoid in November, 1794.

He was of especial importance in the spreading of geoscientific and mineralogical knowledge at this time for several reasons. Firstly, Raspe studied or was inspired to study geoscientific topics at Göttingen University under the famous and inspirational teacher Johann Friederich Blumenbach (1752-1840,) who first attended the University of Jena in 1769 to study medicine. Here, at Jena, Blumenbach attended the lectures of the mineralogist Johann Ernst Immanuel Walch (1725-1774), the author of *Naturgeschichte der Versteinerungen*, published in 5 volumes between 1768 and1773, and which interested him in the study of fossils and rocks. Blumenbach joined the faculty of the University of Göttingen as curator of the natural history collection and became extraordinary professor in February 1776. Blumenbach also provided much inspirational teaching for the Englishman George Bellas Greenough (1778-1856) (Figure 7), who also studied mineralogy at Freiberg under Abraham Gottlob Werner (1749-1817) (see WHITTAKER, 2008). Greenough was an important figure in England, who with others, jointly founded the Geological Society of London. As well as George Bellas Greenough, Sir Joseph Banks (1743-1820) also studied at Göttingen and eventually became a long-serving President of the Royal Society of London who accompanied Captain James Cook as scientist on Cook's exploratory sea voyages around the world. Banks was also a former student at Oxford University who built a large collection of natural history objects including many minerals, which are now preserved in the British Museum.

Figure 7
George Bellas Greenough (1778-1856), one of the founders of the Geological Society of London.

Werner (Figure 8), regarded as the “Father of German geology”, was of course a major influence in the newly developing geosciences, especially the stratigraphical aspects.
A Spanish geoscientist connected with Werner was Fausto d’ Elhuyar (1755-1833) who received a grant to study at Freiberg (see RUIZ, 1996). He later became a highly regarded expert and made a tour of several European universities in 1783, lecturing at Freiberg on metallurgy and mining machinery as part of this tour.
In addition to the discovery and isolation of tungsten jointly with his brother Juan José and the purification of platinum working with François Chavaneau, he spent many years in Mexico and later founded a Mining Academy in Mexico City.

The importance of these connections ensured the passing on of geoscientific and mining methods to scientists and technical workers in the Americas, Australia, South Africa and other parts of the world remote from Europe.

Figure 8
Abraham Gottlob Werner (1749-1817).

Karl Ludwig Giesecke

Karl Ludwig Giesecke (1761-1833) (birth name--Johann Georg Metzler, Figure 9), also a former student of Blumenbach at Göttingen, is mainly best remembered for his geoscientific travels and research in Greenland, Central Europe and in Ireland, in addition to his stage-related work which culminated in his association with the famous Schikaneder Troupe in Vienna as librettist, performer and Stage Manager, but also, for his membership of the Viennese freemasonic lodge ‘Zur Wahren Eintracht’. This lodge had Ignaz von Born as its leader, Giesecke among its members and the occasional presence of Mozart, who although a member of the much smaller lodge ‘Zur Wohlthätigkeit’ (Charity), also often attended the ‘Zur Wahren Eintracht’ (True Harmony) lodge as a Visiting Brother, which was not uncommon at that time (LANDON, 1982).

Robbins Landon also discussed some of the personalities seen in the famous but controversial painting in the collection of the Historical Museum of the city of Vienna, which he thought to be of the Crowned Hope Lodge and which possibly included Giesecke as well as Mozart and Schikaneder (WHITTAKER, 1998; Figure 5). Although Vienna's intellectual elite was strongly represented in the 'Eintracht' Lodge, it was also attended by masons of other nationalities such as the geoscientist and traveler Georg Forster and probably the Swedish geologist Torbern Olaf Bergman, who on occasion was a house-guest of Ignaz von Born. In those days the masonic lodges often served as scientific societies in which some research was carried out, see below (WHITTAKER, 1998; Figure 4).

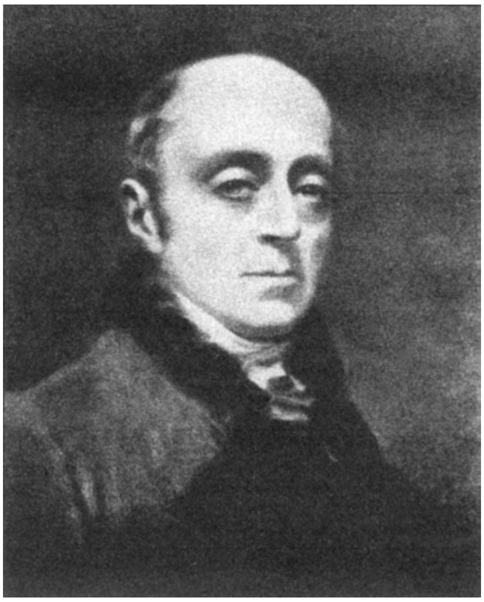


Figure 9
Karl Ludwig Giesecke (1761-1833).

Giesecke is also thought by some people to have inspired Goethe to write the stories of Wilhelm Meister, although this is thought unlikely to be true. However, in the context of Central Europe, it is interesting to note that the name Giesecke, according to STEENSTRUP (1910, page V), may be of Hungarian origin and derived from the Hungarian surname 'Köszegi'.

Like von Born before him, one account of Giesecke's life (SCOULER, 1834) states that he visited, traversed, and inspected the rich mineral districts of Hungary, Transylvania, Bohemia, Styria, and Carinthia. This was while Giesecke was with the Austrian Service in which his desire for scientific travel was gratified by an appointment in the suite of Fürst Metternich as Assistant Secretary of Legation, in his embassy to Selim II, at Constantinople. Apparently he was also engaged on another occasion to the office of a similar embassy to Naples when an opportunity occurred which he eagerly availed himself of, as Mozart had done earlier, to ascend and examine Mount Vesuvius (Figure 10) from which he brought an interesting collection of specimens. According to SCOULER (1834) Giesecke continued in the Austrian service until he received a wound in the right instep, which rendered him slightly lame ever after and obliged him to wear a high heel to his shoe to compensate a contraction that took place in consequence. Again, according to SCOULER (1834), this lameness necessarily led to his retirement from the army (his possible service in the army is also referred to in his travel album (WHITTAKER, 2001, page 459), and subsequently to his settlement in Copenhagen, where he opened a school of mineralogy, and dealt extensively in minerals, in which his intimate knowledge of the mines of Germany and Transylvania enabled him to obtain valuable mineral assortments.

Figure 10

The eruption of Vesuvius on 15th June 1794 by an unknown artist and presented to the Geological Society of London on the 1st June 1810 by Founder Member William Babington. Reproduced by courtesy of the Geological Society of London.

It certainly seems likely that Giesecke, Born and Mozart would have known of each other extremely well and doubtless may even have exchanged or listened to discussions and views, and perhaps even on geoscientific topics. Certainly Born was a regular attendee at Mozart's concerts and performances. Possibly these discussions could even have included Mozart himself, whose interest in science and mathematics is confirmed by his sister (1751-1829), called Nannerl in her diary which amongst other things describes the Mozarts' visit to the British Museum between April and July 1765 to see scientific material (GEFFRAY & ANGERMÜLLER, 1998, p.XVI). She also notes that Wolfgang, Leopold (Wolfgang Mozart's father), and Nannerl herself frequently attended scientific talks and lectures at Salzburg University. Mozart wrote home from Vesuvius during his first visit to Naples where he witnessed the volcanic eruption and felt the associated seismic activity shaking in 1770. He referred musically to these phenomena in his operas, for example, in *La Clemenza di Tito* (Scene 4 Act1) where the famous earthquakes and eruptions of Vesuvius in 79 AD are represented musically. As is well known, (CORNET, 1850; WHITTAKER (1998, 2001, 2009), Giesecke claimed authorship of *Die Zauberflöte* libretto in 1818, while on a visit from Ireland to Vienna. It is now thought that the words for many of Mozart's masonic musical works, rather than being authored by Schikaneder as once thought likely, are much more likely to have been written by Giesecke, as noted by various Mozart specialist authorities, for example see H. C. ROBBINS LANDON (1982).

