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PRECIOUS METALS IN MARTIN FROBISHER'S "BLACK ORES" FROM FROBISHER BAY, NORTHWEST TERRITORIES*

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Abstract

During the second and third Frobisher expeditions to Baffin Island and vicinity (1577 and 1578), small assay furnaces for control of exploration were set up near the present community of Frobisher Bay and, back in England, larger furnaces installed in the London area for bulk assay of the "black ore". Assays were made by lead-fusion extractions. Parting was by HNO_3 (small tests) and sulfidation of silver (large tests). The precious-metal determinations suggested silver potential, with Ag exceeding Au in weight and, for most determinations, in contemporary monetary value. Twelve new analyses (by atomic absorption) show that the "black ores" of Kodlunarn Island contain 5–14 ppb Au and 5–175 ppb Ag, which are several orders of magnitude less than those reported by Messrs Schutz, Burcott and Denham in the 16th century. The discrepancies are probably due mainly to mistakes in analytical procedure by the Elizabethan assayers, although appreciable silver in the later Elizabethan bulk-assays may have been accidentally introduced as argentiferous lead in the crucible charge.

Keywords: gold, silver, Frobisher, Kodlunarn Island, atomic absorption, Elizabethan assays, Northwest Territories, Baffin Island.

Sommaire

Au cours des deuxième et troisième expéditions de Frobisher à l'île de Baffin et aux régions avoisinantes, en 1577 et 1578, des petits fourneaux prévus pour essais, afin de guider l'exploration, furent construits près du village actuel de Frobisher Bay. Des fours à plus grande capacité furent installés dans la région de Londres pour l'analyse du "minerai noir" en grosses quantités. Les essais se faisaient par fusion avec du plomb et séparation par acide nitrique (tests à petite échelle) et par sulfuration de l'argent (tests à plus grande échelle). Les déterminations des teneurs en métaux précieux montraient un potentiel pour de l'argent, qui surpassait l'or en poids et, dans la plupart des cas, en valeur monétaire à l'époque. Douze nouvelles analyses par absorption atomique montrent que le "minerai noir" de l'île de Kodlunarn contient de 5 à 14 ppb d'or et de 5 à 175 ppb d'argent, ce qui est inférieur de plusieurs ordres de grandeur aux valeurs rapportées par messieurs Schutz, Burcott et Denham au seizième siècle. Le décalage serait dû à des erreurs dans les procédures analytiques élisabéthaines, quoique la présence d'une quantité appréciable d'argent dans les analyses de plus grosses quantités pourraient être dues à l'introduction accidentelle de plomb argentifère dans les échantillons à traiter.

(Traduit par la Rédaction)

Mots-clés: or, argent, Frobisher, île de Kodlunarn, absorption atomique, essais élisabéthains, Territoires du Nord-Ouest, île de Baffin.

Introduction

The first mines in Canada were the Frobisher trenches in and near Baffin Island. From these, 1400 tonnes of prospective gold ore were returned to the British Isles in 1577 and 1578. The very first excavations were those of the Countess of Warwick mine on Kodlunarn Island, an 8-hectare islet near the mouth of Frobisher Bay. Ore was taken from two trenches: the "Ships Trench" near tidewater, which was completed in 1577, and the "Reservoir Trench" near the centre of the island, operated in 1578. After supplying 220 tonnes of ore, "The Countesse of Warwick myne fayled being so hard stone to breke" (Stefansson 1938, vol. 2, p. 70).

Considerable literature, in scattered sources, exists on the Frobisher voyages and, fortunately, most has been assembled by Stefansson (1938). Official papers of the Cathay Company, which was assigned to operate the mines, are preserved in the Public Record Office, London, and a copy of about 1824, made for Craven Ord, is kept in the British Library (MS–1, references). A ship's log of the third voyage was published by Kenyon (1981). However, until 1984, few mining or geological data were available on this interesting occurrence of historical interest. A petrographic description of a single specimen of amphibole-rich "black ore" has been published by Roy (1937), and the geology was summarized by Blackadar (1967).

