Forensic isotope analysis leads to identification of a mutilated murder victim

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Abstract

The relationship between diet, geographic location and isotopic composition of human tissue has been successfully exploited in archaeological and palaeodietary studies, i.e. on ancient man, but cases in which this approach has been applied to present-day people e.g. to aid identification of mutilated or deteriorated bodies are far and few between. Stable isotope data are presented here from a case where for the first time stable isotope based intelligence aided victim identification by DNA analysis and subsequent apprehension of the perpetrators thus demonstrating that it is possible in principal for stable isotope data of present-day people to be useful for human provenancing, i.e. to yield valuable information about a person’s life history and geographic origin.

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1. Introduction

Here we present a case where intelligence gained from stable isotope data of human tissue not only helped the investigating officer to establish the identity of a murder victim, which the killers tried to destroy through dismemberment and decapitation but where by proxy this intelligence was also instrumental in the apprehension of the killers. Based on 4 elemental isotopic composition of fast growing tissue such as hair and nails we were able to establish the victim’s recent life history spanning 200 days prior to death. A sequential18O-isotope analysis of femoral bone apatite yielded information not only on the victim’s probable geographic origin but also provided a tentative time frame for his immigration into the country where he met with his untimely death.

2. Stable isotope method background

Since the human body’s main source of basic building blocks such as amino acids and fatty acids are derived from what we eat and drink, the isotopic signatures of the most abundant elements in our body, namely hydrogen, nitrogen, carbon and oxygen contain a record of the isotopic make-up of our dietary intake [1,2]. In particular, the abundance of the heavier stable isotopes of carbon and nitrogen, 13C and 15N, respectively, reflect closely what we eat and therefore can reveal if a person is a vegan or eats a lot of meat [3,4]. Similarly, the abundance of the heavier stable isotopes of hydrogen and oxygen, 2H and 18O, respectively, do reflect the water we drink, water we use to prepare meals and beverages, and the water contained in fruit and vegetables [5,6].

In contrast to the generally held opinion, the natural abundance of stable isotopes is not a fixed constant but displays a considerable, yet subtle, degree of variation. For instance, the variation on the natural abundance of 13C can be as high as 0.1 at.% [7]. This wide range reflects the varying degree of mass discrimination associated with the different pathways of carbon assimilation, fixation and (bio-)chemical transformation of organic compounds. To give an example, in terms of 13C isotopic
abundance, sugar from sugar beet is not the same as sugar from sugar cane even though they are chemically indistinguishable. These sugars differ in their $^{13}$C isotopic composition and they can be distinguished on that basis with the typical difference being of the order of 0.0157 at.%. Since these differences in isotopic composition are so minute on the atom% scale, the $\delta$-notation has been adopted so to more conveniently express relative isotope abundance values.

\[
\delta^{13}\text{C} = \left[ \frac{R_{\text{sample}} - R_{\text{std}}}{R_{\text{std}}} \right] \times 1000
\]

(1)

In this equation, $R_{\text{Sample}}$ is the measured isotope ratio of the heavier isotope over the lighter (e.g. $^{13}\text{C}/^{12}\text{C}$) for the sample and $R_{\text{Std}}$ is the measured isotope ratio for the corresponding international reference material (e.g. VPDB in the case of $^{13}\text{C}$). International reference materials for stable isotope analysis are administered, controlled and issued by the Internal Atomic Energy Agency (IAEA, Vienna, Austria). In this notation, the aforementioned difference of 0.0157 at.% corresponds to a difference in $\delta^{13}\text{C}$-values of 14.3‰.

When interpreting the isotope data obtained from hair and nail of the victim we relied almost exclusively on data from our own longitudinal studies on 20 contemporary people, sex and age matched but of different ethnic background, all living in the same location (Belfast, UK) but with no restrictions imposed on their diet (food and water intake) [5]. Even though these modern-day people had the liberty to consume bottled water and globally sourced food, the dietary isotope profiles ($^{13}\text{C}$ and $^{15}\text{N}$) of hair and nail were typical for people living in the UK (or Central Europe) and the water isotope profile ($^2\text{H}$) was consistent with that of ground and tap water of the location where they were living. When interpreted in the context of inter- and intra-individual variability as well as variability linked to natural matrix inhomogeneity of tissue such as hair and nail, none of the three aforementioned stable isotope markers showed any significant skew that could be attributed to an influence of bottled water or globally sourced food.

