Preventive Conservation Science: assessing the mercury content of a large decorative arts collection

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Looking glass (1970.0644)
ca. 1760-1770
England
Gilt looking glass with four graduated and stacked oval-shaped mirrors

INTRODUCTION

There are some chief reasons why scientists conduct materials analysis within museum collections: to provenance, to inform conservation treatment or to gauge condition. Another motivation for materials analysis in collections is to elucidate health and safety risks. One such risk arises from the presence of gaseous elemental mercury (GEM) originating from the deterioration of tin-mercury amalgam mirrors. We were tasked with identifying the tin-mercury amalgam mirrors to inform preventive conservation decision making, including indoor air quality implications.

'Mirror-making', Diderot's *Encyclopédie*

The process of using tin-mercury amalgams under glass was the dominant method for 'mirror making' from the 16th century through the early 20th century. Silvering was invented in 1835 but was not widely used and accepted until the early 20th century, when the toxicity of mercury was more widely known, and production of tin-mercury mirrors was prohibited.

Collection survey

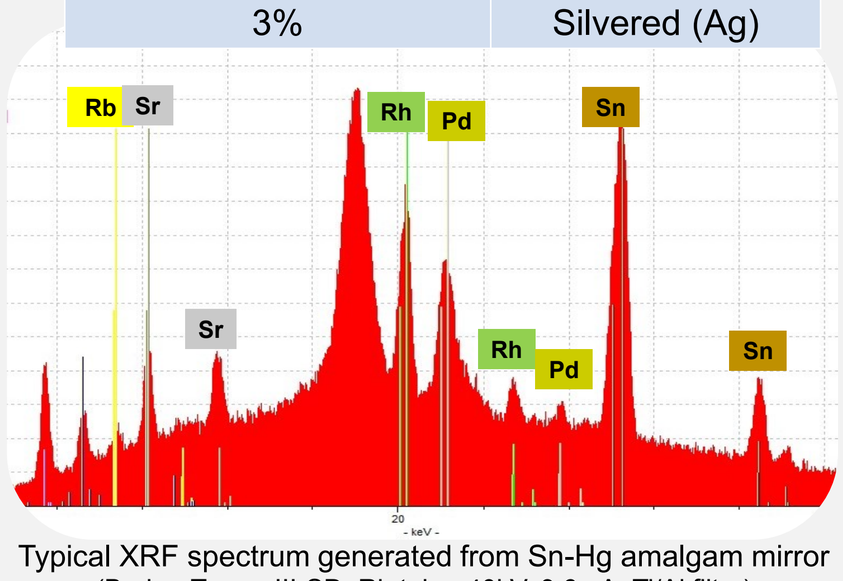
XRF is a known technique to locate tin in mirrors, thus deducing the presence of mercury. Visual analysis is also important.

Some mirrors are heavily deteriorated. Detail showing heavily deteriorated surface of a rectangular looking glass. Tin oxide is detaching from the glazing at the back.

Three mirrors are actively dripping mercury. Detail showing liquid mercury dripping from a mirror in the museum
Photo: William Donnelly

Mirror Compositions at Winterthur Museum
(survey as of June 2018)

Percentage (of 243 total mirrors analyzed)	Mirror Composition
63%	Sn-Hg amalgam
34%	Inconclusive
3%	Silvered (Ag)

