Quantitative Spectrum Analysis. Part VI. An Attempt to determine the Amount of Gold contained in Natural Ores.

By

Arata Iwamura

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I. Introduction.

Although the process is very tedious and laborious, assaying is universally employed for the estimation of gold in natural ores and the intermediate metallurgical products.

Very few works have been published on the spectrographical method for the determination of gold. For instance, R. Bosset and P. Jolibois[1] described the method of detecting a trace of gold by means of a spectrograph, and M. Pierre Urbain[2] published a paper entitled "Sur une méthode quantitative d'analyse spectrale." A. Günther[3] published also a table which may be used for quantitatively analysing gold contained in lead by Gerlach's method.

In the hope of contributing something in this field of analysis, the present writer took up the work and succeeded, first of all, in preparing a good and durable electrode consisting of the natural gold ores in question.

II. Methods of preparing electrodes from a gold ore or a gold solution.

To prepare electrodes, a mixture consisting of 10 gms. of siliceous gold ore, 3.5 gms. of pure carbon and 9.5 gms. of cane-sugar

1. Robert Bosset et Pierre Jolibois, Bull. Soc. Chim. France, **37**, 1297—1304, 1925.
2. M. Pierre Urbain, Bull. Soc. Chim. France, **47**, 1183, 1930.
3. A. Günther, Z. anorg. allgem. Chemie, **200**, 415, 1931.

molasses was treated in the manner described in the preceding paper[1], and satisfactory electrodes were obtained. For the standard electrode, the same amount of quartz sand was substituted for the ore and varying amounts of auric chloride solution were also mixed. Carbon was used to increase the electrical conductivity of the electrodes.

Electrodes in which zinc oxide was used as a binder were prepared by using the following mixtures:

(a) 25 gms. of gold ore,
6 c.c. of 6N-hydrochloric acid,
5 gms. of zinc oxide as described in Part I.

(b) 25 gms. of carbon,
6 c.c. of 6N-hydrochloric acid,
5 gms. of zinc oxide,
varying amounts of auric chloride solution.

Magnesia cement and lime cement were also used. When carbonates were contained in the ore, it was necessary to decompose them by heating beforehand.

III. The apparatus used and the method of experiment.

The apparatus used was exactly the same as was described in the preceding paper[2]. In the early stage of the experiment the so-called "method of comparison" was used but later the analytical results were sought by drawing a density-concentration curve with respect to the spectral line of gold at $\lambda = 2428$ Å, and by extrapolating the curve in the same manner as was shown in fig. 1—2 and in PL. I. a and b of the preceding paper. (Part V)

IV. Reproducibility.

The reproducibility of the spectrograms of electrodes prepared by cementing with zinc oxide and those prepared from carbon and molasses was observed to be satisfactory, as is shown in PL. I. a and b.

In all cases, the electrodes contained gold in the form of auric chloride.

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1. These Memoirs, **14**, 48, 1931.
1. These Memoirs, **14**, 49, 1931.

V. Sensitivity of the spectrographical analysis of gold.

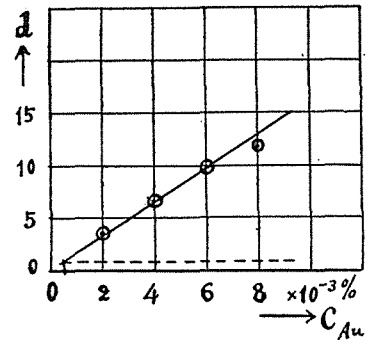
The sensitivity of the spectrographical analysis of gold was determined in the same manner as in the cases reported in Part II. The relation between the concentration of gold and the photographic densities of the gold line al $\lambda=2428$ Å is shown in the following table and figure and also in the spectrograms shown in PL. II. c.

Table I.

Conc. of Au %	$d_{mm}\lambda=2428$ Å
$1\cdot10^{-3}$	
$2\cdot10^{-3}$	3.6
$4\cdot10^{-3}$	6.6
$6\cdot10^{-3}$	9.9
$8\cdot10^{-3}$	11.8

Sensitivity$=4\cdot10^{-4}$%

Fig. 1.



