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A new vision of alchemy: Searching for activity patterns in alchemical transmutations

Introduction

"In its broader aspect, alchemy appears as a system of philosophy which claimed to penetrate the mystery of life as well as the formation of the inanimate substances". These words were written by Professor John Read in 1.936, in his "Prelude to Chemistry", and would have been fully subscribed by the alchemists were it not for them no "inanimate" substances ever existed. For the alchemical thought, the spirit of life impregnated all categories of creation, from the stone to the human being. Indeed, and this is the main difference with the contemporary approach toward the knowledge of Nature, the alchemist was neither a spectator nor a simple practitioner. In the shadow of his laboratory, the external work aiming to prepare the Philosopher's Stone, a substance endowed with the power of transmuting base metals into gold and silver, as well as with the power of prolonging human life, always encompass an internal work devising the spiritual transformation of the alchemist itself.

These two faces of alchemy influence strongly other areas of knowledge. Alchemical heritage can be traced in the development of chemistry, although it has been recognised long ago that the alchemy can not be reduced to the ancestor of chem-

istry. On the other side, the spiritual quest of alchemy shaped the mystical movement who flourished in Europe from XVII onward, as Rosicrucians. Finally, the rich symbolic universe used by the alchemists to express their Opus Magnum, had a persistent influence in the western art, which can be recorded until present. This influence is easily recognised in several aspects of the western culture. The works of Goethe, Blake, Yeats, Mallarmé, the core of the surrealist movement, Breton and the Spanish painter Remedios Varo, more recently Beuys and Klein, to name a few, are all impregnated by hermetic philosophy.

In any case, what remains as the most specific core of the western alchemy is the quest for the so called Philosophers' Stone, a certain substance alleged to change base metals into nobles one, silver or gold. Claims of success in making such a material can be profusely found in the western alchemical literature. A noticeable change seems to take place approximately in the sixteen century onwards, for to the traditional claims of the adepts to posses the Philosophers' Stone public exhibitions showing the transmuting power of their material were added. In some cases, the adept himself, i.e., the individual who succeed in making the transmuting substance, carried out the transmutation experience before a select audience, often no more than one or two persons. However, more frequently individuals who get into possession of the Philosophers' Stone by means often obscure and even fraudulent used to spoil such a precious material by multiplying the public exhibitions, fuelled usually by the desire to gain privilege and nobility.

In any way, such public transmutation events spread all over the seventeen century, peaking at the period 1660-1680, become more scarce at the turning of the century and practically disappear by mid of eighteen century (figure 1).

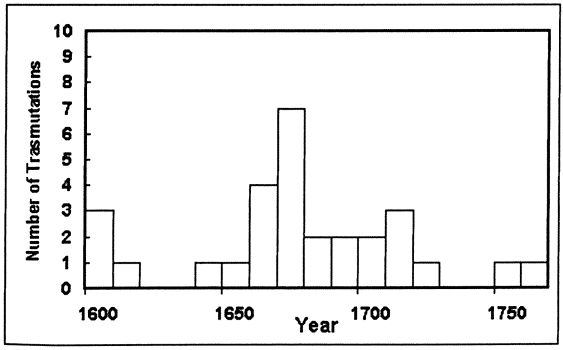

Figure 1. Number of transmutations as a function of time.

These alchemical activities have left behind two kind of records. Firstly, a number of reports in the contemporary alchemical literature. Many of them are coloured by so vivid description of the process, and contain such valuable details given by well credited witnesses, as to conform a specific subclass within the alchemical literature (1). Second, the noble metal outcoming from the transmutation experience, either silver or gold, was used in some cases to cast coins or medals to commemorate such a momentous event. This was done almost exclusively for transmutations performed before nobility, or the Emperors Ferdinand III and Leopold I, in Central Europe (2). Some of these medals and coins have been preserved until present in several museum collections (3), whereas some other notorious examples have been lost (4). In few cases, pieces of silver and gold of alchemical origin survive some time after the transmutation took place, usually kept in private hands, but as far as I know its traces in the history vanished long ago (5).