Mozart himself apparently had an interest in at least some aspects of geoscience as is apparent in his letters from Naples to home. In fact, it is clear from the following letter dated 5th June 1780, in which Wolfgang writes to his sister "Vesuvius is smoking furiously today (Figure 10). Thunder and lightening and all the rest" (Emily ANDERSON, 1938). At the end of the same letter to his sister, Wolfgang writes "Not only shall I bring back all the rare sights in several beautiful copper engravings, but Herr Meurikofer [sic] (actually the Frenchman, Frédéric Robert Meuricoffre 1740-1816), has given me a fine collection of Vesuvius lava, not of the lava which everyone can obtain easily, but choice pieces with a description of the minerals which they contain, rare and not easy to procure. If God permits us to return home in good health, you will see many beautiful things" (ANDERSON, 1938). On the 16th June 1770 Leopold Mozart wrote home to his wife 'On June 13th we drove in a carriage to Pozzuoli, and then took ship to Baia, where we saw the baths of Nero, the subterranean grotto of Sibylla Cumana, Lago d'avero, Tempio di Venero, Tempio di Diana, Sepolcro d'Aggripina, the Elysian fields, the Dead Sea, where Charon was ferryman, la Piscina Mirabile, the Cento Camerelle, and so forth'. Also mentioned in this list of geoscientific features are visits to the Grotto di Pozzuoli and Virgil's grave, plus 'on Monday and Tuesday we are going to Vesuvius, Pompeii, Herculaneum and its excavations, Caserta and Capo di Monte' (ANDERSON, 1938). Given this information it is easy to see how Mozart, for example, managed to place various of the scenes (see Lehmann below) in his outstanding opera *Die Zauberflöte* into a geoscientific context. Further comments on Mozart and scientists are given in WHITTAKER (1998).

In addition, Mozart apparently had a keen interest in the various jewels (minerals) presented to him by various aristocrats including Erzherzogin Maria Theresia von Österreich, Königin von Böhmen und Ungarn (HUBER & HUBER, 1991) and the King of France. Beda Hübner, the librarian of St Peter's, Salzburg, noted in his diary for 8th December 1766 a whole list of gifts given to Wolfgang and Nannerl of material collected by the family on their travels, which were later noted by DEUTSCH (1966) and EISEN (2009). These included several large coffers full of gifts, items that they had purchased on tour plus memorabilia, including gold pocket watches, gold snuff-boxes, gold rings set with precious stones; earrings for the girl and writing tablets and suchlike gewgaws 'without number and without end'. These mostly expensive gifts were given to both the Mozart children after performances in Palaces and Residences. Several of the gifts were in the form of an agate mineral (Figure 11) set in a base of gilded copper, including 'number 27, described as W. A. Mozart's tobacco case given to the Mozart Museum by Constanze von Nissen', Mozart's widow. Also worthy of mention in this context is Leopold's collection of topographical engravings collected on the 'Grand Tour' of Europe between 1763-1766 and in Italy between 1770 and 1773 (EISEN, 1997).
Furthermore, the ongoing keen interests of the Mozarts' in geoscience are seen from Nannerl's diary (GEFFRAY & ANGERMÜLLER, 1998) as well as the letters within the family (Mozart-ways, 2010) in a letter dated 21st August, 1770, written by Leopold to his wife. Reference is made to the great earthquake which had recently affected Haiti and Santo Domenico in 1770 "You'll have read in all the papers about the disaster caused by the earthquake on the island of Santo Domenico" (Figure 12), (VOGT, 2004, for information on the 1770 historical Haiti earthquake details). News of this earthquake (1770) had appeared in the local Austrian news-papers before 21st August 1770) and this event is apparently very reminiscent of the recent terribly destructive earthquake of January 2010 affecting Haiti.

Since the 200th anniversary of his death and the composition in 1791 of *Die Zauberflöte*, Mozart has had the mineral Mozartite (see Figure 13) named after him by BASSO et al. (1993), and PALENZONA & POZZI (1993) following WHITTAKER's (1991) and LUX's (1996) recognition of the relationship of *Die Zauberflöte* to miners, mining and mineralogy in the year marking Mozart's 200th death anniversary (1991).

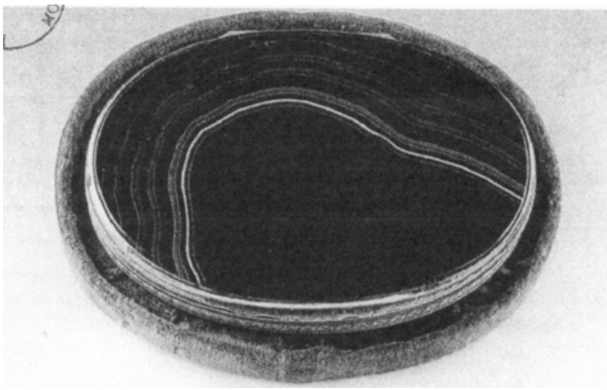


Figure 11
Mozart's tobacco case discussed in the Lapis article by HUBER & HUBER (1991).

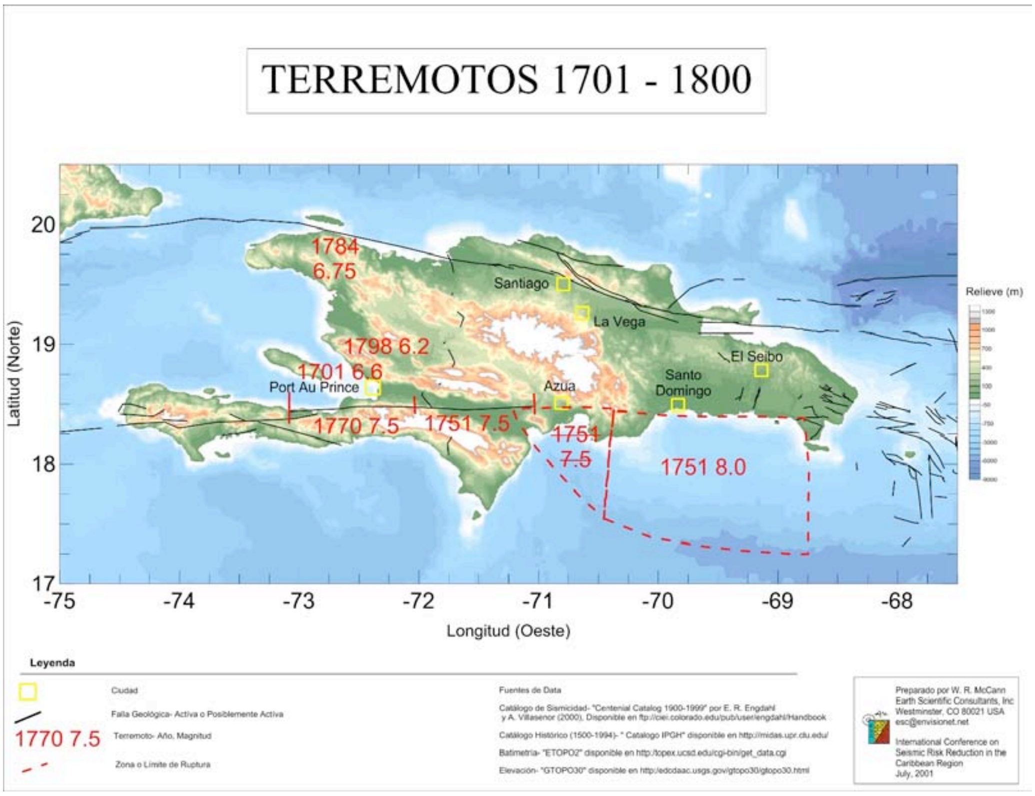


Figure 12
Map of the 1770 Haiti earthquake noted by Leopold Mozart in his August 1770 letter. Map by Bill McCann of Jackson School of Geosciences, University of Texas at Austin.

