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MINERALOGY AND MAGIC FLUTE

by

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Summary

MOZART's seminal opera The Magic Flute was created and realised in the year of his early death, 1791. The opera stands near the transition from the classical to the romantic movement in the arts, and, as well as being immensely influential on later works of art, is seen as the ancestor of present-day popular musical theatre.

The opera was also composed at a time when geology was evolving from mineralogy, chemistry from alchemy, astronomy from astrology and mathematics from numerology. MOZART's little-known association with the scientists of his days is discussed, especially the mineralogists Ignaz von BORN and Sir Charles Lewis GIESECKE.

It is suggested that the story of The Magic Flute owes much to alchemy and related early mineralogy; the opera's architectonic structure, including its musical structure, owes much to numerology. The plot is in large part an allegorical account or description of the alchemical process and the production of the Philosophers' Stone from the *prima materia* stibnite (*spiessglanz*) (antimony trisulphide). In particular it is argued that the amalgamation procedures brought to prominence by the researches of Ignaz von BORN most likely provided the ideas behind, if not the immediate direct source of, the main storyline of the opera.

1. Introduction

Many scientists, even though music lovers, are probably unaware of the intimate links between the early history of the sciences and MOZART's last opera and perhaps Magnum Opus, The Magic Flute. Over two hundred years ago, in the year of his early death in 1791 at the age of 35, MOZART and the impresario and actor-manager Emanuel SCHIKANEDER, collaborated to create one of the best-loved works in the operatic repertoire, but one which has provided numerous puzzles of interpretation and meaning ever since.

The work is seen by many commentators as occupying a pivotal and influential position at or near the transition from the classical movement to the romantic movement in the arts. The last two decades of the 18th Century also saw the establishment of scientific mineralogy, chemistry and geology following the demise of alchemy and speculative Hermetic philosophy over the same period. Above all, the Enlightenment at the close of the 18th Century saw the breakdown of the old social order of the *ancien régime* and the establishment of republics in what had been monarchies in former times.

No less mysterious than the actual meaning of this magical opera is the question of whether MOZART and SCHIKANEDER might have had the assistance of other collaborators. It is suggested here that the opera fundamentally is about the alchemical process, that is about what was at that time the contemporary, but declining scientific paradigm. It is also suggested that the creation of the work may well be a collaborative effort between several people including scientists (WHITTAKER, 1991), and that the storyline may well have been strongly influenced by contemporary scientific research on amalgamation procedures.

The opera was first produced on 30 September 1791 in the *Freihaus Theater auf der Wieden* (Fig. 1) located in the Vienna suburbs and a far cry from the city centre Viennese theatres normally attended by the aristocracy. MOZART himself conducted the first performance, while SCHIKANEDER took the comic role of Papageno.

The playbill (Fig. 2) for the first performance survives and on it are several 'characters' with whom we are mainly concerned, MOZART himself, Sarastro who heads the cast list, and the First Slave. The chain which links these three characters was forged by freemasonry, which in the Vienna of the 1780s was very active and popular amongst intellectuals. It is also worth noting at this stage that two other cast members, Franz Xavier GERL who played the original Sarastro, and Benedikt SCHACK who played Tamino, were both scientists by training, in the fields of physics and logic, and philosophy and medicine, respectively. Furthermore, both of the last mentioned individuals were also talented composers as well as singers who produced operatic works which both preceded and followed The Magic Flute.

Fig. 1
The Freihaus Theater auf der Wieden in 1791.
The performance illustrated is of the opera
The Philosophers´Stone (Der Stein der Weisen)

Some of the circumstances surrounding the composition of The Magic Flute and MOZART's involvement and possible collaboration in other suburban theatre productions, have recently been reassessed by BUCH (1997) and are very germane to the present account. BUCH shows how two slightly earlier operas produced by SCHIKANEDER's *Freihaus Theater* company, '*Der Stein der Weisen oder Die Zauberinsel*' ('The Philosophers' Stone or The Magic Island') (11 September 1790) and '*Der wohltätige Derwisch oder Die Schellenkappe*' ('The Beneficent Dervish or The Fool's Cap') (early 1791) were part of a series of fairy tale or magic operas with music by a corporate *Freihaus* composition team (the 'SCHIKANEDER Firm') made up of SCHACK, GERL, MOZART and the resident theatre composer HENNEBERG. In particular, the opera entitled 'The Philosophers' Stone', in terms of its story and meaning, shows a lot in common with The Magic Flute.

Fig. 2
Playbill for the first performance of the Magic Flute which began at 7pm on 30 September 1791

2. Freemasonry and early scientific research

The history of freemasonry in Vienna can be traced back ultimately to the founding of the masonic Grand Lodge of England in 1717 (ROBBINS LANDON, 1982). FRANCIS STEPHEN, Duke of Lorraine, who was later to be married to MARIA THERESIA of Austria, was initiated into the brotherhood of freemasonry at a lodge in The Hague in 1731. That ceremony was conducted by the past Grand Master of the Grand Lodge of England, Dr J.T. DESAGULIERS, a Fellow of the Royal Society of London and close scientific associate of Sir Isaac NEWTON. In fact several prominent members of the Royal Society of London were freemasons. The foundation of a lodge in Hamburg in 1737 and the initiation of FREDERICK II of Prussia a year later ensured the establishment of further masonic lodges in German-speaking Europe despite the banning of freemasonry by papal bull in 1738 (GIESE et al., 1984).

However, the earliest Viennese lodges (in the 1740s and 1750s) did not survive long, although by the 1760s and 1770s several had been formed based on the French-derived Clermont system with its Scottish Rite, and the German masonic system known as the Strict Observance. Both of these recognised higher masonic degrees above the three basic masonic craft grades of Entered Apprentice, Fellowcraft and Master Mason; they were based upon speculative philosophy, alchemical ideas and Knights Templar traditions (Fig. 3).

In fact the Ancient and Accepted Scottish Rite, as it was known in most countries in the second half of the 18th Century, was often referred to in England as the Rose Croix or Rose Cross. Of the 33 degrees controlled by the Rite it is the 18th degree, the 'Knight of the Pelican and Eagle and Sovereign Prince Rose Croix of Heredom' which is the central feature of the Order. This particular degree (18th) is always worked at length and is regarded by many as the most beautiful and satisfying of all masonic degrees. The number 18 is associated with the Rosicrucian degree and brings to mind the prominence of that number in The Magic Flute. Also worthy of mention here are the birds named in the title of the Rosicrucian degree, that is the Pelican and the Eagle, both of which are very strongly linked with alchemy.

Fig. 3
Ignaz Alberti´s frontipiece to the first published edition of the libretto showing numerous alchemical and masonic symbols

ROSENBERG (1973) in an article entitled '*Alchemie und Zauberflöte*' has commented in some detail on the frontispiece of the original libretto produced by the freemason Ignaz ALBERTI (see Fig. 3). ROSENBERG recognised the influence on the opera of Rosicrucianism, which is closely linked with many aspects of alchemy as well as with freemasonry. ROSENBERG interpreted not only the cave setting, grave, archways, columns, broken columns and triangular shapes of the tools in terms of craft freemasonry, but he also noted that the blazing star (with letter G at its centre), the Egyptian pyramid and the large vase (alchemical vessel) all can be shown to be alchemical references.

For example, the symbols on the steeply-faced pyramid at front left show prominently the head of the Egyptian Apis bull, often a representation of the Egyptian fire and metal-working god Ptah (Greek: Hephaestos, Roman: Vulcan) and an ibis bird, the mercurian symbol of the Egyptian god Thoth (Greek: Hermes, Roman: Mercury). Together these two symbols represent the two principal alchemical qualities, placed in this drawing in an Egyptian setting. Importantly, the other symbols represent six of the seven metals/planets recognised by the alchemists at that time, that is lead/saturn (bottom left), silver/moon (bottom right), quicksilver/mercury (left middle), tin/jupiter (middle right), iron/mars (right side, above Apis bull's head), and copper/venus (topmost symbol). The seventh metal/planet, that is, gold/sun, is not shown.