The sensitivity thus graphically found was $4\cdot10^{-4}$% under the conditions of the experiment. This value of sensitivity is lower than that reported by Bosset and Jolibois, who found it to be $0.2\cdot10^{-4}$% on analysing gold in lead.

The electrodes used in the above experiment were those cemented with molasses. The electrodes cemented with zinc oxide gave a sensitivity of $3\cdot10^{-3}$% (See PL. I. d) and those cemented with calcium oxide were still less sensitive, though fitted for longer service.

The sensitivity found with the electrodes prepared from natural siliceous ores was lower than that found with the electrodes prepared from a gold salt solution, carbon and molasses.

With the object of increasing the sensitivity, gold ore was first roasted together with sodium chloride at dull red heat for several hours and then treated with hydrofluoric acid and concentrated sulphuric acid, and then cemented into electrodes. These electrodes, however, gave no better results, especially when cemented with calcium oxide.

The cause of this lower sensitivity shown in electrodes cemented with calcium oxide can be understood, when we compare the ioniza-

tion potential of gold with that of zinc, calcium, silicon or carbon, as is seen in the following table.

Table II.

Element	Au	C	Zn	Si	Ca
First ionization potentials in volts	9.2	11.24	9.35	8.19	6.09

From the results of the experiments so far described, it can be concluded that for analysis of gold, molasses is most serviceable as the binding material, zinc oxide cement comes next and lime cement gives the worst sensitivity. It is advisable to get rid of any impurities having an ionization potential lower than that of gold.

If such impurities as give some spectral lines near the gold lines at $\lambda=2676$ Å and at $\lambda=2428$ Å, are present in the sample, then the other sensitive lines of gold should, of course, be selected.

VI. Examples of analysis.

Electrodes containing gold in the form of auric chloride were found not to give satisfactory results when analysed by the method of comparison; only the spectrograms and microphometer records, therefore, are shown in PL. II. b and c.

A sample of natural gold ore was cemented into electrodes by means of zinc oxide and hydrochloric acid, and several electrodes containing the same amount of the sample and varying amounts of auric chloride were prepared. With these eloctrodes spectrograms were taken on a plate under the same condititions and developed. The densities of the gold line at $\lambda=2676$ Å were obtained microphotometrically, and the density-concentration curve was drawn. From that curve the unknown concentration of gold contained in the sample of ore, corresponding to the experimentally obtained density, was graphically found. But the result was not satisfactory, so that the application of this method to gold analysis is impracticable.

The spectrograms are shown in PL. II. d.

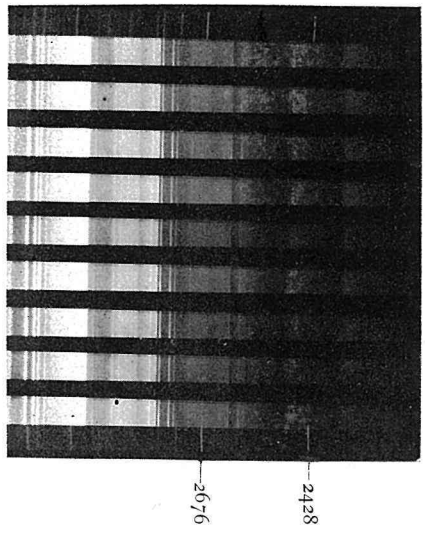
Summary

1) Several ways of preparing electrodes containing gold salt or natural gold ore are described, and the spectrograms of these elec-

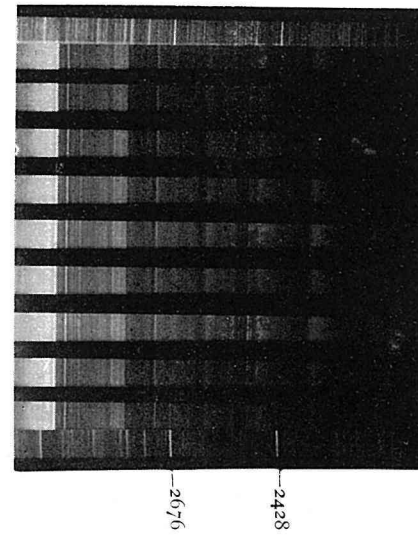
trodes were found to be quite reproducible, as is shown in the plates.