3. Materials and methods

3.1. General considerations

In keeping with stringent ‘good laboratory practice’ (GLP) regulations, all case work was carried out in a fume hood within a dedicated laboratory. Fresh disposable gloves, hats and lab coats were worn at all times and sterile or new equipment (such as scalpel blades and bench cover) were used to prevent contamination. Samples received from the police were logged into the laboratory using an established chain of custody procedure, and the signatures of the police officer and the recipient of the samples collected. All descriptions and procedures were documented contemporaneously using documentation log sheets and examination sheets (compiled based on templates currently used in forensic laboratories).

In September 2005, a complete set of fingernails from one hand, several strands of pubic hair, and a ring shaped slice cut from the femur of the deceased were handed over to us for stable isotope analysis by the investigating officer together with, but for bone, a matching set of tissue samples for comparison. The latter samples had been volunteered by a male person living and working in Dublin and whose recent geographic life history was therefore known.

3.2. Tissue samples

3.2.1. Preparation of hair and nail samples

All samples were cleaned according to a standard procedure. Briefly, this comprised successive washes with methanol/ chloroform (2:1, v:v) and water. In addition, nail samples were rubbed with a diamond emery board prior to being washed. Once cleaned all samples were ground using a SPEX CertiPrep cryogenic freezer-mill using stainless steel vials and impactors in order to overcome problems caused by static electricity. Samples were ground using the standard programme setting of a 15 minute pre-cool followed by three grinding cycles of 2 min each at a rate of 10 of impacts per second. There was a two minute cooling period between each grinding cycle. Ground samples were easier to weigh out in small amounts into silver capsules and also produce a more homogenous sample, producing more reproducible results with minimal sample loss (less than 10%). The cryogenic mill also allows the fine grinding of samples without the heat build up generated by conventional grinding methods — thus avoiding potential fractionation through temperature changes. A comparison of ground versus not-ground samples showed no significant difference in the isotopic values obtained but it was found that grinding samples improved the reproducibility of triplicate analysis.

Following grinding, samples were placed in glass vials, sealed and stored in an evacuated desiccator containing phosphorous pentoxide to remove residual moisture traces from the samples. This was particularly important when performing hydrogen and oxygen analysis as it is known that moisture content as well as hydrogen exchange between moisture and samples can have a significant effect on the measured isotope values of samples [8]. To control this compounding factor, all samples were exposed to the same ambient environment after collection so labile H-atoms prone to exchange would all reflect the same $^2\text{H}$ level, i.e. that of Belfast precipitation ($\delta^2\text{H}$ measured: $-50\%$). Samples were therefore analysed on a ‘like-for-like’ basis, in accordance with the ‘principle of identical treatment (PIT)’ [9,10].

3.2.2. Preparation of bone samples

The sample of femoral bone was still covered with flesh, which made it necessary to remove any soft tissue and bone marrow using a method that would not alter the isotopic composition of the sample. The most effective method was the use of maggots rather than heating in acid or alkaline to avoid artefact formation. A pint of maggots was purchased from the local fishing tackle shop and placed in a clean beaker with the bone sample for 24 h. After this time the maggots were removed and the defleshed bone sample rinsed in a 2:1 methanol: chloroform solution (v:v). Any surface debris was gently

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removed using a sterile scalpel. The bone sample was subsequently left to dry. Two sub-samples were cut from the inner and outer part of the bone sample using fresh diamond cutting blades for each. These pieces were then milled into a fine powder using a liquid N₂ cooled grinding mill (as described in Section 3.2.1).

The hydroxyl-apatite contained within the powdered bone was extracted for oxygen isotope analysis using a procedure originally devised by Stephan [11] but with the following modification. The buffered ammonium solution used on day 5 was prepared on the day and was 0.2 M in AgNO₃, 0.35 M in NH₄NO₃ and 0.75 M in NH₄OH.

The prepared apatite samples were analysed in a batch with two different silver apatite standards of known ¹⁸O composition (commercial silver apatite from Sigma–Aldrich, δ¹⁸OVSMOW = 13.45‰, and the international hydroxyl-apatite standard NBS 120C, δ¹⁸OVSMOW = 21.33‰) as reference materials.