Returning to the development of freemasonry on the European scene however, it was in the 1780s that Viennese freemasonry reached its peak with the foundation of the elite lodge True Harmony (*zur wahren Eintracht*) in 1781 (ROBBINS LANDON, 1982; GIESE et al., 1984). The leading personality of this lodge was Ignaz von BORN who turned it into the cultural centre of Enlightenment Vienna. The most distinguished and articulate people of the day – what we would nowadays call the decision makers, and movers and shakers, were associated with it and included writers, artists, musicians and scientists. By 1784 freemasonry had become so popular that all the existing Austrian lodges had organised and come together to form the Grand Lodge of Austria of which BORN was the General Secretary. Emperor JOSEPH II, however, under the impression that the masonic lodges might be centres of subversion, conspiracy and revolutionary activities, issued a patent curtailing their freedom and necessitating their reorganisation in 1785. Bearing in mind the political situation in France (and the fact that the Bastille was stormed in 1789), and the politically active role of some secret societies at the time, it is not surprising that freemasonry was regarded with suspicion by the Austrian monarchy. Eventually freemasonry was banned altogether in Austria by Emperor FRANZ II in 1794/5, but not before it had facilitated a remarkable flowering of cultural and scientific activity.

Figure 4 shows a picture of the inside of an Austrian masonic lodge of 1750 and illustrates many interesting features relevant to our story. In the foreground we can see various of the brothers carrying out scientific work and utilising the familiar tools of freemasonry. Prominent is a large globe being subjected to various scientific measurements. Behind these workers are other lodge members carrying out some other sort of masonic activity. At the rear of the scene are two small columns, at the top of which are a sun symbol and a moon symbol. In the centre at the rear is an alchemical furnace burning away. Also of relevance are the two large columns surmounted by statues of, respectively, the gods Athena Pallas and Hermes.

Fig. 4
Diorama of a Viennese masonic lodge of 1750 showing scientific work being carried out

The famous picture shown in Figure 5, now in the Historical Museum of the City of Vienna, was painted in about 1790 and shows the inside of what is thought to be the Crowned Hope Lodge in Vienna. There has been much discussion about recognition of the personalities in the painting especially the comments by ROBBINS LANDON (1982). Of particular interest are the possibility that MOZART himself is present at lower right, even perhaps sitting next to SCHIKANEDER. Also tentatively identified is the young actor, playwright and budding scientist GIESECKE (see below) fifth figure from the front left (seated). Little has been said about some of the symbolism seen in the rest of the picture.

Fig. 5
Inside the masonic lodge ´Crowned Hope´ c. 1790

Notice, for example, at the far end of the lodge the presence of a large, rough, unprepared masonry stone (a type of *prima materia*), located opposite a cut and dressed stone (analogous to the Philosophers' Stone). Also of great significance are the two columns at the far end of the lodge, each column decorated by a climbing snake or serpent carved into the column and bringing together masonic and alchemical symbolism. The two snakes are also shown again in the caduceus or wand carried by the statue of the god Mercury (Greek - Hermes; Egyptian - Thoth) seen in the right hand wall of the lodge and holding his flute or clarinet. Opposite Mercury in the other wall is another statue identifiable as the smith god Vulcan (Greek- Hephaestos; Egyptian- Ptah), who is recognised both by his lame leg and the fact that his hand contains a rising flame. Both gods are well established icons of alchemy; they represent respectively (1) the mercury principle of moistness, femininity, the Aristotelian element of water; and (2) the sulphur principle of dryness, masculinity, the Aristotelian element of fire. Of course they can also represent the presently understood chemical elements of mercury (Hg) and sulphur (S).

3. MOZART and the scientists

The association of the mercurial composer Wolfgang Amadeus MOZART with freemasonry is well established (Fig. 6). Figure 6 shows him surrounded by numerous alchemical symbols including the tail-biting ouroboros serpent, lion, sphinx, acacia plant and blazing star. In 1784 he was admitted to the Viennese lodge Beneficence (*zur Wohlttätigkeit*), whose members worked within the ambit of the True Harmony Lodge, and it was mainly, but by no means exclusively, through his masonic activities that he came into contact with the scientists of his day. I say 'not exclusively' because MOZART was a great friend of the JACQUIN family, especially of Gottfried von JACQUIN, the younger son of the distinguished scientist Nikolaus Joseph von JACQUIN (1727-1817), botanist, chemist and significant contributor to the Phlogiston debate (Fig. 7). MOZART was frequently in contact with the JACQUIN family (HORVATH 1996, LUX 1996).

Fig. 6
Wolfgang Amadeus Mozart (1756-1791) surrounded by alchemical and masonic symbols

MOZART's earliest impressions of science, however, apart from some possible influence from his father Leopold, may have been coloured by his experience as a twelve year old when his singspiel *Bastien und Bastienne* was probably performed at the home of Dr Franz Anton MESMER (1734-1815) (see OSBORNE 1986), 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 19th Century) recognised as of value in psychology (Fig. 8). MOZART commented upon animal magnetism in the Act 1 Finale of his opera *Cosi Fan Tutti*, when the maid Despina, disguised as a doctor, waves a magnet over the supposedly poisoned Ferrando and Guglielmo to resuscitate them. The expression used in the opera '*Pietra Mesmerica*', or 'Mesmeric stone' again carries strong echoes of the Philosophers' Stone given the context of contemporary science and the philosophical associations of MESMER's ideas.

Fig. 7
Nikolaus Joseph von Jacquin (1727-1817)

Fig. 8
Franz Anton Mesmer (1734-1815)

MOZART took his masonic activities very seriously as is witnessed by his correspondence and by his remaining a steadfast and loyal member of the brotherhood during the difficult years of Viennese freemasonry. Furthermore, he wrote masonic music (Masonic Joy, *Die Maurerfreude* K471) for occasions such as that in April 1785 when Ignaz von BORN, leader of the True Harmony Lodge, was honoured for his scientific and technological work. In these musical compositions MOZART devised his own musical masonic symbolism and style usually involving numerology, and in particular the number 3. He commonly utilised the key of E flat major or C minor (3 flats) and employed wind instruments (columns of air) and musical intervals of thirds (number 3 again) often joined with tied notes, which symbolised brotherly union (EINSTEIN, 1946; THOMSON 1977).

At this stage in his short life, in terms of financial reward and public recognition, in a sense MOZART's career had been in decline since the high point of his European tours as a child prodigy. The vast musical outpourings of his last seven years veil the fact that he was in precarious financial straits, a position only relieved by a few commissions and by borrowing money from his lodge brother Michael PUCHBERG (ROBBINS LANDON 1988). MOZART was now paying the price for professional freedom and independence after he had severed himself from the safe but stultifying small court of the Prince Archbishop of Salzburg. MOZART in fact was the first composer of stature to declare his independence from aristocratic patronage and to opt for the lot of a freelance musician, reliant only on his own artistic abilities but also at the whim of fickle public taste and fashion. Like the mineralogists and other scientists of his day there were few, if any, opportunities for betterment except through aristocratic preferment in some shape or form.

These restricted employments were in short supply, especially in large cities with big enough populations and infrastructure to support concerts, recitals and operas. Thus MOZART was the first notable freelance professional musician to enter the risky business of relying upon his own talents to make a living and to support his family.

It was in this rather financially depressing atmosphere and under such circumstances that he was approached by SCHIKANEDER, another freemason, to compose a magical opera (CHAILLEY, 1972). In accepting, perhaps MOZART had in mind the possibility that this magic opera might improve his luck and even, perhaps, be useful as a talisman if it were constructed in the right magical way, and therefore useful in restoring his declining fortunes. In fact such a course of action would have been quite ordinary and commonplace amongst those who might believe in natural magic, or, indeed, those who might wish to satirise it.