In 1983 and 1985 the Department of Indian Affairs and Northern Development sponsored a study of the mining and metallurgical activities conducted under Martin Frobisher. This involved both site visits and laboratory studies. The local geology was described by Hogarth & Gibbins (1984), and an updated classification of the "black ores" was given by Hogarth (1985). The present article is a continuation of this project.

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TABLE 1. NINE 16TH-CENTURY ASSAYS OF ROCK FROM THE FROBISHER BAY AREA

No.	Date	Assayers	Furnace site	sample wt. (kg)	Assay (ppm)** Ag	Au	References
1	Feb. 12, 1578*	J. Schutz	Wm Winter's house	100	1800	138	Stefansson (1938), 2, p. 126
2	Feb. 21, 1578	Dr. Burcott	Dr. Burcott's house	50	1530	306	Stefansson (1938), 2, p. 127
3	Feb. 21, 1578	Dr. Burcott	Dr. Burcott's house	0.5	1160	398	Stefansson (1938), 2, p. 129
4	Feb. 21, 1578	Dr. Burcott	Dr. Burcott's house	50	1570	398	Stefansson (1938), 2, p. 129
5	Mar. 8, 1578	J. Schutz	Wm Winter's house	100	1950	80	Stefansson (1938), 2, p. 131
6	Mar. 24, 1578	J. Schutz	Wm Winter's house	100	1520	52	Stefansson (1938), 2, p. 151
7	Feb. 20, 1578	J. Schutz	Wm Winter's house	200	1210	72	MS-1, fol. 80R; MS-3, fol. 12R
8	Feb. 17, 1579	J. Schutz	Dartford	500	1060	36	Stefansson (1938), 2, p. 150
9	———, 1579	J. Schutz & R. Denham	Dartford	16000	623	7	MS-1, fols. 81V - 82R

* All dates are given according to the New Style calendar.
** All assays were assumed originally reported in Troy ounces per long ton.

Elizabethan Assays

A brick-lined assay furnace was set up on Kodlunarn Island in 1577 and was operated by Jonas Schutz and two assistants. It was rebuilt in 1578, and additional furnaces were installed, one on the south side of Frobisher Bay, opposite Kodlunarn Island, and another on the north side, to the northeast of the island. Robert Denham and four assistants were assayers on this third voyage (MS–1).

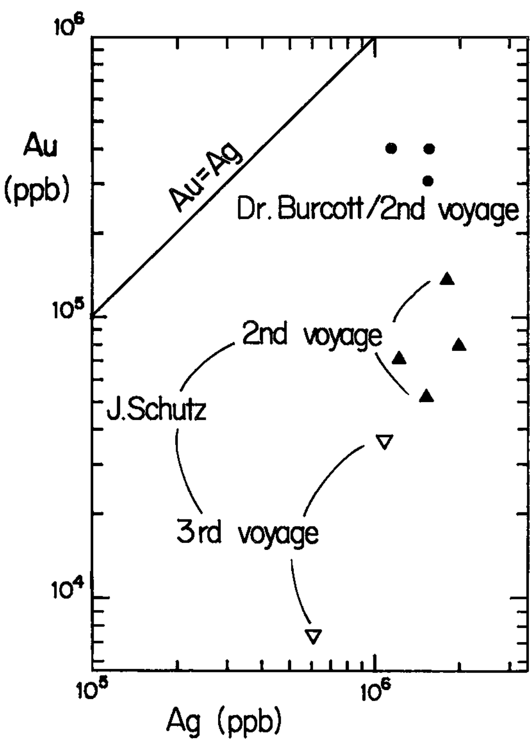

FIG. 1. Gold and silver concentration in nine 16th-century assays of rock specimens from the Frobisher Bay area.

The assays were made by lead fusion. Silver was parted with HNO_3 (MS–1, -2). Little is known of the assays. The "Book of Register" of the third voyage, mentioned three times in Edward Fenton's journal (Kenyon 1981), was apparently lost on the homeward voyage (MS–3). However, after appraisal of the field assays, Robert Denham noted that the overall lading of the third voyage could be expected to run "almost an onse of gold in C [1 cwt] of ewer" (MS–4).