3.3. Bulk ¹³C/¹⁵N isotope analysis

Carbon and nitrogen isotope analyses were performed using an automated nitrogen-carbon analyser (ANCA) coupled to an automated breath carbon analyser (ABCA) isotope ratio mass spectrometer (SerCon Ltd, Crewe, UK) 0.4 mg of ground sample was weighed into tin capsules (Elemental Microanalysis, Devon, UK) and introduced via a solid autosampler. The Elemental analyser (EA) reactor tubes were comprised of two quartz glass tubes filled with chromium(III) oxide and copper oxide, held at 1000 °C for combustion and reduced copper, held at 600 °C for reduction. A post-reactor gas chromatography (GC) column was kept at 80 °C for separation of evolved N₂ and CO₂. The data was processed using proprietary software Calisto (SerCon Ltd, Crewe, UK). Measured ¹³C/¹²C or ¹⁵N/¹⁴N isotope ratios are expressed in the δ-notation [%o] (Eq. (1)) relative to the appropriate international reference material.

3.3.1. Isotopic calibration and quality control of EA-IRMS measurement

Two certified standards of known isotopic composition were used during the analysis of ground match samples; leucine (δ¹³CVPDH = −30.52‰; δ¹⁵NAIR = 10.77‰) and glycine (δ¹³CVPDH = −45.54‰; δ¹⁵NAIR = 1.85‰). At regular intervals, system performance was monitored by running these two standards against an international reference materials obtained from the International Atomic Energy Agency (IAEA, Vienna), namely IAEA-CH-6 (δ¹³CVPDH = −10.4‰). Raw data obtained were blank corrected and calibrated against the REF samples by the proprietary instrument software. If necessary, δ-values were drift corrected according to the deviation of measured δ-values from known δ-values of the quality controls [5,9].

3.4. Bulk ²H/¹⁸O isotope analysis

A high temperature conversion elemental analyser (TC/EA) coupled to a DeltaPlus XL isotope ratio mass spectrometer via a Conflow III Interface (all Thermo Finnigan, Bremen, Germany) was used for hydrogen and oxygen isotope ratio measurement of samples. 0.2 mg of ground sample was weighed into silver capsules and introduced by means of a Costech Zero-Blank autosampler (Pelican Scientific Ltd, Alford, UK). The reactor tube was comprised of an Alsint™ ceramic tube, a glassy carbon tube, glassy carbon granules, silver and quartz wool (SerCon, Crewe, Cheshire), and was maintained at 1450 °C. The post-reactor GC column was maintained at 85 °C. Data were processed using proprietary software, Isodat NT version 2.0 (Thermo Finnigan, Bremen, Germany). Measured ²H/¹⁸O isotope ratios were expressed as δ-values in [%o] relative to Vienna-standard mean ocean water (VSMOW) as per Eq. 1.

3.4.1. Isotopic calibration and quality control of TC/EA-IRMS measurement

The working reference gas, H₂ was calibrated against VSMOW using an international reference material (IRM), IAEA-CH-7 polyethylene (δ²HVSMOW = −100.3‰), as well as a laboratory certified house standard coumarin (δ²HVSMOW = +62.6‰). The H²⁺ factor was determined and checked on a regular basis on reference gas pulses of different signal size and was found to be 4.56‰/nA. Two certified standards of known isotopic composition, were used to quality control samples, coumarin (δ¹⁸OVSMOW = +15.83‰, δ²HVSMOW = +62.6‰) and glucose pentaacetate (δ¹⁸OVSMOW = +23.9‰, δ²HVSMOW = −98.5‰). In addition the internationally reference material, IAEA-CH-7, was used for quality assurance purposes [5,9]. Measured δ²H-values were SLAP-VSMOW normalised according to the method described by Coplen [12] with Z-factors (or ‘stretch’ factors) typically being of the order of 1.05. Reproducibility of ²H and ¹⁸O isotope analysis as monitored by the IRM’s and lab standards was ±1.15‰ and ±0.15‰, respectively. When stated, values for uncertainty of measurement are a composite of the aforementioned reproducibility and sample variability.

4. Case background

The body of a male was discovered on a March evening in 2005 by a group of schoolboys playing along the Royal Canal at Ballybough, in the North Inner City of Dublin. The body had been dismembered with the torso being cut in two, whilst the arms had been separated from the trunk at the shoulders and the legs had been removed at the groin and dismembered further at the knees. The head was missing from the lower neck up and was never recovered.