Magic was very much in the air of the Viennese theatre at this time with impresarios and stage producers mining a rich vein of pseudo-oriental fairy tales from the book by WIELAND published under the title of *Dschinnistan* ('Land of the Djinns') in 1786 (BATLEY 1969). The SCHIKANEDER company had staged a production of WIELAND's *Oberon* in 1789 with music by the well-known composer Paul WRANITZKY and libretto by an apparently up-and-coming young man of the theatre Karl Ludwig GIESECKE. GIESECKE in fact would not be active in the theatre for very much longer because he had a long-standing interest in mineralogical science and was soon to relinquish the stage for a very different lifestyle as a professor of mineralogy far to the west of Austria in Ireland. Eventually, GIESECKE also claimed to have had a more than profound influence upon the creation of The Magic Flute, to which we shall return soon.

4. The plot and setting of The Magic Flute

The elaborate plot of The Magic Flute is too labyrinthine to summarise concisely. It concerns a mysterious young prince (Tamino) who emerges from a rocky landscape being chased by a threatening serpent. As the serpent prepares to strike him, three veiled ladies appear and kill it with silver spears. As Tamino recovers he is surprised to be met by what appears to be a bird, but what in reality is a birdcatcher by the name of Papageno (compare with the mediaeval French word '*papegeai*' = parrot). It appears that the birdcatcher and the three ladies are in the service of the Queen of the Night, also known as the Star-blazing Queen, who informs Tamino that her daughter, a beautiful but pale princess named Pamina, is being held captive by a powerful evil demon named Sarastro. The Queen urges Tamino to rescue her daughter and presents him with a magic flute to help him in this task. Likewise, his reluctant, newly-found companion Papageno is given some magic bells to help them in their quest.
Tamino eventually finds his way to Sarastro's realm helped by three cupid-like boys and is ultimately allowed into one of three Egyptian temples only to discover that Sarastro is in fact not a demon but conversely a wise leader in charge of a band of initiates. After many adventures, and successfully undergoing many trials, Tamino is at the end united with Pamina through further trials by fire and water. As in many other alchemical dramas and stories there is also much mention in The Magic Flute libretto, scene descriptions and stage instructions of gardens and trees or plants, especially roses (see Fig. 13).

Fig. 13
´End. Multiplication´ from the ´Cabala´of Michelspacher. Mercury at the top of the flowing fountain holds his caduceus and the six-pointed star regulus of antimony. The fountain is located in the ´Philosophers´Garden´of trees and roses above the subterranean occurrence of the metals.

The opera contains many scenes whose descriptions are geologically meaningful. The text itself clearly describes the opera's setting in two contrasting geological landscapes or terrains. Firstly, there is the rocky, bare mountainous region described at the beginning of Act 1. Secondly there is a richly fertile, alluvium-filled valley by the River Nile. Scenes identical to these are illustrated in medieval and renaissance accounts and descriptions of the alchemical process. The rocky mountainous landscapes commonly show miners extracting raw ores from the rocks as the first stage in the preparation of the Philosophers' Stone (see Fig. 12). The mountainous, ore-bearing regions are often separated by wide, flat-bottomed valleys.
The character of Sarastro was thought by some of MOZART's contemporaries and many later commentators to be modelled on Ignaz von BORN, the leading Austrian mineralogist, metallurgist and freemason of his day.

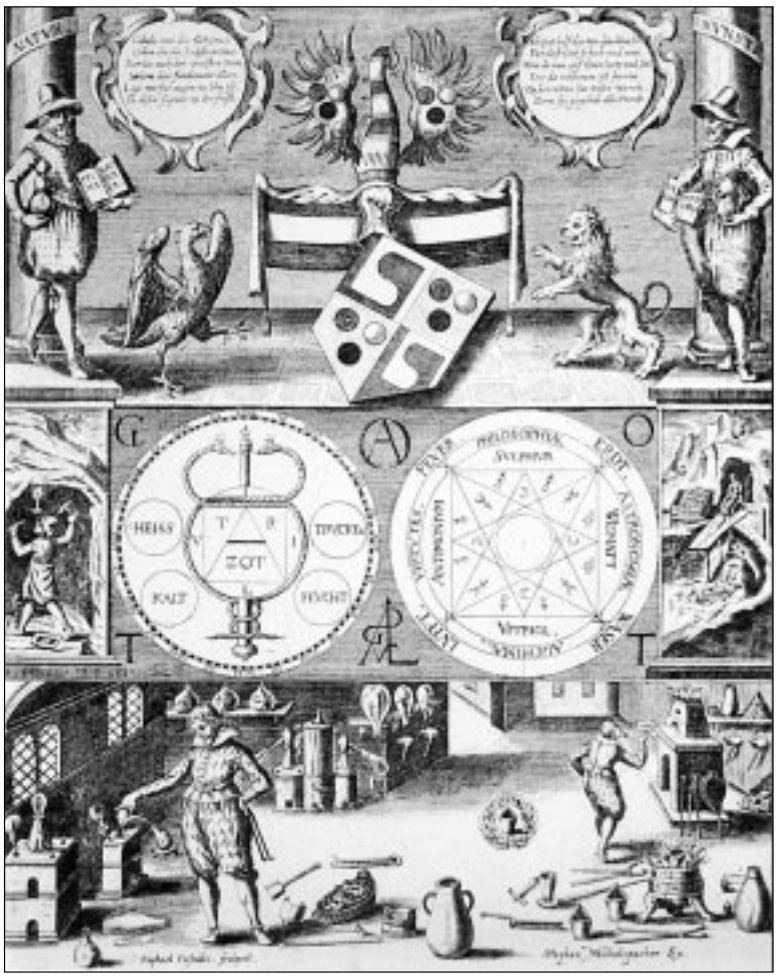

Fig. 12

Mirror of Art and Nature from the 1616 ´Cabala´of Steffan Michelpacher, the Tyrolean physician and alchemist.

The illustration shows the mining of stibnite, the necessary ´prima materia´ for the enetual preparation of the Philosphers´Stone, and shown taking place in the laboratory at the bottom of the picture.

5. Ignaz von BORN and his amalgamation process

Ignaz von BORN (Figure 9), born in 1742 in the mining district of Kapnis in Transylvania, was the son of a 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 mine. He was orphaned by the age of 9, 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 it in 1761 to study law in Prague, where he submitted his doctoral thesis in 1763. Subsequent to this he travelled widely in Germany, Holland, Belgium, France and probably Spain 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 present day Slovakia (HOFER, 1957; CAP, 1969; HUBER & HUBER, 1986; WHITTAKER, 1991; RIEDL-DORN, 1996).

Early in his career BORN was involved in a serious mining-related accident which affected him greatly for the rest of his life. Ostensibly on health grounds, he resigned his official post in 1772 and retreated to his country home where he produced his '*Index fossilium*' in two volumes (published in 1772 and 1775), the catalogue of his own mineral collections and a fine example of the high quality of his work.

Fig. 9
Ignaz von Born (1742-1791)

In addition to all of this BORN was active in attempts to establish an Academy of Sciences. By 1770 he had already initiated a private learned society in Bohemia which issued publications in the form of newsletters, and it has been suggested that he was working towards the establishment of an Austrian Imperial Academy of Sciences. Given the fact that other countries were establishing such institutions it seems likely that BORN may well have had this intention too, especially as he was almost certainly aware that the Royal Society of London had flourished as a result of the freemasonic affiliations of some of its members.