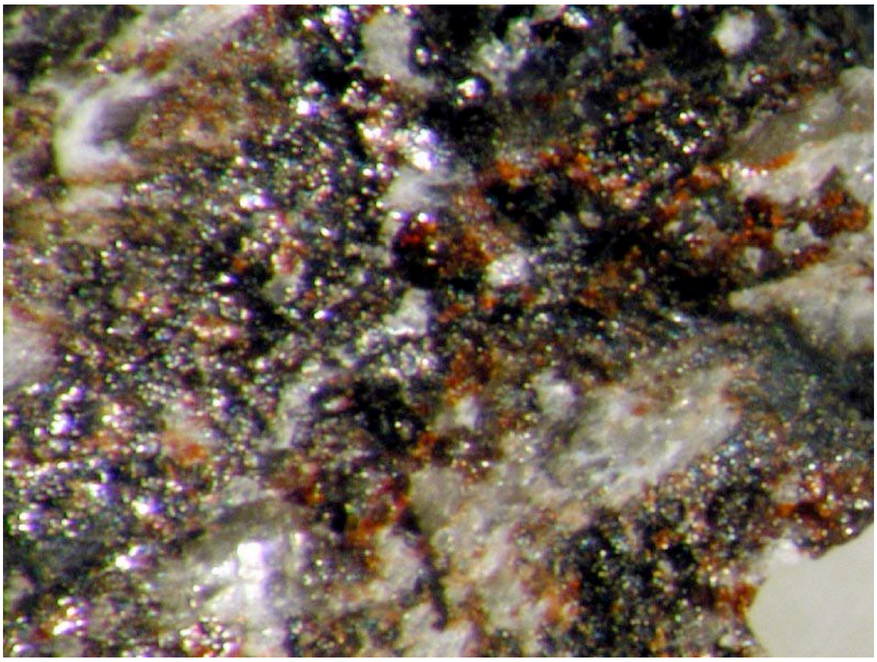


Figure 13
The mineral Mozartite ($CaMn(OH)SiO_4$) [courtesy of Prof. Basso/Italy].

Ignaz von Born and fellow scientists

Ignaz von Born (1742-1791) (Figure 14) Grand Master of the masonic lodge of which Giesecke was a member and Mozart a frequent visitor, held a prominent position in the Habsburg monarchy, is thought by many authorities to have provided the role model for the character of Sarastro in Mozart's famous opera *Die Zauberflöte*. Born was the leading scientist of Central Europe, especially in the fields of mineralogy, metallurgy and mining engineering during the Age of Enlightenment and a leading chemist of the day. Like Raspe he was eventually invited to become a Fellow of the Royal Society of London.
Ignaz von Born was born in 1742 in the mining district of Kapnis in Transylvania and was the son of a noble Saxon military officer serving in the Austrian army and commanding the garrison town of Karlsburg (Alba Iulia in present day Romania). From the time of his birth, his close association with mining was occasioned by his father's financial interest and partnership in various mining enterprises, including a silver and gold mine. Born was orphaned by the age of nine and his early education in Hermannstadt (Sibiu) was continued under the Jesuits in Vienna where he became an outstanding scholar. After entering the Jesuit order in 1760, he left in 1761 to study law in Prague, where he submitted his doctoral thesis in 1763. Subsequent to this he travelled widely in central Europe before taking a course in mining-related subjects (mineralogy, chemistry and engineering) at Prague University. In 1764 he married and settled down in a large estate near Pilsen in Bohemia and became a salaried Mining Adviser (Bergrat) at Schemnitz in the Hungarian Ore Mountains, in latter-day Slovakia.

The Austrian Habsburgs, always short of money, had tried various ways to raise the production of gold and silver in territories under their rule. From about the middle of the seventeenth century much attention was paid to the mining and exploitation of metals in Slovakia. Since the Middle Ages the mountainous regions of Slovakia which belonged to the Kingdom of Hungary were among the leading Central European mining centres. Ever since 1526, which saw the birth of the Habsburg monarchy with the union of Austria, Bohemia and Hungary, the Viennese Court had come to regard the production of gold, silver and copper in Slovakia as a significant contribution to the state economy. There were two large mining areas, one situated in the central part of Slovakia, known as Lower Hungary and the other more to the east, known as Upper Hungary (see TEICH, 1975). First in importance among the mining towns of Lower Hungary was Schemnitz, which together with Kremnitz (Figures 15 and 16, BRIGHT, 1818) had a long history in mining and engineering resulting in the introduction of new mining techniques in addition to the long established methods using hammer, pickaxe and trucks on rail tracks (Figure 17). Amongst the earliest techniques were use of fire and water to crack and break the rock face which eventually resulted in the introduction of new techniques such as the cracking of metallic ore with the aid of gunpowder, and the construction of impressive water engines for the draining of mines and drilling in the mid-eighteenth century, such as the powerful hydraulic machinery of M. Höll (Figure 18), which was later replaced by the first Newcomen-type steam engine outside Britain (Figure 19), all of which were welcome additions to the technologies of the age.

Figure 14
Ignaz von Born (1742-1791).

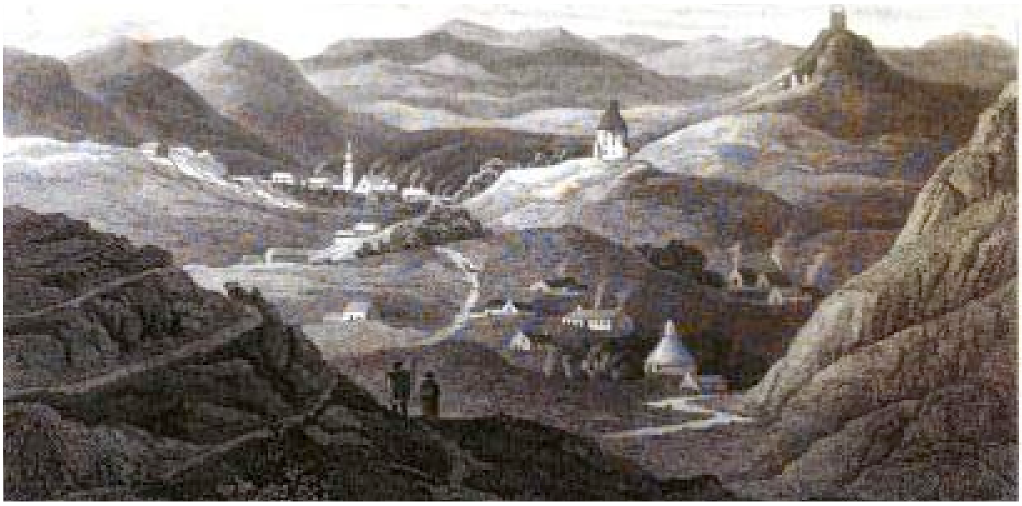


Figure 15
"A View of Schemnitz and the surrounding country". From Richard Bright (1818).

Figure 16
"The Town of Kremnitz and the silver works". From Richard Bright (1818).

Figure 17
Mining at Schemnitz in the 17th Century.

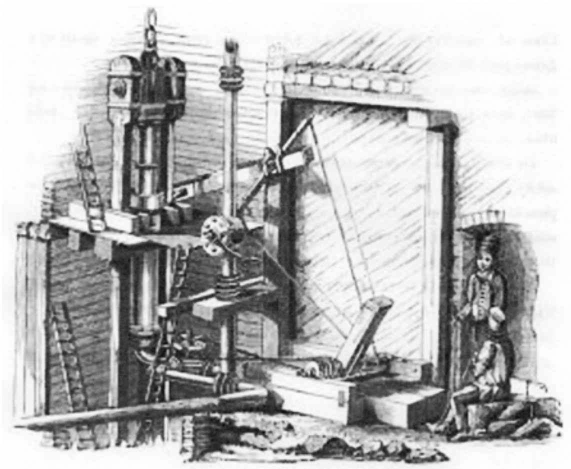


Figure 18
"Schemnitz Mining Equipment 18th Century".
From Richard Bright (1818).