Some of the extant alchemical coins and medals have been subjected to chemical analysis to asses their composition, and a few among them turned to be composed of nearly pure silver or gold (6).

Whereas these "fossil" remains of old alchemical activities merit a place in the history of numismatic, it is by far less obvious their contribution to the understanding of the alchemy itself, not to speak of the alleged alchemical process they were obtained. For instance, as it is pointed out in ref. 3, it is extremely difficult to connect unambiguously a given piece of purported alchemical origin with a specific account of transmutation event.

A closer examination of the means alleged to produce the noble metals used to cast medals and coins allows to distinguish between different types of transmutations, a key aspect relevant to the present work. They can be divided in a simplified manner into two groups, according to the performance of the transmuting substance and the way to use it in order to change the base metals into noble ones.

According to the alchemical authors, the universal transmutation takes place by means of the Philosophers' Stone or Universal Medicine, a substance claimed to change any base metal into gold. A less perfect version of this material would lead only to silver. A very small portion of this substance added or "projected" upon a melted metal or hot mercury is able to convert it into pure gold or silver, in relatively short time, not exceeding in general one hour, few minutes in most reports. This is the transmutation by projection. In contrast to this universal transmutation,

particular transmutations are carried out by using some liquid or solid substances which can change one or few base metals or only silver into gold, and this in a proportion not higher than five times or so its own weight. Indeed, the *particularia* (the transmuting substance) is usually not projected but digested or mixed with the base metal, rendering gold or silver after prolonged heating (7).

The most outstanding transmutation histories that became of public domain, and went shortly after to print in the seventeen and eighteen centuries, took place by using the Philosophers' Stone. This type of universal transmutation by projection will be the subject of this paper.

As it could be expected, such public events invariably lead to strong controversy. Accusations of forgery were jumped on the alchemists, who were charged of fraud to the witness, yet often learned and even leading figures in natural philosophy, by using a large variety of tricks, which have been reported in detail (8). The contemporary development of modern chemistry gives a scientific basis to such forgery accusations. In this context, the few alleged alchemical transmutations made or witnessed by well known and reputed personalities were no signs of fraud could ever been found, were and actually are considered as "closed" historical reports: the absence of independent sources to confirm the claims make impossible further insight into them.

Could these centuries-aged alchemical transmutation records be revisited by using tools other than historical?. Could they be analysed starting from modern scientific thought in a way other than dismissing them all as the ingenuous but nevertheless condemnable early fruits of human hopes?. The present work intends to give a positive answer to this question, by looking for patterns in the transmutations described in the old alchemical literature. The eventual discovery that specific characteristics of the transmutation events clustered around some pattern, would shed new light on the alchemical practices. A scientific approach in the search for such an activity pattern is presented in this conference.

Methodology

The approach that will be developed is based on quantitative aspects of the transmutation events. The qualitative characteristics are by themselves rather vague to sustain any study, although they could be valid in a more general context.

What are the main available numerical parameters of a transmutation by projection?. Typically, a certain amount of the Philosophers' Stone (W_{PS}) is added to a certain amount of a base metal, M_i, having a weight of W_i, contained in a crucible heated at a temperature T. After a certain period of time (t), the crucible is cooled and its content removed, identified and weighted (M_f, W_f). Usually there is no measurement of the reaction temperature T, which is at the best indicated as "boiling quicksilver", "melted lead" and so on. Therefore, six independent parameters could be used: W_{PS}, M_i, W_i, M_f, W_f and t. M_i and M_f are the atomic numbers of the initial and final metals, respectively. In some cases, the metal resulting from the transmutation is submitted to analysis to determine its content of noble metal, which may eventually differ from the initial base metal weight.

From survey of the extant reports on projection it can be concluded that in very few events the six parameters are properly measured. As expected, the starting base metal is with almost no exception, always identified, as well the resulting gold or silver, so M_i and M_f are known. Occasionally, mixtures of several metals were also used.