Certainly BORN did introduce scientific work into the masonic lodge *Zur wahren Eintracht*, which had its own library, facilities for scientific work and cabinet. In fact the lodge would seem very much like the 1750 Viennese lodge discussed above. BORN's lodge also published scientific and cultural periodicals such as the *Physicalische Arbeiten der einträchtigen Freunde in Wien* and the *Journal für Freymaurer*. The first issue of the latter (produced in 1784) is of particular interest in the context of The Magic Flute because it published BORN's long essay '*Über die mysterien der Ägypter*' and compares the customs and ceremonies of the Egyptian mysteries with those of freemasonry. There is much reference in the BORN essay to the Egyptian gods Isis and Osiris, documented from classical sources such as PLUTARCH (*De Iside et Osiride*) and APULEIUS (the *Metamorphoses*), and the relationship of Isis and Osiris to the moon and sun, respectively.

Similar landscape descriptions or inferences to those found in the opera (see above) are common both to Born's essay and to the 'Sethos' account (see BRANSCOME, 1991), which is also regarded as a seminal influence on the opera. Also worthy of mention is the reference in the PLUTARCH account to the saving of the life of the young Egyptian prince Horus from a serpent with which his evil uncle's mistress intended to kill him. Furthermore, 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 (RIEDL-DORN, 1991). He greatly improved the method of extracting noble metals from ores, through introducing a new amalgamation process. BORN's original account of this research was published in 1786 in Vienna (and later rendered into English by Rudolph Erich Raspe, the author of the 'Baron Munchausen' stories, under the title 'Baron Inigo BORN's New Process of Amalgamation' and published in London in 1791). Such was the perceived significance of this achievement that to honour it MOZART composed the masonic cantata *Die Maurerfreude* (K 471), performed in the Viennese lodge Crowned Hope in April 1785 (Fig. 10).

Fig. 10
Title page of Mozart´s masonic cantata ´Die Maurerfreude´written and performed to celebrate the successful outcome of Born´s laboratory and industrial-scale researchers into the use of amalgamation procedures in the production of noble metals from their ores.

In 1786 BORN organised the first international symposium of metallurgists in Schemnitz (the earliest mining academy in Europe) on the occasion of the opening of the first works to use his new amalgamation method, and jointly edited the resulting two-volume tome on mining engineering and related matters with Heinrich von TREBRA.
The whole business of amalgamation is of great relevance in the present context because it is known that the ancient alchemical process used amalgamation to achieve its most secret and important procedure during the preparation of the Philosophers' Stone.

Amalgamation is the mixture or alloying of another metal with quicksilver. The alchemists of the Middle Ages were well aware that silver would amalgamate with mercury although it is not certain that the knowledge was applied by them to the separation of the noble metals from their ores. The famous *Probierbüchlein* of c.1520 describes a method of recovering silver from the cement used in parting gold from silver by mixing the cement (silver chlorides) with quicksilver. However, AGRICOLA does not mention the treatment of silver ores by amalgamation, despite the fact that the Italian metallurgist BIRUNGUCCIO in his well known book '*De la Pirotechnia*' had published the process at least ten years before the publication of '*De Re Metallica*'.
It seems likely that BORN, during his Prague service with Thaddeus PEITHNER VON LICHTENFELS, and whilst curating ancient documents and reports, came across accounts of the testing of ore amalgamation processes by the American Spaniard Don Juan de CORDOBA and the Spanish monk Alonzo de BARBA. CORDOBA had applied to the Viennese court in 1570, and BARBA in 1620, offering to extract silver from ores using mercury. Various contemporary tests were carried out by Lazarus ERCKER using vitriol and salt, but the trials apparently failed with the recommendation that no more money be wasted on the matter. However, in the late 18th Century, BORN carried out small-scale experiments in the Vienna laboratory located in the house of the apothecary Franz Xaver BONSAING and eventually larger, industrial-scale trials at Glassh¸tten near Schemnitz which worked successfully. Although BORN clearly would need, and indeed had, a clear knowledge of alchemy and 'proto-chemistry', his letters show that he was very much against alchemy as practised by earlier generations of speculative philosophers (RIEDL-DORN, 1987).
BORN's scientific achievements were considerable. As a keen and accurate observer and a dedicated and meticulous experimenter he was held in great esteem by his national and international contemporaries. This was underscored by his publications, and his organising and curating of the Imperial collections. His output was prodigious and he had a profound influence upon the scientific and intellectual climate of late 18th Century Europe (HOFER 1957, RIEDL-DORN 1996).

Given the fact that this inspirational figure worked in the scientific fields of minerals, metals and the processes of amalgamation at a time when chemistry had only just begun to consider the possibility of shaking off the Phlogiston theory, it is certain that he must have had a detailed knowledge of alchemy. Although ostensibly firmly against alchemy, especially as practised by the so-called puffers, that is the people attempting to change base metals into noble metals, his own scientific work, even if only as a combatant against alchemy helped keep alive interest in the hotly debated topic of alchemy. In this way at least he had a direct influence on the creation of The Magic Flute. The marriage of the alchemical process to the prevailing philosophy of the freemasonic movement (of which he was the leading light) to provide the plot and libretto of The Magic Flute gives the basic formula for the opera's structure, architecture, and *raison d´être*.

Unfortunately BORN did not live to see the fruits of his brother freemason's labours as he died in July 1791, only six months before MOZART himself was dead. BORN is fittingly remembered in the sulphide mineral bornite (Cu_5FeS_4). Because of his standing in the Viennese enlightenment, his leading position in Viennese freemasonry, and especially his scientific achievements, it is extremely likely that he inspired and motivated the young actor, writer and freemason GIESECKE to take up mineralogy seriously.

6. Karl Ludwig GIESECKE and his claim for part authorship

Fig. 1
Karl Ludwig Giesecke (1761-1833) shown on the medal designed by Mossop and presented to him by the Royal Dublin Society.

In 1817, Sir Charles Lewis GIESECKE, the distinguished professor of mineralogy at the Royal Dublin Society was visiting Vienna to present a collection of samples to the Imperial court. While in Vienna he met a group of old theatrical friends to whom he confided that he himself (that is GIESECKE) was responsible for large parts of the libretto or text of MOZART's opera The Magic Flute (CORNET, 1849; DENT, 1947, BATLEY, 1969; KIRCHMAYER, 1995). Doubtless this caused some surprise because GIESECKE's only known association with the opera hitherto was that he had played the non-singing part of the First Slave, a role almost at the other end of the cast list from that of Sarastro.

Karl Ludwig GIESECKE was born Johann Georg METZLER in 1761 at Augsburg, the second son of a master tailor. Little is known of his early life save that already by the age of 20 he had adopted his pseudonym (STEENSTRUP, 1910). However, it was under his real name that he had registered at the University of Göttingen in 1781 and studied there for two years, ostensibly to read law although he later stated that during the course of his academic work he had applied himself to the study of mineralogy under BLUMENBACH (STEENSTRUP, 1910). Following his university course he became a journalist but eventually found his way to Vienna to become an actor, writer, arranger and translator associated with the SCHIKANEDER company for at least some of the 13 year period up to 1794. GIESECKE was a freemason known to have been present as an Entered Apprentice (and in the company of MOZART) at a meeting of the Crowned Hope lodge in 1790 (ROBBINS LANDON 1982). Although GIESECKE would clearly be well aware of BORN's scientific interests and achievements at this time, it is not certain whether he was actually used by BORN as an assistant in the latter's amalgamation experiments. Nevertheless, GIESECKE would be totally familiar with alchemy and things alchemical. He would have been regarded as 'scientifically' illiterate had he not had such knowledge at the time when modern chemistry was emerging from its alchemical past.

After 1800 he travelled extensively in central Germany and visited Freiberg in 1801, possibly to study with Abraham Gottlob WERNER the celebrated German mineralogist. Over the next two years he was in north Germany and Scandinavia probably collecting mineral specimens and curating collections, especially that of KARSTENS. During this period he was made a foreign member of the Swedish Royal Academy of Sciences and was appointed as a Prussian Mining Adviser.

