

Millisecond Mineral Analysis using High Energy X-rays

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The rapid and accurate determination of the elemental concentration of minerals in ore is essential to ensure the maximum extraction of metals amongst decreasing ore grades worldwide. Gamma Activation Analysis (GAA) is one such method of non-destructive testing with the means to measure precious metals at parts per billion (ppb) levels [1]. GAA utilises high energy Bremsstrahlung X-rays produced by recently available high power electron accelerators to cause photo-nuclear interactions with target nuclei, inducing short-lived radioactivity in mineral samples. These excited nuclei return to their stable state through a series of gamma decays. The energies of these decays are known for a range of elements and can be used to accurately determine the concentration of the desired target element in the sample. GAA has already been experimentally verified as a highly accurate method of determining the concentration of gold through the $^{197}\text{Au}(\gamma, \gamma')^{197}\text{Au-M}$ reaction, with a half-life of 7.73 seconds [1]. This long lived 409 keV isomeric state results in a strong 279 keV γ -ray emission which can be measured some seconds later away from the intense X-ray source, resulting in a relatively clean spectra free from residual short half-life activated background elements [1].

However, to improve the detection of gold concentrations in ores, it is also of interest to determine the concentration of arsenic as well, as this acts as an indicator for the presence of gold [2] and poses a disposal risk in larger quantities due to its high toxicity. Detection of arsenic through the same method applied for gold isn't possible as the meta-stable state of $^{75}\text{As-M}$ has a 17.6 ms half life. To measure arsenic, the detector array must be placed in close proximity to the X-ray source, directly exposing it to a extreme photon and neutron flux. This requires the use of fast, radiation hard detector with reasonable energy resolution. Recent developments in the growth of cerium-doped ceramic gadolinium garnet scintillator such as $(\text{Gd},\text{Y})_3(\text{Al},\text{Ga})_5\text{O}_{12}$ (GYGAG) [3] have the potential to be suitable for this application. These detectors have previously been shown to be extremely hard to gamma radiation [3] but have yet to be exposed to a quantified neutron flux.

This presentation will discuss the challenges involved in operating the above mentioned novel scintillator in this radiation harsh environment, including the ability to measure γ -ray emissions from millisecond isomeric transitions..

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