Next in certitude, ranking well below however, lays the knowledge of the weight of the metals involve in the transmutation. In some examples, only the weight of the base metal W_i or the resulting gold or silver W_f is determined. However, the greatest difficulty in studying the quantitative aspects of the transmutations described in the extant reports on these events resides in the incertitude in the determination of the weight of Philosophers' Stone and the duration of the transmutation experience. In most cases, the use of very small portions of such precious material is reported, but no precise measurement of its weight is given.

Taken into account all these characteristics, few of the recorded transmutation events contain a clear indication of the values of the six parameters. This author has identified a set of eight different transmutation events which meet the requirement describe, to which new examples could eventually be added as a result of a more exhaustive screening of the alchemical literature.

Activity pattern of projections

The selected events have been collected in the table I, together with their corresponding characteristics. These events belong to the XVII (5 events), XVIII (2 events) and XIX (1 events) centuries.

It can be seen in the table that the duration of the transmutation experiences spreads over a large interval, ranging from what is described as instantaneous, as in the case of Van Helmont, to several hours. Among the examples listed in the table, the Philosophers' Stone used in the experience witnessed by Van Helmont (9) possesses the highest efficiency, which is manifested in what he described as "instantaneous" change of mercury into gold. This change is perceived by the observer as a "solidification" of the content of the crucible, due to the difference between the temperature of the hot mercury, which should be below its boiling point, 357 °C, and the melting point of pure gold, 1,063 °C.

Table 1.- Characteristics of alchemical transmutations by projection.

Example	Year	Reference Name	Type of Transmutation	W_i	W_f	W_{ps}	W_f/W_{ps}	Time (min)	Notes
1	1614	Van Helmont	Hg→Au	8 ounces	8 ounces less 11 grains	¼ of grain	19,186	Inst. (<1 min)	9
2	1667	Helvetius	Pb→Au	6 dracmas	6 dracmas plus 6 scrupules	0.020-0.040 gram	700-1,400	15	10
3	1675	Seyler?	Sn→Au	-	8 ounces	-	2,000	5-7	11
4	1678	Boyle	Pb→Au	Several dracmas	≥ ½ ounce	1-2 grains	Several hundred 300-700	15	12
5	1693	C.Eisenberg	Pb→Ag	1.5 pound	37 lothons	32 grains	325	60-70	13
6	1716	Goetzius	Cu→Ag	-	-	-	6,552	2-5	14
7	1717	Colonna	Hg→Au	2 ounces	~ 2 ounces	0.5-0.6 grains	2,000-2,400	120	15
8	1832	Cyliani	Hg→Au	100 grams	100 grams	1 gram	100	60	16

On the other hand, variations of several order of magnitude of the weight ratio between the resulting noble metal and the Philosophers' Stone (W_f / W_{PS}), which is defined as its transmuting power, are also recorded. Both sets of data, time and transmuting power, have been plotted in the figure 2, where it can be observed that they follow an inverse correlation. This trend is highly statistically significant if the example 7 is removed (figure 2, legend). The trend indicates that in the transmutation events where the transmuting power is no more than a few hundred, heating of the base metal and the Philosophers' Stone mixture should be prolonged for at least twenty minutes before completion. Conversely, in those experiences where the Philosophers' Stone manifested a power of several thousand, few minutes are required to complete the transmutation. It is interesting to notice that the transmutation witnessed by Robert Boyle, which only very recently has been exposed to general knowledge and analysed in ref 7, also fits nicely the general trend shown by the other more widely known experiences.

To the best of my knowledge such an activity pattern has not been previously noticed. However, the need for prolonged heating when samples of Philosophers' Stone having low transmuting power are used is mentioned in and interview Boyle conducted with a visitor from Vienna who describe projections carried out at the imperial court of Leopold I (11):

(. . . .) that he told me he saw an other time a projection made on the same metal (Tin) with an imperfect Medicine, which was longer in working before it effected the desire change, & transmuted but (if I mistake not) about 80 times its own weight.