In 1805 he was settled in Copenhagen and applied to the Danish king for support to undertake a three year expedition to Greenland, although it was not until the following year that he actually set sail (PETERSEN & SECHER, 1993; JØRGENSEN, 1996). Between 1806 and 1813 he carried out extensive scientific and exploratory work in Greenland. The extended (seven year) stay in Greenland was occasioned by the war between Britain and Denmark. GIESECKE's main scientific collection was unfortunately destroyed in the British bombardment of Copenhagen while he was stranded in Greenland; nearly as bad, a later set of specimens was commandeered by a British vessel before reaching Copenhagen, and diverted to Leith near Edinburgh.

Despite these trials GIESECKE's luck was on the verge of changing dramatically, rather like an operatic plot. This was because the Leith specimens had been bought in the meantime by Thomas ALLAN the Scottish banker and mineralogist, who, probably as a matter of conscience, managed to find out from whom the specimens originated. Thus, on arrival in Leith in October 1813, GIESECKE, fresh off the ship from Greenland and without funds, was invited to stay with ALLAN as an honoured guest in the fashionable quarter of Edinburgh (FARRAR & FARRAR, 1968).

After staying for a few weeks GIESECKE, at the suggestion of ALLAN, applied for (and later was appointed to) the newly-established Chair of Mineralogy at the Royal Dublin Society in competition with such well known geologists as Thomas WEAVER, Robert BAKEWELL and James MILLAR (HERRIES DAVIES, 1983). This was despite the fact that, on his own admission, he was unable to lecture in English. The climb in GIESECKE's fortunes continued. In the following year he visited Copenhagen and was admitted to a Danish order of knighthood (Dannebrog), thereafter using the title with his now-anglicised pseudonym, Sir Charles Lewis GIESECKE (Fig. 11). It was while visiting Vienna between 1817 and 1819 to present specimens commissioned by museum director SCHREIBER and to purchase specimens for the Dublin Society (MOSER, 1991) that he made his claim for authorship of The Magic Flute.

GIESECKE also took advantage of this visit to Austria to present specimens to GOETHE at Weimar. GOETHE was a person with whom he was subsequently often in contact. They corresponded regularly after that, particularly about meteorology. Also resulting from this was a regular stream of visitors to Weimar from Ireland.

In addition to many works for the stage (including Oberon, Hamlet and possibly The Magic Flute) GIESECKE's scientific contributions include catalogues of mineral collections, reports on the Faeroe islands, publications on Greenland, its mineralogy (especially cryolite), geology, meteorology and anthropology (see GUGITZ & KIRCHMAYER, 1964 for a full list). His Dublin lectures on mineralogy and metallurgy were extremely popular and well-received and he continued to carry out mineralogical field work in Ireland and to publish the results until his sudden death in March 1833 in the Irish capital city.
The mineral gieseckite is named after this early Arctic explorer; it is a pseudomorph after nepheline $(Na,K)AlSiO_4$ brought back from Greenland by GIESECKE and described by ALLAN.

7. Interpretation of The Magic Flute

We have suggested the possible association of several men of early science and especially mineralogy and metallurgy with the genesis and realisation of The Magic Flute. But what of the plot and the music? Despite the fact that no less a person than GOETHE described the work as of 'high significance' (JAHN, 1856), and produced part of a sequel to the opera, the bewildered response of many people on first experiencing the opera is that it is simply a pantomime, or even a joke, populated with lots of diverse characters, bright colours and special effects, all set within a rather disjointed plot (complete with poor dialogue) but set to sublimely beautiful music. The fairy tale-like first section, however, is followed by a much more solemn second part in which the hero is initiated into a noble, enlightened, Egyptian brotherhood or priesthood who worship in a temple dedicated to the gods Isis and Osiris.

Other interpretations of a political type, very distinct from the fairy tale outlined above, often identify the operatic characters with prominent personalities, and the plot with issues current at the end of the 18th Century. One such was put forward by Moritz Alexander ZILLE (DENT, 1947) who identified Sarastro as Ignaz von BORN, Tamino as Emperor JOSEPH II and Pamina as the Austrian people: the Queen of the Night was supposed to be the Empress MARIA THERESIA, herself who, it was alleged was trying to mobilise the opinion of the Austrian people against freemasonry.

However, the key to unravelling this gordian knot and to shedding light on the hidden meaning of the opera involves a third and more subtle level of understanding based on early cosmogonic theories and Hermetic philosophy (YATES 1964). Hermetism, a set of semi-religious and quasi-magical ideas, was derived from the writings of Hermes Trismegistus (Hermes the Thrice Great), thought by Renaissance Europeans to have originated at the time of Moses and to have been inspired by the Egyptian god Thoth, the deity of wisdom and learning (ROSENBERG, 1973). Hermetism emphasised analogies, correspondences, influences and the doctrine of microcosm and macrocosm; it was closely associated with magic, astrology, Pythagorean number symbolism and other occult 'sciences', particularly alchemy. It also exerted a profound influence upon Renaissance and post-Renaissance studies of the natural world and was a powerful stimulus to early scientific observation (RONAN, 1983). It is also worth emphasising once again the close relationship between alchemy and the Rosicrucian aspects of freemasonry.

8. Alchemy and astrology

Alchemy is the principal Hermetic operation and comprises an arcane mixture of science, art and magic. It was concerned with the transformation of things in the presence of what was thought to be a spiritual agent, sometimes known as the Philosophers' Stone, the Elixir or Tincture. Metals and minerals were used in the attempted transformations and each of these earthly substances had its astrological counterpart so that gold was equivalent to the sun, silver to the moon, quicksilver to the planet mercury, copper to venus, tin to jupiter, iron to mars and lead to saturn. The seven so-called planets (as known to the earlier generation of proto-scientists) were thought to revolve around the earth in distinct, separate planetary spheres; these were surrounded in turn by the outer or celestial sphere.

One important aspect of the production or manufacture of talismans or amulets was the belief in the necessity of their preparation from the right sympathetic material (mineral or metal) at the precise time when the prevailing astral conditions were congenial for bringing down the proper influences from the outermost celestial sphere. These influences were thought to travel down from the celestial sphere through each of the planetary spheres to the earth where the talisman was being prepared.
The zodiac was the most prominent feature of the celestial sphere. Of particular interest, because of its perceived relationship and association with the sun, was the lion constellation (Leo), at whose heart (another very important alchemical symbol) lay the star of first magnitude known as *Cor Leonis* (the heart of the lion), or to give its other popular name, *Regulus* (which means 'Little King').
The most notorious part of the alchemical work was the attempted transformation of the base metals into gold, a process involving the symbolic alchemical death, dissolution, coagulation and resurrection or rebirth of the original or first material (*prima materia*).

Alchemy provides a bewildering and often exotic set of symbols to describe chemical processes which were seen to take place in the alchemical or hermetic vessel. Amongst the most prominent and frequently used symbols for the chemical materials used and the chemical processes taking place in the sealed glass vessel were animals such as snakes (or serpents, dragons), lions and the mythical griffin, birds (crow, dove, peacock's tail, eagle, pelican, mythical phoenix), and related colour changes going from black to white to red or gold.
The alchemical process as described by the secretive medieval alchemists and later protoscientists began with the search for the first matter or *prima materia*, invariably symbolised as a serpent, snake, dragon or lion. In alchemical terms, the slaying of the dragon was the first procedure to be undertaken followed by blackness (*nigredo*) and the appearance of the Crow's Head. After many dissolutions and coagulations (*solve et coagula*) the appearance of white birds such as the dove symbolised the arrival of the white stage (*albedo*) of the work. After more laboratory procedures involving washings, purifications and eventual prolonged heating, the multicoloured stage of the peacock's tail (*cauda pavonis*) appeared and eventually the gold or red (*rubedo*) stage was achieved with the production of the Philosophers' Stone. Often the latter stages of the process were accompanied by descriptions and symbols of trees and flowers (commonly roses).

