The Geological Society

Forensic Geoscience Group

FGG 2008

Geoscientific Equipment & Techniques at Crime Scenes

Programme and Abstracts of the 2nd FGG Conference

The Geological Society, Forensic Geoscience Group

Burlington House, London, 17 December 2008

Edited by Laurance Donnelly

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17 December 2008

Conference organiser: Laurance Donnelly
Chair, The Geological Society, Forensic Geoscience Group

Front cover:
(Upper): Police officers and a forensic geologist conduct a search for a murder victim's grave in a remote, mountainous part of Eastern Europe.
(Lower): Human remains found at a crime scene in woodland, in Europe.
Photographs © Laurance Donnelly

Bibliographical reference:

It is recommended that reference to all or part of this booklet should be made in one of the following ways:

Donnelly, L. J. 2008. *Geoscientific Equipment & Techniques at Crime Scenes.* The Geological Society Forensic Geoscience Group. FGG 2008 conference, booklet of abstracts, 17 December 2008, Geological Society, London.

Murphy, J. & Cheetham, P. 2008. A comparative study into the effectiveness of geophysical techniques for the location of buried handguns. In: Donnelly, L. J. 2008 (ed). *Geoscientific Equipment & Techniques at Crime Scenes*. The Geological Society Forensic Geoscience Group. FGG 2008 conference, booklet of abstracts, 17 December 2008, Geological Society, London.

This document was designed, produced and edited by Laurance Donnelly on behalf of The Geological Society, Forensic Geoscience Group. Some research reported here may not yet have been peer-reviewed or published elsewhere.

Conference sponsored by:

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Acknowledgements:

The following people and organisations have contributed to enable this conference to take place.

Conference co-convenor: Alastair Ruffell, (Queens University Belfast, Northern Ireland).

Conference support: Paul Linford, Louise Martin, (English Nature).

The Geological Society, Forensic Geoscience Group Committee (Laurance Donnelly, Chair, Halcrow Group Ltd; Alastair Ruffell, Vice-Chair, Queens University Belfast; Duncan Pirrie, Secretary, Helford Geoscience LLP; Kym Jarvis, Treasurer, Imperial College London; Jamie Pringle, member, Keele University; Ruth Morgan, member, University College London and Jill Dando Research Institute).

Edmund Nickless, Ted Nield, Louise Dyer, Sara Anders (The Geological Society).

Howard Siddle, Matthew Wernham, John Daly, Garry Whittaker, Bronwen Reeves, Colin Johnston, Suzie Hames, Carolyn Pearce (Halcrow Group Ltd); Mark Harrison (National Policing Improvement Agency); Marianne Stam (California Department of Justice); Raymond Murray (Missoula, Montana); Elisa Bergslien (Buffalo State College, New York, USA); Nelson Eby, Stephanie Eby (University of Massachusetts, Department of Environmental Earth & Atmospheric Science, USA); Isabel Fernandes, Fernando Noronha, Alexandra Guedes, Fernando Noronha, Armanda Dória, Bruno Valentim, Perla Ferrer (Centro e Departamento de Geologia, Faculdade de Ciências, Universidade do Porto); Angel Carmelo Prieto, (Física de la Materia Condensada, Cristalografía y Mineralogía, Facultad de Ciencias, Universidad de Valladolid, Spain); Olga Borisovna Gradusova, Ekaterina Michalovna Nesterina (Federal Centre of Forensic Science, Ministry of Justice of Russian Federation, Moscow, Russia); Patricia Wiltshire (University of Aberdeen, Forensic Ecology and Palynology); David Hawksworth (Natural History Museum, Department of Botany, London and University of Gloucestershire, Department of Natural & Social Sciences); Lorna Dawson, (Macaulay Institute and BBC Countryfile); David Miller (Macaulay Institute); Kate Hollingsworth (BBC Countryfile); John Jervis, Jamie Pringle, Tim Millington, Luigia Nuzzo, Nigel Cassidy (Keele University, Applied & Environmental Geophysics Group); John Cassella (Staffordshire University, Department of Forensic Science); Armin Schmidt, Chris Gaffney, Rob Janaway, Andy Wilson, Hazel Woodhams, (University of Bradford, Department of Archaeological Sciences); Howell Edwards, Tasnim Munshi (University of Bradford, Chemical & Forensic Sciences); Emma Allen; Federica Balestri, Gabriella Davies, Peter Bull (Oxford University, Centre for the Environment); Luis Gaya-Pique, Rainier Arndt (On-Site Inspection Division, CTBTO PrepCom, Vienna International Centre, Vienna, Austria); Peter Barker, Claire Graham (Stratascan Ltd); John Hunter, Barrie Simpson (University of Birmingham, Department of Ancient History & Archaeology and Forensic Support Archaeology Group; in particular Barrie Simpson for the spider diagram concept); Richard Teeuw, Ben Williams, Hugh Datson, Mike Fowler (Earth & Environmental Sciences, University of Portsmouth); Mieke Dekens, Paul Cheetham, James Murphy, James Fenn, Jeremy Pile (Bournemouth University, Centre for Forensic Sciences); Matthew Bennett (Bournemouth University, School of Conservation Sciences); Mike Allen, Kate Horn (Council for the Representation of Forensic Practitioners); Andrew Smith (CERAM Building Technology); Caroline Simms, Peter Masters (Cranfield University, Centre for Archaeological and Forensic Analysis); Roger Walker (Geoscan Research Ltd); Colin Jenkins, Ludovic Letourneur (Bartington Instruments Ltd); Norman Bell (Allied Associated Ltd); Chris Leech (Geomatrix Earth Science Ltd); George Tuckwell (STATS Ltd); Genevieve Eastwood (Wiley-Blackwell); David Wilbourn (DW Consulting).

Gratitude is also expressed to those police officer and forensic scientists who have supported and contributed to this conference but wish to remain anonymous.

Figures & tables:

Fig. 1, page 15, after; Murphy & Cheetham (University of Bournemouth).

Fig. 1 & 2, page 19, after; Fenn, Cheetham & Pile (University of Bournemouth).

Tables 1 & 2, page 29, after; Eby & Eby (University of Massachusetts and Syracuse University).

Fig. 1, page 31, modified after; Donnelly, L. J. 2002. *How forensic geology helps solve crime.* All-Party Parliamentary Group for Earth Science. House of Commons, Westminster Palace, 12 March 2002. British Geological Survey & International Mining Consultants. Published in; Donnelly, L. J. 2008. *Communication in geology: A personal perspective and lessons from volcanic, mining, exploration, geotechnical, police and geoforensic investigations.* In: Liverman D.G.E., Pereira, C.P. & Marker, B. (eds) *Communicating Environmental Geoscience.* Geological Society, London, Special Publication, 305, 107-121.

Fig. 1, 2 & 3, page 37 & 38, modified after Donnelly, L. J. 2002. *How forensic geology helps solve crime*. All-Party Parliamentary Group for Earth Science. House of Commons, Westminster Palace, Tuesday 12 March 2002. British Geological Survey & International Mining Consultants. Fig. 1. published in; Harrison, M. & Donnelly, L. J. 2008. *Locating concealed homicide victims; developing the role of geoforensics.* In: Ritz, K., Dawson, L. & Miller, D. (eds) *Criminal and Environmental Soil Forensics.* Springer, 197-220.

Fig. 1, page 39, after; Dekens & Cheetham (University of Bournemouth).

Fig. 1 & 2, pages 41 & 42, after; Cassella, Pringle & Jervis (Staffordshire University & Keele University).

Fig. 1, page 43, after; Millington, Nuzzo, Cassidy & Pringle (Keele University).

Fig. 1, page 45, after; Roger Walker (Geoscan Research Ltd).

Fig. 1, page 46, after; Colin Jenkins & Ludovic Letourneur (Bartington Instruments Ltd).

Fig. 1 & 2, page 47, after; Norman Bell (Allied Associates Geophysical Ltd).

Fig. 1, page 48, after; Chris Leech, (Geomatrix Earth Science Ltd).

Fig. 1, page 50, after; David Wilbourn (DW Consulting).

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Welcome and foreword

It is an honour and a privilege to welcome you to the second meeting of The Geological Society, Forensic Geoscience Group (FGG 2008), held at The Geological Society, Burlington House, Piccadilly, in London. This is the second day of a two-day event, held in association with the Environmental and Industrial Geophysics Group (EIGG). The theme for the first day, held on 16 December 2008, was; '*Recent Advances in Archaeological Geophysics'* and the theme for the second day is; '*Geoscientific Equipment and Techniques at Crime* Scenes'. The main focus for FGG 2008 is aimed at, but not necessarily limited to, presenting, discussing and debating the use of existing and innovative equipment, techniques and methods that potentially may be applied to crime scenes.

In recent years there has been a tremendous increase in interest in Geoforensics (known also as Forensic Geoscience or Forensic Geology), in academia, industry, consultancy, police, law enforcement, military, universities, schools, the public and the media. Geoscientists and geoforensic specialists increasingly are supporting serious crime investigations such as; murder, rape, kidnapping and fraud. What is more, forensic science and geology both also have captured public interests and imaginations, and have benefited from increased coverage in the media, film and on television over the past decade or so. It is perhaps now timely and appropriate to reflect on some of the principal events in Geoforensics which have taken place, in particularly in the UK, over the past few years.

Fourteen years ago I began to apply and develop conventional and innovative geological techniques to help search for a murder victim's grave. At this time geologists rarely, formally, supported police investigations, apart from occasionally when soil, rock or man-made materials on clothing were analysed. In British universities there were relatively little, if any, courses or research specifically focussed on, or drawing attention to geoscientists and their potential role in supporting law enforcement. However, this gradually began to change after 2002, when I was invited to give a presentation on 'Forensic Geology' in Westminster Palace, House of Commons, as part of the All-Party Parliamentary Group for Earth Science. This raised the profile of forensic geology in the UK and drew attention to the potential support which may be provided by geoscientists to help the police and other law enforcement authorities in certain types of criminal investigations.

Six years have now passed since an article on forensic geology was published for the first time, in 'Geoscientist' (Donnelly, L. J. 2002. *Finding the silent witness.* Geoscientist. The magazine of The Geological Society of London, 12(5), 16-17). This was followed by the publication of a second article in 'European Geologist' (Donnelly, L. J. 2003. *How forensic geology can help solve crimes.* European Geologist. Journal of the European Federation of Geologists, 16, 8-12). Since then there has been a rapid explosion in interests in geoforensics, in particular in the UK, but also internationally. This has occurred at an alarming rate in academia, industry and within law enforcement. In 2004, The Geological Society hosted a forensic geoscience conference, which further fuelled interest in forensic geoscience (Pye, K. & Croft, D. J. 2004 (eds) *Forensic Geoscience: Principles, Techniques and Applications*. Geological Society, London, Special Publications, 232). Following the Westminster Palace presentation a proposal was submitted to The Geological Society to set up a new, 'Forensic Geology' specialist group (Donnelly, L. J. 2005. *Considerations for a Geological Society of London Forensic Geology Specialist Group.* The Geological Society, London). The Geological Society approved the 'Forensic Geoscience Group' (FGG) which was formally launched at its inaugural meeting in Burlington House, in London, on 20 December 2006.

Since 2002, there have been at least seven international meetings on forensic geoscience, at least five 'books' have been published on forensic geology, and many papers on the use of geology in forensic investigations of crime, search, engineering, geotechnics, mining, disaster and warfare have also been published (see for example: Ruffell, A. R. & McKinley, J. 2008. *Geoforensics*. Wiley-Blackwell, Chichester, UK; Murray, R. C. 2004. *Evidence from the Earth: Forensic Geology and Criminal Investigations.* Mountain Press Publishing Company, USA and Ritz, K., Dawson, L. & Miller, D. 2008. *Criminal and Environmental Soil Forensics.* Springer, UK).

Together, these events since 2002 all demonstrate the wealth in activity and interest in geoforensics in the UK and world-wide. There are now over 120 courses in the UK which feature 'forensic' in their course title, although some of these 'teach' geology there is much scope for improvements. Teaching and research in geoforensics is now established in a number of universities, on BSc courses and as part of PhD research. Furthermore, many practitioners regularly provide geological advice to the police and law enforcement agencies as part of their routine professional services as geoscientists.

