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Analyses of Helium, Uranium, and Thorium in Ancient Gold Objects and Estimates of their Time of Manufacturing

Otto Eugster*

*Correspondence: Prof. Dr. O. Eugster, University of Bern, Physics Institute, Sidlerstrasse 5, CH-3012 Bern, Tel.: +41 31 631 4418, Fax: +41 31 631 4405, E-mail: eugster@space.unibe.ch

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When gold crystals are formed in the Earth's crust, other elements, such as U and Th, are incorporated into the crystal lattice. Thus, gold from mines and found in river beds always contain traces of U and Th. The three long-lived isotopes ^{238}U , ^{235}U , and ^{232}Th decay to Pb by emitting α -particles. An α -particle is the nucleus of the ^4He atom, so when two electrons combine with an α -particle, a ^4He atom is formed. Because gold is highly retentive for this gas up to about 500 °C, the He atoms remain trapped. We have studied these characteristics, beginning in 1992, in numerous natural gold samples from all over the world. In a publication on genuine and faked gold crystals of the Santa Elena gold mine in Venezuela, we mentioned that this method can also be applied to historical ancient gold objects.^[1] The challenge to perform these analyses for such objects is big, because the He concentration in about 2000 year old gold is extremely low and because only very small samples are available from valuable antiquities. In 2005 we purchased a mass spectrometer specialized for low He concentration measurements from SPECTRON in St. Petersburg, Russia. Since then we determined the He, U, and Th concentrations in a large number of art objects. In the past five years we have investigated numerous gold objects in order to verify their antiquity.^[2] Here we present two typical objects for which the authenticity was doubtful after art historical assessments.



Signet ring attributed to King Childebert I or II of the sixth century Merovingian dynasty of Western Europe.

A signet ring with the picture of a male bust in side-view and writing in reflected face 'HILDEBERTISREGIS'. In a comprehensive study of this ring, Weber^[3] concluded that it can be attributed to one of the two kings Childebert I or II of the sixth century Merovingian dynasty of Western Europe. The weight of this gold ring (40.56 g) corresponds almost exactly to the weight of nine Byzantine *solidi* (gold coins), indicating that coins of this type were used by the goldsmith to manufacture the royal ring. Our results for He, U, and Th yield a manufacturing time of 1460 ± 400 years, in good agreement with the time when the kings Childebert I and II lived. The second object is a gold torc, purported to originate in the Hallstatt/La Tène transition period, about 5th century BC. For this torc we obtained an age of 2200 ± 1100 years confirming the authenticity of the torc.

In many cases the antiquity of a gold object can be determined using the U/Th-He dating method. Due to the extremely low He concentrations in the samples, the method is not applicable to objects younger than about 1000 years.

In samples from young objects, such as a Napoléon gold coin or commercial gold wire, the observed He concentrations were extremely low or below the detection limit of the mass spectrometer.

About one fifth of the objects purported to be genuine tested in the past years were modern forgeries.

For some gold objects we observed an excess of He resulting in an unreasonably high age. Thus, these objects were undatable. The reason for the He excess are He-rich crystalline inclusions that were included in the gold when the objects were manufactured.

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Gold torc purported to originate in the Hallstatt/La Tène transition period (5th century BC). Diameter 16.5 cm.

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Please contact: Dr. Veronika R. Meyer, EMPA St.Gallen, Lerchenfeldstrasse 5, 9014 St.Gallen
Phone: 071 274 77 87, Fax: 071 274 77 88, Mail to: veronika.meyer@empa.ch