The activity pattern describe in the figure can hardly be the result of a hypothetical stoichiometric reaction between the Philosophers' Stone and the base metal, owing to the disparity in their relative weights. On the contrary, it could be understood in the frame of a sort of catalytic reaction where the Philosophers' Stone would be the catalyst. In catalysis science, the ability of different chemical substances to catalyse a given chemical reaction is usually compared on the basis of the time required to transform a given amount of the initial reactants into products. Highly efficient catalysts leads to high reaction rates, and are usually able to transform a large amount of the starting reagents before its activity begins to decline in a significant manner. Indeed, as the catalytic activity of a given chemical substance is improved, less amount of such a substance is required to obtain high reaction rates.

By following this catalytic approach it could be thought that even the smallest portion of a catalyst would be able to transform any quantity of the starting chemical compounds provided the reaction time is sufficiently long. However, this is not the case with real catalysts. Materials having poor catalytic performance or good catalysts used in excessively low amount, i.e., at large reactant to catalyst ratio, never bring to completion the targeted reaction, as usually the catalyst transforms slowly into an inactive substance or it is deactivated or "poisoned" by undesired parallel side reactions. For this reason, the maximum reactant to catalyst working ratio should be properly adjusted for every catalytic material.

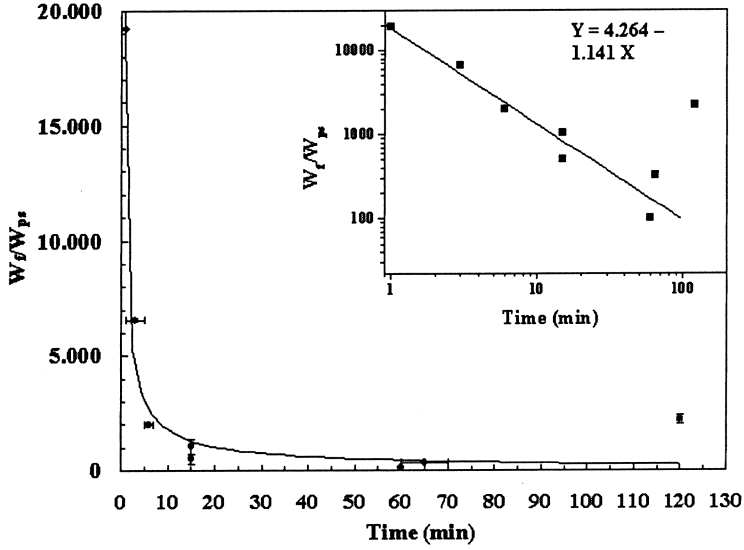

Figure 2. Transmuting power as a function of the transmutation time. The inset shows the linear correlation (solid line, logarithmic scale) obtained upon removal of the example 7. The linear correlation coefficient is in this case 0.97. If the example 7 is included, the correlation coefficient drops to 0.76.

Interestingly, the existence of an upper limit for the transmuting power of the Philosophers' Stone has also been describe in the alchemical literature. For instance, the anonymous visitor of Helvetius remarks the following, as it is accounted in his "Vitulus Aureus" (10):

If you are not able to deal with such a small amount of lead (four grains), take two dracmas, or half once, or even more lead, for it will not be ting more than it could be.

The alchemical transmutation process has been conceived as an acceleration of the ripening of base metals towards the more perfect gold and silver, by authors prone to an alchemical conception of nature, as Johan Joachim Becher (2).

It could be thought that the relationship between the transmutation time and the transmuting power would eventually be affected by the nature of the resulting noble metal, either gold or silver, or even by the starting base metal. Indeed, some indications of this influence can be already tracked in the alchemical literature. For instance, the anonymous owner of the Philosophers' Stone referred to by FranÇois-Marie Pompée Colonna states that the change of mercury into silver required only a quarter of hour, instead of the two hours needed to transmute it into gold (15). Therefore, further improvement of the relationship would result by analysing independently both reactions.