Published in this booklet are the abstracts for the papers presented at FGG 2008 and in general, these seem to continue the main, two-fold, division of geoforensics, as follows:

- Firstly, mainly laboratory based geoscientists (including for example; geochemists, sedimentologists, mineralogists, petrologists, micro-palaeontologists and isotope experts). This involves the collection, analysis, interpretation, presentation and explanation of physical (trace, or micro-scale) evidence, which can be soils, rocks, micro-fossils or man-made materials (such as concrete or bricks). Using evidence sampled from a crime scene, human remains (such as skin and finger nail scrapings), vehicles, clothing or other objects. A forensic geoscientist may be able to assist the police in determining the possible location where a crime took place, linkage of the offender or evidence to a crime scene, linkage of the offender to the victim, assess the possible movement of human remains, or eliminate potential suspects or offenders. Although these types of 'geological' samples are analysed in a laboratory it is important they are properly collected by the geoscientist, from the crime scene, object, or body.
- Secondly, mainly field-based geoscientists, whose skills in the mapping and exploration of the Earth's (ground) surface and ground investigations are used to help the police search for locating (and sometimes recovery) buried or concealed organic remains (such as a murder victim's graves, mass graves and human remains) or non-organic objects (such as clothing, weapons, firearms, improvised devises, explosives, drugs, stolen items, money, jewellery and antiques). These searches may take place in urban, rural and remote locations, in both the terrestrial (land) and marine (including also underwater such as canals, rivers, streams, seas, lagoons, estuaries, reservoirs, lakes and ponds) environments.

Forensic geoscientists may also be called upon to be an expert witness or to provide expert opinion in a range of investigations, which may include for example; domestic incidents, international terrorism, humanitarian, environmental, geohazards, mining, geotechnical, civil engineering, materials engineering and fraudulent investigations; all which may be regarded as part of the emerging and growing discipline of 'Geoforensics'. Some examples of such investigations are presented in this conference. These are not necessarily associated with supporting directly law enforcement (police) investigations, but nevertheless may be regarding as 'forensic' in its broader definition (for further information see for example: Shuirman, G. & Slosson, J. E. 1992. *Forensic Engineering. Environmental Case Histories for Civil Engineers and Geologists*. Academic Press, Inc., California, USA and Day, R. W. 1998. *Forensic Geotechnical and Foundation Engineering.* McGraw-Hill, USA).

Perhaps some of the principal challenges which forensic geoscientists may face in the future include for example; (a) improving methods of communication between geoscientists and law enforcement officers, (b) formal training and education in forensic geoscience and in particular sample collection, giving evidence in court, and the design and delivery of a search strategy and methodology for buried or concealed graves and other objects, (c) the development of new laboratory and search techniques and their acceptance by law enforcement and courts, (d) training on giving evidence in court, (e) the geoscientists understanding of strict police search and crime scene investigative protocols and the judicial system, (f) regulation and accreditation of forensic geoscientist practitioners (given the increase in academia and practising 'forensic geologists' this particular issue is extremely important if professional standards are to be maintained), (g) maintaining international geoforensic links, (h) promoting publications in refereed scientific journals, (i) multi-disciplinary collaboration with other specialists, (j) the development of operationally based geoforensic practitioners to become more aligned with the police and (k) funding for training and research.

The papers presented in this conference demonstrate how 'Geoforensics' is a discipline that can bring significant benefits to policing, law enforcement and criminal investigation throughout the world.

Laurance John Donnelly 17 December 2008

Dr Laurance John Donnelly *BSc (Hons), PhD, CSci, CGeol, EurGeol, FGS, FGSA*
Chair, Geological Society, Forensic Geoscience Group
Engineering, geohazards, mining, & exploration geologist
Forensic geologist & police search advisor

Lecture and events programme: Wednesday 17 December 2008

Time (hour)	Duration (minutes)	Title of presentation, authors and affiliations
		Registration & coffee: **The Geological Society, Burlington House, London**
08:30 - 09:25	55	Ruth Morgan, Laurance Donnelly & Kym Jarvis
		Welcome & opening
09:25 - 09:30	5	**Laurance Donnelly** Chair, The Geological Society, Forensic Geoscience Group
		Session 1. Chair of session, Jamie Pringle
09:30 - 09:40	10	**A comparative study into the effectiveness of geophysical techniques for the location of buried handguns** James Murphy[1]*, Paul Cheetham[1] [1]Centre for Forensic Sciences, School of Conservation Sciences, Bournemouth University, Bournemouth, BH12 5BB, UK **Corresponding author: James Murphy (g7895042@bmth.ac.uk)*
09:40 - 09:50	10	**Seeing the wood for the trees: the use of GPR in detecting clandestine graves** George Tuckwell[1,4]*, John Jervis[2,4], Jamie Pringle[2,4], John Cassella[3,4] [1]STATS Ltd, Porterswood House, Porters Wood, St Albans, AL3 9PQ, UK [2]Applied & Environmental Geophysics Group, School of Physical Sciences & Geography, Keele University, Keele, Staffordshire, ST5 5BG, UK [3]Department of Forensic Science, Faculty of Science, Staffordshire University, Mellor Building, College Road, Stoke-on-Trent, Staffordshire, ST4 2DE, UK [4]Burials Research Group, West Midlands, University of Keele & Staffordshire University, UK **Corresponding author: George Tuckwell (george.tuckwell@stats.co.uk)*
09:50 - 10:00	10	**Electrical resistivity surveys over several simulated graves in Staffordshire, UK** John Jervis[1]*, Jamie Pringle[1], John Cassella[2], George Tuckwell[3] [1]Applied & Environmental Geophysics Group, School of Physical Sciences & Geography, Keele University, Keele, Staffordshire, ST5 5BG, UK [2]Department of Forensic Science, Faculty of Sciences, Staffordshire University, Stoke-on-Trent, Staffordshire, ST4 2DE, UK [3]STATS Ltd, Porterswood House, St. Albans, Hertfordshire, AL3 6PO, UK **Corresponding author: John Jervis (j.jervis@epsam.keele.ac.uk)*
10:00 - 10:10	10	**The use of topographic and geophysical survey techniques in the characterisation of search sites** Peter Barker[1]*, Claire Graham[1] [1]Stratascan Ltd, Vineyard House, Upper Hook Road, Upton-upon-Severn, Worcestershire, WR8 0SA, UK **Corresponding author: Peter Barker (peter.barker@stratascan.co.uk)*
10:10 - 10:20	10	**Pigs in Shelf** Armin Schmidt[1]*, Chris Gaffney[1], Rob Janaway[1], Andy Wilson[1], Hazel Woodhams[1] [1]Archaeological Sciences, Division of AGES, University of Bradford, Bradford, West Yorkshire, BD7 1DP, UK **Corresponding author: Armin Schmidt (A.Schmidt@Bradford.ac.uk)*

10:20 - 10:30	10	**An evaluation of the combined application of ground penetrating radar and 3D laser scanning in the location and rapid recording of skeletal human remains** James Fenn[1]*, Paul Cheetham[1], Jeremy Pile[1] [1]Centre for Forensic Sciences, School of Conservation Sciences, Bournemouth University, Bournemouth, BH12 5BB, UK **Corresponding author: James Fenn (jamesfenn1@gmail.com)*
10:30 - 10:40	10	**Forensic geophysics in support of the comprehensive nuclear test ban** George Tuckwell[1]*, Luis Gaya-Pique[2], Rainier Arndt[2] [1]STATS Ltd, Porterswood House, Porters Wood, St Albans, Hertfordshire, AL3 6PQ, UK [2]On-Site Inspection Division, CTBTO PrepCom, Vienna International Centre, PO Box 1200, A1400, Vienna, Austria
10.40 - 10.50	10	**From Cromwell Street to Jersey: 25 years of cables and images** John Hunter[1]*, Barrie Simpson[1] [1]University of Birmingham, Department of Ancient History & Archaeology and Forensic Support Archaeology Group, Edgbaston, Birmingham, West Midlands, B15 2TT, UK **Corresponding author: John Hunter (j.r.hunter@bham.ac.uk)*
10:50: - 11:00	10	**Discussion & questions. Rapporteur, Ruth Morgan**
11:00 - 11:30	30	**Refreshments & poster session**
		Session 2. Chair of session, Duncan Pirrie
11:30 - 11:40	10	**Raman Spectroscopy: A forensic geological and geoarchaeological perspective** Howell Edwards[1]*, Tasnim Munshi[1] [1]Chemical & Forensic Sciences, University Analytical Centre, School of Life Sciences, University of Bradford, Bradford, BD7 1DP, UK **Corresponding author: Howell Edwards (h.g.m.edwards@bradford.ac.uk)*
11:40 - 11:50	10	**The application of Raman Spectroscopy for the analysis of a range of biomaterials with forensic implications** Tasnim Munshi[1]*, Howell Edwards[1] [1]Chemical & Forensic Sciences, University Analytical Centre, School of Life Sciences, University of Bradford, Bradford, BD7 1DP, UK **Corresponding author: Tasnim Munshi (t.munshi@Bradford.ac.uk)*
11:50 - 12:00	10	**Application of micro-Raman spectroscopy to forensic geosciences** Alexandra Guedes[1]*, Angel Carmelo Prieto[2], Armanda Dória[1], Bruno Valentim[1], Perla Ferrer[1,2], Fernando Noronha[1] [1]Centro e Departamento de Geologia, Faculdade de Ciências, Universidade do Porto, Portugal [2]Física de la Materia Condensada, Cristalografía y Mineralogía, Facultad de Ciencias, Universidad de Valladolid, Spain **Corresponding author: Alexandra Guedes (aguedes@fc.up.pt)*
12:00 - 12:10	10	**Forensic investigation of soil in the Russian Federation** Olga Borisovna Gradusova[1]*, Ekaterina Michalovna Nesterina[1] [1]Russian Federal Centre of Forensic Science, Ministry of Justice of Russian Federation, Moscow, Russia **Corresponding author: Olga Gradusova (bio_soil@rambler.ru)*

12:10 - 12:20	10	**Field Portable X-ray Fluorescence (FPXRF) spectrometry of soils and the transfer issue** Elisa Bergslien[1]* [1]Earth Sciences & Science Education, Buffalo State College, 271 Science Building, 1300 Elmwood Avenue, Buffalo, NY, 14222, USA **Corresponding author: Elisa Bergslien (BERGSLET@buffalostate.edu)*
12:20 - 12:30	10	**The spatial and temporal distribution of pollen in an indoor setting and upon writing paper** Ruth Morgan[1]*, Emma Allen[2], Federica Balestri[2], Gabriella Davies[2], Peter Bull[2] [1]UCL Jill Dando Institute of Crime Science, Brook House, 2-16 Torrington Place, London, WC1E 7HN, UK [2]Oxford University, Centre for the Environment, South Parks Road, Oxford, OX1 3QY,UK **Corresponding author: Ruth Morgan (ruth.morgan@ucl.ac.uk)*
12:30 - 12:40	10	**Application of geological knowledge in solving disputes** Isabel Fernandes[1]*, Fernando Noronha[1] [1]Centro e Departamento de Geologia, Faculdade de Ciências, Universidade do Porto, Portugal *Corresponding author: Isabel Fernandes (isabel.migfer@gmail.com)*
12:40 - 12:50	10	**Bricks and mortar: how much circumstantial evidence is enough?** Andrew Smith[1]* [1]Principal Consultant, CERAM Building Technology, CERAM Research Ltd, Queens Road, Penkhull, Stoke-on-Trent, Staffordshire ST4 7LQ, UK **Corresponding author: Andrew Smith (andrew.smith@ceram.com)*
12:50 - 13:00	10	**Discussion & questions. Rapporteur, Ruth Morgan**
13:00 - 14:20	80	**Lunch & poster session**
		Session 3. Chair of session, Alastair Ruffell
14:20 - 14:30	10	**Preservation and analysis of three-dimensional footwear evidence in soils: the application of optical laser scanning** Matthew Bennett[1]* [1]School of Conservation Sciences, Bournemouth University, Dean of Conservation Sciences, Talbot Campus, Fern Barrow, Poole, Dorset, BH12 5BB, UK **Corresponding author: Matthew Bennett (mbennett@bournemouth.ac.uk)*
14:30 - 14:40	10	**Instrumental Neutron Activation Analysis (INAA): practice and potential forensic applications** Nelson Eby[1]*, Stephanie Eby[2] [1]Department of Environmental Earth & Atmospheric Sciences (EEAS), University of Massachusetts, Lowell, Massachusetts, USA [2]Department of Biology, Syracuse University, Syracuse, New York, USA **Corresponding author: Nelson Eby (Nelson_Eby@uml.edu)*