Furnaces in London produced the first assays from the second voyage. Precious metals were extracted by lead fusion and parted mainly with HNO_3. Giovano-Battista Agnello, a Venetian living in London, and Jonas Schutz and Burchard Kranick (*al.* Dr. Burcott), two Saxon immigrants, were the principal assayers.

The later and larger tests were made at the Dartford metallurgical plant, which operated discontinuously from December 1578 to April 1579. Here also gold and silver were extracted by lead fusion, but silver was separated by sulfidation. Sulfur in the first large tests ("proffes") was provided by stibnite ("antimonie") from near Saltash, Cornwall. This method of parting was shown to be efficient by Goddard (1678) and was later used at the Dresden Mint and described by Percy (1880, p. 367-373) and Hoover & Hoover (1950, p. 451-452). After the stibnite supply gave out, it was replaced by pyrite from Newcastle ("marchasite") and rich copper ore ("copslighe") from the Mines Royal at Caldbeck, Lake District. Jonas Schutz and Dr. Burcott, along with Robert Denham of London, were the principal assayers (Stefansson 1938, 2; MS–1, -3).

These assays, *i.e.*, those of Agnello, Schutz, Burcott and Denham, were characteristically high in precious metals, with silver commonly reported in tens of ounces, and gold in ounces per tonne. Even with the high cost of mining, transportation and refining, the ore was thought to have potential to clear a handsome profit.

In contrast, some old analyses showed very low precious-metal content. For example, Public Record

Office manuscripts (Stefansson 1938, 2, pp. 83-84, 88, 121) give four such determinations, derived from the single specimen collected in the first voyage. Two sets of samples, smuggled out of England to Spain, one derived from the second voyage and the other from the third voyage, gave negligible gold and silver (Hume 1894, pp. 567-569, 595, 664-665). Assays of 1583 made from two 100-lb samples by William Williams, assay-master of the Tower of London (MS-7), produced silver beads measuring 0.2 and 0.3 mm in diameter, equivalent to 1 and 3 ppb, respectively.

Quantitative Appraisal of the High-Grade Elizabethan Assays

Results of nine analyses with parted gold and silver, taken from the literature, are listed in Table 1 and plotted in Figure 1. Samples 1-7 probably represent the Countess of Warwick mine. Samples 8 and 9 are from unknown locations in the Frobisher Bay area. Assays, as reported, have been converted into metric equivalents (*i.e.*, in ppm, equivalent to g/tonne). It can be seen that all samples gave high precious-metal assays, with silver exceeding gold. If the weights are converted to monetary equivalents (Elizabethan values), silver exceeds gold in all but the early assays of Schutz (Fig. 2). As reported, the rock was essentially a silver ore with by-product gold.

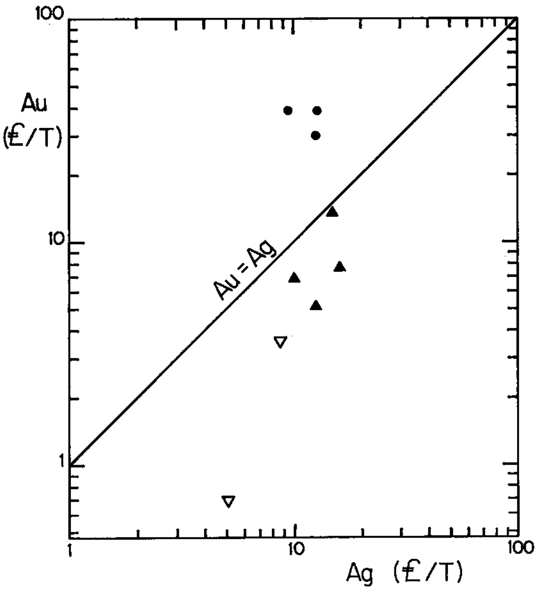

FIG. 2. Gold and silver values of assays shown in Figure 1 given in pounds per tonne. For symbols, see Figure 1.

