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*Actas de la VIII reunión del Comité Internacional de Museos
Monetarios y Bancarios (ICOMON) = Proceedings of the 8th
Meeting of the International Committee of Money and Banking
Museums (ICOMON), Barcelona, 2001.*

*ICOMON. - Barcelona : Museu Nacional d'Art de Catalunya, 2003.
pp. 139-142*

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CURRENT GOLD AND SILVER COINS: EROSION AND CONSERVATION

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Since the 1980s, gold and silver coins have been prevailing in China and every year the Central Bank of China (People's Bank of China) issues gold and silver coins. However, in recent years, people have found white spots on silver coins, besides the usual color change (silvery white becomes brown), and brown spots emerging on gold coins (fig. 1, gold coins with rust on surface). It heavily puzzles numismatic museums and collectors. So, we set up a project and constituted a research group, which consists of our department of research, the Chemical Institute of Beijing University, and Beijing University of Science and Technology, to research this problem.

Researches and Analyses

We made a series of researches. We collected a lot of related gold and silver coins. From them we chose some typical samples - first observed then analyzed by SEM. The analytical data are as follows.

The Analytical Data of Rusty Gold Coins

The related data are listed in tables 1-4. There are five kinds of rusty spot.

- The first is made of rusty silver, consisting of Ag, Ag₂O, AgCl and Ag₂S (fig. 2).
- The second is made of silicate, with silicon, oxygen, calcium, magnesium, and aluminium elements (fig. 3).
- The third is made of iron and chromium oxide (fig. 4).
- The fourth is such spot which consists of organic compounds (fig. 5).
- The fifth is inorganic salt (fig. 6).

The Analytical Results of Rusty Silver Coins

The brown materials are Ag₂O and Ag₂S. The white spots consist of AgCl (see fig. 7).

Discussion

We believe that this problem mainly results from two factors: surroundings and coin blanks.

The surroundings include packing materials and air condition. We found that the current packing materials are made of PVC, which can be decomposed into chlorine (Cl). Chlorine can erode silver to form silver chloride: $\text{Ag} + \text{Cl} = \text{AgCl}$.

We also found that there are relatively high concentrations of detrimental gases: NO_2 24-29ppb; SO_2 41-61ppb; ($\text{H}_2\text{S} < 0.2\text{ppb}$).

They are all oxidants (nitrogen dioxide, sulfur dioxide), so also erode silver.

The quality of bullion or coin blanks is not good, on which there are many kinds of impurities: silver (powders), dust, organic compounds.

Protective Measures

- First, we installed an air-purifying system in the museum to improve the air and placed some sorbents (active carbon, TEA) in the display and collection cases to eliminate harmful gases.
- Second, we changed the packing materials: substitute plexiglass or polypropylene for PVC.
- Third, we asked everybody to put on gloves to handle coins.
- Fourth, we referred a constructive report to the mints to ask them to improve the quality of bullion and to keep the production surroundings clean.

Table 1. Analytical Data by SEM (W%)

Samples	Ag	Mg	S	Cl	Place/manner	Type	Picture
Panda 1 (Au) A	2.19			0.30*	Spot/A-scan	I	01
	2.50			0.21*	Spot/A-scan	I	
	1.37*		4.84	11.80*	Spot/S-scan	V	02
	0.76*		5.49	9.27	Spot/S-scan	V	
			2.93	11.14	Spot/S-scan	V	03,04
	0.31*			Base/A-scan			
Kylin (Au) B	18.78		17.97	5.22	Spot/S-scan	I	05
	13.71		4.60	5.54	Spot/S-scan	I	06
	1.98		0.94*	3.68	Spot/S-scan	V	07
	0.63*	24.64	0.53*		Spot/S-scan	II	08
Panda 2 (Au) C	6.38		5.22	6.84	Spot/S-scan	I	09
	3.42		2.25	2.72	Spot/S-scan	I	

Table 2. Gold Coin D. Analytical Data by SEM (W%)

No.	Ag	Si	C	O	Zn	Ba	Cl	Place/manner	Type	Picture
Au-2		1.51	0.43	8.60				Spot/A-scan	IV	00
Au-3		12.64	0.84	33.63	4.03	1.39	0.01*	Spot/S-scan	II	01
Au-4	1.72		0.71	13.17		Fe=29.38		Scrape/S-scan	III	03
Au-5	2.79							Spot/A-scan	I	02
Au-6	25.93		0.34	1.82			0.01*	BriS/A-scan	I	
Au-7	16.21		0.86	19.68			0.18*	WhiS/S-scan	I	04
Au-8	95.29							BlaS/S-scan	I	
Au-9	0.12*	0.28	13.29	12.05			2.91	BriS/S-scan	IV	05
Au-10	0.05*	21.58		35.51	11.01	2.76		WhiS/S-scan	II	06

Table 3. Gold Coin E. Analytical Data by SEM (W%)