14:40 - 14:50	10	**Communication in forensic geoscience featuring an example from TV** Lorna Dawson[1,5]*, Laurance Donnelly[2]*, David Miller[1], John Cassella[3], Jamie Pringle[4], Kate Hollingsworth[5], Alastair Ruffell[6], Mark Harrison[7] [1]The Macaulay Institute, Craigiebuckler, Aberdeen, AB15 8QH, UK [2]Halcrow Group Ltd, North West Regional Office, Manchester, Deanway Technology Centre, Wilmslow Road, Handforth, Cheshire, SK9 3FB, UK [3]Department of Forensic Science, Faculty of Science, Staffordshire University, Mellor Building, College Road, Stoke-on-Trent, ST4 2DE, UK [4]Applied & Environmental Geophysics Group, School of Physical Sciences & Geography, Keele University, Keele, Staffordshire, ST5 5BG, UK [5]BBC Countryfile, Level 9, The Mailbox, Wharfside St, Birmingham, West Midlands, B1 1RF, UK [6]School of Geography, Archaeology & Palaeoecology, Queens University, Belfast, BT7 1NN, Northern Ireland [7]National Policing Improvement Agency, Knowledge Centre, Wyboston Lakes, Bedfordshire, MK45 3JS, UK *Corresponding author: Lorna Dawson (l.dawson@macaulay.ac.uk)* *Corresponding author: Laurance Donnelly (donnellylj@halcrow.com)*
14:50 - 15:00	10	**The Council for the Registration of Forensic Practitioners (CRFP): an opportunity for forensic geoscientists** Mike Allen[1]* [1]Council for the Registration of Forensic Practitioners (CRFP), 3rd Floor, Tavistock House, Tavistock Square, London, WC1H 9HX, UK *Corresponding author: Mike Allen (mike.allen@crfp.org.uk)*
15:00 - 15:10	10	**Using remote sensing to map and monitor London's geohazards** Richard Teeuw[1]* [1]School of Earth & Environmental Sciences, University of Portsmouth, Burnaby Building, Burnaby Road, Portsmouth, PO1 3QL, UK *Corresponding author: Richard Teeuw (richard.teeuw@port.ac.uk)*
15:10 - 15:20	10	**Discussion & questions. Rapporteur, Ruth Morgan**
15:20 - 15:50	30	**Refreshments & poster session**
		Session 4. Chair of session, Laurance Donnelly
15:50 - 16:00	10	**The future of geoforensics** Alastair Ruffell[1]*, Laurance Donnelly[2], Lorna Dawson[3], [1]School of Geography, Archaeology & Palaeoecology, Queens University, Belfast, BT7 1NN, Northern Ireland [2]Halcrow Group Ltd, North West Regional Office, Manchester, Deanway Technology Centre, Wilmslow Road, Handforth, Cheshire, SK9 3FB, UK [3]The Macaulay Institute, Craigiebuckler, Aberdeen, AB15 8QH, UK *Corresponding author: Alastair Ruffell (a.ruffell@qub.ac.uk)*
16:00 - 16:10	10	**Soils, plants, pollen, and fungi: a key multidisciplinary approach in criminal investigation** Patricia Wiltshire[1]*, David Hawksworth[2] [1]Patricia Wiltshire, Forensic Ecology & Palynology, Milford House, The Mead, Ashtead, Surrey, KT21 2LZ and University of Aberdeen, Department of Geography & Environment, Elphinstone Road, Aberdeen, AB24 3UF, UK [2]Natural History Museum London, Department of Botany, Cromwell Road, London, SW7 5BD and University of Gloucestershire, Department of Natural & Social Sciences, Francis Close Hall, Swindon Rd, Cheltenham, GL50 4AZ, UK *Corresponding author: Pat Wiltshire (patricia.wiltshire1@btinternet.com)*

		Forensic Geoscience Group, Invited Guest Speaker 1: Marianne Stam
16:10 - 16:25	15	**Forensic geology in the United Kingdom and the United States** Marianne Stam[1]*, Raymond Murray[2] [1]California Department of Justice, Riverside, California, USA [2]106 Ironwood Place, Missoula, Montana, 59803, USA *Corresponding author: Marianne Stam (marianne.stam@doj.ca.gov)*
16:25- 16:35	10	**The 3rd international conference on soil forensics, California, USA** Marianne Stam[1]* [1]California Department of Justice, Riverside, California, USA *Corresponding author: Marianne Stam (marianne.stam@doj.ca.gov)*
16:35 - 16:45	10	**Discussion & questions**
		Forensic Geoscience Group, Honorary Guest Speaker 2: Mark Harrison
16:45 - 16:55	10	**Summary of the conference** Mark Harrison[1] [1]National Policing Improvement Agency (NPIA), UK National Police Search Advisor
		Conclusions and close
16:55 -17:00	5	**Laurance Donnelly** Chair, The Geological Society, Forensic Geoscience Group

The following abstracts are included and may be presented (in reserve)
Forensic investigations in engineering geology, mining geology, geomorphology and geohazards Laurance Donnelly[1]* [1]Halcrow Group Ltd, North West Regional Office, Manchester, Deanway Technology Centre, Wilmslow Road, Handforth, Cheshire, SK9 3FB, UK *Corresponding author: Laurance Donnelly (donnellylj@halcrow.com)*
The development and significance of a conceptual geological model, in different geomorphological settings, to search for a murder victim's grave Laurance Donnelly[1]* [1]Halcrow Group Ltd, North West Regional Office, Manchester, Deanway Technology Centre, Wilmslow Road, Handforth, Cheshire, SK9 3FB, UK *Corresponding author: Laurance Donnelly (donnellylj@halcrow.com)*

Posters

Cutting it fine: blood pattern detection on grass

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Diatoms: how useful are they in the recovery of human remains?

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Analysis of simulated clandestine grave contents to assist search teams in the detection of clandestine burials

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Forensic geophysics

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A modelling/inverse-scattering approach to investigate the potential of GPR for the location of archaeological human remains

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Source apportionment of nuisance dust with directional collection and multi-element fingerprints

Ben Williams[1], Hugh Datson[2], Mike Fowler[1]*
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Commercial displays and exhibitors

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FGG 2008 supported meetings

The Geological Society Geochemistry Group, Annual General Meeting (AGM)*

Kym Jarvis[1]
[1] Chair, Geological Society, Geochemistry Group, Imperial College, Centre for Environmental Policy, Room 108, Manor House, Silwood Park, Ascot, SL5 7PYUK
*The Geological Society, main lecture theatre, 17 December 2008, 13:00 - 14:20

Geoforensics and Information Management for crime Investigation (GIMI)*

Lorna Dawson[1], David Miller[1]
[1]The Macaulay Institute, Craigiebuckler, Aberdeen, AB15 8QH, UK
*The Geological Society, Burlington House, William Buckland Room, 16 December 2008, 18:00 - 19:00

Lecture Abstracts

A comparative study into the effectiveness of geophysical techniques for the location of buried handguns

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The proliferation of firearms in the UK, deemed 'intolerable' by Prime Minister Gordon Brown has been the cause of great concern amongst law enforcement agencies and the increase in firearm related homicides by gangs in inner city areas combined with the recent large scale criminal alteration of replicas into effective firearms justifies this concern. The burying of firearms for the purposes of storage or disposal after criminal activity is much documented both in the UK and abroad and the US phenomenon of 'block guns' or firearms buried strategically in gang neighbourhoods for rapid access gives pause for thought. Consequently, considering the current gun climate, ascertaining the most effective methods to locate these buried weapons is timely. Much forensic geophysics research that has been published recently relates to the location of burials, both mass and individual. While this is important there has been less published research into the location of associated evidence, which may be located in a different location to the remains. Previous studies in the location of firearms and metal weapons with magnetic locators and metal detectors have been undertaken, but systematic high resolution area coverage as frequently applied in archaeological geophysical survey and employing range sensitive archaeological grade magnetometry instrumentation has not been thoroughly evaluated.

In this study 0.5m and 1.0m fluxgate and 1.0m caesium gradiometer results were compared with 500 and 800MHz frequency ground penetrating radar (GPR) surveys. The two different high-quality replica handguns employed were buried at two depths (0.30 and 0.50m) both singly and as a cache. The site chosen was a flat grassed area set within an urban environment, the near-surface geology being a uniform sand. The site contained significant amounts shallow ferrous material which was partially cleared by the use of a metal detector prior to the main surveys. Overall, the results from the magnetic surveys were problematic with the responses from the buried handguns difficult to distinguish clearly from site noise. However, some of the GPR surveys proved particularly successful (Fig. 1), although the type of handgun and changes in the orientation of the guns resulted in significant effects on their delectability

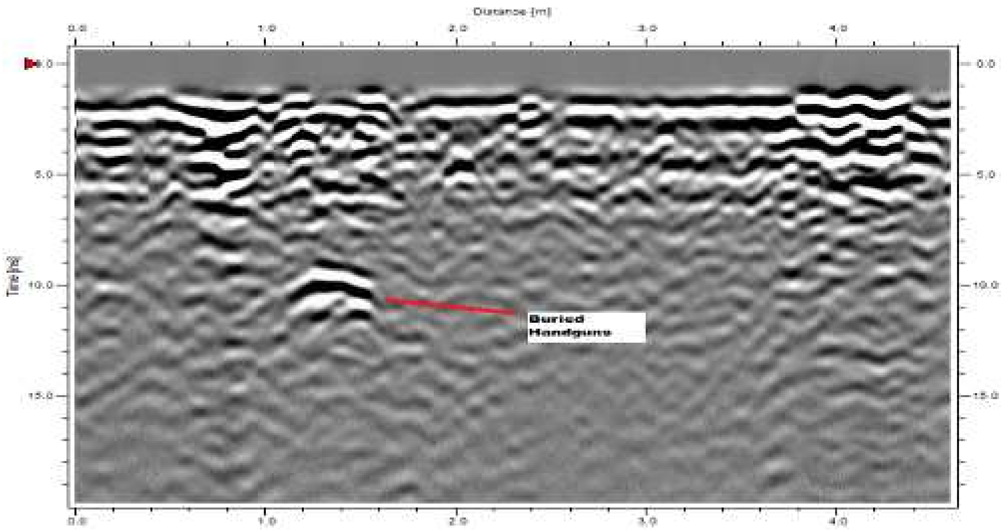

Fig. 1. 800MHz GPR profile with handgun cache buried at a depth of 0.50m

Seeing the wood for the trees: the use of GPR in detecting clandestine graves

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Ground Penetrating Radar (GPR) is a well recognised technique for the detection of clandestine graves. There are numerous published examples of its successful use in forensic casework. The technique is also extensively used in the engineering and environmental sectors to image the subsurface. There are several examples of the GPR response to buried natural and man-made features beneath the ground and within building structures. The shallow subsurface will typically contain many variations that will provide a GPR reflection response. In the built environment and in brownfield sites the upper few meters are typically dominated by made ground, all of which by definition is modified by human activity. In greenfield sites numerous natural features will be visible to the GPR system including tree roots, animal burrows, and changes in geology or the soil profile. GPR surveys are perhaps best recognised in forensic application for their success within, beneath and immediately around buildings. This is a very complex environment within which to obtain any non-invasive data, however the GPR system is well suited because of its resolution and its directionality. Strong reflections are typically obtained from internal voids (chimneys, flues, drainage pipes, wall cavities and basements), foundation structures, internal metalwork, changes in construction material, paving construction and landscaping including excavations and level changes. The problem remains how to distinguish a suspicious response in the GPR data from the many innocent variations that will exist. We do not suggest that it is possible to discount all but the genuine clandestine grave response, however we do suggest that a better understanding of the types and origins of GPR response expected in particular environments will allow a more efficient survey progress and minimise the need for more time consuming intrusive investigations. We will review GPR data that we have obtained over clandestine graves. In this context, we also present a representative sample of some of the reflection types typically obtained using GPR. Reflection geometry and character will be described in each case and the benefits or hindrances to a forensic investigation explored. The time critical nature of investigations of this type are, of course, an additional technical and logistical constraint, and the most efficient GPR data collection, processing and interpretation methodologies should be employed. Data collection strategies are also critical to the successful identification of certain features. We will provide a review of these together with a discussion of the data processing and visualisation steps that can be undertaken to best interpret the data.

