

VI.—*On Refining Gold when alloyed with Tin or Antimony, so as to render it fit for the purposes of Coinage.*

BY ROBERT WARINGTON.

TOWARDS the latter end of the year 1857, I received from the Australian Bank, a specimen of bar-gold for analysis, which was stated to have been obtained from the quartz-crushing process. On the exterior, or what had been the surfaces of the original bar, it presented the general appearance of a golden hue, though perhaps, an experienced and critical eye, might have considered it a little paler than pure gold. Interiorly, or on the broken surface, however, it had a crystalline structure of a greyish yellow colour. It was very brittle and rotten, and by analysis, yielded the following results on the 100 parts.

Gold	.	.	92.50	
Silver	.	.	4.60	
Tin	.	.	2.00	with a trace of antimony
Copper	.	.	0.75	
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			99.75	
Loss	.	.	0.25	
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			100.00	

I have been informed that numerous bars of this white and brittle gold, had arrived in this country from Australia, and had caused much trouble and annoyance to the refiners, melters, and also to the Mint officers, as it will be evident, that the nature of the alloying metals is not rendered apparent in the ordinary mode of assay, by the processes of cupellation and quartation, they being oxidized, dissolved, and carried into the cupel with the lead; and that therefore, in the after larger operations of melting, when the gold passes forward for the purposes of coinage, the existence of the tin and antimony not having been discovered, is not provided for, and consequently, from the brittle nature of the alloy, the subsequent processes of rolling, to which it has to be subjected, are rendered impracticable. I am informed that about 47,000 ounces of gold bars have in this condition been returned to the Bank of England authorities from the Mint, as unfitted for the purposes of coinage.

A short time after the foregoing examination was completed and reported on, I received another specimen of this brittle gold for analysis, through other parties. This second sample presented somewhat the same appearances, both externally and internally, as the one just described, being perhaps, a little whiter in its colour, and more rotten or friable in texture. It yielded by analysis, on the 100 parts :—

Gold	.	.	.	93·80
Silver	.	.	.	2·20
Antimony	.	.	.	2·28
Tin	.	.	.	1·40
Arsenic	}	.	.	traces
Copper		.	.	
				<hr/>
				99·68
Loss	.	.	.	0·32
				<hr/>
				100

An interesting question arises from the above results as to the origin of these injurious alloying metals; do they occur associated with the gold, or are they introduced during the melting process? As regards the first, we know that in stream works, gold and oxide of tin are commonly found associated, as is the case in Ceylon, in Cornwall, and other districts. We know also, that considerable quantities of stream-tin are brought from Australia. The presence, therefore, of that metal in small quantities, as an alloy, in the resulting gold bars, might be almost anticipated. But this view of the case does not account satisfactorily, for the other alloying metals found in the second analysis, particularly the antimony. My own impression, derived from a careful examination of the specimens and the foregoing results, is, that they are introduced during a rough process of refining, through the employment of sulphuret of antimony, and that, for want of efficient management, the operation has been imperfectly carried out.

The use of sulphuret of antimony, for the purpose of refining gold and raising its standard, is so well known, that I need hardly dilate upon it; suffice it to say, that, if successfully applied, it converts the iron, zinc, tin, &c., that may be present, and much of the silver, into the form of sulphurets, which float, in their melted state, upon the surface of the gold; a portion of the antimony at the same time alloying with that metal. This antimony should, of course, be afterwards removed by a second

operation.* From a specimen which has since come into my possession, it will be seen that the particles of gold dust have been so imperfectly melted, before running into bars, that many of them are still visible in their flattened and rounded forms, and must therefore have remained suspended in the melted alloy. I feel that this explanation of the source of the alloying metals is, therefore, to some extent substantiated, as a want of a sufficiently high and continued heat would leave the gold very much in the state above described.

On delivering the report of this second analysis to the parties from whom I had received the sample, they were anxious to know if I could suggest to them a method by which these injurious alloys could be removed, and the gold rendered capable of being rolled or hammered, without, at the same time, greatly increasing the expense of the operations, or entailing a loss of the gold. I was in consequence induced to turn my attention to the effecting of this desirable object. The proper resolution of this problem required a little consideration, inasmuch, as, although it was evident that it must be accomplished by a process of oxidation, to burn out, as it were, the antimony and tin; yet it was also necessary that the oxygen should be applied to the alloyed gold while the metal was in its fluid state, and also that the oxidizing agent should not part with its oxygen simply by the high temperature to which it would be subjected.

Nitrate of potash I was informed had been suggested, tried and failed, although a very large percentage had been used; experiments in that direction were therefore considered unavailable, and my attention was consequently turned to the employment of metallic oxides having a weaker affinity for oxygen, at these high temperatures, than the metals which it was required to remove from the contaminated gold.

After a few experiments, all of which were more or less successful, I succeeded in obtaining the desired result, and submitted for the consideration of the parties concerned, a simple process, which, from their liberality, I was enabled at the time to communicate to several friends interested in such matters, and which I also desire now to lay before the members of the Chemical Society. The process consists in the employment of oxide of copper, about 10 per cent. of which is to be added

* Since making this communication, I have been informed that sulphate of antimony also sometimes occurs in association with native gold in Australia.

to the alloyed gold, with the addition of a small quantity of borax, and the whole maintained in a well fused state for about half an hour. The result is a perfectly malleable gold containing a small percentage of metallic copper, and well fitted for the purposes of coinage. The proportion of oxide of copper used must of course greatly depend on the percentage quantity of the oxidable metal requiring to be removed; but I believe, from the specimens which I have worked on, that it never need exceed the 10 per cent. Oxide of manganese might be employed to effect the same purpose; but I found that the fusibility of the oxide of copper and its powerful fluxing properties, rendered its action much more efficient and complete, from its flowing continually over the surface of the molten gold, and thus thoroughly oxidizing and removing the tin and antimony from their combination. As thus conducted the resulting alloy should always be better than standard, unless the baser metals occur in very large proportion.

By the action of nitro-hydrochloric acid upon these samples of alloyed gold, the resulting solution deposited on cooling beautiful crystals of chloride of silver; and I may be allowed here to mention a very curious case of the same kind, but to a much greater extent, which was brought under my notice some time since, by the late Mr. Maurice Scanlan. It appeared from his statement, that he had been requested to obtain the gold from a beautifully wrought and small sized rope-chain, of Indian manufacture; and on submitting it to the action of nitro-hydrochloric acid for this purpose, he found that it did not dissolve; and although he obtained some gold in solution, yet the form and size of the delicate fabric remained unaltered; it had become, however, very brittle and rotten, and was of a dingy brown colour. It was submitted to me for examination by the microscope, and when subjected to this scrutinizing agent, it was at once evident what had taken place, and of what the chain had been composed. It consisted almost entirely of chloride of silver, beautifully crystallised on the surface or strands of the rope, and having, in the cross section, a radiating structure from the interior to the circumference, the central core, in some fragments, exhibiting still a portion of the original alloy from which the gold had not been removed, it having, most probably, been protected from the action of the acid by the comparatively thick coating of chloride of silver which had been formed around it.
