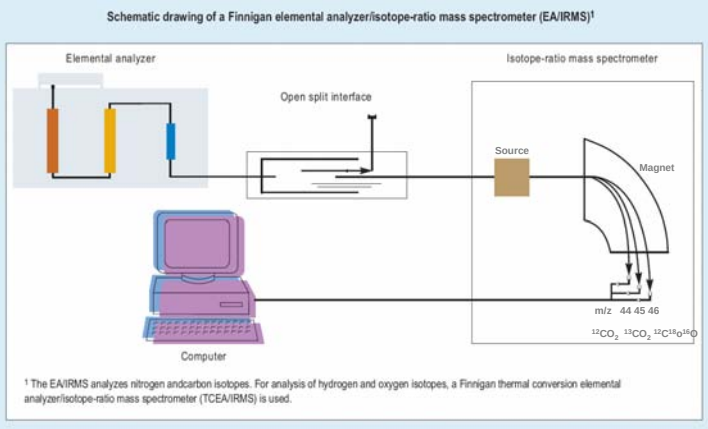
A Stable Future for Forensic Chemistry: Identification of Human Bodies using Stable Isotopes

W Meier-Augenstein, I Fraser, RM Kalin, Environmental Forensics & Human Health, Environ. Eng. Research Centre, Queen's University Belfast

Overview

- Isotope Ratio Mass Spectrometry (IRMS) is a novel tool for forensic applications.
- The technique holds great promise and potential for forensic science due to its unique ability to determine source and geographical origin of materials [1].
- Current applications of this technique include anti-doping control, archaeology and bio-archaeology, environmental chemistry, food authenticity, food webs, palaeo-ecology and human physiology, to name but a few [2].



Background

IRMS can measure the mass difference of isotopes of the same chemical element with great accuracy and precision. Variations in isotopic abundance between to chemically identical compounds are the result of thermodynamic and kinetic isotopic fraction or mass discrimination. Results of IRMS analysis are compared against international reference materials of known isotopic composition and data thus calibrated are given in the δ-notation to enable convenient and direct comparison of results [2].

The authenticity of natural and synthetic materials can be checked by measurement of the isotopic abundance of ^{2}H, ^{13}C, ^{14}N, ^{18}O and ^{34}S. Controlled substances like drugs of abuse (**cocaine, ecstacy, heroin**) and explosives (**TNT**) or, simply, traces of paint can hold information in their isotope composition. Total combustion of samples in an elemental analyser followed by on-line determination of the isotopes of the combustion products (e.g. CO_2 and N_2) in an isotope ratio mass spectrometer coupled to an elemental analyser (EA-IRMS) provides high sample throughput with a minimum of sample preparation.

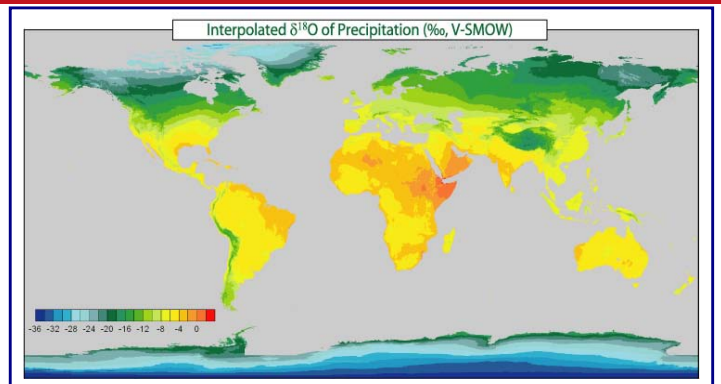


Figure 1: Diagram showing global variation of ^{18}O isotopic abundance in rain water [3].

Human Identification

Variations in the isotopic abundance of ^{2}H, ^{13}C, ^{14}N and ^{18}O in compounds forming the human body reflect the isotopic make-up of food and water consumed and as such reflect life-style and geographic origin of a person (Fig. 1). In other words, diet and geography influence the isotopic signature of body tissues such as hair, nail, teeth and bone, and can hence be used in forensic anthropology to aid human identification in cases where no material is available for DNA comparison or where no DNA match can be found.

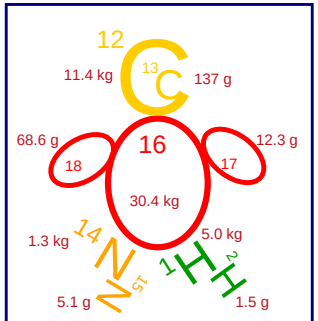


Figure 2: Typical isotopic composition of an average built adult.