Electrical resistivity surveys over several simulated graves in Staffordshire, UK

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The electrical resistivity survey method has been shown to be capable of detecting graves in both criminal investigations and controlled experiments over buried animal cadavers. Graves are usually

associated with low resistivity anomalies in the survey data and soil resistivity formulae suggest that this may be a result of increased porosity of the grave soil, or alternatively, the release of conductive fluids by the decomposing cadaver, or a combination of the two.

In this study, repeat survey data, collected monthly from two study sites and over several simulated graves, including buried pig cadavers and empty 'test pits' (i.e. graves that do not contain a body), are used alongside a program of soil and groundwater sampling to determine the relative importance of disturbed soil and cadaver decomposition in causing the resistance anomalies associated with the graves.

Initial results suggest that in the first few months after burial the grave anomaly in the resistivity data is caused entirely by the fluid produced during cadaver decomposition. However, statistical analysis of the soil sampling data indicate that there is a significant difference in porosity between the grave soil and the undisturbed control samples, and a subtle anomaly is observed to coincide with an empty test pit from approximately six months after the graves were created. Low resistance anomalies caused by decompositional fluids appear to have a finite lifespan, and the results of these experiments suggest that in the longer term (one year to a few years post-burial), the ability of a resistivity survey to detect a grave may be determined solely by the resistivity response of the disturbed soil.

The use of topographic and geophysical survey techniques in the characterisation of search sites

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Search areas for clandestine burials can be very large. Good quality intelligence can help in reducing the size of the search area but for this to be effectively used it may be necessary to characterise the site to match the information in the intelligence with appropriate sections of the site.

The characterisation process can involve adding topographic detail onto readily available base mapping from, for example, the Ordnance Survey. Geophysics can also help with the process in determining the extent and depth of various deposits or ground conditions.

This characterisation can reduce the search areas either permitting cost effective dog searches, further more detailed geophysics, which may identify individual targets, or 100% intrusive investigation. Examples of recent work will be shown to demonstrate the use of these techniques together with the results of field trials to detect known targets with a variety of techniques.

Pigs in Shelf

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Geophysical methods are increasingly being used in the search for clandestine burials and it has been recognised that they can help to identify 'hotspots' as part a forensic investigation sequence. To establish their efficiency, several tests were undertaken but published results report mixed success. Some authors were positive despite poor results ("…should not be discarded as hopeless") and it is possible that problems arose because standard geophysical techniques were not sufficiently modified for the specific requirements of forensic search.

The Archaeological Prospection Research Group at the University of Bradford has carried out geophysical tests since the 1990s to investigate responses of geophysical techniques to buried decomposing bodies. It is generally accepted that pig carcasses form an appropriate analogy to human

bodies in relation to body mass, fat content and decomposition. Several pigs were therefore buried in different soil environments and various burial contexts (e.g. wrapped in polythene), and geophysical techniques were employed to measure the variation of responses with time. This paper reports on the results from a site in Shelf, near Bradford, where earth resistance surveys and ground penetrating radar (GPR) were used to test several such burials, together with the collection of environmental data.

Although the buried carcasses produced clear geophysical anomalies at some stage, their identification against general soil variability proved difficult overall. Environmental conditions were shown to be critical and their analysis assisted the interpretation of geophysical results.

An evaluation of the combined application of ground penetrating radar and 3D laser scanning in the location and rapid recording of skeletal human remains

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The location and recording of buried skeletal remains, particularly if disarticulated and lying through the plane of excavation spits, presents a considerable challenge to investigators recovering and recording with such material. This paper considers the application of high frequency ground-penetrating radar (GPR) in combination with 3D laser scanning for the direct locating and recording of skeletal elements in a shallow burial environment. It assesses the ability of the GPR and to aid the forensic expert in the locating of skeletal remains where the disturbance of the grave itself might not provide a sufficient geophysical contrast. The research was conducted on an archaeological excavation of a cemetery containing a series of inhumations dating to the mediaeval period and earlier. It investigated an area of backfilled ditch that had revealed a series of apparently disarticulated human remains protruding from the ditch section. The soil at this test area was a relatively dry, loose, sandy clay loam which would be expected to prove suitable for high frequency GPR survey. The experiment used high frequency ground penetrating radar (800 MHz) to conduct two orthogonal surveys over a survey area of 1.2m x 2m employing a 0.01m sample interval along the survey traverse and a 0.10m traverse interval (Fig. 1). Prior to the commencement of the GPR survey, and in during the intrusive investigation, 3D laser scanning was applied as a potential rapid pre, mid, and post-excavation recording technique in addition to the traditional photographic and 2D plan recording. Having cleaned the section face and cleared the surface of vegetation, an initial 3D scan was carried out. The GPR survey then commenced running north-south, transverse to the assumed burials, and then east-west, parallel to the assumed burials. Significant anomalous GPR reflections occurred, which were consistent in grid location on both directional surveys (see Fig. 2 for sample GPR slices).

Although the application of high frequency GPR (800MHz) provided considerable guidance as to the precise location of the buried crania and as to the general orientation of the burial as a whole, further experimentation applying a higher frequency radar antenna at a traverse of less than 0.10m would be recommended to improve resolution in the hope of individuating bone with greater precision. 3-D laser scanning as a rapid recording technique demonstrated impressive capability both in terms of scan resolution and in general measurement accuracy, however; finite resolution and time consumption are issues to be readdressed with the emergence of upgrading models and advancing scan technology.

Fig. 1. Ditch section containing disturbed burials (surface, 2m x 1.2m GPR survey area).

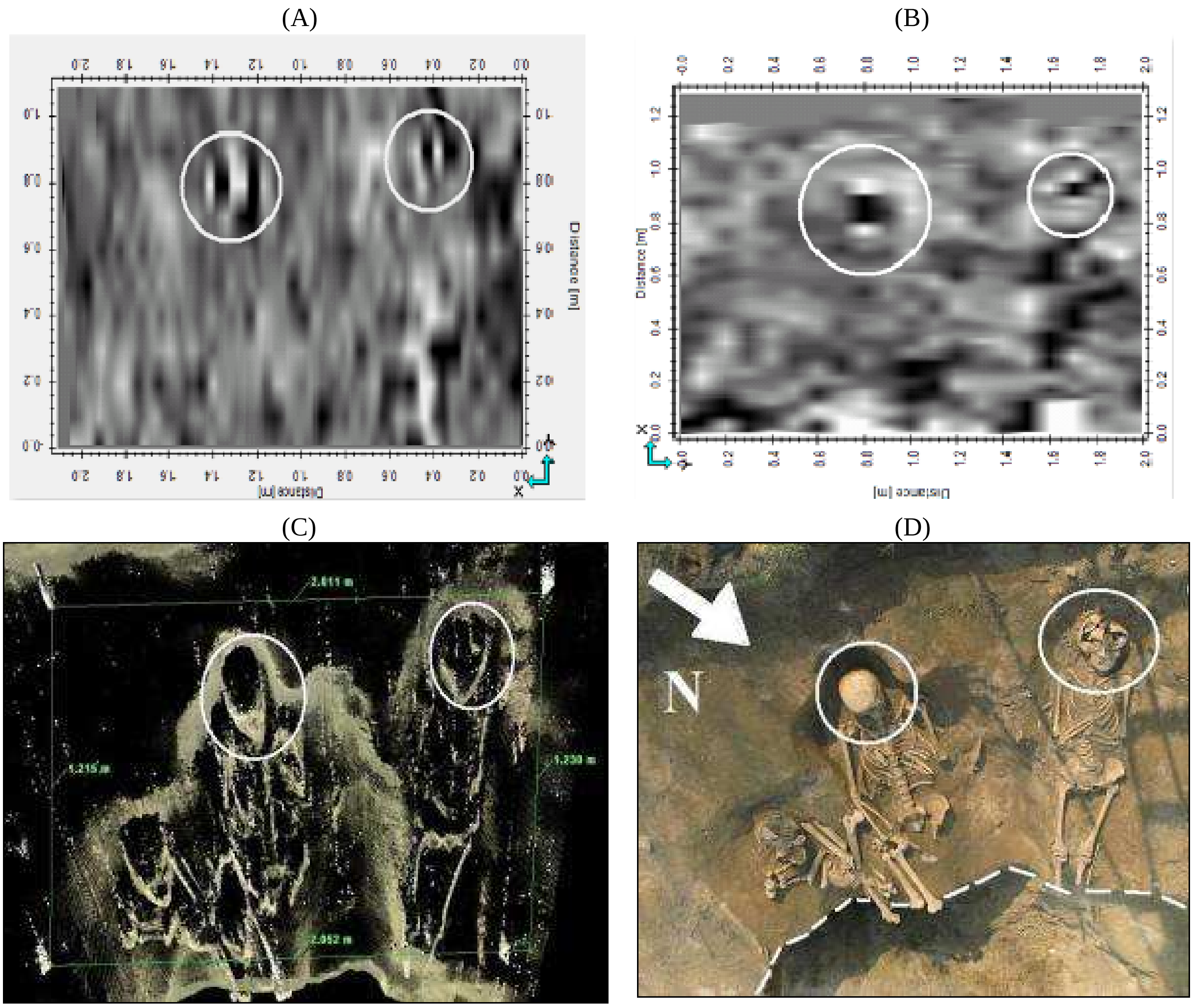

Fig. 2: Images A and B are a sample raw data slices of the 800MHz GPR orthogonal surveys in which two clear GPR anomalies are highlighted. On excavation of the target area a conclusion was reached that these anomalies represented the crania of two shallow burials (one intact and one partially fragmented, highlighted in the 3D laser scan, image C, and in site photograph, image D).

Forensic geophysics in support of the comprehensive nuclear test ban

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Near-surface geophysical techniques are a critical tool set for the verification of a suspected nuclear explosion. Beyond the seismic and radionuclide signatures of an underground explosion, further evidence is required to locate and verify the nature of a suspicious event.

We will provide an overview of the expected geophysical signatures of an underground nuclear explosion (UNE) in terms of deep disruptions to geological strata and hydrogeology, and in terms of the shallow buried remains of the infrastructure associated with the preparation and monitoring of the test. Data from published cases studies and collected during recent field exercises will be presented to stimulate useful discussion within the expert community.

On-site inspections are conducted to verify States' compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT). An on-site inspection is launched to establish whether or not a nuclear explosion has been carried out. During such an inspection, facts are gathered to identify a possible violator of the Treaty. It thus constitutes the final verification measure under the CTBT. The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation was established on 19 November 1996 by a Resolution adopted by the Meeting of States Signatories at the United Nations in New York. This Preparatory Commission is laying the groundwork required to build up the global verification regime and monitor compliance with the Treaty.

Preparations for an on-site inspection have to be swift as there is only a narrow time window during which some of the conclusive evidence for a treaty violation can be obtained. Time scale is only part of the web of logistical and technical challenges to face the international team of geophysicists and other experts involved in an inspection.

The most recent field exercise, "The Integrated Field Exercise 2008" will be the first large-scale, as well as the most comprehensive, on site inspection exercise ever conducted by the CTBTO. Kurchatov is a small, sleepy town on the river Ertis in Kazakhstan, downstream from the town of Semey. The exercise took place in a deserted area roughly 160 km to the south east of the town, within the former Soviet Union's nuclear test site Semipalatinsk. The technical challenges identified as part of the exercise will inform the ongoing training and research undertaken by the CTBTO.

From Cromwell Street to Jersey: 25 years of cables and images

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Geophysics has now been used for almost a quarter of a century in the UK in supporting criminal investigation, mostly in the location of buried murder victims. But how far has geological, engineering, or archaeological geophysics developed from a straight forward application into a forensic discipline in its own right? Published literature includes a number of specific case studies where geophysics has been used, but the nature, role and limitations of the subject are rarely defined or explored.

This paper attempts to review the position of geophysics in criminal investigation through the experience of two 'clients', both forensic archaeologists, one being a former Senior Investigating Officer (SIO).

