Goldschmidt 2024 Abstract
https://doi.org/10.46427/gold2024.21365

Forensics: Quantitative tracing of Silicon in nuclear power plant CRUD

VITOR BARROTE, PETER SPRUNG AND SASHA DIAZ
Paul Scherrer Institut (PSI)
Presenting Author: vitor.barrote@psi.ch

Chalk River Unidentified Deposits (crud) are dissolved and suspended solids, product of the corrosion of structural elements in water circuits of nuclear power plants. The chemical composition of crud is variable as it depends on the composition of the reactor's structural material, as well as the types of refueling cycles. Recent investigations have found unexpected but significant amounts of Si present in tenacious zinc-rich crud, in nuclear light-water reactors, where zinc is applied to the reactor water to reduce the activation of ^{60}Co. The chemical composition of crud holds key information for an improved understanding of crud formation, possible impact in fuel reliability and prevention of contamination of cooling-water systems and spent-fuel storages.

Due to the volatilization of Si, intrinsic of hydrofluoric acid (HF)-comprising multi-acid digestions, a precise quantification of Si content via ICPMS is not possible with the technique utilized in previous studies. The PSI Hotlab is a unique facility in Switzerland for the safe and hazard-free investigation of the properties of highly toxic, radioactive substances. The available sophisticated, extensive laboratory infrastructure, analytical facilities and well-trained personnel allows for the development of analytical strategies such as presented here, which tackle unforeseen obstacles in the characterization of radioactive samples.

Here we propose an adapted flux-fusion digestion which reliably provides concentrations of several elements within crud, including Si. Real crud samples are commonly collected in PFTE-membrane and secured with MYLAR foil. A controlled consumption of filter and foil is achieved by burning the sample assemblage at 600°C in a muffle furnace without the presence of flux and under restricted oxygen supply. This reduces dispersion of the sample and consequent contamination, while preventing the development of insoluble organic components from interaction between foil, filter, sample, and flux. The fusion and complete dissolution of the sample is then performed subsequent to the amalgamation and burning steps.

As a test subject and inactive crud analog, we have devised an inactive mixed reference material named "Synth-crud". The method presented here can reliably provide concentrations of several elements commonly found within crud, including Si, which was not possible in methods used previously for ICPMS measurement.