No.	Ag	Si	Mg	Al	C	O	Fe	Cl	Place/manner	Type	Picture
2-1		2.21	1.20	0.92	41.97	21.86	2.15	0.89	WhiS/S-scan	IV	
2-2		29.97	20.43		2.73	44.28	0.39		BlaS/S-scan	II	5000
2-3					2.14				BlaS/S-scan	IV	
2-4	1.98	20.73	0.28	14.03	8.43	41.80	0.87	0.54	BlaS/S-scan	II	5001
2-5	0.37	7.89	1.10	3.02	4.82	26.00	1.79	0.22	WhiS/S-scan	II	
2-6	68.16							7.09	WhiS/S-scan	I	5002
2-7		1.75	0.64	1.23	4.88	17.22			BlaS/S-scan	IV	

Table 4. Gold Coin F. Analytical Data by SEM (W%)

No.	Ag	Ca	Mg	Si	C	O	Cr	Place/manner	Type	Picture
3-1	1.46					3.81	3.21	A-scan	III	
3-2	1.14				10.22	5.47	1.85	BlaS/S-scan	IV	5003
3-3	1.38	5.30	2.69	0.10	5.95	15.91	2.31	BriS/S-scan	II, IV	5004
3-4	1.25				1.97	2.07	1.27	Base/S-scan	III	



Figure 1. Gold coins with rust on surface.

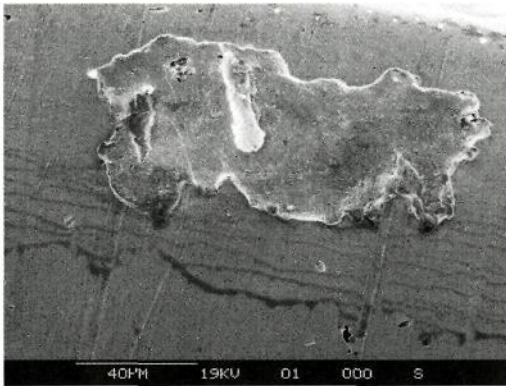


Figure 2

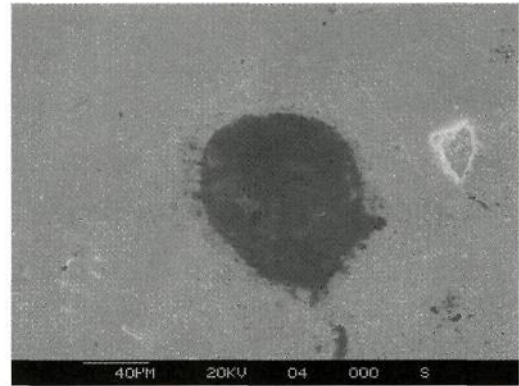


Figure 3

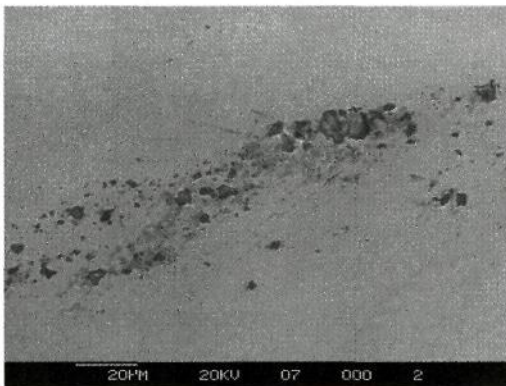


Figure 4

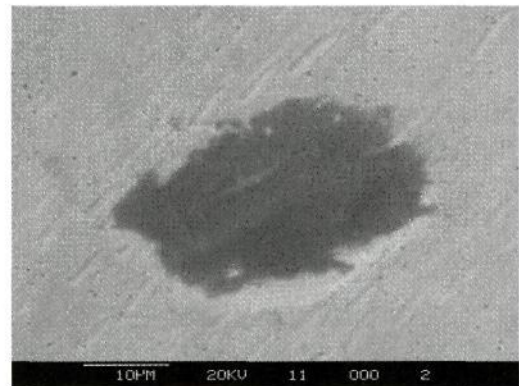


Figure 5

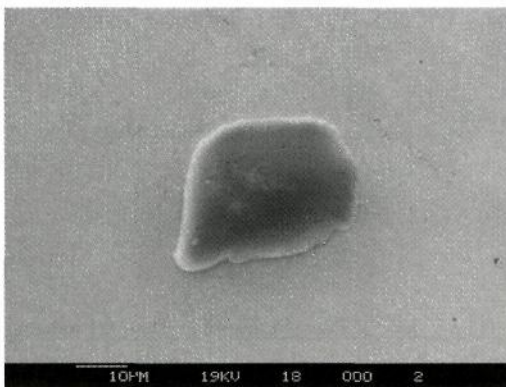


Figure 6

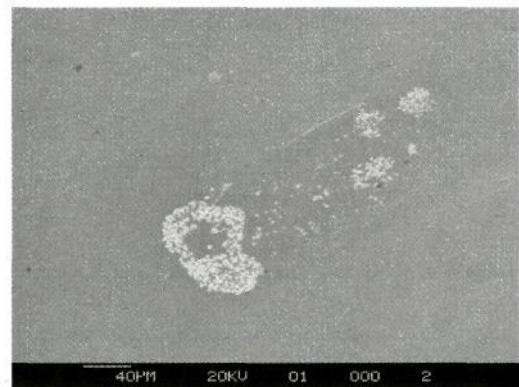


Figure 7

Figure 2-7. The analytical data of rusty gold (fig. 2-6) and silver coins (fig. 7).