Specific areas of enquiry include:

- The integration of geophysicists within the criminal investigation framework.
- Wider awareness of geophysical processes and their limitations (feasibility and logistics).
- Real time analysis.
- The significance of site histories.
- Levels of confidence in site elimination.
- The importance of 'ground truthing' and feedback.

Raman Spectroscopy: a forensic geological and geoarchaeological perspective

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The importance of the molecular analytical information resulting from the adoption of Raman spectroscopic techniques in geological and geoarchaeological science is now well realised. In this survey of recent work carried out in our laboratories several aspects of the data provided by the non-destructive Raman spectroscopic analysis of wall-paintings, rock art, frescoes, skeletal remains and buried artefacts will be used to illustrate Raman spectroscopic applications to geoarchaeological problems. Since Raman spectroscopy does not require either the chemical or mechanical pre-treatment of the specimen, it is now being advocated as a primary, first-pass analytical technique for the examination of samples, highlighting regions of interest which may then be subjected to further testing of a more destructive nature, so maximising the information that can be obtained from the specimen. Unlike infrared spectroscopy, Raman spectra can be routinely recorded over a wave-number range from 3500-100 cm–1 using one instrument, so encompassing the molecular vibrations of organic and inorganic compounds and affording the opportunity to assess the interactions between pigments, biomaterials and their substrates without detachment or separation of the components of the specimen. This has particular advantage for the study of specimens that exhibit variable states of degradation, such as those obtained from forensic geoarchaeological excavations. A further advantage of confocal Raman microscopy is the ability to record subsurface molecular information from inclusions in transparent, crystalline geological materials without cleaving the specimen and exposing them to the atmosphere.

Examples of this approach will be selected from the following case studies in geology and geoarchaeology:

- Specimens of rock art and frescoes that have been subjected to biodegradation processes from prehistoric to the Renaissance periods; definition of the use of ancient technologies for the preparation of materials.
- Geographical sourcing of resins from buried artefacts; Raman spectral discrimination between the botanical origins of several resins that have been commonly used in antiquity up to the present time, effects of degradation in the depositional environment.
- The use of Raman spectroscopy as a first-pass molecular analytical probe for an Egyptian Dynastic painted sarcophagus fragment and the identification of deposits on Inuit boots.
- The degradation of biomaterials and human skeletal remains from a stone cist dating from the Dark Ages (ca. 1400 y BP) and from the excavation of a Bronze Age tumulus.

- The identification of fragments associated with human skeletal remains found during pipeline construction work.
- The conservation and restoration of an important fresco, c300y BP, that was badly damaged by gunfire and conflagration during the Spanish Civil War in 1936, for which no information was available about the mineral pigments used by the artist and the thermal effects to which they were exposed.
- The Raman confocal microspectroscopic study of biogeological inclusions in a crystalline mineral matrix from hot and cold deserts: cyanobacterial colonisation of selenite form the Haughton Crater in the Canadian Arctic, from the Rhub-al-Khalil sabkha in the Arabian Desert and from the ancient stromatolitic deposits at the North Pole Dome at Pilbara in Western Australia. These are classic examples of the use of Raman spectroscopy to characterise non destructively organic components, often only representing nanogram quantities in several hundred grams of matrix.

The characteristic biosignatures of lichens and cyanobacteria found in the Raman spectra of deteriorated wall-paintings and their substrates and in buried biomaterials pointed to early signs of biodeterioration which could be used by forensic archaeologists for the prioritisation of their specimen conservation strategy. The Raman spectroscopic identification of organics in pigment mixtures can be used to select areas for special destructive sampling for supporting further analytical characterisation using other techniques.

The miniaturisation of laboratory-based Raman spectrometric instrumentation for forensic and geological field work is appreciated for future analytical development and some statements and preliminary data will be given on this aspect at the end of the presentation.

The application of Raman Spectroscopy for the analysis of a range of biomaterials with forensic implications

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Raman spectroscopy is non-destructive and requires little or no sample preparation. This allows the application of this technique to be suitable for the identification of a range of materials encountered in the forensic field. The advantage and application of Raman techniques to evidential material from crime scenes is attractive and this current study addresses the application of this technique to a range of biomaterials.

The objective of this study was to characterise biomaterials encountered in the forensic context. The Raman spectra of a range of drugs, explosives and ivories are reported using Fourier-Transform, conventional dispersive and remote sensing portable Raman spectroscopy. The ability to characterise different biomaterials was evaluated. The application of portable Raman spectrometer for the identification is also demonstrated and proposed for the insitu characterisation of suspected biomaterials at airports.

The degradation of materials exposed to the environment or in a burial context can affect the observed Raman bands in recognisable ways, which assists the interpretation of the deteriorative processes through characteristic biomarkers. Raman spectra, therefore, can provide a source of data on the historical environmental conditions to which forensic archaeological specimens have been subjected and can give forensic scientists a new perspective on excavated artefacts and materials. Several examples will be used to illustrate the application of Raman spectroscopic techniques to the characterisation of biomaterials, including human and animal skeletal remains and the influence of the burial environment on the protein degradation, discrimination between real and fake ivories, and resins such as dragon's blood, amber, and their geographical sourcing.

Application of micro-Raman spectroscopy to forensic geosciences

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Forensic scientists analyse a wide variety of materials to help solve some crimes. New developments in techniques for determining the origin of these materials are making the science of detection much more precise.

Micro-Raman Spectroscopy (MRS) is a highly sensitive technique used to characterise materials since this provides unique spectra, or a characteristic 'fingerprint' (signature). This analytical technique combines reliability and sensitivity, it is non-destructive and may be applied *insitu*. MRS does not require sample preparation and may be performed with different sized samples. Therefore, MRS is an ideal technique in forensic sciences and the applicability of Raman spectroscopy to solve forensic problems has been improved in recent years.

The use of MRS in the Centre of Geology, University of Porto, is mainly related to the identification and characterization of minerals, gemstones, pigments, fly ash, carbon materials and the discrimination of writing inks, among others. Samples can be analysed without extraction and contact, with high speed of analysis and preventing contamination. This equipment allows an analysis of spot samples, which can be as small as 1μm.

This research centre has been developing and implementing analytical protocols for the identification and characterization of different materials. Furthermore, a database has been developed, which may be applied to judicial cases related to different types of crimes. Therefore, minerals and pigments (used in artwork), fly ash and carbon materials, and a collection of writing inks are being characterised and catalogued in a MRS database of material types that are more frequently used throughout Portugal.

Forensic investigation of soil in the Russian Federation

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The Russian Federal Centre of Forensic Science is the parent organization of the State Expert Institutions of the Ministry of Justice, in the Russian Federation. Forensic examination status and forensic expert status are included in the 'Code of Criminal Procedure of the Federation', and the Federal Law covers experts within the Federation. The 'State Expert Institutions' encompasses about 50 laboratories and centres, situated all over Russia. The basic purpose of the Centre is to undertake forensic examinations with the aim of guaranteeing protection of human rights and freedom, and interests of the State. The main tasks of the Centre includes; scientific investigations, developing new and original forensic research methods, writing manuals for use by forensic experts, reviewing experts' practice in Russia and globally, training and certification of forensic experts; reviewing experts' investigations with the purpose of improving the quality of their work.

A state expert, according to the federal law, must be highly educated, possess special knowledge in the field of forensics, study the main principals of 'The General Theory of Forensic' and take the examination.

The Centre consists of numerous laboratories offering services that cover about 100 different specialities. Within the Centre, the 'Laboratory of Forensic Soil and Biological Investigations' is one of the oldest. This laboratory collaborates with other laboratories and academic institutes.

Soils, whether natural or anthropogenic, are complex materials containing a large number of components, from both a natural and anthropogenic source. A forensic soil specialist usually has to analyse numerous soil samples and its components in order to determine the origin of the soil, which often may be a complex and time consuming procedure. Teams of international specialists seem to have independently concluded that the multi-disciplinary analysis of soil enables a greater number of soil characteristics to be measured, which potentially may be used as evidence in court as part of a forensic investigation.

In the period 1970-80, forensic analysis developed markedly in the Soviet Union, which formalised the discipline, previously absent and the 'Theory of Forensic (Legal)' examination was developed (jurist theorists). In 1976, V.S. Mitrychev developed one of the main principles of this theory, the method of 'identification of the whole by parts'. Many soil forensic investigations were reviewed and summarised to provide a strategy for the analysis of soil. The main principle developed, was soil forensics experts should investigate the whole crime scene (for example, soil cover or soil from a burial) by a sequential examination of the component parts. For example, the analysis of each individual soil layer (such as the soil micro-aggregates, mineral particles, anthropogenic particles, plant particles and pollen) on items of clothing or other objects. By adopting this method the forensic soil specialist undertakes an investigation which may link a victim, or object, to the crime scene, a suspect, offender, or particular geographical location, based on the complex analysis of soil and its components. This may be achieved by adopting the following procedure:

- Identification tasks: are the soil layers on the items under investigation derived from, or composed of soil, and if so do they have generic and/or specific association with the crime scene (burial or other place)? Are the soil layers on the items from the crime scene or elsewhere?
- Diagnostic tasks: what is the provenance of a substance, which geographical region, or location could the soil originate? Often there is no intelligence to assists with the investigation, only the soil samples (known as a 'blind case').
- Situational tasks: what is the position of a soil sample on clothes (such as footwear) and what is its distribution and stratification? Does the position of the soil support the accounts given in case reports? How was the soil deposited on the evidentiary item?

As similar soil types are widely distributed it is rarely possible to determine absolutely the source and location of a particular soil sample, without some degree of uncertainty.

Typical investigations involve the bulk analysis of soil and the identification of trace evidence. These may be derived from a complex, highly variable geological and/or anthropogenic source, which includes for example; rocks, soils, dust derived from building materials and other materials from an anthropogenic origin.

There are a number of difficulties during the analysis of soil as part of a forensic investigation. As stated above, rarely can a definitive association be established between soil samples and a crime scene, because many similar soils occur in many different places, which is the case in the region around Moscow. Bulk sampling of soils layers may result in a mis-representation of the individual soils types. The physical and chemical characteristics of soils at a crime scene can vary within a short distance of less than 1m, and therefore the soil samples taken may not give a complete representation of the soil present at the crime scene. There is also a problem when only very small amounts of soil are available to be analysed. In these cases chemical analysis, and qualitative and quantitative X-ray phase analysis, should be applied with great care. The application of simple, more primitive methods can also be particularly useful when there is only a small soil sample, for example; comparative examinations of morphological singularities of soil micro-aggregates using light stereomicroscopy, and/or the comparative study of morphological features of small amounts of soil put into a water drop with the visualization of the results using a digital camera.

In cases when soil layers on items/objects originate from urban areas, there may be complex particles and materials from an anthropogenic origin. This may increase the likelihood for the characterization of the soil at a crime scene and to establish a possible link between items/objects and the crime scene.

Very often, in forensic samples there is a mixture of soil micro-aggregates, mineral particles of natural and manufactured origin, plant particles (including pollen) and mammalian hair. In these types of complex investigations there is an expert-coordinator, who is familiar with all available analytical techniques and methods. We operate on the principle of involving a number of experts, with a balanced suite of methods. This combined approach is always more effective than separate investigations. Furthermore, the analysis of diverse information, using different specialists, strengthens the evidence of an individual case.

To determine the nature of small, non-organic, anthropogenic materials, these are subjected to a morphological examination using light microscopy, in combination with chemical analysis using X-ray micro-probe fluorescence and energy dispersive micro-probe X-ray analysis. If small organic particles are present in a soil sample then the infrared (IR) spectroscopy method with Fourier analysis have proved to be the most effective techniques. Some forensic scientists are particularly interested in developing new instrumental techniques for analysing more precisely mixtures of small particles from different sources, within a shorter time frame.

This paper will discuss cases where the forensic identification and analysis of soils has been undertaken in the Russian Federation. This paper also draws attention to potential constraints during the forensic analysis of soil and invites other delegates to discuss how an international standard approach may be developed for the forensic analysis of rocks, soils and man-made materials, so that this physical evidence may be permitted to be used in court.