2) The sensitivity of the gold line at $\lambda = 2428$ Å was found to be $4 \cdot 10^{-4}$ % in carbon electrodes, and $3 \cdot 10^{-3}$ % in electrodes containing gold chloride cemented with zinc oxide and hydrochloric acid. The reason why the sensitivity of the gold contained in the electrodes is lowered in the presence of calcium, silicon etc. is discussed.

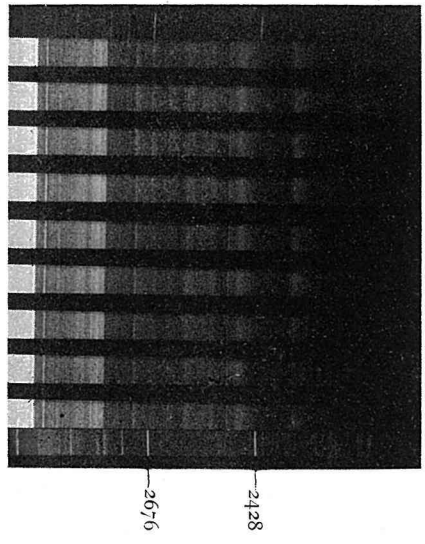
Plate I



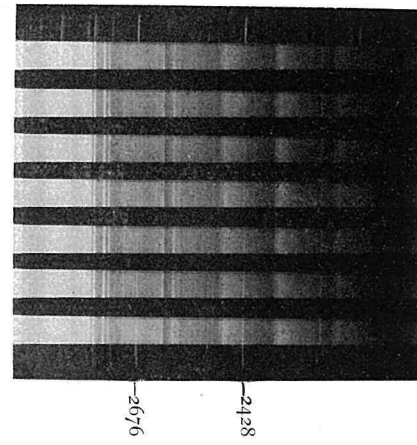
a



b

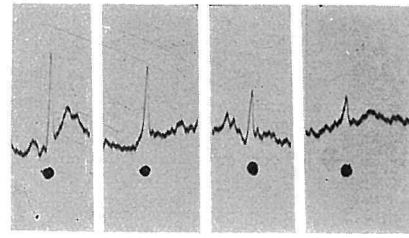


c

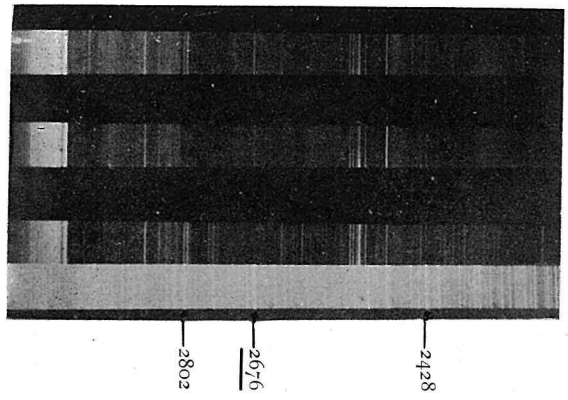


d

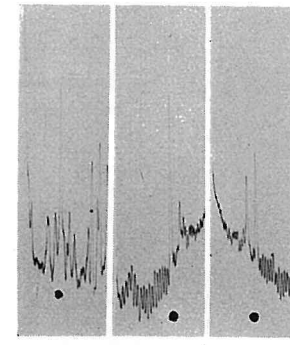
Plate II



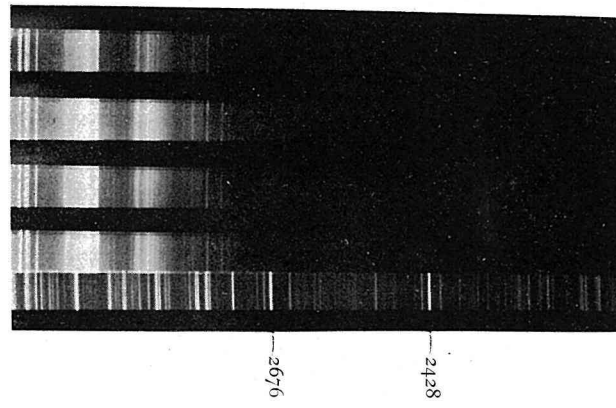
a



d



c



b