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The Arezzo seminar on precious metals

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A GOLDEN STORY

Gold is a valuable bright yellow metal with a resplendent lustre and high density (more than 19 times the weight of an equal volume of water). Due to its inalterability, brilliant appearance and occurrence in the native condition, or elementary state, gold was certainly one of the first metals to attract the attention of men.

It was known, highly valued and widely employed by earliest civilization. In our Peninsula, Etruscan made gold ornaments with great variety of workmanship. Some of them survived over the centuries and appear today as perfect as they were over two thousand years ago.

Under a certain point of view, gold has to be considered the driving force that led to modern chemistry. In fact, the making of gold from other metals, by means of the philosopher's stone, and the discovery of the elixir of eternal life were the chief aims of the alchemists in the Middle Ages. It is reasonably correct to say that advances in early chemistry were a direct outcome of such experiments.

Gold, whose symbol is Au (from Latin, Aurum) has atomic number 79 and atomic weight 196,9665 g/mol. Physically, gold is of chief interest for its remarkable ductility, malleability and resistance to chemicals. Gold can be drawn into extremely fine wire or beaten into the filmiest gold-leaf. With exception of boiling aqua regia, alkali cyanides or free chlorine, gold will not readily combine with other chemicals (neither compounds nor elements).

In every culture, gold was taken as model of wealth. Throughout history, human beings have fought and toiled for this precious and durable metal.

It is estimated that the greater amount of all gold mined from the earth in the last ten millennia could still be accounted for in the bank and government vaults, and in the widely distributed wealth of ornaments, jewellery, technological or clinical artefacts through the world.

No other possession in all time has been so zealously and effectively protected. Silver, gold and their alloy (or artificial mixture) called *electrum* were used for manufacturing ornaments, vessels, weapons, minted for coin-

age, as well as for inlaying and plating baser transition metals.

The occurrence of gold in nature is quite particular among the other elements. Being thermodynamically stable at ambient conditions and the least chemical active of all metals, gold is generally found in the native or uncombined state. Gold has not only attracted the interest of alchemists: in recent time also, physicists and industrial chemists looked with interest at this peculiar element. Many articles have been written about the presence of gold in sea water. In the last century more than 50 patens have been issued on processes for recovery of gold from sea.

We may mention only two of the most significative episodes: the first one occurred at the turn of the XIX century, when analysts and chemists realised that seawater was filled with gold. Element 79 was just floating out there for being taken. "The trouble was figuring out how to extract this precious metal. For over a century, dreamers, artists, lunatics and well-intentioned inventors have been trying to find a way to pull the trigger on an oceanic gold rush. So far, the search for all those riches proved fruitless. In the early 1920s, the German Nobel Prize winner and sadly renowned chemical-weapons developer, Fritz Haber (1868-1934) sought to refill Germany's post-World War I coffers by developing a process to extract gold from the sea. Haber and his colleagues spent years trying to perfect a profitable extraction method, involving centrifugal force and electrochemical laws, before realizing they had overestimated the total amount of gold in seawater already in their initial calculations. The project was consequently abandoned.

Gold was around us but Haber discovered its major flaw: it costs more to extract it rather than to take it already minted" [1]. According to the sentence "if you cannot beat them, then join them", chemists resorted to their skills: create gold! Or in better words, they tried to synthesise it artificially.

In the second case, as early as 1922, a wealthy man asked Georges Urbain (1872-1938), member of the French Academy of Science, a feasibility study before launching the enterprise to synthesise gold via radioactive transmutation. Only in recent years – *i.e.* in the atomic age – the transmutation of bare metals into isotopes of gold was made possible. Even though these experiments were experimentally accurate, they also proved that great improvements are still needed to make this "synthesis" economically viable [2].

Presently, gold covers a wide range of applications, some of which are related to cutting-edge innovation in science and technology. A few examples: it is well known that gold wires are the backbone of computers. Gold coatings protect astronauts as well as aerospace equipment from radiation and heat, thanks to gold reflective properties. Gold is a proven material for catalytic converters, but it also plays a key role in innovative tools for medical diagnostics (from well-established Rapid Diagnostic Tests to improved HIV/AIDS diagnosis technologies, based on the use of gold nanoparticles for sensing the presence of a target molecule at ultra-low concentration). Gold-based drugs have been developed and used to treat rheumatoid arthritis and research into the role of gold in cancer treatment is in progress. Gold is also involved in the development of implantable electronics, allowing monitoring of patients' vital signs and warning of potential health problem.

From an environmental point of view, gold nanoparticles are involved in the development of more effective solar cells (including stretchable solar panels that can be integrated into our clothing) and fuel cell catalysts, as well as in solving problems related to groundwater contamination, since gold helps break down contaminants. In broader terms, gold will play an increasingly important role in technologies for the transition to a low carbon and a more sustainable economy, as well in protecting our health and well-being [3].

HISTORY OF THE GOLD-AND-SILVERSMITH DISTRICT IN AREZZO

The Tuscan gold industrial district is located almost exclusively in the province of Arezzo. As it has been well documented by Luciana Lazzeretti [4]. Arezzo, along with Vicenza and Valenza Po, represents one of the highly specialized centres of the Italian goldsmith sector.

The local gold smithery developed between the fourteenth and fifteenth centuries thanks to the growth of power of the rich bourgeoisie and of the confraternities. Initially it was barely able to satisfy the inner market. During the following centuries, the history of gold smithery is closely linked to the development of religious art.