Field Portable X-ray Fluorescence (FPXRF) spectrometry of soils and the transfer issue

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Field Portable X-ray Fluorescence (FPXRF) spectrometry has become a common technique for many forensic and environmental geoscience applications. A typical FPXRF system uses either an x-ray tube or radioisotope as an excitation source to irradiate samples. The incident x-rays interact with the samples atomic structure by knocking electrons from their inner shells, leaving vacancies that are filled as outer shell electrons release energy to fall in to new ground states. The energy released will be an x-ray equivalent in energy to the energy difference between the two shells. Since each element has a characteristic arrangement of electrons, the x-rays released by such transitions will be unique to that element, allowing its identification. By comparing the intensities of x-rays from an unknown sample to those of a suitable standard, elemental composition can be quantified.

Field portable units employ energy dispersive analyzers that convert the x-rays incident on the solid-state detector into an electronic signal based on photon energy. The major limitations of this technique are lower detector resolution than wavelength dispersive systems and more significant spectral overlap issues that also effect resolution, especially on light elements. Laboratory based energy-dispersive x-ray (EDX) fluorescence systems can analyze for elements from sodium to uranium, but FPXRF systems, because they are working in air, generally are unable to detect elements lighter than phosphorus. This latter limitation has significance from a forensic geology perspective, as the most common elemental constituents of minerals, silicon, oxygen, aluminum and magnesium, are not detectable. However, heavier elements can be readily detected, some with great sensitivity. This suggests that it may be possible to differentiate geological materials, such as soils, based on their trace element content. Potential forensic applications include analysis of mineral and rock deposits on automobile tires, shoes, carpets etc. and direct comparison with materials found at the crime scene.

For the past three years samples have been collected for an ongoing intrusive analysis project to determine the mineralogy, using x-ray diffraction, and elemental composition, using x-ray fluorescence, of soils in western New York, with the long term goal of developing a database. Soil samples weighing approximately 100g each are collected from urban, suburban and rural recreation areas using a 50 mm x 50 mm x 20 mm sample frame. The samples are oven dried for 24 hours then homogenized and placed in XRF sample holders.

The samples are then analyzed using a Niton XLt Field Portable X-ray Fluorescence (FPXRF) unit with a low power (1.0W) Ag anode x-ray tube and a Si PiN detector. The unit is set in bulk soil mode and sample data is collected for 150 seconds. The lower detection limits for this approach are typically 10–50 ppm for titanium to plutonium, 250 ppm for potassium to scandium, and between 1–5% for phosphorous to argon.

Broadly speaking there are two major sources of trace elements in the environment. The first is the local geological environment. The second is anthropogenic releases into the environment via such activities as manufacturing, mining and power generation. At this point in the project, 58 samples, collected from 14 different sites, have been analyzed. For the majority of the soil samples there are no clear distribution characteristics to allow differentiation based on composition. This is relatively unsurprising since geologically speaking all of the samples collected have been from approximately the same basic underlying parent material: dolomite and/or limestone with some addition of shale. Iron concentration appears to be geologically controlled, while other elements, such as silver, strontium and rubidium, do not show any significant trends.

In general, the urban samples do show significantly higher levels of lead (150-370 ppm), iron (c28,350 ppm) and zinc (230 ppm) than the suburban samples (c35ppm, c20,000 ppm and c100 ppm respectively), which could potentially become a useful discriminator. Lead especially varies significantly from <13 to >600 ppm. More of interest, arsenic and chromium show localized anthropogenic highs associated with proximity to sources such as chromated copper arsenate (CCA) treated wooden structures. Thus, broadly speaking, most local soils do not appear to have strong trace elemental signatures, but some soils that have been affected by local anthropogenic sources may indeed be distinguishable.

To take the forensic aspects of this project a step further, samples that have been transferred to fabric are also being analyzed. A variety of samples have been characterized using XRF. These samples are then poured loosely into large plastic mixing pans and the surfaces moisten using distilled water. A section of clean denim, which shows up as a blank when analyzed using XRF, is pressed into the soil using the knee. The denim is then lifted, placed on a flat surface and analyzed. The objective is to compare the trace element composition of the soil that transferred to the bulk sample. Thus far, too little data has been collected to make any significant statements.

The spatial and temporal distribution of pollen in an indoor setting and upon writing paper

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This study investigates the spatial and temporal distribution of various palynomorphs with particular reference to the enclosed setting of the interior of a house and on writing paper. Experiments were conducted to ascertain the natural distribution of pollen derived from cut flowers which had been placed in a vase, in a normally used living room. The spatial distribution of pollen was identified at 24 hour intervals for a duration of 9 days. The results show that pollen is collected on various surfaces within the room and this facilitates transfer onto a person who enters it. The second experiment investigated the ability of pollen to adhere to writing materials that were used within a room containing cut flowers. The seasonal distribution of different flowering plants provided the possibility that ink on the paper might collect pollen. The presence of such temporally specific indicators could provide a means of verifying or indeed casting doubt the purported calendar date of the written document with implications for the detection of document fraud. The results demonstrated that whilst ink did indeed trap pollen (and that ball point pen was the most receptive type of ink), the paper had greater retentive properties, particularly if the side of the hand rested on the paper during the process of writing. Various papers were tested and differences were identified between their retentive capabilities thus suggesting that pollen on paper does indeed have great potential for verifying purported document dates such as is found in contracts, wills and other legal documents.

Application of geological knowledge in solving disputes

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Disputes related to water supply are common in Portugal, especially in the northern interior of the country, where mainly granitic and schist rocks outcrop. In small villages and farms, many water wells, some of them drilled in the first half of the 20th century, are sited based on local knowledge. In theses regions the geology is important as it strongly determines the locations and depth where groundwater can be found. The growth and expansion of urbanization, agricultural intensification and climate changes are leading to water scarcity in some places where local people thought good quality water would always be available. In some instances, disputes between neighbours are being settled in courts of law, which have recently started to request the assistance of experts. In this presentation, some case examples are presented related to these disputes and this is explained from a technical (geological) perspective.

Bricks and mortar: how much circumstantial evidence is enough?

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Forensic analysis of geomaterials very often is used as circumstantial evidence to help build a case. As such judging when ‘enough is enough’ is not for the forensic scientist, but for the legal team to

decide. This case history highlights just a situation when following initial matching of fired clay bricks to a murder investigation, with an extremely high degree of assurance, the barristers acting for the Crown Prosecution Service (CPS) wanted more!

The case study shows that some times, three times the evidence provides more that 3 times the assurance that the evidence is very strong and helps the legal team build a very robust case. This paper shows how evidence collected during a murder investigation was used to establish a prosecution case backed by 'hard' evidence from what are, at face value, very common and widely available construction materials. Evidential links range from the very obvious to the more tenuous, but together presented a package of circumstantial evidence that was deemed so strong that it was not challenged.

The analytical techniques used are not at the 'cutting edge of science' however, they do show that sound analytical techniques and a knowledge of the materials in question, how they are made, what they are made from, and where they are sold/supplied from, can help reduce the size of the proverbial 'haystack' when looking for evidence from commonly occurring materials found throughout the region, country or even world.

Preservation and analysis of three-dimensional footwear evidence in soils: the application of optical laser scanning

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This paper explore the application of optical laser scanning to the collection, preservation and analysis of footwear evidence in soils using examples from the geo-archaeological record along with a series of scenario based experiments. Optical laser scanning provides a direct, non-invasive method of recording footwear evidence with sub-millimetre accuracy. It allows the original print to be re-visited at any time using a range of viewing angles and light illuminations at any time within an investigation. The paper explores the practical aspects associated with the routine deployment of the technique at a crime scene and how these can be over come as well as providing evidence of how the technique could revolutionize the collection and analysis of footwear evidence. The latter point is illustrated with examples from the geo-archaeological and geological record and via a series of scenario based experiments. The results demonstrate the potential of optical laser scanning for forensic investigations.

Instrumental Neutron Activation Analysis (INAA): practice and potential forensic applications

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Instrumental Neutron Activation Analysis (INAA) is a relatively straightforward technique for determining elemental abundances in a wide range of materials. The method utilizes the interaction between a thermal (or higher energy) neutron and a nucleus to produce a radioactive nuclide that emits characteristic gamma rays. The energy of the emitted gamma rays is used to identify the nuclide and the intensity of the radiation can be used to determine abundance. Solid state detectors are used to sense the emitted gamma rays, and after suitable corrections and comparisons with standards, an elemental concentration is determined.

The advantages of INAA are; (1) it is a relatively cheap analytical method, a state-of-the-art facility can be acquired for significantly less than US$100,000 compared to the much higher costs of competing analytical methods; (2) the method is non-destructive, hence the same sample can be used for other measurements; (3) sample size can be very small, often as little as a milligram; (4) detection limits for many elements are in the nanogram range; (5) no chemical preparation is required, samples are analyzed as is; and (6) on the order of 40 elements can be measured essentially simultaneously. The major disadvantage of INAA is that there are elements that may be of interest in the periodic table that cannot be analyzed by INAA. For this reason INAA laboratories often partner with laboratories that do X-ray fluorescence (XRF) analysis, which is a complementary technique to INAA. The combined methods can produce high quality data for about 60 elements in the periodic table. The elements that can routinely be determined by INAA, and their detection limits, are listed in Table 1.

DL (nanograms)	**Elements**
0.01-0.1	Au, Eu, Ho, Ir, Sm, Lu
0.1-1	Ag, As, Co, Cs, Hf, La, Sb, Sc, Se, Ta, Tb, Th, Tm, U, W, Yb
1-10	Ba, Br, Ce, Cr, Gd, Mo, Na, Nd, Ni, Rb, Sr, Zn, Zr
10-100	K
100-1000	Fe

Table 1. Detection limits (DL) for elements that can be determined by INAA.

There are numerous potential applications for INAA in forensic investigations. Here we give two examples, determining the source of maple syrup and identifying the region of origin of grass samples.

Maple syrup: During the production of maple syrup there are several opportunities for the introduction of characteristic elemental signatures. Initial elemental signatures in the sap due to differences in the underlying soil chemistry, trace elements introduced during the tapping of the tree and transport to the sugar house, and trace elements introduced during the boiling down of the sap to produce maple syrup. In Table 2 we list selected elements and elemental ratios for maple syrup from various sources that allow us to distinguish between these different sources.

	Quebec	**Newton**	**Winsor**	**Parker**	**Gale**
Sc	0.030	0.010	0.009	0.004	0.006
Cr	1.67	0.67	0.71	0.83	0.87
Co	0.119	0.094	0.064	0.073	0.057
Zn	19.4	9.3	13.1	**50.6**	**76.3**
Rb	9.0	7.5	3.1	10.2	15.7
Sr	17.5	**28.6**	13.7	10.7	8.3
As	0.016	0.029	0.014	0.022	0.010
Sb	0.009	0.018	0.010	0.034	0.010
Se	**8.72**	ppb			
Zn/Cr	11.6	13.9	18.5	61	88
Rb/Cs	419	642	363	**433**	**175**
Ba/Sr	0.37	0.59	**0.18**	0.76	1.29
As/Sb	1.91	1.59	1.50	0.64	2.24

Table 2. Elemental characteristic of maple syrup. Numbers in bold are characteristic of the particular sample.

Serengeti grasses: Grass samples were collected from a variety of locations in a several hundred square kilometre area of Serengeti National Park, in Tanzania. The major genera are Digitaria, Pennisetum, Sparobolus, and Themeda. The samples were analyzed for a number of trace elements by INAA. Many elements were determined in the ppb to 10s of ppm range. Grass samples collected from different areas show different abundances and abundance ratios for a number of the trace elements. These variations are in part due to variations in the chemistry of the underlying soils. Hence, trace element abundances can be used to identify the geographic location of a grass sample. It should be noted that 50 years ago mineral exploration geologists used the chemistry of plant materials to explore for ore deposits. Elevated abundances of the elements of interest in the plant material suggested a possible exploration area. Ecologists have also shown for the more common elements that there is a relationship between soil chemistry and plant chemistry. Hence the relationship between soil chemistry and the chemistry of plant material is well established and can be used to differentiate between grass samples collected from different areas.

Communication in forensic geoscience featuring an example from TV

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Over a century ago Georg Popp was the first scientist to present a case in court where the geological composition of soils was used to secure a criminal conviction. Since then there have been considerable advances in the theory and practice of forensic geoscience. Geoscientists frequently may form part of a multi-disciplinary team of specialists involved in the investigation of a particular crime or forensic investigation. The disciplines of geology, geophysics, soil science, microbiology, and geomorphology have all been used to aid such forensic investigations. Increasingly, interest has been shown by investigating authorities in the application of earth science to forensic case work. This places an onus on the scientist to develop effective means of communicating sophisticated methods and complex terminology to a diversity of audiences.