The body was that of a middle-aged man of African, Afro-Caribbean or Afro-American descent although this was not apparent from the first viewing of the body. Pigment dissociation had occurred on a massive scale leading to exposed skin appearing as completely white. Only during the body’s examination by the forensic pathologist was it discovered that the un-exposed skin was of a dark complexion and that the pubic hair was of Africoid characteristics.

Apart from the aforementioned details, the investigating team of the Garda (An Garda Síochána, Dublin, Ireland) had no other information about the body, its point of origin or its true ethnicity, let alone a name since nobody was reported as missing
that fitted this description. Fingerprints were recovered from the dismembered arms but they did not match anybody on the national or Interpol databases. The investigators were considering checking the fingerprints of every immigrant into Ireland. However, since this work would have meant spending over 1000s of man hours the investigating officer decided to contact our laboratory to see if stable isotope analysis of various body tissue might yield forensic intelligence helping him to focus the search for the victim’s identity. As it turned out later, checking all the immigrants’ fingerprints on record would have meant pursuing a fruitless avenue because the deceased had entered the Republic of Ireland prior to compulsory fingerprinting of immigrants.

5. Results and discussion

Sample preparation and comparative stable isotope analysis of hair and fingernail samples from both the victim and the control person were carried out according to published methods and principles [13,10,5,14] and described in Section 4.2. Comparing the isotope fingerprints for $^2$H, $^{13}$C, $^{15}$N and $^{18}$O obtained from the victim’s hair and nail with those of the control person showed no significant differences with one exception. Based on the assumption that both victim and control person were in a comparable good state of health, a $\delta^{15}$N-value for nail of 10.9‰ on average suggested the victim’s diet was protein rich whereas a $\delta^{15}$N-value of 9.26‰ suggested the control

Fig. 1. Data from the longitudinal sequential multi-isotope analysis of the victim’s fingernails showing (a) consistent dietary intake during the 7 months prior to death and (b) no indication of geographic movement with a possible exception between month 5 and 6.
Table 1
Measured δ18O-values of bone phosphate and corresponding δ18O-values of drinking waters calculated according to Luz and Longinelli [16–18]

<table>
<thead>
<tr>
<th></th>
<th>δ18O of Bone Phosphate [‰]</th>
<th>δ18O of Drinking Water [‰]</th>
<th>Pooled 95% CI Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Femur inner section</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.1</td>
<td>−3.1</td>
<td>−3.3</td>
<td></td>
</tr>
<tr>
<td>20.8</td>
<td>−3.5</td>
<td>−3.8</td>
<td></td>
</tr>
<tr>
<td>21.7</td>
<td>−2.3</td>
<td>−2.4</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>21.2</td>
<td>−3.2</td>
<td>−3.0, 0.7</td>
</tr>
<tr>
<td>S.D.</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Femur outer section</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.4</td>
<td>−1.4</td>
<td>−1.2</td>
<td></td>
</tr>
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<td>21.8</td>
<td>−2.1</td>
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<td>0.6</td>
<td>0.7</td>
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Person to be an omnivore eating a balanced diet (Fig. 1a). Neither the δ13C-value for the victim’s nails and hair of −22.34‰ and −22.16‰ (Fig. 1a), respectively show any sign of C4 plant derived carbon sources in his diet thus excluding a recent North American or African point of origin [15]. Dietary intake of C4 derived carbon sources in his diet would result in tissue δ13C-values of about −18‰ or greater (i.e. more positive values).

Both δ2H and δ18O time averaged values of the victim’s hair and nail where in line with those obtained from matching samples from the control person. The mean δ2H value of −66.2‰ (SD 2.7‰) from the victim’s hair sample was not significantly different from that of −66.2 (SD 2.1‰) obtained from the control person’s hair sample (Fig. 1b) and this value correlated well with known δ2H values of −57.4‰ for tap water in Dublin. Within the observed standard deviations these tissue δ2H-values were also indistinguishable from δ2H-values obtained from our longitudinal study carried out using volunteers living within a 20 miles radius of Belfast. With the control person serving as an exemplar for the population in and around Dublin in terms of geographic location and dietary habits, we deduced that in all probability the murder victim lived for at least the last 7 months prior to death either in or around Dublin or any other part of Ireland or Northern Ireland with a similar isotope water signature surrounding counties along the East coast including Co. Down and Belfast. This time line was based on the known growth rate for finger nails of approximately 3 mm/month [16] and the length of the nails submitted for analysis (on average 19 mm).

