MATERIAL WITNESS

Old gold

In 1896 the Louvre museum declared that it had bought an ancient Greek gold tiara for 200,000 French francs — roughly €1.3 million today, but considered a bargain in view of the object's antiquity. It had allegedly been given to the Scythian king Saitapharnes around

the end of the third century BC as part of a bribe to leave the Greek colony of Olbia unmolested.

But almost immediately doubts surfaced, as experts questioned both the tiara's design and its apparent lack of ageing. The Louvre defended the item's authenticity, but then one day a Russian goldsmith named Israel Rouchomovsky came knocking at the door with an incredible claim. "I made the tiara", he said. He explained that two dealers had commissioned him to make a gift in the antique style for an archaeologist friend. Now news had reached Rouchomovsky of their true intent. When the goldsmith demonstrated that he could reproduce part of the tiara, the Louvre officials had

no choice but to believe him. They quietly consigned the gold object to their vaults.

Were it not beyond the capabilities of *fin de siècle* science, a new technique for spotting forgeries of ancient gold objects would have saved the Louvre its embarrassment. Otto Eugster and his co-workers at the University of Bern in Switzerland say that radioisotope dating can be used to estimate the last time that gold was melted down (O. Eugster *et al. Archaeometry* doi:10.1111/j.1475-4754.2008.00426.x; 2008).

Forgeries of gold artefacts are probably the most difficult to detect of all fakes. Aside from stylistic grounds, the more objective criterion of patination is unreliable because gold's noble character leaves signs of surface decay tenuous and easily removed by cleaning. And gold has no intrinsic isotopic signatures of age, because it has only one stable isotope.

Eugster and his co-workers have for over a decade been studying the signatures of radioactive trace elements such as uranium and thorium that get incorporated into gold in the Earth's crust. Alpha decay of these elements leads to the

accumulation of helium-4 in the metal. So measurements of U, Th and ⁴He in gold can reveal when it was last solidified, as radiogenic helium is expelled on melting.

The researchers proposed in 1996 that this approach could be used to date ancient gold artefacts, but only now do they have the instrumentation needed to put the idea into practice. It demands an ability to detect extremely small amounts of ⁴He, both because it will have accumulated for only a relatively short time compared with geological samples, and because such analyses, being destructive, must be based on very small amounts of material.

The Bern group has now used their dating method on a variety of historical gold items, ranging from gold bowls of the first or second centuries BC from Central Asia to a French gold coin minted in 1857. Although at present the method doesn't constrain the dates very tightly, the researchers found that all the ancient objects were made more than 350 years ago, whereas the French coin is of more recent provenance.

Philip Ball

CONDENSED-MATTER PHYSICS

Complex oxides on fire

Oxide materials have long been known as hosts for exotic and useful physical properties. Recent advances in their design and fabrication establish the means to tailor their response for applications.

Yoshinori Tokura¹
and Harold Y. Hwang²

are in the ¹Department of Applied Physics, University of Tokyo, and ERATO Multiferroics Project, JST, Tokyo 113-8656, Japan; ²Department of Advanced Materials Science and the Department of Applied Physics, University of Tokyo, Kashiwa, Chiba 277-8561, Japan.

e-mail: tokura@ap.t.u-tokyo.ac.jp;
hyhwang@k.u-tokyo.ac.jp

Despite the vast field and multiple disciplines encompassed by the term 'complex oxides', there has been a growing convergence of trends for

manipulating the functionality of oxides on micro-, meso- and macroscopic scales. The starting point for this endeavour is the very rich variety of physical properties of complex oxides, which has long been noted and commercially used. These include their use as dielectric, magnetic and superconducting materials. Much of the recent scientific interest in developing oxides has been devoted to engineering them for novel functionality. For this, fundamental physics within their crystalline unit, in their defect structure, or at thin-film heteroepitaxial interfaces is being explored. Exciting developments in these efforts were

the focus of discussion amidst the falling ash of the California wildfires at the Workshop on Frontiers of Complex Oxides, held in July 2008 at the International Center for Materials Research of the University of California, Santa Barbara.

Tremendous progress has been made at the level of engineering oxides on the atomic scale, in both the understanding and design of microscopic coupling between magnetism and electric polarization. Large magnetoelectric coupling is anticipated to be hosted by 'multiferroics' in which electric and magnetic order can coexist¹. Magnetically induced ferroelectricity has recently been