Current state-of-the-practice of applied forensic geochemistry within the environmental engineering/consulting community

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Many environmental engineering/consulting companies now routinely conduct forensic geochemical investigations previously provided almost exclusively by academia. Such investigations include trace element and stable isotope analyses of soil/groundwater, fingerprinting of fuel and other hydrocarbon releases, and age dating contaminant releases and groundwater using stable and radioactive isotopes.

Trace and heavy elements and their respective isotopes are used to track surface and groundwater contaminant plumes; e.g., boron and $\delta^{11}B$ can track municipal solid waste landfill leachate and rare earth elements have been used to track refinery effluent and sediment as well as waste soil dumped into rivers.

For more than a decade fuel release sources have successfully been identified by chromatography/mass spectrometry chromatogram pattern recognition. Polycyclic aromatic hydrocarbon (PAH) analysis and biomarker signature analysis have been used to determine diesel release age dates. Chlorinated volatile organic compound releases, such as trichloroethane, have been age dated using mass balance degradation or daughter product concentrations collected over time.

Stable isotope lead analyses have identified petroleum and gasoline source signatures and release age dates using the Anthropogenic Lead Archeostratigraphy **(**ALAS**)** model of Hurst (2000). Nitrogen and oxygen stable isotopes in dissolved nitrate can identify nitrate sources; oxygen-deuterium isotopes in water can distinguish water sources; and chlorine and oxygen isotopes in dissolved perchlorate are used to determine perchlorate sources (Sturchio, 2004). Tritium, coupled with ^{3}He, can date groundwater to within several years.

References

Hurst, R.W. (2000) Environ. Foren. 1, 11-23.
Sturchio, N.C. (2004) GRA 11th Ann. Sym., Glendale, CA.

Application of heavy stable isotopes to forensic isotope geochemistry

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Trace element geochemical tools have been applied for many years to understand sources of materials in the geological environment and in such diverse fields as anthropology, archaeology, biology and oceanography. Further advances have been made by the application of light stable isotopes (C, N, O, S, H). The advent of multiple-collector ICP-MS in addition to thermal ionization mass spectrometry have opened up the field considerably. It is now possible to use isotopic signatures of both radiogenic and stable isotopes for many elements in the periodic table to carry out fingerprinting studies.

Many of these systems rely on processes that give rise to different isotopic compositions either as a consequence of radiogenic decay or as a result of natural isotopic fractionation. A result of this is a range of different isotope ratios that may be used as tools to examine sources.

Whilst many of the “new” isotope systems offer new tools it is important not to forget the old tools such as Sr and Pb, which in many cases offer better fingerprinting techniques. This is partly a consequence that the systematics of these new isotope systems are not completely understood and that the extraction and purification of these “new” isotope systems can be troublesome.

This paper will give an overview of some of the applications of heavy stable isotopes in the field of forensic geochemistry with examples from archaeology, anthropology, palaeobiology and environmental studies amongst others.