Notes and references

1. Ewald von Hoghelande, *Historiae aliquot transmutationis Metallicae*, (Cologne, 1604); Daniel George Morhof, *De metallorum transmutatione ad Langelottum, (*Hamburg, 1673), in *Bibliotheca Chemica Curiosa (B.C.C.)*, (Geneva, 1702), vol. 1,p 168; Johann Friedrich Helvetius, *Vitulus Aureus* (Amsterdam, 1667), in *B.C.C.*, (Geneva, 1702), vol. 1, p 196; Philipp Jacob Sachs von Lewenheim, "Aurum Chymicum", in *B.C.C.*, (Geneva, 1702), vol. 1, p 192., Siegmund Heinrich Güldenfalk, *Sammlung von mehr als hundert wahrhaften Transmutationsgeschichten*, (Frankfurt and Leipzig: J. G. Flesiher, 1784). This is one of the biggest (and latest) collections of alchemical transmutation accounts, and listed, as explained in the title, more than one hundred, 112 exactly according to the contents.

2. Pamela H. Smith, *The Business of Alchemy. Science and Culture in the Holy Roman Empire*, (Princeton: Princeton University Press, 1994), pp. 173-227.

3. S. Reyher, *De nummis quibusdam ex chymico metallo factis*, (Kiel, 1692). For a more recent and comprehensive review of medals and coins of purported alchemical origin, see: V. Karpenko, "Coins and medals made of alchemical metals", *Ambix*, **35** (1988), 65-76.

4. The most famous example is probably the large medal cast with alchemical gold resulting from the transmutation performed in Prague, on the 15 of January 1648, in the presence of Austrian emperor Ferdinand III. The medal has been reproduced many times in a variety of works since then, see for example Karpenko, *op. cit.* (3), p. 67.

5. There are several accounts of transmutation stories published in the XVII century where the possession of pieces of gold of alchemical origin by individuals is claimed. For instance, the gold piece kept by Johannis Antonida Van der Linden, resulting from the transmutation performed by Alexander Seton in 1602. Two other fragments of alchemical gold resulting from the activities of this alchemist were in the hands of Johann Wolfgang von Dienheim, professor of medicine

at the University of Freiburg, and Jacob Zwinger, professor at the University of Basel. I have used the french translation of the Dienheim account given in: Louis Figuier, *L'Alchimie et les Alchinistes*, 2nd ed, (Paris: Hachette, 1856), pp. 227-228. For a recent updated account of the Alexander Seton and Sendivogius relationship, see: T. Prinke, "The Twelf Adept" in R. White ed., *The Rosacrucian Enlightmenmt Revisited* (New York: Lindisfarne Books, 1999), pp 141-192. In my opinion, the most notorious example of a piece of gold surviving for some years the projection has been reported by professor L. M. Principe, *The Aspiring Adept* (Princeton: Princeton University Press, 1998). In his book, professor Principe has described the Boyle's witnessing of a projection and the fact that he (Boyle) carries always with him a fragment of transmuted gold (*op. cit.*, p. 105). In this book is also mentioned a piece of silver transmuted into gold that Olaus Borrichius sent to the king of Denmark (*op. cit.*, p. 260).

6. See *op. cit.* (3) and references therein for chemical analysis of pieces of metals of alleged alchemical origin. The commemorative medaillon cast from the metal obtained by J. J. Becher after transmuting lead, and housed in the Vienna Kunsthistorische Museum, is pure silver, according to W. D. Müller-Jahncke and J. Telle, "Numismatik und Alchemie. Mitteilungen zu Münzen un Medaillen als 17. und 18. Jahrhunderts", in Die Alchemie in der europäischen Kultur und Wissenschafts-geschichte, ed. Christoph. Meinel (Wiesbaden: Otto Hanassowitz, 1986), pp 251-252. This statement has been taken from *op. cit.* (2), p. 176.

7. For a recent and clear exposition of the different varieties of transmutations, see L.M. Principe, *The Aspiring Adept*, (Princeton: Princeton University Press, 1998), pp. 77-80.

