B10   Combating the Illegal Gold Trade Using Chemical Profiling

Roger D. Dixon, MSc, Forensic Science Laboratory, South African Police Service, Private Bag X620, Pretoria, Gauteng 0001, South Africa; Henriëtte Ueckermann, MSc*, Institute of Food Research, Norwich Research Park, Colney, Norwich, Norfolk NR4 7UA, United Kingdom; and Herman J. Espach, Lionel L. De Jager, MSc, and James R. Roberts, PhD, Forensic Science Laboratory, South African Police Service, Private Bag X620, Pretoria, Pretoria, Gauteng 0001, South Africa

After attending this presentation, attendees will be made aware of the need for a procedure for the elemental and isotopic profiling of gold in South Africa and worldwide for provenance determination and the anticipated benefit to be gained from the successful implementation of a standard procedure to achieve this. Attendees will be introduced to relevant analytical techniques, and informed of current results and conclusions. Many other fields of analytical chemical investigation follow similar procedures, and still many more could potentially benefit from such profiling methods.

This presentation will impact the forensic community and/or humanity by demonstrating how an international network following universally accepted standard operating procedures is necessary to cooperatively fight precious metals theft at an international level.

The theft of gold-bearing material from the mines and plants of the Witwatersrand Basin is estimated to cost the South African gold industry R1 billion per annum, or between 0.8 and 1.6% of the annual world production of gold. As a result, identifying the original source of precious metal materials recovered during police operations is of huge financial interest, and intelligence gained in this manner also provides assistance in combating the syndicates profiting from and enabling gold theft.

Determining the profile ("fingerprinting") of gold-bearing material is a technique involving the determination and quantification of minor and trace components in the gold for provenance determination. This allows for unique characterization of materials from ores and precious metal minerals to flotation concentrates, smelter products, materials at different steps in the refining process, and finally the commercially available products.

Analytical procedures for comprehensive chemical analysis vary depending on the type and amount of material available. Routinely, XRF and ICP-OES are used for major element determination; ICP-OES is used for trace elements in metallic matrices; quadrupole ICP-MS is used for selected trace and ultra-trace element determinations in solution; and laser ablation time of flight ICP-MS is used to measure element ratios, as well as to detect *in-situ* microscopic phenomena that might be distinctive. In special cases mineralogical characteristics are identified by any combination of polarized light microscopy, scanning electron microscopy and XRD.

An extensive collection of samples from gold producers and deposits across southern Africa and elsewhere in the world has been established at the Forensic Science Laboratory in Pretoria. In addition, gold seized from illegal sources for which the provenance is known has been included in the collection. This collection is continually updated. These samples are analyzed using the techniques described above and the results are entered into a database that is linked to purpose-built statistical software. The software applies and compares two different statistical techniques in source-identification, to ensure consistency. Firstly the similarity, or dissimilarity, between a questioned sample and all other samples in the database is assessed and calculated as distances between each pair, and a probability for correct allocation is determined. The second procedure is based on Principle Component Analysis and the comparison of unknown and reference data in n-dimensional space. This allows allocation of individual analyses to material groups and probabilities are allocated for similarity to other data in the database.

This statistical analysis of the database has shown that, dependant on the size and representivity of the sample populations, it is possible to clearly discriminate between gold from within various parts of the Witwatersrand Basin, and between the Witwatersrand Basin and gold from other southern African and world-wide sources, both in the native and processed forms. Furthermore, there is a clear discrimination between bullion, manufactured gold alloys, and illegally produced gold. This ability to thus determine the provenance of gold, whether within the borders of South Africa or across borders, promises to add value to combating the illegal gold trade, and organized criminal networks on an international level.

Gold Profiling, Provenance Determination, Chemical Fingerprinting