9. The mineralogy and chemistry of the alchemical process

The actual chemistry of the alchemical process is difficult to elucidate because of the secrecy surrounding the so-called 'Great Work' (*Magnum Opus*) and the deliberate obscuring of the names of the ores, minerals and chemicals used. The mineral sought from the mines (Fig. 12) was stibnite or antimonite (German: *spiessglanz*), originally because of the power of antimony to purify gold (antimony has a great chemical affinity for sulphur and since ancient times has been used for this purpose). However, it is important to remember that minerals, ores and their chemistry were extremely poorly understood and were most commonly used in a very impure form. In the 18th Century and earlier, the ore stibnite (antimonite, *spiessglanz*) was known only as 'antimony' or '*antimon*' in German (an anagram of Tamino), or to the alchemists, the 'serpent', 'dragon' or 'green lion'.

Given the scientific paradigm of the time (alchemy), it was believed that 'antimony' (that is, 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, the antimony metal separated from the sulphurous slag at the bottom of the smelting dish and was known as the *Regulus*. In those days it was the only metal known by this name (although the term 'regulus' is now associated with any metal produced from its ore by this technique). 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 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 the power to bring down influences from the heart of the constellation Leo located in the zodiac (in the outer celestial sphere) via the separate spheres of the seven planets to the earth within (or below). The star regulus of antimony was at times associated with the phenomena of magnetism or attraction and to the alchemical concept or quality of 'mercury'.
The first stage of the alchemical process therefore was the production of the star regulus of antimony (that is, pure antimony metal Sb) from antimony ore (stibnite Sb_2S_3 - the *prima materia*) by reduction using iron. This was achieved in the alchemical laboratory by fusing two parts of antimony ore with one part of iron (usually nails) in the presence of a nitre flux. The fusion was recommended by the alchemist, or 'artist' as he was sometimes known, to be carried out four times to produce the star regulus of antimony, represented by the following reaction:

$$Sb_2S_3 + 3Fe = 2Sb + 3FeS$$

Fundamentally, the subsequent and most difficult part of the alchemical procedure was about amalgamation, specifically the amalgamation of antimony metal with mercury. This is not at all a straightforward operation but can be achieved or facilitated with the addition of silver when used in the right proportions. The process is fairly simple in general terms but lengthy and laborious.
The stellate antimony regulus was thus fused with silver to produce an antimony-silver alloy; in this situation the silver used for the fusion process was known to alchemists as the 'Doves of Diana'. The antimony-silver alloy was then amalgamated with ordinary mercury to produce a black amalgam, which was subsequently heated in a sealed (Hermetic) vessel on a slow fire for a short time and then ground in a mortar without moisture while being warmed moderately. This got rid of some of the blackness. It was then washed several times with water until more of the blackness disappeared. The amalgam was next dried and kept in the heat near the fire for three hours or so, after which it was ground again in a dry and warm mortar.
This eliminated yet more blackness and was washed again, the process being eventually repeated several times until the whole amalgam became 'like shining and cupellated silver, whereas at first it had a dark leaden colour' (see DOBBS, 1975).
This mixture, known as 'animated mercury' to the alchemists, was 'distilled' and amalgamated between 7 and 9 times with associated heating, grinding and washing. The alchemical 'animated mercury' was reputed to dissolve all metals particularly gold, which was the final metal ultimately added to the amalgam; this metalline mixture was heated yet again in the final stages of the alchemical process to produce the Philosophers' Stone.

The quote of George STARKEY ('Eiranaeus Philalethes') who was particularly associated with this antimonial processing and was avidly read by NEWTON and GOETHE is as follows: „I have in the fire manifold glasses with gold and this mercury. They grow in these glasses in the form of a tree, and by a continued circulation the trees are dissolved again with the work into new mercury. I have such a vessel in the fire with gold thus dissolved.....it makes gold begin to swell, to be swollen, and to putrefy, and also to spring forth into sprouts and branches, changing colours daily, the appearances of which fascinate me every day" (DOBBS, 1975; NEWMAN 1987, 1994). This phenomenon of colour change was the peacock's tail (*cauda pavonis*); it was associated with the observation of plant-like growth of these inorganic ingredients and was referred to by many of the alchemists in contemporary accounts (Fig. 13).

It is likely that the observers were watching, in the Hermetic vessel, the production of iridescent intermetallic compounds of mixed gold, silver, mercury and antimony composition in the heat of the furnace or fire. It is also likely that the frequently reported tree or flower growth effect was caused by fractal growth of these iridescent, intermetallic compounds. The 'trees', 'flowers' or 'roses' can be thought of as unstable dendritic crystals, growing rapidly, irregularly and with fractal geometry. It was thought by the alchemists that the result of this so-called 'lawful marriage' was the birth of a living creature - the vegetating gold. Such microcosmic experiments would clearly reinforce the macrocosmic idea that metal veins actually grew in the Earth's crust rather like trees at the Earth's surface.

They may even have given rise to the concept of a 'mineral tree' at the Earth's centre whose branches and twigs were thought to be manifest as ore and metal veins just beneath the surface. This view was propagated by LEHMANN, the German mineralogist as late as 1753.
From this it can be seen why the alchemists and speculative philosophers were so interested in experimenting with and producing the Philosophers' Stone. It can also be seen why there is a likely connection between the plot of The Magic Flute, which alchemically (and indeed chemically) is mainly about a difficult type of amalgamation, and MOZART's scientific friends and lodge brothers. The one scientist in late 18th Century Austria who had researched amalgamation in depth and knew most about the procedures was Ignaz von BORN, celebrated by the masonic lodges with the 'Masonic Joy Cantata' (*Die Maurerfreude*, K 471) for this very achievement. (It is also relevant to note here the exact quotation (identical key, notes and phrasing) by MOZART of a musical phrase from the Masonic Joy Cantata at the words '*wie dem starren Forscher auge*' with Pamina's statement '*Führt mich hin, ich möcht' ihn seh'n*' in the Finale to Act 2 of the opera.) Now although Ignaz von BORN was undoubtedly a leading antagonist against alchemy in the great scientific debates of the day, he would certainly, as an expert on amalgamation, be more than aware of the amalgamation procedures and techniques used by alchemists. Indeed, it was his specialist subject, and a research topic that some authors suggest that BORN may have been assisted in by GIESECKE (see HILDESHEIMER, 1982; HORVATH, 1996; LUX, 1996).
The Magic Flute can thus be seen as an alchemical drama encompassing the eternal conflict between the forces of light and darkness, as represented by the sun (in the shape of Sarastro) and the moon (Queen of the Night). Concurrently, the audience witnesses the operatic version of an 'alchemical wedding', a process in which the young hero and heroine are subject to various 'ordeals' (including testing and tempering by the Aristotelian elements of earth, air, fire and water), representative of various laboratory operations, purifications and chemical combinations.

The real chemical referents and laboratory procedures of the alchemical process, allegorically represented on the stage as outlined above, and which inspired The Magic Flute are as follows. (1) The chemical reduction (= allegorical death) of antimony ore (= stibnite = snake or green lion) to give pure antimony metal (= allegorical rebirth to produce the star regulus of antimony = Antimon = Tamino). (2) Its eventual subsequent alloying with silver (= Doves of Diana = Pamina) and its amalgamation via the mercurial aeolian magic of the flute and the coincident first addition of gold (via the magic flute), to give the multi-metalliferous alloy present at the end of the initiation scene (Act II, Entrance 28).