For example, differences in dietary composition between Europe and North America leads to differences chiefly in ^{13}C and ^{15}N isotope abundances in body tissues of people living there (Fig. 2). While hair and nail can provide a record of both diet and water, apatite in bones and teeth reflect geographic environment by recording isotope signatures of elements present on drinking water, such as oxygen but also strontium. Since they do not remodel, adult teeth provide am isotopic record of the region where a person has lived during adolescence.

Murder Case Investigation

In a recent case under investigation by the Police Service Northern Ireland (PSNI), the body of female Caucasian was found dumped in a ditch. Due to circumstances and locality, 1200 DNA samples were collected from potential next of kin but no match for a relative was found, prompting the question by the office in charge of the case as to whether the person was actually local or from a different part of the country.

Results

Samples of scalp hair and bone (femur) were analysed for isotopic composition of ^{2}H, ^{13}C, and ^{15}N and ^{18}O, respectively. Results of the ^{18}O analysis from bone apatite (Fig. 3) showed clearly the deceased did not come from Northern Ireland, the Republic of Ireland or mainland UK but pointed towards either East Europe or northern part of the US as potential points of origin. Analysis of the hair samples for ^{13}C and ^{15}N isotopic abundance ruled out North America as geographical origin (Fig. 4) .

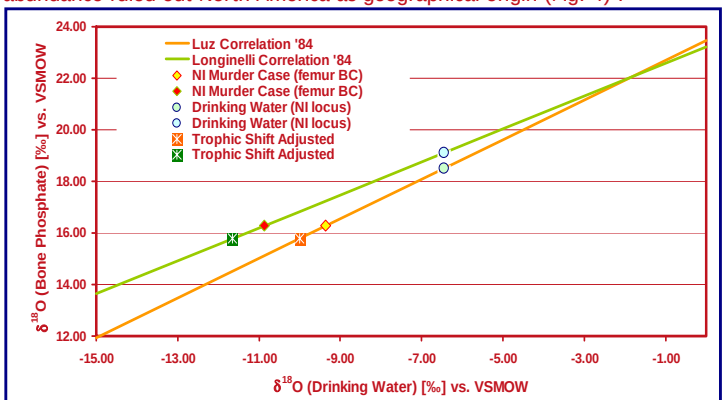


Figure 3: Intelligence on geographical origin based on drinking water isotope signature recorded in bone apatite. Both Luz and Longinelli correlation place victim outside NI and mainland UK. Even adjustment for presumed throphic shift does not alter this conclusion.

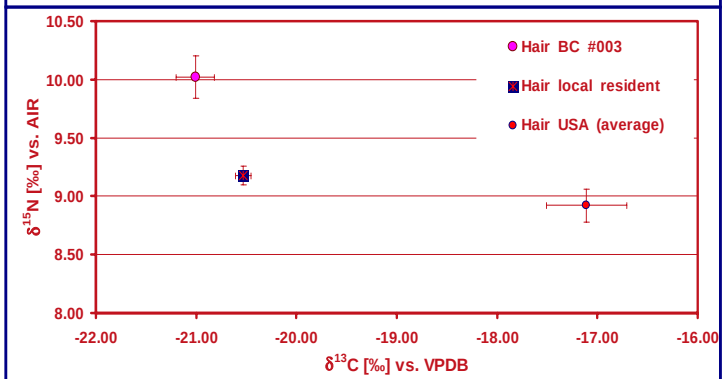


Figure 4: ^{13}C and ^{15}N isotope signatures in hair from the murder victim, a person living in the village where the body was found and from people living in the USA.

Conclusions

- Murder victim came not from NI or mainland UK.
- Victim's point of origin is most likely an Eastern European country such as Poland or Latvia.
- This is the second case where IRMS was used in the UK as forensic tool to provide valuable intelligence on the origin of a human body.

[1] W. Meier-Augenstein and R.H. Liu: "Forensic Applications of Isotope Ratio Mass Spectrometry", in **Advances in Forensic Applications of Mass Spectrometry** by Jehuda Yinon [ed.], CRC Press, Boca Raton, Florida (USA), (2003), 149-180, ISBN 0-8493-15220.
[2] W. Meier-Augenstein: "Applied Gas Chromatography coupled to Isotope Ratio Mass Spectrometry", *J. Chromatogr. A.*, **842**, 351-371 (1999). [3] Bowen, G. J. and B. Wilkinson: "Spatial distribution of $\delta^{18}O$ in meteoric precipitation." *Geology*, **30**, 315-318 (2002).