8. V. Karpenko, "The Chemistry and Metallurgy of Transmutation", *Ambix* **39** (1992) 47-62.

9. The transmutation witnessed by Van Helmont in 1614 is the one where the transmuting power has been determined with the highest accuracy. Johan Baptista Van Helmont, *Ortus Medicinae*, 4ª ed., (1667), p. 452. Regarding the duration of the trial, he described it as an instantaneous "congelatium" of the quicksilver. In order to facilitate the numerical treatment of the data, a maximum duration of one minute has been safely assigned to this projection. It may be conceived that the duration of the projection was even shorter, for compliance with the Van Helmont 's description. Despite of this, it will be shown later that the incertitude range of the transmuting time is much smaller than the time difference between the several transmutations reported in the table.

10. Helvetius, *op. cit.* (1). In the Helvetius account of his transmutation the duration of the projection is clearly stated, but no weight of the Philosophers' Stone is given. Instead, the volume of PS used in the projection was described as being "half seed of swede" or "a quarter of mustard grain". According to these indications, the volume of PS has been estimated to be between 1 and 2 mm^3. From this volume, the PS weight could be estimated if the density is known. There are several descriptions that emphasise that the PS is very heavy in relation to its volume, i.e., it has a high density. For instance, Karl Cristoph Schmieder, *Geschichte der Alchemie*, (Halle, 1832) provides a full account of the description given by Dippel, who in 1706 examined portions of a substance allegedly to be the Philosophers' Stone. In Dippel's own words: "a block of lead of the same volume would have been much less weighted". We have assigned a density of 20 g/cm^3 to the substance describe by Helvetius.

11. The information regarding this transmutation has been taken from *op. cit.* (7), p 299. The person interview by Boyle reports the transmutation to last "half a quarter of an hour or less". Therefore, a range of 5 to 7 minutes has been assumed in this case. Professor Principe has assigned temptatively this projection to Wenceslaus Seyler, an Agustinian monk active in the Vienna court around 1675. J. J. Becher gives a full account of the Seyler's activities in his *Magnalia Naturae*, (London, 1680).

12. *Op.cit.* (7), pp. 264-267. The transmuting power of the PS is estimated by Robert Boyle to be "several hundred". According to the reported weights of gold and PS, a range of 300-700 for the transmuting power can be safely assumed.

13. The projection was performed before the Duke Christian Eisenberg (1653-1707). Details of this event have been taken from B. Husson, *Transmutations Alchimiques*, (Paris: Editions J'ai Lu, 1974), pp. 98-101. The original account can be found in: Rosinus Lentilius, *Ephemeridae medico-physicae Germanicae Curiosae*, Decuriae III, Annus Tertius, Annorum 1695 & 1696, Appendix ad Annum Tertium, pp 111-112, (1696.

14. A full account of this transmutation is given in Husson, *op. cit.* (13), pp 107-115. This is a French translation of the original Latin version reported by Johann Christoph Goetzius. *Commercium Litterarium ad rei medicae et scientae naturalis incrementum institutum*, n° 43 (1731). In this example, two copper coins, one of them being a Vienna Polture from 1707, were transmuted into silver. The coins were heated at thigh temperature (one of the coins shows signs of melting after the experience) but not melted. The Philosophers' Stone was then contacted for a short time over the hot coin surface. No precise measurement of the transmutation time is provided in the account, but it is nevertheless reported that after the surface contact with the PS the coins were poured into water for getting them cold. The first coin remains in water for such a short time that it was still hot when it was picked up from the water recipient. Taken this observation into account, it has been assumed that the total duration of the experience could not have been longer than few minutes. Therefore, an interval from 2 to 5 minutes has been assigned to this event. The weight of the PS, coins and silver resulting from the experience were measured, and as a result a transmuting power of 6,552 is obtained. This high transmuting power approaches this experience to the transmutations by projection.

15. Crosset de la Haumerie, "*Les secrets les plus cachès de la Philosophie des Anciennes*" (Paris, 1722). For a more recent French version, see Husson, *op. cit.* (13), pp. 254-255.

16. Cyliani, *Hermès Dévoilé*, (Paris: Félix Locquin, 1832). For a more recent French edition, see B. Husson, *Deux traités alchimiques du XIX siécle*, (Paris: Editions La Table d'Émeraude, 1988) pp. 203-233.