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Argor-Heraeus SA

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Profile

Argor SA was established at Chiasso in 1951 and became active in the refining of gold and the production of gold, silver, platinum, and palladium bars. *Union Bank of Switzerland* acquired an 80% holding in 1960 and effected the full takeover in 1973. In view to the future, a partnership was agreed in 1986 with *W.C. Heraeus GmbH*, Hanau, designed to secure the enterprise renamed *Argor-Heraeus SA* an edge over its competitors in regard to the know-how for the processing of precious metals. *W.C. Heraeus* holds a 25% participation in the new firm.

The unique link between *Union Bank of Switzerland*, a universal bank active in all parts of the world, and *W.C. Heraeus*, one of the leading high-technology companies in the precious metal sector, can be regarded as trend-setting and future-oriented in nature.

The combination of a bank and an industrial firm offers the customers of the jointly-owned subsidiary *Argor-Heraeus SA* essential advantages, be it in connection with the financing of materials or in the area of the constantly changing technological environment, to name only the most important ones.

The new refinery, opened at Mendrisio in 1988 and enlarged in 1994, employs 85 people and disposes of facilities for the electrolytic gold and silver refining, for the wet chemical parting of low grade, precious metal bearing materials and for the refining of platinum and palladium, of a modern foundry with induction furnaces and with a continuous casting facility allowing an output of more than 400 kg/h of fine gold, and of a department for the mechanical manufacturing of small bars, medals, and coins, and of semi-finished products; modern installations for the treatment of waste water and air care for an efficient environmental protection.

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Argor-Heraeus figures in the Good Delivery List for gold, silver, platinum, and palladium, and its smelter-assayer mark is recognized and accepted internationally as a warranty of quality. Closest attention is devoted to the technological advance in the area of assaying techniques and *Argor-Heraeus*' specialists are actively involved in international normalization carried out by the relevant ISO working group.

A new kind of fine gold bar, the *kinebar™*, was introduced in 1993. Developed in cooperation with *Landis & Gyr Communications*, it bears a *KINEGRAM™*, a patented security feature providing added protection against counterfeiting; *Argor-Heraeus* holds in exclusivity the license to apply this new security mark, based on the diffraction of light and used by governments to secure banknotes, passports, and identity cards, onto its precious metals.

Beside fine precious metals *Argor-Heraeus* produces jewellery alloys and semi-finished products for the watch industry, thus connecting Canton Ticino with the most renowned manufacturers located at the opposite end of the country.

An Example out of the Everyday's Laboratory Practice: The Search for Excellence in the Analysis of Gold

Cupellation (Fire Assay)

Gold is traded since the oldest times, and its high value made it soon necessary to determine its purity with the highest possible accuracy. Cuneiform tablets indicate that the Babylonians used the fire assay technique in the 14th century B.C. when they suspected that gold sent by an Egyptian pharaoh was impure. It is thus to believe that this has to be considered the first chemical analysis developed in the history.

The fire assay, various features of which are also cited in the Old Testament, continued to be used and to be improved