Geoscientists are frequently required to present results, give advice and provide recommendations to a variety of end users (for example, policy makers, the public, lawyers, juries, non-technical specialists, police officers, the public and the media). However, often, the communication of such information is challenging, and can often be more difficult than the forensic investigation itself. The challenge is to know and understand the communicative style of your intended audience and then adjust accordingly. For instance, it is vitally important to understand how law enforcement officers communicate to each other, which is typically in a forthright and decisive fashion. Often by communicating results in a balanced academic fashion this is poorly received and misunderstood by law enforcement officers as being indecisive or inconclusive.

Forensic scientific investigators often use highly sophisticated scientific techniques and complex terminology, which, when combined with cultural and language barriers, social, political, religious or economic constraints, it can be difficult to convey the correct messages. The recipient can be disadvantaged in trying to fully understand the implications of the information available. In addition, there are multiple requirements to meet the demands of our legal systems.

Communication between scientists and victims and their families, the public and the press is a very sensitive matter. This may be potentially difficult to manage at a crime scene or during a search. This requires special training and careful monitoring, as both can go very wrong. This may be traced, in part, to poor communication skills and lack of appropriate training. By comparison, law enforcement officers are adept and experienced at communicating with all sections of society. Effective communication is a core policing skill. Scientists have much to learn from law enforcement officers, and much can be gained from this scientist law enforcement pairing.

Communication must be considered to be part of any geoforensic investigation, from the first point of contact with the investigating officer, to the discussions with the press officer after the case has been heard in court.

If the correct message is not conveyed properly, is misunderstood, or mis-interpreted, the consequences can be unpredictable and to the disadvantage of many parties. Different context and types of the communication also must be appreciated by geoscientists. For instance, the communication may be rapport building, ‘on-or-off the record’, providing information, providing investigative intelligence or providing evidence.

Communication is a natural instinctive process, but also can be a skill learnt by both training and experience. It relies on the ability to convey information effectively, confidently, clearly and consistently. This paper provides examples from case studies and draws upon UK and international experiences of the authors, and is primarily aimed at raising the awareness of the importance of communication in forensic geoscience. We must embrace the various routes to that effective communication, whether it be scientific, newspapers, radio or TV. All have their different focus and audience types, wording and lines of communication should reflect this. We should also consider other routes to communication to the wider public (Fig. 1).

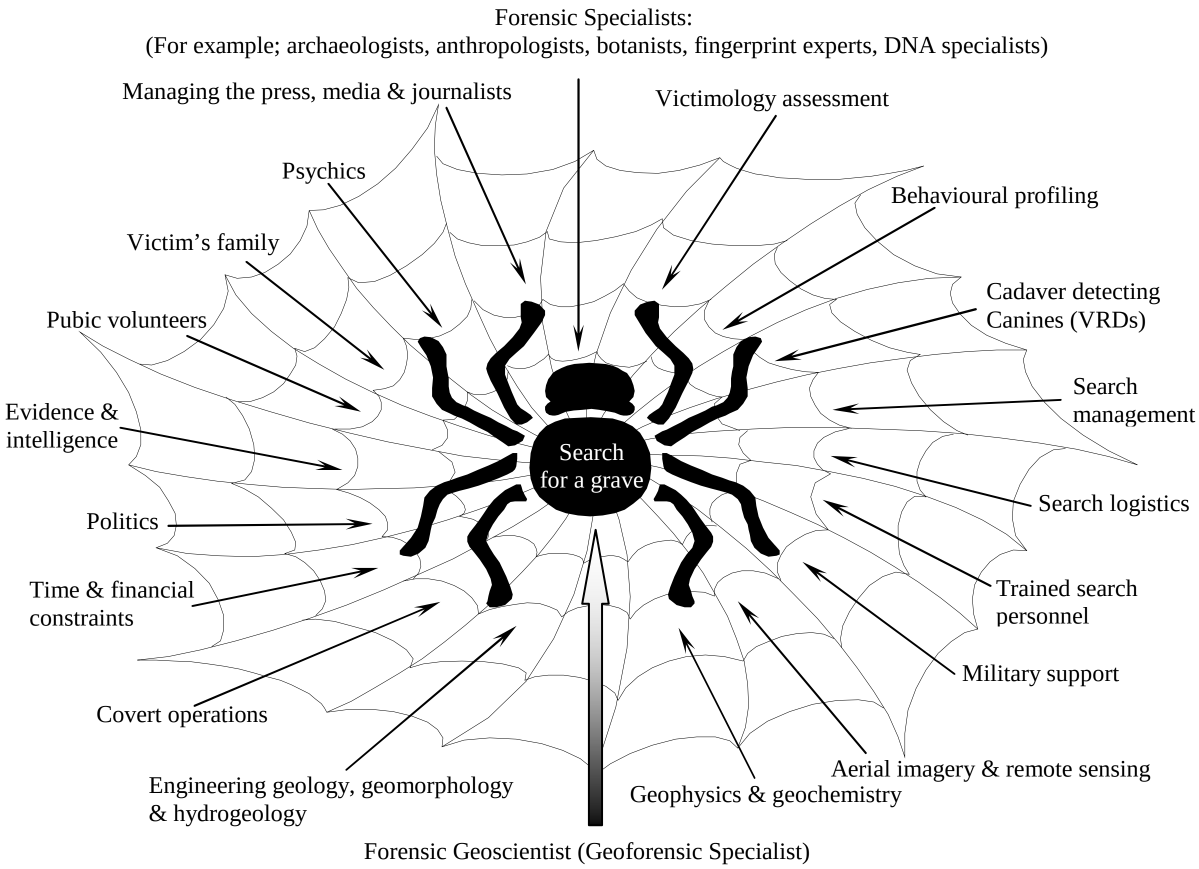

Fig. 1. The introduction of a geologist to an already established police search team must be carefully co-ordinated and properly managed. The geologist must be able to effectively communicate with the other subject matter experts, be aware of his/her limitations and understand the role and capabilities of other experts (modified after Donnelly 2002, published in; Donnelly 2008, Harrison & Donnelly 2008).

The Council for the Registration of Forensic Practitioners (CRFP): an opportunity for forensic geoscientists

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The Council for the Registration of Forensic Practitioners (CRFP) currently has over 2700 registrants in a wide range of forensic disciplines, from anthropology to firearms, to linguistics to toxicology, on its register. Increasingly, courts are looking to see whether those who present forensic evidence are registered. CRFP is completely independent of other professional groupings and organisations. Successful registration follows an assessment process that demonstrates current casework competence as determined by the peer review of a selection of recent cases by experienced assessors from within one's own discipline. Assessment of casework is against published criteria, which include matters such as the appropriateness of techniques chosen and the interpretation of results in the context of alternative hypotheses. The specialty of 'Natural Science' has been created as an umbrella specialty within CRFP under which a number of smaller disciplines can operate. Currently those disciplines that have been identified as suitable to come under this grouping are earth science, entomology, environmental science, hydrology, marine science, meteorology and plant science. It is possible that others may be added in due course. The specialty is headed by the Lead Assessor for Natural Science, Dr Adrian Linacre of the University of Strathclyde.

Initially, in the 'Natural Science' specialty assessment will be carried out by experienced CRFP specialty assessors from related CRFP specialties. They are able to assess the forensic process, with additional support available from a number of academic experts in the relevant fields who have indicated a willingness to assist in more technical matters. The creation of the 'Natural Science' specialty provides an opportunity for those in the geosciences and related areas who carry out forensic work on a fairly frequent basis to consider registration and to benefit from the additional value that gives when presenting their evidence in court.

Using remote sensing to map and monitor London's geohazards

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Remote sensing involves observing the Earth's surface from a distance using various types of sensor, from cameras through to infra-red sensors, radar and laser scanners. There are many geohazards in and around London that can be detected using remote sensing. The London Clay and Wealden Clays poses a less dangerous but more widespread hazard, causing costly damage through shrink-swell activity and occasional slope failure. The chalk lands have a subsidence hazard, from underground mining and natural sinkholes. Satellite radar interferometry (InSAR) can detect mm-scale ground deformation in urban areas and has shown that the Earth beneath the feet of many Londoners is not as solid as they may think.

Aerial photographs collected by the Luftwaffe in World War 2 (WW2) and the Royal Air Force (RAF) in the late 1940s now form a valuable archive, showing the locations of factories and sites associated with contaminated land. Recently, airborne Laser Altimetry (or LiDAR: Light Direction And Ranging) has been used to produce detailed digital elevation models of the land surface, with decimetre contour intervals. Because LiDAR can determine the top and base of vegetation cover, "seeing" through tree cover; it has been used for mapping sinkholes in woodland and floodplain hydrological modelling. The biggest threat to lives and property in London comes from flooding, especially as global warming is increasing the probability of a major North Sea storm surge, remote sensing is helping us to visualise, model and (hopefully) better manage such a disaster.

The future of geoforensics

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The halcyon days of forensic geology, when the application was 'new' for geoscientists, and promised to solve all manner of crimes for the police, are over. The reality is that we really are in the best position by taking what we do best as geoscientists and applying it to problems that can broadly be described as 'forensic' (for example; search, comparison/exclusion of materials, identification of suspect materials/counterfeit goods).At least seven international meetings; five text and research books and numerous papers on geoforensics since 2002, allow us to review what has been achieved. Together, these can be used to demonstrate where geoforensics has been and some likely avenues of research and application in the future.

At the macro-scale, the increased use of landscape (geomorphological) interpretation, integrated with geology, and based on advanced, multi-sensor remote sensing, geophysical instrumentation and the development of new search philosophies, strategies and methodologies has enhanced both the search for buried objects and sampling for forensic analysis. Advances made in the 'search' aspects of geoforensics have been made largely directly from the results of police officers and geoforensic practitioners working more closely together, in the field and at crime scenes, to develop geological search strategies within a law enforcement context. At the micro-scale, multi-proxy analysis of samples for exclusion and comparison will increasingly begin with non-destructive testing, followed by selected specialist work through mineralogy, geochemistry, biochemistry, crystallography and microbiology. Further advances may well come from the analysis of precipitation-based residues, atmospheric materials and cosmogenic fall-out. Geological techniques also have the potential to be used on unusual materials used in fraud (fakes), drugs and explosives manufacture and in construction. One of the most significant geoforensic advances since 2002 has been the recognition of the need for clear and effective communication between geoscientists and the police investigators. The objectives of this presentation are to provide an overview of recent developments in geoforensics and to consider the future role of geoforensics in this rapidly emerging and evolving field of geology.

Soils, plants, pollen, and fungi: a key multidisciplinary approach in criminal investigation

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In many forensic investigations, soils and sediments have yielded important evidence. In others, soiling is not even visible on the exhibit but good results have been achieved. Rapid scanning of biological particulates can confirm whether or not an item has even touched soil and, in many cases, it can differentiate between mineralogically similar soil and sediment samples.

In recent years, the authors have been involved in cases where the examination of pollen, spores, fungi, and whole plants have had important outcomes in: finding clandestine burials; finding murder sites; eliminating irrelevant places; estimating time of death; and time of deposition of murder victims. In a recent test situation, analysis of pollen and spores from clean fabric has even resulted in the accurate location of the site of transfer when it could have been anywhere in the world.

In a considerable number of cases, the palynological, botanical, and mycological contributions have provided the only forensic evidence and contributed to successful convictions. Some recent case histories will be presented to exemplify the use of these types of evidence in different situations.

Forensic geology in the United Kingdom and the United States

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Forensic geology is currently enjoying a renaissance in the United Kingdom, and to a lesser extent in the United States. Since Murray and Tedrow's 'Forensic Geology', was first published in 1975, the field has grown such that 'Forensic Geology' is regarded especially in Great Britain as a subset of the larger discipline of 'Forensic Geoscience' or 'Geoforensics' and these include the broader field of 'Environmental Forensics'.