Results of our Analyses

The Kodlunarn Island "black ores" are coarse, black, amphibole-rich rocks that are interlayered with biotite gneiss in a Proterozoic metamorphic sequence. They are also stockpiled on the island from rocks derived from this locality and elsewhere. Our specimens were collected *in situ* (K5A, K5B) and from the stockpiles (remainder). The specimens have been classified as Type 1 (rich in Al and Mg; Cr ≤ Ni) and Type 2 (rich in Ca and Ti; Cr > Ni). Type 1 has been subdivided into mineral associations a, b, c and d, as shown in Table 2. Additional information on

TABLE 2. SILVER, GOLD AND PLATINUM CONCENTRATIONS IN "BLACK ORES" FROM KODLUNARN ISLAND

No.	Rock type	Mineral association	Location	Ag	Au	Pt
K5A	1a	Hbl + Pl + Bt	in situ, bottom ST	45	5	
K5B	1a	Hbl + Pl + Bt	in situ, bottom ST	50	5	5
K5C	1c	Hbl + Spl + Ol	loose, bottom ST	45	<15	5
K8B	1b	Hbl + Spl + Pl	loose, top ST	5	<10	5
K9C	1b	Hbl + Spl + Pl	loose, bottom RT	135	10	5
K9D	1b	Hbl + Spl + Pl	loose, top RT	175	10	<5
K9E	1d	Hbl + Opx + Pl	loose, top RT	90	14	
K8A	1d	Hbl + Opx + Pl	loose, top ST	25	<15	<5
FB22	1d	Hbl + Opx + Pl	loose, top ST	40	<15	
FB30	1d	Hbl + Opx + Pl	loose, top ST	<75	<20	
FB6	2	Hbl + Cpx + Bt + Il	loose, top ST	50	14	
FB54	2	Hbl + Cpx + Bt + Il	loose, top ST	40	<15	

Abbreviations: Bt biotite, Cpx clinopyroxene, Hbl hornblende, Il ilmenite, Ol olivine, Opx orthopyroxene, Pl plagioclase, Spl spinel; RT "reservoir" trench, ST ship's trench. < for Au and Ag signifies below determination limit; minimum determination limit based on 10 gram sample weight. All values in ppb;
Rock Types: 1, Al and Mg-rich, Cr ≤ Ni, subdivisions a, b, c, d indicate mineral associations as in column 3; 2, Ca-and Ti-rich, Cr > Ni.

the occurrence and specimens can be found in Hogarth & Gibbins (1984) and Hogarth (1985).

Results of our analyses for gold and silver, along with sample location and mineral associations, are shown in Table 2. In addition, four samples from the Kenyon collection, Department of New World Archeology, Royal Ontario Museum (FB6, FB22, FB30, FB54) were assayed; data are included in the table.

Gold and silver were extracted from the sample matrix with an aqua regia digest, and then treated with HF to eliminate silica. The precious metals were then precipitated by reduction of tellurium chloride to tellurium by stannous chloride. The precipitate was redissolved, and the concentration of precious metals determined by atomic-absorption spectroscopy (AAS) using a graphite furnace. The method is similar to that described by Fryer & Kerrich (1978), who reported a detection limit of 0.18 ppb gold on a 30-g sample (based on 2σ); no value is stated for silver. We believe our detection limit to be 2 ppb based on a 10-g sample. We used the CANMET gold ores MA-1 and MA-2 as standards. For MA-1 the recommended value is 17.8 μg/g, and our values are 17.6 and 17.4 μg/g (based on a 1-g sample). For MA-2 the recommended value is 1.86 μg/g, and our value is 1.856 μg/g (based on a 1-g sample).

The relatively large samples (each about 10 g) used in the atomic-absorption determinations are considered more representative than the small samples used in direct-current plasma (DCP) and nuclear-activation analysis (NAA) determinations, listed by Hogarth & Gibbins (1984). Data are plotted in Figure 3. Values given as maximum (<) are assigned half-maximum quotation.

It can at once be appreciated that these values are much lower than the Elizabethan determinations (several orders of magnitude as shown in Fig. 3a). Insufficient samples prevent any generalization on Au–Ag characteristics of the various types of "black ore" (Fig. 3b).