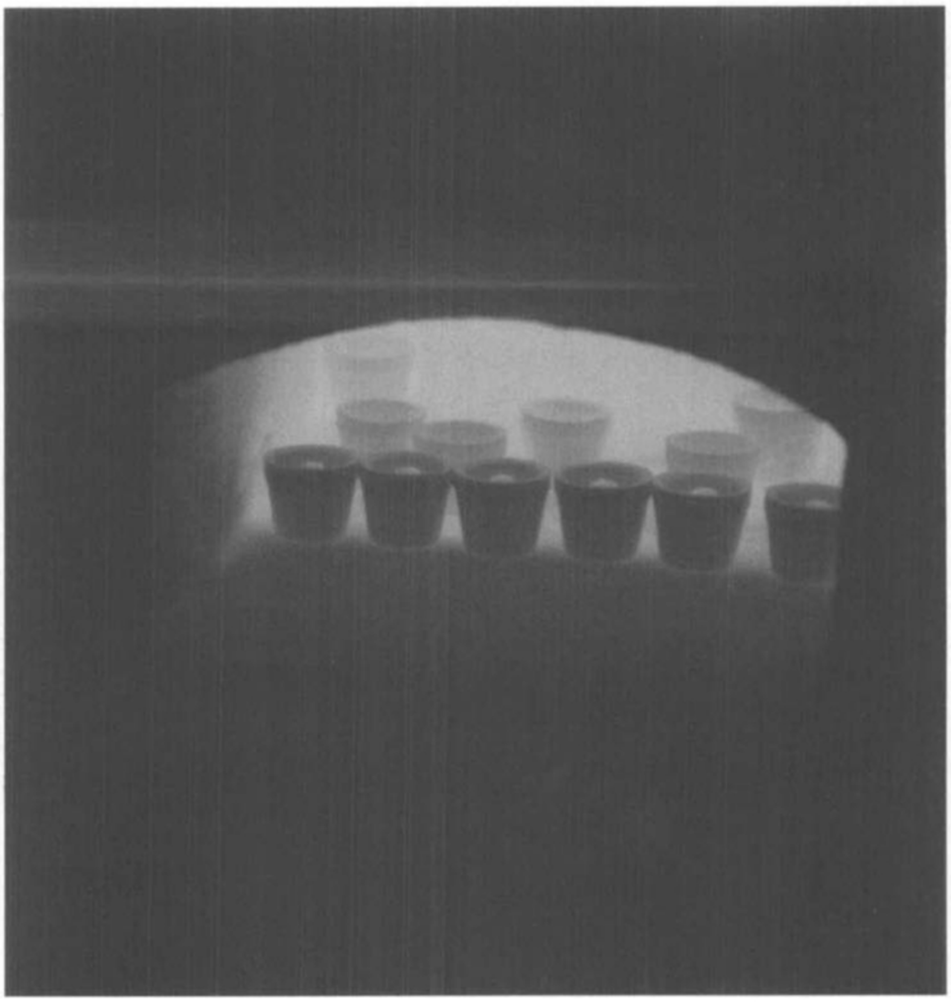

Fig. 1. *Cupellation is performed in a specially designed furnace at some 1100°*

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through the centuries; the discovery of the mineral acids in the Middle Age and the development of precision balances with ever improved accuracy contributed in a decisive manner to confer to this method the highest degree of analytical precision and of reliability.

As it is the case for most of the classical analytical techniques for the determination of the fineness of precious metals, the fire assay, also called cupellation, is in fact a refining procedure, just applied on a small scale.

The gold samples, obtained by drilling, sawing or cutting, are weighed accurately, inquarted with pure silver so that the ratio between pure gold and the total amount of precious metal becomes equal to 1:4, and compounded with lead; they are then put into cupels made of magnesium oxide or of some other porous, refractory material, and treated in the oxidizing atmosphere of a specially designed furnace at a temperature of some 1100°. There the base metals of the resulting melt are oxidized and absorbed by the cupel, leaving a bright bead of precious metal. This bead is then flattened down and rolled into a cornet, which is subsequently subjected to a repeated treatment in nitric acid, where the silver is dissolved completely, leaving a gold cornet deprived of the other components initially present. This one is rinsed, dried and weighed again accurately: the ratio between final and initial weight gives the gold fineness.

With some minor corrections allowed by the use of proof samples, this technique allows today a precision ranging around 0.1 parts per thousand by weight, absolute, for high grade gold, and 1 part per thousand for the most critical alloys, so that the results are commonly given with four significant digits.

Despite his venerable age this method is still considered the most accurate available. It has recently been standardized by ISO for the analysis of jewellery alloys as ISO 11426, and it is the only analytical technique accepted by the London Gold Exchange to evaluate the fineness of gold bullion and karat gold.

X-Ray Fluorescence Analysis

An alternative analytical technique being applied increasingly for production control in the industry is the X-ray fluorescence (XRF) analysis. The wavelength dispersive instruments, more sophisticated and expensive than the energy dispersive devices, make it possible nowadays to reach the same accuracy level of the fire assay.

In comparison to the cupellation, XRF spectrometry has anyway some disadvantages:

- the method fails to give a correctly representative result if even limited segregation occurs, because only a thin surface layer of the sample is analyzed
- expensive calibration standards with a chemical composition close to the one of the sample (one series for each particular type of alloy) are required, because of the strong matrix effects encountered in XRF spectrometry
- large samples, with a diameter of several centimetres, are required in order to obtain high precision results
- high investments are required for the purchase of the device, and a payback is thus possible only if high quantities of analysis have to be performed.

