CASE REPORT

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Unlawful Possession of Silver

In a previous paper [*1*] the interpretation of a variation in trace element content as a function of manufacture was used to show that two parts of a vehicle dismantled by cutting with oxygen had originally been one. The principle has wide application in forensic metallurgy, and this communication describes its employment in a case involving the unlawful possession of silver.

Problem

Six ingots and 45 pieces of a silvery metal were found in the possession of a person who could not reasonably explain their origin. The authors were requested to answer two questions:

1. What is the nature of the silvery metal?
2. What is the likely origin of the silvery metal?

Method of Analysis

After specific gravity measurement suggested that the metal was silver, laboratory analysis confirmed this indication. The exhibit (Fig. 1) consisted of three forms: (1) six ingots, (2) 21 fragments that appeared to have been mechanically separated from the corners of the larger ingots, and (3) 24 thin, flat pieces showing porosity on one surface consistent with evolution of oxygen during solidification (called spillage).

Spectral analysis of the ingots, separated fragments, and spillage pieces is shown in Table 1. With respect to the ingots and spillage pieces, small particles of foreign matter adhering to the surface (called dross and black inclusions, respectively) were detected. The analyses of these are also shown in Table 1. In the case of the dross, the specimens for analysis were contaminated by silver during sampling so that the analysis for dross can be considered as semiquantitative at best.

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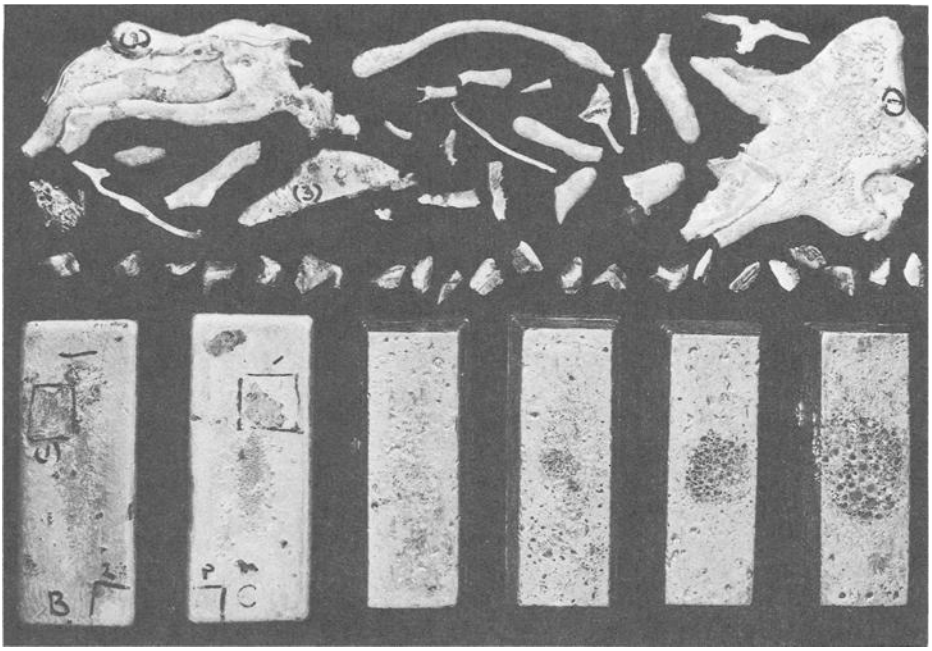

FIG. 1—*Silver grouped into three categories: spillage pieces* (top), *fragments* (middle), *and ingots* (bottom). *The two ingots on the left were photographed from the top, the four on the right from the bottom.*

Discussion of Results

All 21 fragments that appeared to have been mechanically separated from the corners of the larger ingots were analyzed as 99.98+% silver.

The silver content of the six ingots, labelled A to F, varied from ~99.91% (Ingot A) to ~99.96% (Ingot C). The interesting feature of the analysis of the silver ingots was the composition of the dross. The high copper, antimony, arsenic, bismuth, gold, and iron cannot be explained as the result of remelting pure silver with other pieces of silver or silver-like (for example, pewter) jewelery. However, the largest refiner of silver in Australia is Broken Hill Associated Smelters (BHAS) at Port Pirie in South Australia (~80% of Australian production). The silver at this plant is recovered from lead concentrates that contain copper, antimony, arsenic, bismuth, gold, and iron. Thus the elements in the dross on the silver ingots correspond with those associated with the silver in the concentrates treated by BHAS.

During the refining of silver by BHAS, a silver-zinc alloy is produced as an intermediate step. The spillage pieces (Table 1) were essentially high-purity silver contaminated with zinc. The black inclusions were most probably particles of chromite refractory from the melting furnace or crucible. In summary, the 21 fragments were 99.98+% silver, the grade of silver produced by BHAS; the ingots were contaminated by a number of elements exactly matching the elements in the concentrates processed by BHAS; and the spillage pieces were high-purity silver contaminated by zinc, and a silver-zinc alloy is an intermediate step in the production of 99.98+% silver by BHAS.