By convention it is established that modern goldsmith industry was born soon after 1900. The province of Arezzo experienced, after World War II, a first significant process of industrialization. It was transformed from a purely agricultural economy to an industrial structure. These changes were facilitated by some exogenous factors that modified the productive network of this territory: in particular the crisis of sharecropping and the birth of numerous small and medium industries.

Citing the study of Luciana Lazzeretti,

... the development of small industry led Arezzo towards

its great economic and social transformation. The city became, in the late sixties, one of the most advanced poles of economic development, not only in Tuscany but also in wider area: Central Italy.
The Arezzo economy grew in size and turnover. It experienced a dizzying growth and a continuous increase in production, which was oriented not only to the local market, but also to foreign markets.
This was made possible by the continuous progress of technology. The development of the goldsmith sector proceeded at a very intense pace in the decade 1961-1971, also favored by the Italian economic boom.

The industrial development suffered a sudden setback in the late seventies, when the price of gold and silver surged, due to problems of a monetary nature, international conjunctures combined with the fierce competitiveness of the other Italian goldsmiths. In the 1980s, the Arezzo industrial economic system lost its initial connotations, i.e. of being an economic center-based on a core of great industries (*e.g.* Lebole, UnoAErre) to attain the characteristics of local system of small and medium firms.

In the 1990s, the use of a new technology, *i.e.* electroforming, took place: it was thus possible to create products with higher added value. Jewels of great value, incredible lightness and difficult shapes were created. With the development of this and other new technologies, the local Arezzo system was able to broaden its products range. It has been able to focus on new markets and satisfy an increasing number of customers.

HISTORY OF TCA

TCA SpA was born in Tuscany, in the pulsating heart of the Italian gold-and-silversmith district [5]. Founded in 1977 in Arezzo, where the headquarters are located, the TCA has two other offices in Vicenza and Valenza Po, for a total of over 100 employees and three industrial installations.

The TCA has a consolidated experience and a deep knowledge of the gold industry. This Tuscan company must be considered a leading company in the global jewellery world.

From the initial specialization in the treatment of ashes containing gold and silver, TCA grows up to expand its skills to the recovery of platinum, palladium and rhodium. With the motto – "*The resources are not infinite, recovering them and recycling them makes them endless*" – TCA has entered the world of modern jewellery.

Increasing the recovery percentage of precious metals means reducing extraction costs and environmental impact: the recovery of metal costs less than its extraction, both in economic terms and in terms of CO_2 emissions. Precious metals are present in many sectors of industry and consequently in many waste materials.

Europe produces 8.7 million tons of electronic waste per year and recycles just over 2 million; in the United States less than 20 percent of electronic waste and only 10 percent of personal computers are recovered. If we consider that a ton of hardware waste contains about 16 grams of precious metals, it is clear that the percentages of recovery of gold and silver could be much higher than the current ones.

Even the quantity of palladium could be increased up to 90 percent, while today only 5-10 percent is recycled. Low recovery rate is also found in jewellery, medical and chemical sectors. Every day TCA faces its own challenge to increase its skills and put them at the service of the environment and the Arezzo area.

AIM OF THE PRESENT SEMINAR

The organization of the Seminary "Precious Metals in the History of Science and Technology" in Arezzo [6] (in May 2018, within the program of events associated with the Gold Fair) belongs to the history of the economic network of this city and its province.

The TCA's sponsorship is a welcome gift to citizens of Arezzo. It is at the same time a message to the public of how dynamic and sensitive the present industry is towards its territory.

The continuous technological progress and the continuous challenges of the variable financial markets, as well as everything that revolves around this world - which we could call "golden world", is of interest not only for insiders (industrialists and technicians of high specialization), but also for economists, historians, chemists, philosophers, physicists and last but not least, for customers, who will certainly be the first to appreciate the history of what they are going to buy, to either to adorn their homes or their bodies.

This transition metal, symbol of both sun and life, has no equal among all the elements of the Mendeleev periodic table. For it wars have been fought, prophecies have been launched and countless theories have been debated. Gold is certainly the most symbiotic element with man and his inclinations (artistic, technical, speculative or scientific).

This Seminar aims to bridge the gap between Academy and Industry; a bridge that connects two opposite banks, the study and the practice of a single river called "knowledge". And for this we hope that this event may be the first of a series of many other meetings between industrial and academic society.

The readers of this volume will meet with technical terms as well as with erudite historical and philosophical terms. In fact, the peculiar aim of this publication is to unite different aspects of current, recent or ancient knowledge around this noble element. The past, the present and even the near future are addressed, particularly in the paper where the use and intrinsic value of gold in the monetary and economic field are discussed. In the paper dedicated to the role and the evolution of gold in alchemy, terms such as *chymistry*, chemistry, alchemy, *chemeia*, and *al-kīmyā* merge, from the dawn of time, into a "crucible" of words embracing either the philosophical aspect (linked to the mutability of matter) or the physical experience of the manipulator, or proto-scientist. In other, more strictly technical papers we can observe how man loses his centrality in chemistry to the advantage of the objectivity of the experiment. And perhaps, in recent times, we can observe how gold, once again, changes over time acquiring a haphazard halo of mysticism. We are no more talking about alchemy, proto-chemistry or chemistry, but we can take a glance at macroeconomics and most recent monetary theories.

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