In order to eliminate the possibility that platinum has been confused with gold and silver in the early analyses (the element was not recognized at that time), six samples were analyzed for PGE at the Nuclear Activation Services, McMaster University. These values are also reported in Table 2, but are very low in comparison to the Elizabethan Au–Ag values.

Discussion and Conclusion

The strikingly high Au–Ag values of the Elizabethan assayers are difficult to explain. The fact that Jonas Schutz (the assayer) and Michael Lok (the organizer and one of the chief sponsors of Frobisher's northwest ventures), independently, tried to purchase all the ore themselves (MS-3, fols. 52–54) indicates a genuine faith in the ore's richness and virtually eliminates deliberate fraud on the part of the assayer and administrator. We are left with the inescapable conclusion that the assay methodology was at fault. This seems strange because, as shown by Hoover & Hoover (1950) and Sisco & Smith (1951), the art of fire assaying was well developed by the 1570s and closely resembled fire assaying today. There is, however, the possibility that some of the silver can be attributed to additives in the charge. Stibnite running 900 ppm Ag, which was specifically mentioned as an argentiferous contaminant by Lok and others (Stefansson 1938, 2, p. 128), would be

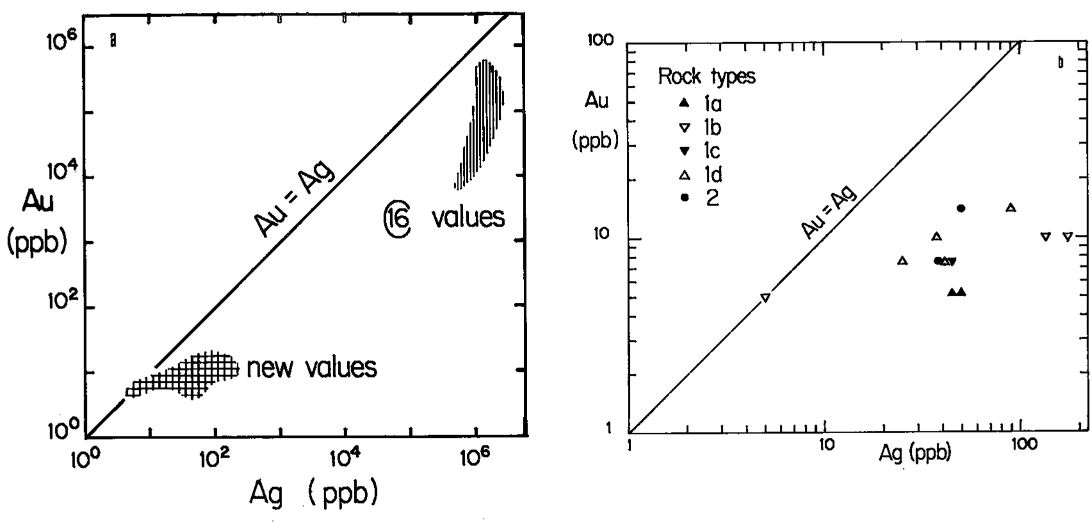

FIG. 3. New determinations of hornblende-rich rock from the Frobisher Bay area: a) compared with 16th century values, b) plotted with respect to rock type, as defined in Table 2.

ineffective because this mineral was added in small amount during the parting stage. A more likely candidate would be lead, which was added in large amounts to the crucible charge.

Argentiferous lead would have a special role in the later, lower-grade assays. Consider the largest Elizabethan bulk assay (16,000 kg; No. 9 of Table 1). From this sample a total of 330 oz (Troy) Ag and Au were extracted in two tests. A sampling of the lot suggested that it contained 3 oz (Troy) Au (MS-1). The ore, therefore, averaged 600 ppm Ag and 6 ppm Au. This is about 10,000 times higher in Ag and 1000 times higher in Au than the average of our determinations.

Lead consumed in these tests commonly surpassed, by a factor of 2, the weight of the ore assayed, and it is conceivable that the bulk of the silver was accidentally added as argentiferous (300 ppm Ag) lead and litharge in the crucible charge. This is not an improbable composition, especially for lead derived from the silver-bearing region of the northern Lake District (MS-1). The possibility exists, therefore, that at least some of the silver can be ascribed to an enriched additive in the Dartford tests.

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