The conclusion reached from this information was that the ingots were produced by

TABLE 1—*Spectral analysis of silver*

Specimen	Copper	Lead	Antimony	Arsenic	Zinc	Bismuth	Gold
Dross Ingot A	1000	minor	7000	3000	minor	30	<10
Ingot A	100	500	<30	<50	<100	<5	<10
Dross Ingot B	500	1000	200	<50	1000	10	150
Ingot B	150	30	<30	<50	<100	<5	<10
Dross Ingot C	500	1000	100	<50	3000	<5	100
Ingot C	50	50	<30	<50	<100	<5	<10
Dross Ingot D	500	minor	2000	500	minor	10	<10
Ingot D	100	300	30	<50	<100	<5	<10
Dross Ingot E	500	minor	7000	2000	minor	50	<10
Ingot E	100	500	<30	<50	<100	<5	<10
Dross Ingot F	200	3000	500	500	500	<5	<10
Ingot F	70	100	<30	<50	<100	<5	<10
Spillage 1 smooth surface	70	50	<30	<50	<100	<5	<10
Spillage 1 black inclusion	10	20	<30	<50	1000	<5	<10
Spillage 2 smooth surface	70	200	<30	<50	200	<5	<10
Spillage 2 rough surface	300	500	<30	<50	700	<5	<10
Spillage 2 black inclusion	30	800	<30	<50	minor	<5	<10
Spillage 3 smooth surface	100	70	<30	<50	<100	<5	<10
Spillage 3 dross surface	150	300	<30	<50	500	<5	<10
Spillage 4 smooth surface	100	50	<30	<50	<100	<5	<10
Spillage 5 smooth surface	70	300	<30	<50	100	<5	<10
Spillage 6 smooth surface	100	100	<30	<50	200	<5	<10
Each of 20 separated fragments	~50	~20	<30	<50	<100	<5	<10

[a] Approximate parts per million; minor = 1 to 10% and major = >10%.

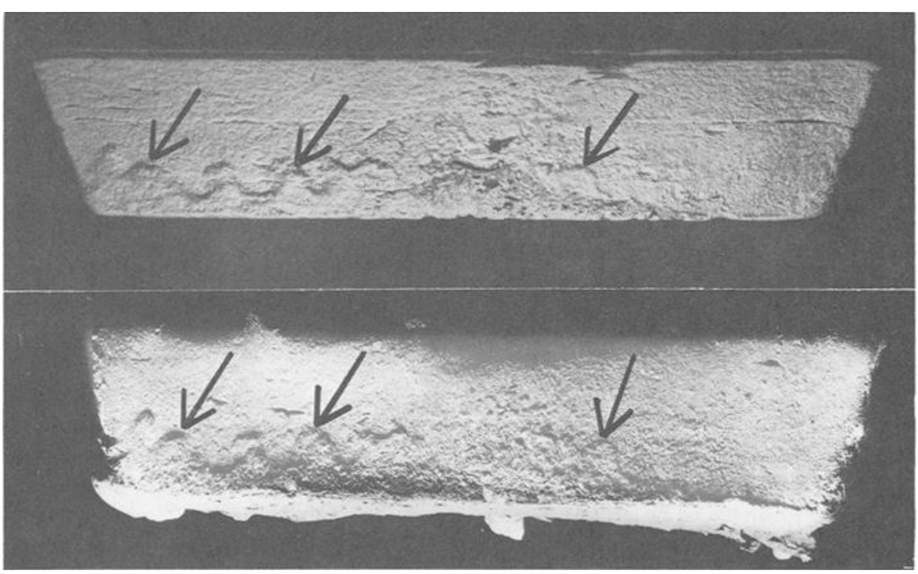

FIG. 2—*Ingot* (top) *was cast from the gold mold* (bottom). *The surface topography is identical, confirming that the ingot was produced from that particular mold.*

for impurity content in parts per million.[a]

Iron	Chromium	Magne-sium	Aluminum	Titanium	Nickel	Silicon	Molyb-denum	Tin
minor	200	2000	1000	100	100	5000	<3	30
100	<10	<100	<100	<100	<10	<100	<3	<10
minor	100	1000	1000	100	100	5000	3	30
100	<10	<100	<100	<100	<10	<100	<3	<10
minor	70	1000	700	100	200	5000	3	50
100	<10	<100	<100	<100	<10	<100	<3	<10
minor	200	500	500	100	100	200	<3	<10
300	<10	<100	<100	<100	<10	<100	<3	<10
minor	200	3000	1000	100	100	1000	<3	50
100	<10	<100	<100	<100	<10	<100	<3	<10
3 000	20	200	100	100	70	<100	<3	30
300	<10	<100	<100	<100	<10	<100	<3	<10
30	<10	<100	<100	<100	30	<100	<3	<10
10 000	major	minor	2000	100	200	3000	10	10
30	<10	<100	<100	<100	<10	500	<3	<100
300	500	1000	300	<100	30	200	<3	<10
minor	major	minor	major	1000	1000	1000	70	30
500	70	<100	<100	<100	100	300	<3	<10
3000	300	100	<100	<100	300	<100	200	10
20	10	<100	<100	<100	20	<100	<3	<10
30	<10	<100	<100	<100	<10	<100	<3	<10
50	10	<100	<100	<100	<10	<100	<3	<10
~20	<10	<100	<100	<100	<10	<100	<3	<10

remelting 99.98+% silver and some silver contaminated by zinc, both originating from the BHAS plant.

Personnel at the plant agreed that the silver originated from BHAS and that the molds used to cast gold matched the size of the six ingots. Subsequently a cast was made of one of the molds and was found to match the surface of four of the ingots (Fig. 2). The gold molds are not used for the casting of silver ingots and therefore the casting of the six silver ingots was carried out illegally.

Conclusion and Summary

Silver in three different forms was identified on the basis of impurity content as having originated from a silver refinery in South Australia. A mold used for melting gold at the refinery was shown to have been used illegally for the casting of four of the six silver ingots. This information and other evidence were presented at a lower court hearing at which the accused pleaded guilty.

Acknowledgment

We are grateful to Inspector W. J. Low of the South Australian Police Department for permission to publish this communication.

Reference

[1] Powell, G. L. F. and Robinson, R. R., "Trace Element Analysis of Steel Sections on Either Side of an Oxygen Cut in a Vehicle Suspected of Being Stolen," *Journal of Forensic Sciences,* Vol. 23, No. 4, Oct. 1978, pp. 707-711.

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