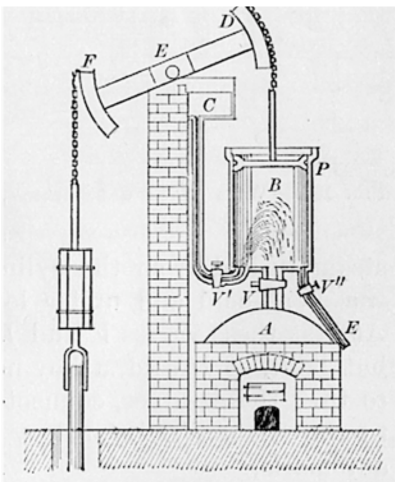


Figure 19
Newcomen engine used for raising water and drilling.

Dr. Richard Bright (1789-1858), was principally a very distinguished physician after whom Bright´s disease is named, and was also a very enthusiastic geologist and one of the founder members of The Geological Society of London. He travelled across this part of Lower Hungary (BRIGHT, 1818) in the early 19th century, visiting and making drawings of many of the places described in this account and meeting many of the geoscientists mentioned.

In fact, when visiting the Hungarian mines at Felsöbánya Born looked at a new ore winning process consisting of heating the ore red hot and cooling it with a water jet and thus cracking it (HORVÁTH, 1996). As a result of the insufficient airing of the workings Born suffered such a severe smoke toxicosis in August 1770 that it took the physicians several days to resuscitate him and he bore the consequences of the associated lung problems for the rest of his life. In 1776 Erzherzogin Maria Theresia von Österreich, Königin von Böhmen und Ungarn (Empress Maria Theresia) invited Born to Vienna and commissioned him to rearrange and look after the Imperial Science and Natural History Collection. In his work he was assisted by Karl Haidinger (1756-1797), a future professor at Schemnitz. When Haidinger discovered a sulphide containing copper ore in the mountain ranges of Hungary, he called the mineral bornite Cu_5FeS_4 (Figure 20) named after von Born in 1845.

Figure 20
The mineral bornite, specimen belongs to the author.

In addition to his commission, Born instructed in Natural Sciences Erzherzogin Maria Anna, the physically disabled daughter of Maria Theresia von Österreich, and guided her in the assembly of a mineral collection, which is today a highly esteemed part of the collection of the Institute of Mineralogy of the Eotvos Lorand University of Arts and Sciences in Budapest. He was appointed aulic councillor of mining and minting in the Treasury in 1779.

In 1781 or 1782 von Born began some early work on an amalgamation process because he had experienced the relatively low production of gold and silver metal ores in his Father's Transylvanian mines while fuel consumption and lead loss were high in the lead smelting process. Born roasted the raw materials in the presence of chlorine, cemented the silver from the silver chloride with copper or iron and eventually brought the material containing 'pure' silver into contact with mercury. After completing the successful experiments, Anton Ruprecht (1748-1814) {chemistry professor} built a pilot plant at Skleno near Schemnitz, where he proved the correctness and feasibility of the ideas of Born with the assistance of Haidinger.
Another of Born's great achievements was to establish an international conference at The Mining Academy of Schemnitz to witness the pilot works experiments of amalgamation in1786, and he jointly edited the resulting two-volume tome (see BORN & TREBRA 1789-1790) on mining engineering and related matters with Heinrich von Trebra (1740-1819), who also spent a decade working at Zellerfeld. At the first conference in 1786 there were participants from all over the world who as well as witnessing the amalgamation also performed the experiment on ores they had brought with them. The second three week conference was held with twelve participants in Schemnitz in 1817. The Academy at Schemnitz saw the establishment of the first international mining metallurgical society of the world (the ´Society for Bergbaukunde´). According to KLEMUN (2007) this paved the way towards breaking down the secrecy within mining which had until that time been ordered by the State. The 'Society for Bergbaukunde' was founded in 1786, the first organisation that facilitated an international exchange of technological mining knowledge.
The first two heads of the Department of Mineralogy, Chemistry and Metallurgy at Schemnitz, Nicolaus Joseph von Jaquin and Anton Scopoli, were physicians originally, who both made their scientific mark initially as botanists. In recognition of the botanical work of Jaquin, Linné named a genus of plants *Jacquinia* in his plant systematics.
Scopoli discovered in the Bükk mountains a genus of plants now called Scopoli grass or scopolamine or *Scopolia carnionalica* and the drug Scopolamine used in psychotherapy and made from its atropine contents. These heads of department with the assistance of specialists from nearby works developed laboratory practices which were further improved by their successor, Professor Anton Ruprecht, mentioned earlier, and were studied by visiting professors of universities abroad, who regarded them as models for the establishment of universities with a similar profile (see HORVÁTH, 1996). Also noteworthy in the context of Schemnitz's Mining Academy is the mathematician and professor of Mining Technology Nicolaus Poda (1723-1798) who also was well known as an entomologist following the taxonomic practices of Linné too. From 1766 to 1771 he was professor of mining at Schemnitz and possibly co-author of the publication 'Monachologia' under the pseudonym of Ignaz Physiophilus together with Ignaz von Born.

It was about this time that alchemy (the precursor of scientific chemistry) was widely practiced in Central Europe. Alchemy itself was succeeded by the phlogiston theory (see below) introduced by another early Central European chemical scientist (Johann Becher) - [1635-1685] who studied the chemistry of metals and minerals published in a work entitled *Subterranean Physics* in 1669. Becher reckoned that all minerals and metals were composed of three qualities, a *terra lapida* or transparent vitrifiable component (equivalent to the 'salt' of Paracelsus), a *terra mercuralis* or subtle or volatile component and *terra pinguis*, an igneous fatty and combustible component.

As far as other substances were concerned, those that were combustible also contained *terra pinguis*. Becher also made the point that none of these components were true chemical elements; they were only behavioural qualities. These ideas were taken up by the German physician Georg Stahl who was a strong believer in vitalism, the idea that there is a vital force operating throughout Nature. Stahl's place in the history of chemistry rests on his *Fundamentals of Chemistry* published in 1723. Stahl introduced 'phlogiston' (from the Greek *phlogistos*, burnt) to replace Becher's *terra mercurialis*, and the extension of this to all combustible materials. The importance of the 'fire principle', phlogiston is that it acted as a great unifying concept in chemistry. It brought together a wide variety of facts being applicable not only to combustion, but also to respiration and calcination (the roasting of metals to a high temperature, but without fusing), thus bringing some deeper understanding to all kinds of reactions. For the next thirty or forty years chemists pursued the theory with vigour until it became so entrenched in chemical thinking that a great intellectual effort had to be made to break away from it. After the advent of the phlogiston theory the study of combustion and gases was pursued because chemists were still puzzled by the nature of air.

Nicolaus Joseph von Jaquin (1727-1817) was born in Leyden, Holland. He studied medicine and botany, worked in Paris as a hospital intern and met an old friend of his family, Gerhard van Swieten, who was also born in Leyden. Gerhard van Swieten, a professor of the University of Vienna eventually became physician to the Erzherzogin Maria Theresia and also became her principal adviser in cultural matters. Thus, Jaquin's first assignment in Vienna was to systematise the plants in the botanical gardens of the Emperor and then to enrich it after a study trip in America. By this means he laid down the foundations of the botanical gardens of the University of Vienna with the rarities he collected. In the course of his activities he developed training materials for the courses of the Academy department.
In addition to coal distillation, he studied the fashionable research of the period, lime-burning, and proved by the absorption of the gases produced in the burning in a solution of potassium hydroxide (KOH) that they were not phlogiston, and thus that the air was not a scientific 'element', as now understood, but an 'element' as believed and understood by the alchemists.

The introduction of amalgamation in the Habsburg dominions gives an excellent example of what is meant by links between science, industry and government at the end of the eighteenth century, not just in Central Europe but in many other parts of the world also. Ignaz von Born was a firm believer in the potentialities of science for technological change and economic development (see TEICH, 1975).

Born considered his proposal to extract precious metals from ores and metallurgical products by treatment with mercury to be based on sound chemical principles. Indeed, in the preface to the German version of his book (but omitted in the French and English translations) he went out of his way to eliminate any notion that his method was akin to the procedures adopted by alchemists and that he possessed the arcanum of how to turn base metals into gold (see TEICH, 1975). It is essential to be aware that the chemical paradigm of the time was based on the theory of phlogiston within which he (i.e. Born) worked. This theory derived from attempts to provide a straightforward answer to questions about the composition of metals, their calcination, and the reduction of products obtained by calcination of metals, called 'calces' (Figure 21).