In much the same way that the body’s major source of hydrogen (and hence 2H) is water be it directly or indirectly consumed, water is also the major source of oxygen for bone minerals and in particular the phosphate fraction of bioapatite. The mineral salts are primarily in a crystallized form of tricalcium apatite called hydroxyapatite [17–19]. To see if 18O isotope data from bone bio-apatite would provide more information about the victim’s past life history and in particular about his point of origin, a segment cut from the slice of femur was subdivided into an inner part and an outer part (see Section 3.3). Apatite from powdered bone samples was extracted and precipitated as silver phosphate for 18O isotope analysis using a modified procedure of that originally described by Stephan [11].

Due to the various chemical processes involved during bone formation and bone mineralization, δ318O-values obtained from bone apatite have to be translated into corresponding δ18O-values for drinking water. At present, the best two models we have for determining 18O isotope signatures of water taken up by a human body and used for bone mineralization come from studies by Luz and Longinelli for bio-archaeological and palaeo-ecological applications [20–22]. We used both equations to ensure we would not exclude potential geographic areas of origin (Table 1).

The inner and, hence more recently formed part yielded a δ18O value of 21.2 with an uncertainty of ±0.5‰. Given the results of the Luz and the Longinelli correlations were all but identical within the error of measurement, we pooled the correlation data resulting in a mean oxygen signature of 21.2 (95% CI range: 21.2 to 21.8‰). Since the cortical bone of the femur remodels approximately every 20 to 25 years [23,24], this signature was interpreted as being a composite of the 18O-

![Fig. 2. Proposed time line for the victim’s geographic life history and arrival in Ireland.](image-url)
signature of the drinking water consumed by the victim in recent times and of that prior to his arrival in the Republic of Ireland. If the victim would have lived in Dublin for longer than 25 years, one would have expected to find a \( \delta^{18}O \) value in the region of \(-7.3 \text{ to } -8.3\%\).

In contrast, the outer and, hence ‘older’ part of the femur yielded an \( \delta^{18}O \) signature of 22.3 with an uncertainty of \( \pm 0.5\%\). Following the same approach as above, the corresponding drinking water was calculated to show a \( \delta^{18}O \) value of \(-1.4\%\), with a 95% CI range of \(-2.1 \text{ to } -0.8\%\). This isotopic signature is very unique. Broadly speaking, it is indicative of a hot, low altitude coastal region near the equator. Based on the latest data released by the IAEA from its Global Network for Isotopes in Precipitation (GNIP) for observations up to December 2001, there were only 5 regions worldwide with a matching signature (URL: [http://www.iaea.org/programs/ri/gnip/gnipmain.htm](http://www.iaea.org/programs/ri/gnip/gnipmain.htm)). These regions include part of the East coast of Brazil (from Salvador [Bahia] to Recife [Pernambuco]), from the Windward Islands (Lesser Antilles) to Puerto Rico, the Horn of Africa, the United Arab Emirates and part of Oman and on the West coast of India the area between the Gulf of Kachchh and the Gulf of Khabbat.

The above findings suggested that the victim could have lived in Dublin for a prolonged period of time prior to death but did come originally from one of the five regions mentioned above. Based on a presumed remodelling time for femoral bone of 25 years, we tried to estimate for how long the victim had lived in Ireland for the inner section of the femur to reflect a \( \delta^{18}O \) value of \(-3.0\%\). Using a simplistic linear two-pool mixing model, a linear regression line was determined connecting the \( \delta^{18}O \) values for the victim’s geographic point of origin and Dublin (Fig. 2). Using the solution of the linear regression analysis for that line, the point in time was calculated for which the \( \delta^{18}O \) value from the inner part of the femur would fall on that line. The 95% confidence limit determined for the \( \delta^{18}O \) value was translated into a corresponding interval around the time point by calculating times for \( \delta^{18}O \) values at either end of the 95% confidence range. Based on the above our tentative interpretation was that the victim had come to Ireland approximately 6.3 years prior to death though this time is associated with a window of uncertainty of \( \pm 2.9 \) years. Taken into consideration this time frame, we looked to interpret our findings in the context of published GNIP \( ^{18}O \) data in meteoric precipitation prior to 1999. We also consulted modelled interpolated data for \( \delta^{18}O \)-values in precipitation based on these GNIP data [25] and on this basis decided to rank the Horn of Africa, i.e. countries such as Ethiopia, Somalia, Kenya, Eritrea, Uganda and the Eastern part of Sudan as the most likely point of origin out of to the aforementioned five possible regions.