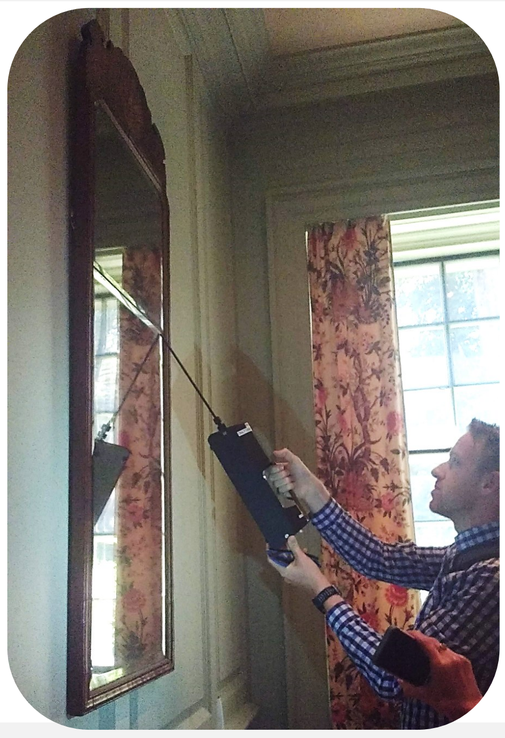


Typical XRF spectrum generated from Sn-Hg amalgam mirror
(Bruker Tracer III-SD, Rh tube, 40kV, 9.6mA, Ti/Al filter)

Winterthur scientists conducting XRF survey of mirror collection

Indoor air quality

We know that over half our mirror collection contains an amalgam which is at risk of deteriorating to GEM. What are the implications for the health and safety of museum staff and the general public when mirrors are on display, in storage (wrapped to contain drips) or undergoing treatment?



Right: Brandon Calitree (UD Environmental Health and Safety) conducting a Hg IAQ test on a dripping mirror

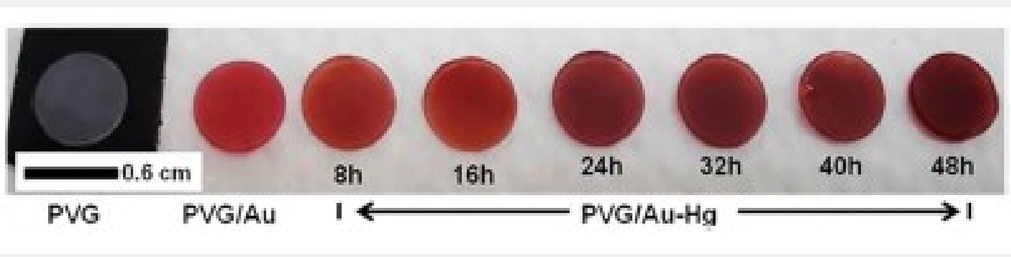
A Jerome® 431-X Mercury sensor was used to analyse two areas:

1. From a mercury drip: 0.79 mg/m^3 (above NIOSH but below OSHA recommended exposure limits)
2. From an area of mirror known to produce drips: *below detection limit of sensor*

Coincidentally, the sensor is based on Au-Hg amalgam technology. GEM adsorbs onto Au thin film (<70 Å), inducing a conductivity change which is proportional to the amount of Hg adsorbed.

A low-cost alternative? [2]

A low-cost passive sensor, prepared by the direct reduction of gold into the porous nanostructures of Vycor® glass (PVG), was developed by Brolo *et al* for the gold mining industry.
Mercury adsorption induces significant color changes. Color changes on the 'badges' can be measured using a colorimeter app on a smart phone.



From left to right: PVG disc (colorless), PVG/Au sampler (red), and PVG/Au-Hg sampler after exposure to Hg° vapor in different times (8–48 h) (from Brolo 2017).

Ongoing research questions

- Once the actively dripping mirrors are in storage, **what is the efficacy of low-cost sensors** in proximity to mercury-producing mirrors?
- We will have obtained spectra for over 250 mirrors**. How do we mine this data** for information on antique glazing, mirror technology and condition?

Girandole mirror (1957.0523.001)
ca. 1800-1810
England
Small, gilt, circular girandole mirror with molded frame.

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2. De Barros Santos, E., Moher, P., Ferlin, S., Fostier, A. H., Mazali, I. O., Telmer, K., & Brolo, A. G. (2017). Proof of concept for a passive sampler for monitoring of gaseous elemental mercury in artisanal gold mining. Scientific Reports.