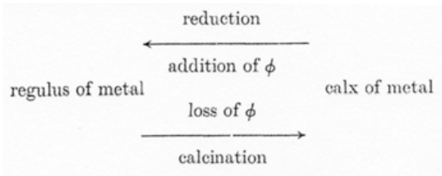


Figure 21
The relationship of phlogiston (ø) to the calx and regulus [referred from TEICH (1975)].

The calx (or oxide) of the metal was the ash left behind on heating or burning the metal. The metallic state known as the 'reguline', could be restored by heating the calx with charcoal. It was assumed that combustible bodies contained a larger or smaller proportion of phlogiston (ø), which they gave out during burning. Substances like charcoal or sulphur, which burnt well, comprised a good deal of this material. Calcination of metals and reduction of calces was interpreted in terms of phlogiston transfer (Figure 21). Thus metals were thought to exist either in the reguline or calcine state according to phlogistic thinking. The calx of a metal was not combustible; it lacked phlogiston and therefore was not a compound entity. Calces of metals and not their reguli were considered to be elementary bodies. The combination of mineral alkali (soda) and phlogisticated marine (hydrochloric) acid produced common salt. This substance was recognised to be different from dephlogisticated marine acid (chlorine). Nowadays, the Latin word *Regulus* (Little King) refers to any metal produced from the smelting of ores, whereas in the late eighteenth century it was restricted to the extremely pure semi-metal, antimony. Because Born was aware that native gold and silver occurred and exhibited metallic properties, apparently without the intervention or incorporation of phlogiston, this observation appeared to be in direct conflict with phlogistic tenets. That the latter apparently applied to known metals, with the exception of gold and silver, demonstrated a weakness in the phlogiston armour, of which Born was aware.

He stated that gold and silver occurred in nature in metallic condition either free (*nativa*) or concealed *(larvata*) in ores. In the latter case, metallic particles of gold and silver were built into aggregates composed of base metals and so-called semi-metals (for example antimony and arsenic), their calces and earths. European metallurgists were aware that native gold and silver could be amalgamated, but doubted that their ores could be treated in the same manner. It was Born who paved the way in Europe for large-scale amalgamation of silver ores by devising a method which freed the metal from various matrices and enabled it to be treated by mercury, a process comprising three operations as follows:

(1) The mechanical reduction of silver ores to a fine powder in order to enlarge the surface area of the mass to be amalgamated.

(2) The roasting of the ore either without or with common salt, the amount of which had to be determined by experience (about 8% of the weight of the ore)- calcination was to be the crucial operation because it freed silver particles in the surrounding mass of non-silver material.

(3) The action of mercury which only now had the chance to amalgamate the disengaged silver. The trituration was conducted in copper vessels in which the mass (to which salt was added if that was not carried out during the roasting stage) under constant stirring was raised to the boiling point.

Thus it can be very strongly argued that Born was in the forefront of the demise of alchemy and phlogiston and their replacement by 'modern' chemistry.

In addition to his scientific interests, Born was a regular subscriber to and attendee at the concerts and recitals given by Mozart in Vienna, a fact which brought him closer to the Jaquin family and probably to Mozart or even Giesecke too who, also of course, was very interested in music. Nicolas Jaquin's wife, Katarina Schreibert, was a pianist, and Jaquin himself was very fond of music so that in the mid 1780s after their move to Vienna, the family became very friendly indeed with Mozart; Nicolaus took great care of the musical education of his younger children and thus W. A. Mozart taught Gottfried, who had a very fine deep bass voice, to sing, and Franziska Jaquin to play the piano and wrote the piano part of the Kegelstatt-Trio (KV 498) for her. In addition, the Jaquins frequently held musical evenings in their home with the participation of Mozart. Close personal relationships developed between the participants, so that a particular friendship developed between Mozart and Gottfried who was eleven years his junior. During his travels in 1785 and 1787 Mozart wrote a great number of letters to Gottfried and described his travel experiences, together with his musical successes and difficulties.

According to LUX (1996), the metallurgical engineer who graduated from Sopron and who has lived in Cleveland Ohio USA since 1956, there are today nineteen pieces of music by Mozart known to have been dedicated to one or more of the members of the Jaquin family between 1786 and 1788, and which were often performed at home concerts. Jaquin was called the Linné of Vienna. The Republic of Austria issued in 1977 a commemorative postage stamp in his honour on the 250th anniversary of his birth. In Hungary a commemorative Jaquin medal was issued in 1935 on the 200th anniversary of the foundation of the Mining Academy of Schemnitz.
Mozart, Giesecke, and Born were all freemasons; it was Born, who perhaps inspired much of *Die Zauberflöte* with regard to freemasonry and geoscience, (see his essay' On the Mysteries of the Egyptians' mentioned below), and Giesecke, who perhaps introduced much alchemical thought into its structure and storyline as he had heard similar material previously in 1783 in a stage work by Meissner, that is, Meissner's comic operetta 'Der Alchemyst, oder der Goldmacher´(The Alchemist , or the Gold maker', see WHITTAKER, 2001). The details of alchemy relevant to *Die Zauberflöte* are presented by WHITTAKER (1998) and VAN DEN BERK (2004). It seems certain that Mozart used Giesecke to provide the words for his masonic cantata *Die Maurerfreude* ('Masonic Joy') (masonic cantata K471) in celebration of Born's scientific and technical work.
Other musical friends and acquaintances of Mozart's were scientists or closely related to scientists. For example, two other members of *Die Zauberflöte* (K620) cast were, Franz Xavier Gerl (1764-1827), who played the original Sarastro, and Benedikt Schack (1758-1828) who played Tamino. Both were scientists by training in the fields of physics and logic, and philosophy and medicine, respectively. Furthermore, both of these individuals were also talented composers as well as singers, who composed and produced operatic works which both preceded and followed *Die Zauberflöte*, for example *Der Stein der Weisen* oder *Die Zauberinsel* (The Philosophers' Stone or The Magic Island, 11th September 1790) which included music by Gerl, Schack and even a contribution by Mozart.

Also worth mentioning in this context is Dr Franz Anton Mesmer (1734-1815), as it is possible that perhaps Mozart's earliest impressions of science may have been coloured by his meeting and experience of Mesmer when Mozart was a twelve year old boy, and when his singspiel *Bastien und Bastienne* (KV50) was probably performed at the home of Mesmer (see OSBORNE, 1986).

Mesmer was the discoverer of 'animal magnetism' or'mesmerism', a phenomenon regarded by many at the time as a new scientific explanation of the invisible forces of nature and only later (in the nineteenth century) recognised as of value in psychology. Mozart commented musically upon animal magnetism in the Act one Finale of his opera *Cosi fan Tutti* (K588), when the maid Despina disguised as a doctor waves a magnet over the supposedly poisoned Ferrando and Gugliemo to resuscitate them. The music sounds very much like an electric shock. Also, the expression used in the opera ('*Pietra Mesmerica*') or 'mesmeric stone' carries strong echoes of the Philosopher's Stone given the context of contemporary science and the philosophical associations of Mesmer's ideas. Again of particular interest is the fact that Mozart was a very close friend of the Jaquin family, especially of Gottfried von Jaquin, the younger son of the distinguished scientist Nikolaus Joseph von Jaquin (1727-1817), mineralogist botanist, chemist and significant contributor to the Phlogiston debate, as mentioned previously.

Born, PAEF, Müller and tellurium

Born introduced scientific work into the Viennese masonic lodge *Zur Wahren Eintracht* which had its own library, facilities for scientific work, and cabinet. By 1770 he had already initiated a private learned scientific society in Bohemia (see ROSNER, 2008), which issued publications in the form of newsletters.
Certainly Born did introduce such material into the lodge *Zur Wahren Eintracht* ('True Harmony') which published scientific and cultural periodicals such as the *Physicalische Arbeiten der eintrachtigen Freunde (PAEF)* in Wien and the *Journal für Freymaurer*. Mention of the PAEF scientific masonic journal brings to mind the case of the element tellurium discovered by Franz -Josef Müller (Figure 22) and published in the second and final published volume of *PAEF*.