Anyway, the fast response time, the possibility to perform a full analysis of the sample in a single run without the need of prior separation of its different components, and the possibility to introduce extensive automatization make XRF analysis a powerful instrument for the quality control and warranty in the industrial practice.

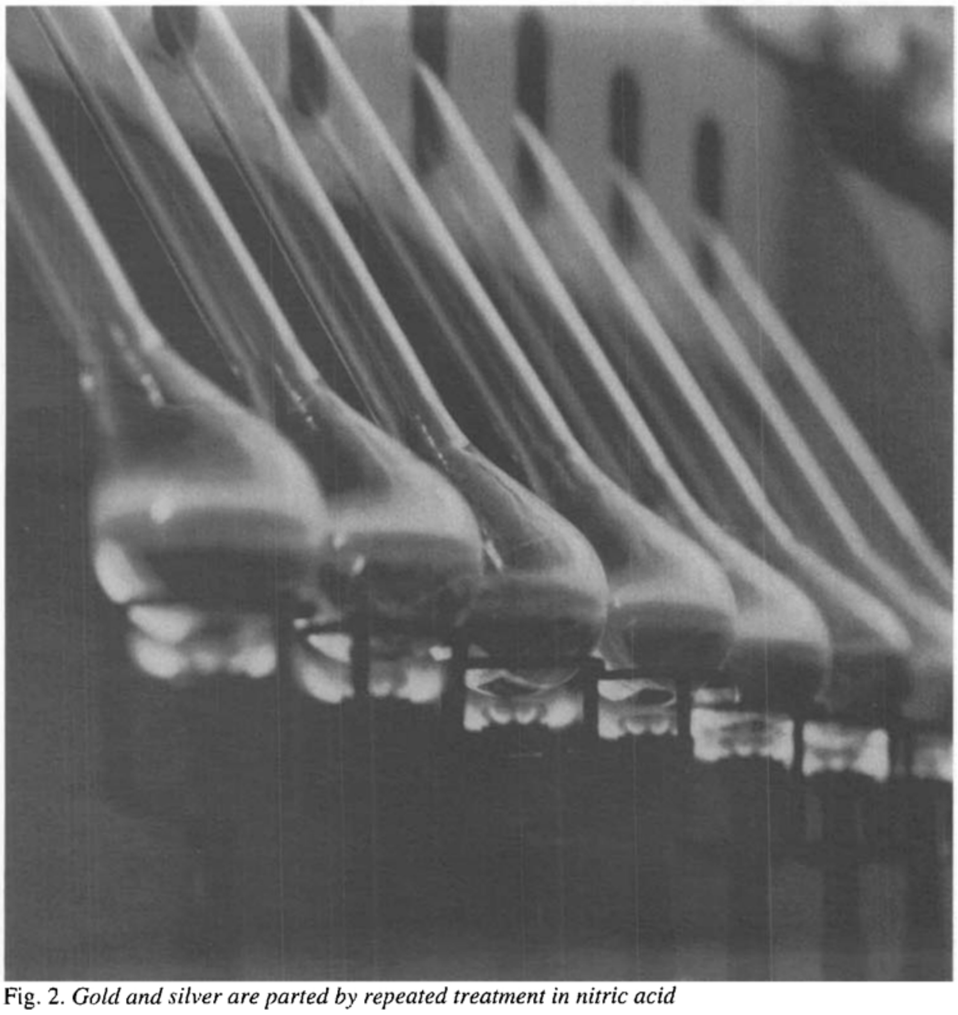

Fig. 2. *Gold and silver are parted by repeated treatment in nitric acid*

ICP Analysis with Internal Standard

Although not yet ready to replace fire assay or XRF analysis, this technique is meeting increasing interest, owing to the small sample size required, to the virtual absence of interferences between spectral lines of the usual alloy components and to the acceptable price of the analytical devices, atomic emission spectroscopy by inductively coupled plasma (ICP) is meeting increasing interest among precious metal analysts. Already published by ISO as Draft International Standard for the analysis of platinum and of palladium in jewellery alloys (ISO DIS 11494 and ISO DIS 11495), this particular analytical method is presently undergoing extensive study within the Working Group ISO/TC 174/WG 1, looking for a further improvement of the achievable accuracy.

