Gamma Activation Analysis of Gold and Other Elements in Mineral Samples

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With the wide-spread availability of reactor-based sources and maturity of neutron activation methods, gamma activation analysis (GAA) has played something of a secondary role for routine elemental determination. However, the method has several significant benefits for analysis of mineral samples, including high sensitivity and specificity for targeted elements, the ability to measure large volumes and the possibility of field deployment, close to mining operations.

CSIRO has been developing GAA as a practical tool for minerals industry applications. The existence of a convenient meta-state in ^{197}Au (409 keV, $t_{1/2}$ = 7.73 sec) that can be readily excited using relatively low-energy X-rays, together with the economic importance of gold as a commodity, make this metal an ideal target for the GAA method. Elements lacking suitable meta-states can be analysed by producing radioisotopes via (γ,n) reactions; commercially important metals that can be analysed this way include copper, silver, zinc, tin and lead, the platinum group metals and many rare earth elements.

In this paper, I describe results from three measurement campaigns carried out using a high-powered X-ray source built and operated by the Canadian company Mevex. To meet our target of a turn-key analysis system with a detection limit for gold in the low parts-per-billion range and an absolute relative accuracy of 1-2% presents significant theoretical and practical challenges.

I present results of measurements undertaken to better characterize the activation and decay of the 409 keV ^{197}Au meta-state. These include cross-section measurements, an improved determination of the energies of low-lying states of the ^{197}Au nucleus and evidence for non-resonant excitation of the meta-state at incident X-ray energies above 6 MeV.

A prototype elemental analyser has been constructed that uses a pneumatic transfer mechanism to shuttle samples between the X-ray source and a custom-built detector station. The system's performance has been evaluated using suites of mineral samples from a wide range of sources. I will present the latest results from these tests.

Lastly, I discuss some of the practical considerations for deploying GAA as a routine analysis technique in the field. Potential applications include replacement of conventional laboratory assay and in-situ analysis for exploration, mine-control and process-plant monitoring.