Müller was examining the gold-containing ores of Transylvania, from one of which, initially named aurum paradoxum, a supposedly pure sample of antimony (a close neighbour of tellurium in the periodic table) had been obtained. After many experiments, the possibilities that the new material was a type of antimony, bismuth, or an alloy of both, were eliminated. Müller called the new element, for that was what he had found, "metallum problematicum" or problematic metal. He published his findings (MÜLLER, 1783-85) in the *PAEF* under the title of "An Investigation of the Supposed Native Antimony from the Mariahilf Mine in the Facebaj Mountains near Zalatna". In 1798, Müller's discovery was rescued from oblivion by Martin H. Klaproth, who examined the "problematical metal" and named it tellurium (Figure 23).
In recent times tellurium plays an important role in the conversion of solar energy into electricity via CdTe. Gold telluride or calaverite (Figure 23) is a rare mineral but an important source of gold (see DITTMER, 2009).

Figure 22
Franz-Joseph Müller (1740-1825).

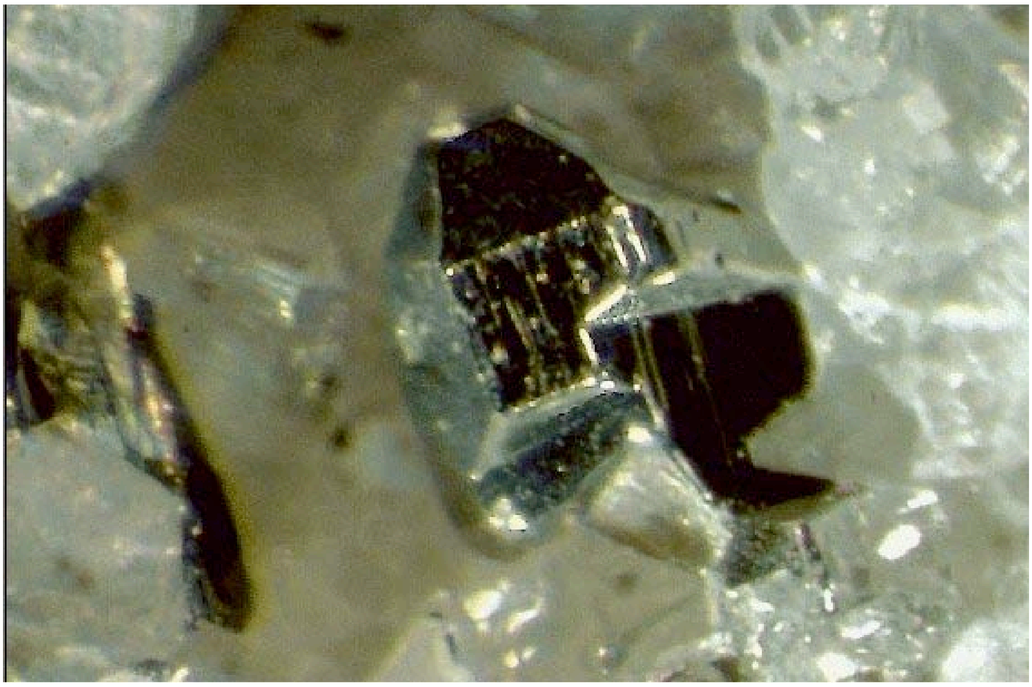


Figure 23
Tellurium mineral, gold calaverite.

Franz-Joseph Müller Freiherr von Reichenstein

He was one of the outstanding Transylvanian scientists at the time when Ignaz von Born, himself a native of Transylvania, was a famous scientist and writer in Vienna. Müller studied philosophy and law at the University of Vienna, but eventually specialised in mining, mineralogy, and chemistry. He continued his studies (1763) at the newly founded Mining Academy in Schemnitz (Selmec bánya formerly in Upper Hungary).

He was posted as manager of the mining office at Banat and undertook a study trip to Carinthia and Lower Austria. In 1768 he was appointed as engineer for mining surveys in Schemnitz and in 1770 he became mining engineer in Banat. While in Banat he was involved with the charburner colony at Steierdorf. In 1775 he was appointed as mining director in Schwaz, Tirol, but in 1778 he returned to Sibiu and occupied high positions in the Transylvanian administration of mines in Alba Iulia (Karlsburg). In 1788 he became government councillor and overseer of mines and ironworks in Transylvania and Banat; he was subsequently knighted as Edler von Reichenstein. He headed a commission which inspected large areas of terrain from the Banat to Moldovia. After his nomination as court councillor he left Transylvania and Banat for Vienna, where he was created a Freiherr (baron) by Emperor Franz I.

Whilst in the Tirol Müller discovered the presence of tourmalines. He also discovered in the Carpathian area several mineral species including alabandite, (a manganese blende, MnS) discovered in 1784 in Sacaramb, and sylvanite, discovered in 1785 in Baia de Aries (HOROVITZ, 2008). The two minerals sylvanite and nagyágite were both found in the Sacaramb (Hungarian; Nagyág) orebody. Interestingly, the exploitation of the gold- and silver-bearing ores there had apparently started before 1750, on the property of the Born family (BORN, 1774; STÜTZ, 1803). However, the two minerals which played the most important role in Müller's most famous discovery and description, that of the element tellurium, namely sylvanite and nagyágite, were both found in the Nagyág ore body. The chemical complexity of these ores was a very serious challenge for mineralogists and chemists of the time, reflected in the various names used for the two minerals (see lists in HOROVITZ, 2008). This complexity was further complicated by the continuing chemical paradigm (alchemy, or 'chymistry') of the time, especially since Born in his 1782 paper, entitled *Nachricht vom gediegenem Spiesglaskönig in Siebenbürgen*, ostensibly dealt with the antimony Regulus. Certainly it seems that Anton Ruprecht, professor at the Mining Academy in Schemnitz considered antimony to be present in this mineral, and responsible for the diminution of gold yield, by combining with this element. Spiesglas or Spiessglanz was an old Germanic name for the mineral antimonite Sb_2S_3, while *Spiesglaskönig* designated pure antimony (that is, what is known in English as *The Star Regulus of Antimony*). The complications are easy to imagine and understand when it is realised that Gold telluride, or calaverite, is a rare mineral but nevertheless an important source of gold.

In 1798 Müller's discovery was eventually designated as the new element Tellurium by the German chemist, Martin H. Klaproth (1743-1817), a chemistry professor in Berlin and the discoverer of uranium. Klaproth was sent mineral samples and after carrying out experiments in Berlin (see KLAPROTH, 1803) the relevant matters were discussed in a lecture in 1798 at the Royal Academy of Sciences in Berlin, where he designated the element *Tellurium* from Latin Tellus = Earth. "In order to complete the gap in the chemical mineralogy, I present my tests and experiments made with these precious minerals, whose main result is the discovery and confirmation of a *new specific metal*, to which I give the name Tellurium from the old mother *Earth*". In fact when Lavoisier proposed his anti-phlogiston theory in Paris it was natural for the German chemical community to close ranks and defend the phlogiston theory of Georg Stahl (professor at Halle, Germany) claiming Lavoisier's new theory was "just another French speculation". Klaproth volunteered to repeat his experiments in an attempt either to refute or to validate Lavoisier's views.

With Klaproth's reputation as an unbiased authority, the Berlin Academy had full confidence in his work. When Klaproth eventually in 1792 successfully duplicated Lavoisier's experiments, the Berlin Academy "became antiphlogistians" (see MARSHALL & MARSHALL, 2008).
This may be virtually the nearest we can get to an actual 'critical point' at which the old alchemy was finally defeated as a result of the application of good chemical and mineralogical practice (including also the observation of crystalline structure) and when 'modern' chemistry succeeded both alchemy, 'chymistry' and the phlogiston theory.
The discovery of tellurium was also claimed by the Hungarian botanist and chemist Kitaibl Pál (1757-1817). He did find the new element in a gold ore from the Hungarian mining centre Nagy-borzsony (German-Pilsen) in 1789.