6. Conclusion of the case

These results and conclusions were reported to the investigating officer in November 2005, who at the time of receiving the report had several leads pointing at as many potential victim identities. However, what little intelligence the investigating team had on each of these leads was not enough to justify resources being committed to investigate any of them further. In particular, one potential line of further investigation required obtaining legal and financial authorisation for requesting DNA samples and to have a parental cross-DNA matching procedure carried out. According to the investigating officer the results of the forensic isotope analysis provided him with the justification needed to pursue the DNA testing of a child believed to have been fathered by the victim as well as the mother of the child. The DNA cross-match showed the victim to be indeed the father of that child, which in turn helped the police to establish the victim’s true identity. The deceased, the live-in boyfriend of the mother of his eventual killers was a 39 year old man of African descent, originally from Kenya who immigrated to Ireland in 1998, i.e. 7 years before his death alleging to be a Somalian national to enable him to claim asylum from the civil war in Somalia. Once the victim’s identity was established the two murderesses, dubbed the ‘Scissor Sisters’ were quickly identified. The two sisters were convicted for murder and manslaughter on 28 October 2006 and eventually sentenced to life and 15 years’ imprisonment, respectively on 4 December 2006.

7. Caveats

When interpreting stable isotope data from samples of unknown history with the view of forming hypotheses about potential provenance and life circumstance of a hitherto unidentified person naturally certain assumptions have to be made based on what is known or presumed to be known at the time. Attention is therefore drawn to the following. Data on \( ^{13}C \) and \( ^{15}N \) isotopic composition of human tissue provide information on a person’s diet and, hence life style or life circumstance and changes therein. These data can also be used as qualifiers when interpreting \(^2\)H isotope data with regards to geographic point of origin or change in geographic location in instances when \(^2\)H isotope data are not unique to one particular region but when several regions in the world meet the selection criteria derived from tissue \( ^{2}D \)-values. However, even in conjunction with information on dietary intake it may not always be possible to narrow down provenance of a person to e.g. 5 regions in the world or less whose \( ^{2}H \) isotopic profile are consistent with that obtained from that person’s tissue samples.

Other potentially compounding factors are bottled water and globally sourced food, at least for people living in so-called First World countries. However, a published study of bottled waters of the world suggests that on average the isotopic composition of bottled water is quite similar to that of normally available local water sources [26]. From the data of our own longitudinal studies on 20 contemporary people who were all living within a 20 miles radius of Belfast (UK) but had no restrictions imposed on their diet (food and water intake) [5] we knew the 95% confidence interval for the inter-individual mean \( ^{2}D \)-value of \(-62.4\%\) of scalp hair was 1.8% while intra-individual variability for \(^2\)H isotope analysis of repeat analyses of the same hair sample and of hair samples over a period of 12 months were typically \( \pm 2.1\% \) and \( \pm 3.9\% \), respectively. Hence, to the best of our knowledge the uncertainty of \(^2\)H...
isotope analysis associated with modern life style (e.g. bottled water and/or globally sourced food) is of a similar order as the uncertainty arising from the inhomogeneity of hair.

8. Concluding remarks

To the best of our knowledge this is the first case in which intelligence generated by stable isotope analysis of human remains on a victim’s geographic point of origin and life history was not only confirmed by the official police investigation but also lead to the arrest and conviction of the victim’s killers. This case study demonstrates that if interpreted in context and with cognisance of potentially compounding factors that may skew results, stable isotope fingerprints of present-day people can yield valuable information on a person’s life history and provide investigative focus to scenarios where identification of a body using traditional methods is hampered by circumstances such as mutilation to prevent identification, severe deterioration of the body or mass disasters be they due to natural causes or the result of e.g. a terrorist attack.

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