This particular application of emission spectroscopy overcomes the relative deceiving reproducibility of ICP (typically not much better than 1% relative, a very poor one in the eyes of the gold analyst) by adding an internal standard, such as yttrium, both in the calibration and in the sample solutions, and measuring simultaneously the intensity ratio of the precious metal's and of the internal standard's emission line. In this way an improvement of the accuracy of the results by a factor of ten, at least, can be obtained. A further improvement in the overall precision is achieved by diluting by weight instead by volume, and by the averaging of repeated determinations, with strict conditions concerning the acceptable relative standard deviation.

Trace Analysis by Spectroscopical Techniques

For the determination of the purity of fine gold (999.9‰) indirect determination of the fineness is mainly used.

For the analysis of trace amounts of impurities atomic absorption spectroscopy, which has been the working horse of many laboratories during the last decades, has been replaced by atomic emission spectroscopy techniques. Different excitation sources are available both for solid samples (arc and spark spectral sources, glow discharge lamp) and for solutions (direct current plasma or inductively coupled plasma).

Devices with fixed channels allowing the simultaneous analysis of not less than twenty different metallic elements allow a rapid analysis of the samples, with detection limits ranging typically around 1 mg/kg. The fineness of the samples is then obtained subtracting the sum of the detected impurities from 1000‰, achieving in this case a much better accuracy than the one obtainable by fire assay.

The Ultimate Touch of the Sworn Assayer

As one can see, there is no lack of good analytical methods to determine the fineness of gold. Nevertheless, the ultimate accuracy needed for this task requires special experience in the choice of the appropriate analytical technique and in the application of modifications of the procedure needed in dependence of any particular case. Special care has further to be put in the sampling operations, so that the analytical results are really representative for the whole lot of material.

The high responsibility related to the precious metal analysis is thus attributed by the Swiss law to sworn assayers, specially educated and subjected to the authority of the Swiss Federal Office for Precious Metal Control, as ultimate warranty for the accuracy and reliability of the results.

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PAMP SA Production Artistiques Métaux Précieux SA*

Corrosion of Precious Metals

C. Marcolli and **M. Genel**

Company Profile

Production Artistiques Métaux Précieux SA (*PAMP SA*) was established in Chiasso, Switzerland, in 1977. Initially the company made its name by pioneering a wide range of 999.9 small gold bars which all carried stylish designs on the reverse side. The most famous is the 'Fortuna', depicting the Roman goddess Fortune emerging from a conch shell, which has won worldwide acclaim for *PAMP SA*.

Building on this reputation as a serious producer of high quality bars, *PAMP SA* opened its new gold refinery at Castel San Pietro, just outside Chiasso, in 1984. Work is undertaken on a toll or on a full service basis.

This high-technology refiner, which meets the strictest Swiss environmental requirements, provides full services in precious metals, from pick-up of doré at the mine, through assaying, refining, edging, and delivery of bars throughout the world. *PAMP SA* bars are accepted as good delivery by the Swiss National Bank, the London Bullion Market Association (LBMA), the commodity exchange (COMEX) New York, and the Tokyo Commodity Exchange (TOCOM).

PAMP SA prides itself on its agility and flexibility, as a fully accredited Swiss refinery, able to provide unrivalled and comprehensive customer service. The philosophy is to offer the best product at the best price in the shortest time, through a high degree of specialisation and automation, backed by large capacity.

The level of automation enables *PAMP SA* to operate a competitive, efficient refinery with a modest staff of 65 men and women. This skilled team has long experience in all aspects of refinining. They combine to offer a wealth of knowledge in the treatment of precious metals.

Foreword

It is generally assumed that all precious metals, *i.e.*, those metals which have a high electropositive reading on the scale of the standard electrochemical potentials of the elements, are characterised by total chemical inertia and by inalterability in relation to the air and corrosive surroundings. Such assertions are certainly true, but cannot be intended as universal concepts.

The fact that *e.g.* silver turns brown, *i.e.*, the tendency of the metal to be covered by nonconducting sulfur compounds, is one of the greatest problems in the electric field and in jewellery, and has been the subject of many studies.

Gold, too, though characterised by a standard positive electrochemical potential with respect to silver, and therefore, by a greater degree of chemical inertia, is not inalterable (it dissolves in *aqua regia*) and forms two very stabile oxides.

The presence of spots of a persistent reddish-brown colour has been noted on the surface of fine gold bars of various

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