The first chemical reaction taking place in the alchemical process was the reduction of the antimony ore stibnite (Sb_2S_3) known to alchemists as the prima materia or the green lion to give the following reduction 'reaction':

$$Sb_2S_3 + 3Fe \Leftrightarrow 2Sb + 3FeS$$

The resulting pure antimony was known to the alchemists as the Star Regulus (Little King) of antimony (Figure 24), which has always been known to possess a great chemical affinity for sulphur and hence useful in the purification of gold. The stibnite or antimonite (old German: spiessglanz) was long known to chemists and miners to have the power to purify gold because of antimony's great chemical affinity for sulphur and for gold. Given the scientific paradigm of the late eighteenth century, it was believed that 'antimony' (that is, the mineral stibnite) was composed of a metallic or 'mercurial' quality (the antimony metal) and a sulphurous quality (the sulphur part). After smelting of the stibnite ore, as was well known, the antimony metal separated from the sulphurous slag at the bottom of the smelting dish and was known as the *Regulus* or *The Star Regulus of Antimony*.

Figure 24
The Star Regulus of Antimony (Spiesglanzkönig), produced from stibnite (Sb_2S_3). The specimen is from Schlaining im Burgenland, Austria, and provided by Courtesy of the Mineralogy/Crystallography Department of the University of Vienna.

In those days it was the only metal known by this name (although, of course, the term regulus is now associated with any metal produced from its ore by the technique of smelting). It was also known that under certain circumstances a very special form of *Regulus*, which we would now know as a particularly pure form of antimony semi-metal, would be formed in the shape of a star known as the *'Star Regulus of Antimony'*. This star regulus was thought by the alchemists to be a manifestation, or the earthly counterpart, of the first magnitude *star Regulus (Cor Leonis)* in the zodiacal constellation of the Lion (Leo). Accordingly it was believed to have extra special properties and power to bring down influences from the heart of the constellation Leo located in the zodiac (importantly in the outer celestial sphere) via the separate spheres of the seven planets to the earth within (or below). Further details of the alchemical process can be found in NEWMAN (1994) and WHITTAKER (1998).

Tellurium, PAEF, scientific research and the masonic lodges

In 1784, in the PAEF, Born published a long essay entitled ‘On the mysteries of the Egyptians’ in which he compared the customs and ceremonies of the Egyptians with those of the freemasons. There is much reference to the Egyptian gods Isis and Osiris documented from classical sources such as Plutarch and Apuleius (see ECKELMEYER, 1991), for background and English translation). The Plutarch account refers to the saving of the life of the young Egyptian prince Horus from a serpent, which partly reverberates with the story of *Die Zauberflöte* (and Tamino’s ‘contest’ with a snake near the opera’s beginning) but unlike the Plutarch story, in which the evil uncle’s mistress intended to kill him. In addition, Born’s essay also mentions metallurgy which he links with Osiris and the Nile. Alchemy in fact has long been thought to have its roots in Egypt.

Born not only produced many seminal scientific works but was also a technological innovator (see RIEDL-DORN, 1991). He greatly improved the methods of extracting the noble metals from ores, through introducing the new amalgamation process. Born’s original account of this research was published in 1786 in Vienna and later rendered into English by the above mentioned Rudolph Erich Raspe and published under the title ‘Baron Inigo Born’s New Process of Amalgamation’ and published in London in 1791.
The whole business is of great relevance to *Die Zauberflöte* because the ancient alchemical process used amalgamation which was believed to achieve its most secret and important procedure during the preparation of the Philosopher’s Stone. In fact the presence of gold and silver ores in abundance in this part of Central Europe probably played a most significant role in the demise of alchemy and the successful development and further evolution of scientific chemistry and mineralogy. Central Europe was for a long time one of the leading centres of alchemy in Europe, particularly Prague, which provided the destination for several generations of alchemists from all over the known world including the Elizabethan English alchemists John Dee and Edward Kelley. Emperor Rudolph II himself took a keen interest in alchemy and his court was well known all over Europe for this. In the Habsburg countries during the 16th Century science was characterised by a considerable rise in the fields of chemistry and mining, but shortly after the Emperor (‘the New Hermes Trismegistos’) that is, Rudolph II had died in 1612 in Prague, an exodus of physicians, alchemists, scholars, and mining experts took place. During the Thirty Years War, apparently obsolete transmutational alchemical experiments were performed at the Imperial Court in Prague and Vienna (see SOUKUP, 2008). Emperor Ferdinand III and his brother Archduke Leopold Wilhelm, High Commander of the imperial troops were interested much more in alchemy than in military or political questions as apparently can be seen from reading their correspondence.

Under Emperor Leopold I (the son and successor of Ferdinand) alchemy became an affair of representation, show and display. According to SOUKUP (2008) hitherto unknown documents from the Moravian Archive in Brno throw a completely new light on the story of the Imperial Chymicus Wenzel Seiler (1648-1681). The letters enable reconstruction of important episodes in Wenzel Seiler’s life. A more or less complete curriculum vitae of this well known alchemist could be obtained, starting with his flight from the church of St. Thomas in Brno in December 1671 up to September 1673, when Seiler performed transmutational experiments in the presence of Emperor Leopold I.

Without doubt the 'Prince Charles of Lichtenstein' (i.e. Karl Eusebius von Liechtenstein 1611-1684), who supported Wenzel Seiler, was "a great sponsor of chymistry". As is also clear from the documents, numerous noblemen of this time were very interested in alchemy too. The decline of attempted transmutational alchemical activity happened only very gradually during the regency of Emperor Karl VI.

Johann Gottlob Lehmann and Mozart's *The Magic Flute*

The noted geologist and mineralogist Johann Gottlob Lehmann (1719-1767) produced many geological drawings and sections (Figures 25 and 26) which provided much scope for the development of geological ideas in the middle part of the eighteenth century.

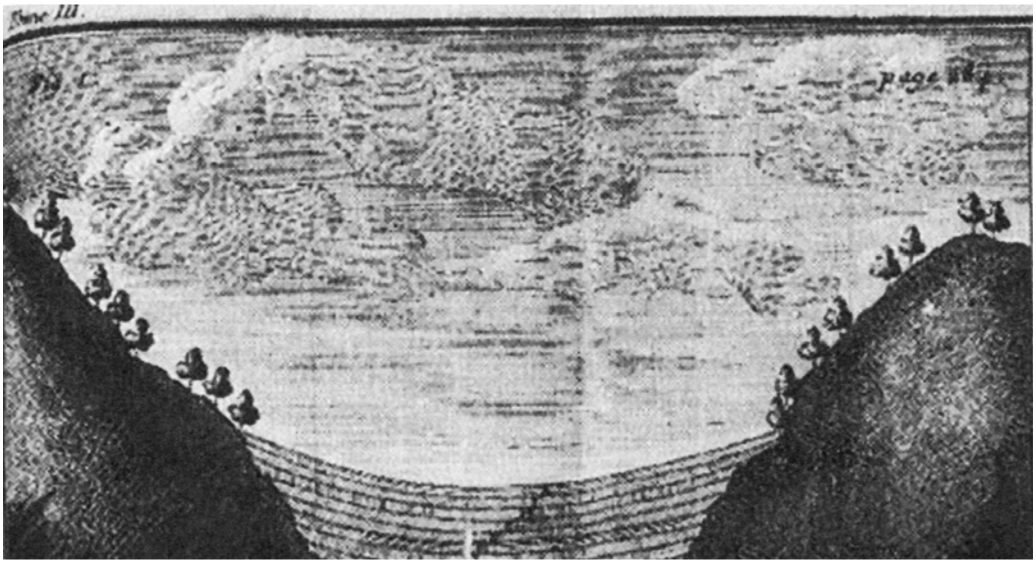


Figure 25
Portions of two Primitive Mountains between which are bedded deposits laid down by the Mosaic deluge forming the materials from which a group of Secondary Mountains will be developed. From LEHMANN, Berlin, 1756.