This is followed by (3) a change in the allegorical alchemical vessel to the garden scene (Act II, Entrance 29) again (and the alchemical phenomenon of fractal 'vegetative' growth), the appearance of the peacock's tail (= Papageno and Papagena) and the eventual total alchemical elimination of darkness or blackness (the demise of the Night Queen, Monostatos and the Three Ladies in Act II, entrance 30). Ultimately (4) the final allegorical addition of gold to this amalgam (= the whole theatre being represented as a sun - Act II, Entrance 30, bar 70) represents the alchemical stages of 'multiplication' and 'projection' which produce the Philosophers' Stone. This magical operatic brew results, during the course of the performance, in the transmutation by initiatory symbolic death and rebirth of the hero and heroine, the overthrow of darkness and chaos, and the triumph of light and order. Also the architecture of the work and the music itself are deeply imbued with elaborate Pythagorean number symbolism so that the Hermetic concern with weight, proportion and measure is given full and proper treatment.

10. Numerology and mathematics

Mathematics and number have for long been associated with music, ever since the time of the establishment of a relationship between Pythagorean ratios and musical intervals, through to the modern science of acoustics. Parallel and similar to the case of materials science, in which modern chemistry had a partly magical and mystical forerunner in alchemy, likewise number science or mathematics had a Hermetic and partly magical predecessor in numerology.

Numerology as a doctrine allocated special properties and associations to certain numbers which were commonly used by medieval, renaissance and later philosophers to enhance and support alchemical laboratory and astrological observations as well as general philosophical writings. This is not at all surprising given that astrological observations in particular since earliest times were clearly and closely associated with mathematical calculations. Also astrology was, of course, a prime Hermetic magical activity, believed to be the power controlling divination, correspondences, influences and macrocosm-microcosm relationships ('as above, so below').

The common perception of numerology in The Magic Flute is that it is simply associated with the number 3 and is there only as a result of masonic influence and for masonic reasons. It is true to say that the number 3 is important in masonic thought and practice, and certainly the number 3 abounds in The Magic Flute, ranging from key signatures with 3 flats, to 3-based 'knocking' rhythms, to groups of 3 characters (3 ladies, 3 boys, 3 slaves etc.). However, the numerological content of the opera is much fuller and more complex than that.

GRATTAN-GUINNESS (1992) has presented a detailed exposition of numerological aspects of The Magic Flute. He explains that the roots of numerology probably lie in gematria, a sacred type of arithmetic in which a number was assigned to each letter of the alphabet (usually Hebrew, Greek or Latin). Names, words or phrases could then be expressed in number by calculating with these numbers. Also important, and so as to illustrate some of the methods used, is a numerological technique of ancient standing used to produce the so-called reduced number (R) of a number (N). R is derived by adding together the digits of N until a sum R between 1 and 9 is obtained (eg, N = 763; 7 + 6 + 3 = 16; 1+ 6 = 7 = R).

Returning briefly to Pythagorean ratios, Pythagoras and his followers observed that the pitch of a note of a vibrating string depended on the length of the string so that a tonic, its fifth and its octave were in the ratio 2 : 3 : 4. This led Pythagoras to explain the order and harmony of Nature in terms of numbers and to suggest that harmonious sounds ought to be given out by the planets as they moved in their heavenly or celestial orbits (the 'harmony of the spheres').

Also known to the Pythagoreans was the existence of only 5, regular convex solids each of which could be circumscribed by a sphere. The dodecahedron (12-sided solid) was given particular significance because its 12 regular faces corresponded to the 12 signs of the zodiac and it was thus a symbol of the cosmos. Additionally, each pentagonal face of the dodecahedron was associated with the ratio known as the 'golden section'; this was the ratio called by KEPLER 'the divine proportion'.

The golden section or the golden proportion occurs when a smaller term is to a larger term in the same way as a larger term is to the smaller plus the larger. It is represented by a : b :: b : (a+b), where the largest term (a + b) is a unit made up of the sum of the other two terms. It is designated *phi* (ϕ), the 21st letter of the Greek alphabet. The presence of this proportion is found in the sacred art and architecture of most of the traditional civilisations, and persists through to medieval, renaissance and later times in Europe. Not only are many works of art built upon it, but it also permeates the natural world in, for example, the arrangement of leaves on the stem of a plant (phyllotaxis) especially 5-petalled plants such as roses, and the growth of certain mollusc shells like *Nautilus*.

The golden proportion manifests itself in the structure or architecture of The Magic Flute. Both the number of musical pieces and the number of entrances (*auftritt*) are arranged to conform to the golden section. The total of musical pieces (excluding the overture) in the whole opera is the magic number 21 (3*7); the music is placed in the two acts as 8 pieces in Act I, and 13 pieces in Act II. This is a golden proportion. Similarly, the number of entrances in the whole opera is the magic number 49 (7*7); the action is placed in the two acts as 19 entrances in Act I, and 30 entrances in Act II. This is also a golden ratio.
At least one of the individual musical pieces is structured according to the golden proportion. Interestingly, this is the overture, which is not included in the 21 musical items noted in the previous paragraph. The overture has a slow 15 bar introduction which comprises 3 bars of a 'knocking' motif followed by 12 bars of what might represent chaos and be symbolic of the cosmos (via the zodiacal number 12). It is the separate, succeeding *allegro* part of the overture which displays the golden proportion.

The *allegro* of the overture, in contrast with the mystical, 'fuzzy' nature of the slow opening section, is clear cut and well defined. It contains a total of 211 (possibly 210) bars of music of which the first 81 bars form a complete section. These first 81 bars give way to 6 bars of 9 (3*3) 'knocking' chords (also appearing near the beginning of Act II). These 'threefold' chords (*Dreimaliger Accord*) of Act I in turn are followed by 124 bars of the remainder of the *allegro* making 130 bars in the golden proportioned structure of the *allegro* (81 bars of music:130 bars of music).

Mathematics and numerology are manifest not only in the golden proportions noted above, but are also detectable in the melodic, rhythmic and even harmonic construction of the music. In particular the 'magic' numbers 3 and 7 are prominent (plus their reduced number 1 (3 + 7 = 10; 1 + 0 = 1). In fact all the so-called numbers of completeness 1, 3, 7, 9 are of special significance in the opera.

The numerological organisation of the music is observed in many places and is commonly well-disguised. A good example of the melodic association with number is provided by the descending 7-note scale which virtually forms a *leitmotif* in many parts of the opera. It appears prominently in the '*Bildniss*' aria sung by Tamino, in the duet '*Bei Männern*' sung by Pamina and Papageno and in many other places including the initiation scene of the trials by fire and water. Incidentally, this initiation scene includes a duet sung to a BACH chorale some of whose original words were about the purification of silver (carried out 7*7 times) (see CHAILLEY, 1972).

Melodic and rhythmic numerical elements come together very cleverly indeed in the overture, not surprisingly perhaps considering the elaborate play on the magic numbers 3 and 7 in the golden proportioning of the opera's architectonic structure noted above. Apart from the opening 3 bar 'knocking' motif, followed by the 12 bar (R = 3) slow adagio section possibly representing chaos, there follows the *allegro* fugato main section which displays elaborate treatment of descending scales of 7 notes. Together with this is a rhythmic pulse which initially starts as a dynamically *forte*-marked emphasis of every 7th note (of 10 notes in a bar; that is, 6 quavers followed by 4 semiquavers). To this *forte*-marked 7th quaver is soon added another strongly-pulsed note marked *sforzando* at quaver number 3 (in 4/4 time) leading to emphasis of quaver beats 3 and 7. These strongly pulsed 3rd and 7th (quaver) notes are eventually turned into a syncopated rhythm (crotchet, minim, crotchet in 4/4 time) which is much used throughout the opera and is well 'in tune', as it were, with a musical and numerical representation of alchemical transformation.

Indeed, if one were to try to construct a good, magical, yet musical and numerical device to relate macrocosm to microcosm, one of the best ways of achieving this would be to use a descending scale of 7 notes reinforced with other hidden numerologically-based rhythmic and harmonic patterns. Whether one's intention was serious, or whether one wanted to create a sympathetically constructed work of art, in this way it would be possible to attract, or to simulate the bringing down of, the desired good influences from the celestial sphere (say, from the star of first magnitude *Cor Leonis* or *Regulus*) via the 7 planetary spheres down to the Earth by using a descending scale of 7 notes.

11. Alchemy and the development of early geological thought

The authors and inspirers of The Magic Flute, amongst the former of whom we might include many individuals with a scientific background such as GIESECKE, GERL, SCHACK, and the latter among whom we should include BORN and JACQUIN, were clearly wholly familiar with alchemical and Hermetic ideas. This is not at all surprising seeing that chemical theory in the late 18th century was only just emerging from its alchemical past (RONAN, 1983). LAVOISIER, who actually began his scientific career in mineralogy, had only just discarded the Phlogiston theory in 1783, a theory that was introduced by the German physician Georg STAHL in his 'Fundamentals of Chemistry' published in 1723 (RONAN, 1983; LAUDAN, 1987). STAHL, like MESMER after him, believed in a vital force operating throughout nature, especially in living things. Phlogiston, his 'fire principle', provided a great unifying scientific concept at the time, being applicable to combustion, respiration and calcination.

The phlogiston theory was derived by STAHL from the work of the Hermetic philosopher and alchemist Johann Joachim BECHER. In his book *Physica Subterranea* (1688), BECHER had concluded that all metals and minerals were composed of three qualities or principles. These were (1) a transparent, vitrifiable component (*terra lapida*), (2) a subtle or volatile component (*terra mercurialis*), and (3) an igneous, fatty, combustible component (*terra pinguis*); it was this last quality that STAHL identified with phlogiston. These BECHER principles were derived, in turn, from the three alchemical principles of PARACELSUS (JACOBI, 1988), that is from the alchemical concepts of (1) 'salt', (2) 'mercury' and (3) 'sulphur'.

LAUDAN (1987) has shown that WERNER's late 18th Century theory of the earth owed much to the BECHER-STAHL (and thus Paracelsan) tradition of chemical mineralogy and alchemy. Her assessment of the early history of geology concludes that 'the Wernerians formulated the conceptual foundations of geology and dominated its intellectual development in the period between 1780 and 1830'. These researches into the early history of mineralogy and geology show that, like The Magic Flute, early geological thought and theory were greatly influenced by Hermetic alchemical philosophy.

GOETHE was greatly interested in alchemy, a subject which inspired the Faust stories and some of the fairy tales (*Märchen*). He was also a gifted scientist with a particular interest in mineralogy and geology. It is well known that he incorporated some of the great geological debates between the Neptunists and Plutonists of his time in the Faust stories (ADAMS, 1954). Here we have a prime example of science, or natural philosophy, influencing literature directly in the earliest stages of the romantic movement.

A similar situation obtained in Britain where the English lake poets, especially WORDSWORTH, were greatly influenced by geologists such as SEDGWICK and WHEWELL at Cambridge University. SEDGWICK and WORDSWORTH were great friends (WYATT, 1995). In fact WORDSWORTH's brother was the Master of Trinity College when Adam SEDGWICK was the first professor of geology at Cambridge. A close network of contacts took a great interest in geology and the related philosophy, because of their mutual interest in landscape and in dramatic mountain scenery. This great influence of geology on the development of the English romantic movement is paralled in German-speaking Europe by GOETHE's association with the scientists of his day, including GIESECKE.

12. Coda

The profound and seminal influence of The Magic Flute on later works of art, and the continued influence of mineralogy and geology on the development of the romantic movement are only now becoming fully apparent. As well as this influence, the direct association of mineralogical and geological science with MOZART's music continued well into the 19th century after MOZART's death. Austrian-born Ludwig Alois von KÖCHEL (1800-1877) (Figure 14) visited many parts of Europe acquiring a considerable reputation as a mineralogist and botanist (HYATT KING 1956). He was also a great music lover. In 1851 as a result of a plea from a friend for the proper investigation and preservation of MOZART's works, he responded (as a scientist with a keen interest in Linnaean taxonomy) by undertaking the huge task of systematically cataloguing all of MOZART's works.

During his scientific travels he diligently sought out manuscript copies of MOZART's music, culminating in the publication in 1862 of his monumental catalogue. Not content with a mere listing, KÖCHEL became the main driving force behind the first complete published edition of MOZART's works. Unfortunately he died only six years before the realisation of his editorial efforts. Fittingly, however, he is remembered whenever the works are played, by the initial letter of his surname (K), which is added as a prefix to the catalogue number. The Magic Flute is catalogued as K 620.

Fig. 14
Signed photograph of Dr. Ludwig Ritter von Köchel (1800-1877)

In 1991, the 200th anniverary of MOZART's death and of the first performance of The Magic Flute, Italian scientists from the University of Genova discovered a new silicate mineral species during their continuing studies of manganiferous mineralisation of the northern Apennines. Being aware of MOZART's association with mineralogists from the account by WHITTAKER (1991), the new mineral was named mozartite (BASSO et al., 1993).
Mozartite usually appears as minute anhedral crystals, is transparent and deep red in colour (PALENZONA & POZZI 1993), with the chemical formula $CaMn(OH)SiO_4$ (Fig. 15).

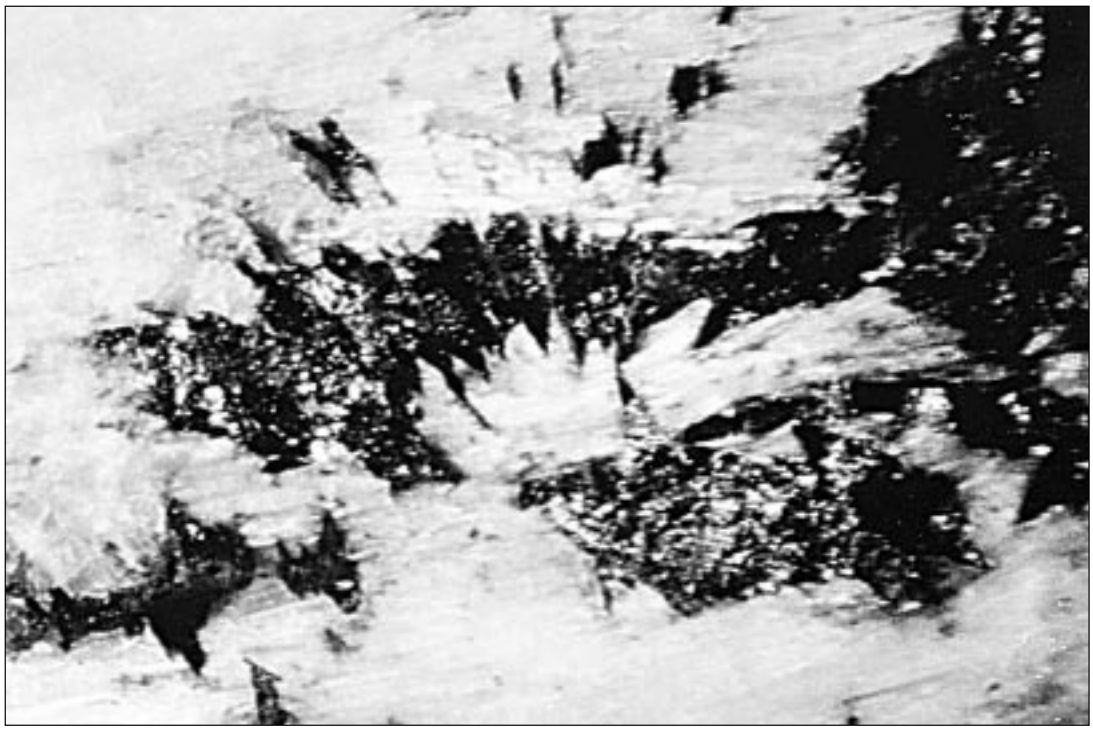

Fig. 15
The mineral species mozartite ($CaMn(OH)SiO_4$)

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