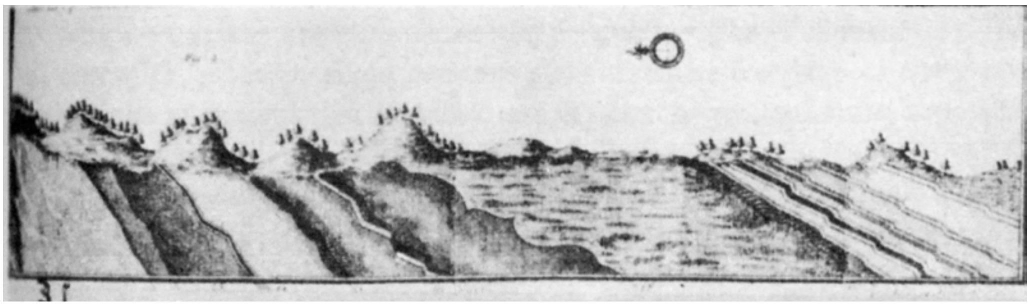


Figure 26
A Primitive Mountain (31) overlain by a sequence of thirty beds forming a group of Secondary Mountains. Ilfeld-Rudigforfdorf District. From LEHMANN, Paris 1759.

Particularly noteworthy and relevant here were his studies of the mountain ranges of Northern Europe which led to the belief that there were three classes or types of mountains. Those of the first class were called the Primitive Mountains which included the oldest mountains. They were allegedly formed at the time of the creation of the world and differed in their structure from the other mountains in that they were composed of beds or strata which were thicker and showed less variation in mineralogical character. Indeed, having been deposited from waters which were thought to be in a state of violent agitation, the bed is not even and well defined, as in the mountains of the second class, whose constituent beds were deposited more slowly and from a more tranquil sea. Moreover, these beds are not horizontal but have a vertical or inclined attitude and pass into the depths of the earth, so that their ultimate extension downward cannot be determined. The Primitive Mountains were also characterized by the occurrence in them of mineral deposits of a peculiar type. These differ from those found in the mountains of the second class in that they occur in the form of veins and irregular shaped masses rather than as bedded deposits. Certain metallic minerals were also thought to be peculiar to them. The Primitive Mountains comprised all the great and high mountains in the world. They were occasionally found as isolated peaks but usually in the form of long mountain ranges, such as the Alps, Carpathians, and Apennines. The Hartz mountains and Erzgebirge also belonged to this class. These were processes which made the earth ready for the Creation. This earth, or Lehmann's earth, is conceived as having been originally a great body of earthy matter mingled with water.

After this earth was deposited and the water withdrew a portion to form the oceans and lakes upon the earth's surface, whilst the remainder passed down into the great abyss which was thought to be in the centre of the earth. The earth then dried out and on the surface of the world thus laid bare the Primitive Mountains were present.

Then came the Mosaic deluge, the physical cause of which Lehmann says will always present for us 'An inexplicable enigma.'! The waters overtopped the highest mountains and from these waters earthy materials held in suspension were deposited. As the deluge subsided the retreating waters washed down from the slopes of the Primitive Mountains the loose earth which lay upon them together with the remains of all animals and any shellfish which were in the lakes on the mountains slopes and redeposited there as a series of beds on the adjacent plains.

This is why the Primitive Mountains present the bare and barren surfaces which they now display. Thus also it comes about that the Primitive Mountains have, abutting against their lower slopes, a series of well bedded deposits which dip away from them at a low angle, or should two of the Primitive Mountains happen to be situated near one another, these bedded deposits form a basin-like deposit filling the depression between them, the beds of which slope gently away from each mountain and toward the middle of the valley. Figure 25 is a diagram which shows two Primitive Mountains with the bedded deposits out of which the Secondary Mountains were to be developed lying between them.

To illustrate the broader connections of the opera (*Die Zauberflöte*) with geoscience, Figure 26 presents an actual section, although not drawn to scale, of the geological succession which is seen in the Ilfeld – Rudigfdorf district of Thuringia (LEHMANN, 1756 and 1759) near the Hartz mountains which shows a succession of thirty beds forming a group of Secondary Mountains, the lowest reposing on the slopes of a Primitive Mountain (number 31) traversed by mineral veins. This is an almost complete section through what are now known as the Permian rocks of Thuringia. (These two figures are illustrations taken from a French translation in 1759 entitled *Essai d'une histoire naturelle de la Terre*, from Lehmann's original German version published in Berlin in 1756.

This concept of geological terrain strongly recalls the scene description from Act 1 Scene 1 of *Die Zauberflöte* 'The scene is a rocky region, overgrown here and there with trees; on both sides are low mountains, in addition to a round temple.' (translation from ECKELMEYER, 1991). At this point Tamino enters right, coming down from a rock. (The name Tamino is a near-anagram of antimon the German word for antimonite or stibnite (antimony trisulphide), and is of considerable significance to the alchemical interpretation of the opera, see WHITTAKER (1998), and VAN DEN BERK (2004)). The scene described is extremely similar to that shown in Figure 25. The scene description of Act 1 Scene 6 is 'the mountains part and the scene changes into a splendid chamber. The Queen of the Night sits on a throne, studded with transparent stars. The next reference to mountains accompanies the scene description for Act 2 Scene 28 which forms the climax of the opera: 'The theatre changes to two great mountains. In one is a waterfall in which one hears rustling and splashing; the other spews fire'… (ECKELMEYER, 1991).

Figure 27
Part of the exhibit at the Miskolc University to celebrate the 250th anniversary of the Selmecbánya Mining Academy and its relationship to "Die Zauberflöte" by Mozart (from HORVÁTH, 1986).

In connection with *Die Zauberflöte*, Nicholaus von Jaquin, who was an oxygenist and associate of Lavoisier, played an important role in the great chemical debate of phlogistonists versus oxygenists and many of the chemical scientists already mentioned above undertook a critically important part in this controversy.

The biggest difference between the phlogistonists and the oxygenists was that the phlogistonists considered soil particles – now understood as alkalis and alkaline metal oxides – to be the smallest building blocks of matter, i.e. those which could not be further broken down, whereas the oxygenists subscribed more along the lines of today's understanding of the elements and their chemical structure: in the case of burning, the former scientist noted above (Jaquin) ascribed importance to phlogiston, the latter (Lavoisier) to oxygen (HORVÁTH, 1986).

A display case containing information about the Schemnitz/Selmecbánya Mining Academy and at least one major connection with W. A. Mozart and the relationship between the Academy and *Die Zauberflöte* is shown in Figure 27. In particular a picture of Mozart and von Born can be seen along with a drawing of a flute and a music manuscript entitled *Die Zauberflöte*.

LUX (1996) devised an interesting and unusual interpretation of the opera's meaning in connection with the geoscientists, to celebrate the 250th anniversary of his Alma Mater, the Mining Academy Selmecbánya. Performances of the opera took place in Blossom, Ohio, USA (HORVÁTH, 1986) on August 30th and September 1st, 1985, on the occasion of the Selmecbánya anniversary. The famous Cleveland Orchestra conducted by Christoph von Dohnányi gave a rather unusual performance of Mozart's opera, based on the studies and ideas of Lux. In this version of the opera The Queen of the Night, representing Mother Earth was lifted on high during the eruption of a volcano; the three ladies-in- waiting appeared dressed as miners with flat caps and miners' lamps, and Papageno was dressed as a woodsman. This interpretation by Lux is considered a source of pride by the Miskolc College of Technology and Heavy Industry as well as other establishments including the Technical College at Kassa, the Osztrava College of Mining and Metallurgy, The Leoben College of Mining and Metallurgy, and of course the College of Forestry in Sopron.

As well as a common acceptance that the character of Sarastro was based on the mineralogist Ignaz von Born, it is Lux's hypothesis that Mozart also intended to portray the Queen of the Night as Mother Earth, Tamino as a successful scientist, (for example Franz Müller, who as well as tellurium, discovered hyalite, a derivative of tourmaline from which the glass opal known as 'Müller glass' is made); Monostatos, the opera's dark character represented the chemist Klaproth who was relatively apparently very slow out of loyalty to Stahl (see above) to recognise the demise of the phlogiston theory, with Papageno as Mozart himself, and the aged priest as the chemist Nicholas Jaquin.

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