Recently published papers and discussions with practitioners indicate differences between the United Kingdom and the United States in analytical methods and approaches to forensic soil/geology cases. These differences include more emphases on environmental forensics, geophysical methods to detect buried bodies and objects, the use of instrumental methods such as scanning electron microscopy, x-ray microanalysis, stable isotope applications, statistics in forensic geoscience research and casework in the United Kingdom than in the United States. Casework in the United States is dominated by traditional particle characterization. Glass identification is generally similar in both countries.

Many factors contribute to these differences. However, privatization of all forensic laboratories in the United Kingdom, including all governmental laboratories, appears to be dominant. This has resulted in an explosion of both small and large private and university related laboratories. These laboratories, which are highly competitive among themselves, have access to instrumentation not available in most governmental laboratories. Crime rate, population and geographical size also contribute. Case studies illustrate the different approaches and emphases observed across the Atlantic.

The 3rd international conference on soil forensics, California, USA

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The 3rd International Conference on Soil Forensics will be held in the 'fall' (autumn) of 2010 in Southern California. The conference is hosted by the California Department of Justice and the California Association of Criminalists. Plans are to cover a wide variety of topics related to Forensic Geosciences and Environmental Geoforensics and to have a large international contingent of participants.

Southern California is an exciting venue as it offers beautiful weather all year round, breath-taking coastal, mountain and desert scenery, top-rated shopping and restaurants, attractions such as the original Disneyland and Universal Studios where many of the sets of your favourite movies and television programs are located, the Getty Museum, the world famous Long Beach Aquarium, quaint

Catalina Island, and many other sites. Announcements will be posted on various forensic geoscience websites and forensic websites in the near future. We are looking forward to your participation and hope to see you there!

Forensic investigations in engineering geology, mining geology, geomorphology and geohazards

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Geoforensics is not only concerned with the application of geology to help the 'police' solve certain types of crimes. Engineering geologists for example, may be required as expert witnesses or expert advisors in liability claims, litigations, arbitrations and tribunals for geological hazards (such as floods, erosion, landslides, rock slides, mudslides, problem soils, shrink-swell clays), mining (including fraud, subsidence, mine roof collapses, floor heave, gas emissions, contamination, tailing dam failure, underground and surface explosions, the collapse of high-walls in open pits) or the failure of civil engineering raw materials (like concrete), building collapses, or the failure of structural foundation.

The specific details of each individual case are unique, vary considerably and may often be complex. In general, many of these types of investigations may be aimed at determining; what happened, where, and when it occurred, and how and why 'it' (the geological event) took place. Often, there may be a claim of 'negligence' or 'unreasonableness' or 'unforeseeable' ground conditions, which may have caused or exacerbated the particular geological problem. There may also be focus on whether the geological event was actually foreseeable and if it was possible to forecast the timing, magnitude and likelihood of occurrence of a particular geological hazard or event.

This paper provides four 'forensic' case histories all of which required specialist expertise in engineering geology, geomorphology, mining or geohazards.

The first case discusses the reactivation of geological faults and the generation of a major compound landslide which caused the demolition of at least 10 houses and widespread damage to other house and infrastructure, in Derbyshire, UK. This investigation focussed on whether the landslide was caused by the natural failure of an escarpment or whether it was induced by mining subsidence and fault reactivation.

The second example describes a case in Latin America where roof supports failed in an underground mine due to the presence of soft rocks which could not support the load of the mine machinery.

The third case provides an overview of a fraudulent mining 'scam' which influenced significantly a stock exchange. This was caused by the introduction of 'similar' (but not identical) mineral grains into drill core to artificially inflate the price of the mineral resources and the mine assets.

Finally, when a person fell into a crown hole (surface cavity created by the collapse of soil and rock into mine workings) in the Former Soviet Union, mining geologists with an appreciation of the geology, mine layout and mining methods influenced the underground search for the body, which was subsequently found in the mine, in an abandoned mine roadway.

The development and significance of a conceptual geological model, in different geomorphological settings, to search for a murder victim's grave

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Traditional methods and techniques used by geologists during mineral exploration and geotechnical site investigations, to map, explore and characterise the ground are increasingly becoming used to help the police search for murder victims' graves, in the UK and world-wide. Techniques such as; geophysics, geochemistry, geomorphological mapping, probing, trenching, trial pitting and remote sensing have been used by geologists for several decades to, for example; explore for mineral resources, locate groundwater supplies, investigate geohazards or conduct geotechnical and engineering geological ground investigations as part of a civil engineering site investigation. These are directly applicable to law enforcement searches as the underlying search philosophy, concepts and principles are similar. That is, an object/target (such as a murder victim or associated items) is buried or concealed and the ground must be searched as it is desirable to find the victim.

Historically police searches for murder victim's graves were conducted using visual or manual probe line (finger-tip) searches, 'trial and error excavations' sometimes in association with large numbers of police, military, or public (non-specialist) volunteers. These searches may cover large areas of ground and walking along formalised gridded sectored areas. Police dogs (known also as victim recovery dogs (VRD) or cadaver detecting canines) have been used with varying degrees of success. These types of searches were not always efficient, labour-intensive and often may have destroyed the potential to acquire 'evidence'. What is more, subtle ground disturbances (such as settlement, compression, fissures, seeps and springs) often associated with reinstated graves may go noticed. Geologists with a 'trained eye and an informed mind' are more likely to observe such features as they are able to 'read the ground'. Combining the skills and experience of a police officer (search advisor and associated assets) with the search and exploration capabilities of a geologist has enabled police searches to be more effectively and professionally conducted to a high level of assurance.

The most valuable service a geologist can offer a Senior Investigating Officer (SIO), Scene of Crime Manager (SOCO), Crime Scene Manager (CSM), Police Search Advisor (POLSA), coroner, or law enforcement search strategist; is a conceptual model of the geology and expected ground conditions in the area where a grave (or buried object) is suspected to be located. Beforehand however, this relies on the police providing intelligence on the likely area where a grave may be located (for example; in a desert, on a mountain, coastline, estuary, woodland, beach, remote moorland, landfill site, back garden, field, quarry, and so on). Possible burial sites may further be deduced if there is information available on behavioural profiling of the offender/suspect, and victimology assessment of the victim. The geologist is able to provide information on areas where a body may be buried (ie. the digability of the ground). Equally important in the early stages of a search, a geologist may be able to suggest areas where burial or concealment is less likely to have taken place, therefore enabling resources and assets to be prioritised, which may be significant in searches which are 'time critical'. The geologist may be able to provide an assessment of the geological and geomorphological processes which contributed to soil formation and determine if these processes have continued since the burial of a body took place. An understanding of the origin, source, types, thicknesses, engineering, chemical and physical properties of the soil, rocks, groundwater and the body (and associated objects such as; clothing, jewellery, money, drugs, explosives and weapons) will be required. The geological factors which may have a bearing on search scale, philosophy and strategy includes; tectonic setting, stratigraphy, lithology, structures, hydrogeology, hydrology, groundwater, hydrochemistry, superficial deposits, soil types and thickness, nature of the bedrock interface, engineering properties of the ground, geomorphological processes, past and current land use, and man's influences in the ground (such as mining, building, tipping, digging, utilities, services and civil engineering). The conceptual geological model will also need to estimate the geological 'properties' (condition) of the grave and body, and determine how these have been influenced by geological and geomorphological processes since burial took place.

The conceptual geological model, especially if combined with reconnaissance visits to a crime scene or search area (to conduct a ‘walk-over’ survey) will determine the types of detection methods and search assets that are most likely to locate the grave. The conceptual geological model should evolve and develop as the search begins, being refined and improved as more information on the ground (geology) is acquired. The accuracy of the geological model will be proven only when the grave and body has been located. The associated value of the conceptual geological model is that it may also facilitate communication between the multi-disciplinary subject matter experts that are usually involved in such a search, and may not necessarily be familiar with complex geological terminology. What is more, it enables the search for a grave to be conducted to the highest level of assurance to prove the presence or absence of a human body, within an area suspected to contain a homicide grave. No single model can be applied to all crime scenes, due to the complex range of geological conditions which are unique to each location. Examples for burials in interbedded granular and cohesive soils (or layered peat) in a temperate environment, a desert sabkha and a desert sand dune are presented in Fig. 1, 2 & 3).

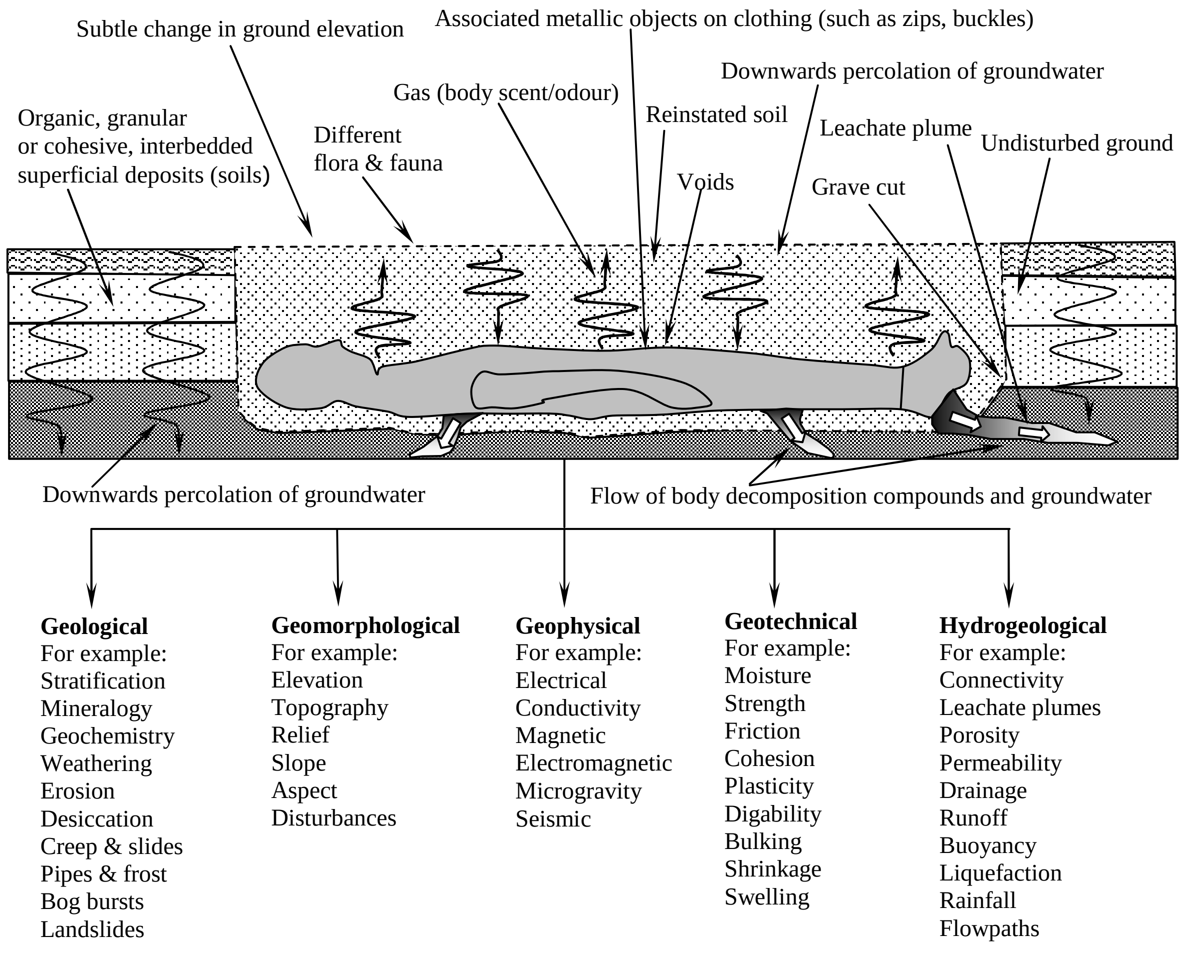

Fig. 1. Conceptual geological model for a shallow homicide grave in interbedded, granular, cohesive or organic (peat) superficial deposits and soils, in a temperate environment. The geological, geomorphological, geophysical, geotechnical and hydrogeology properties of the body, reinstated ground and undisturbed ground may change after burial. This type of model may assist in determining the most suitable suite of assets for conducting a search. This may include for example the deployment of geophysical surveys and specially trained cadaver dogs (modified after Donnelly 2002, published in; Harrison & Donnelly 2008).

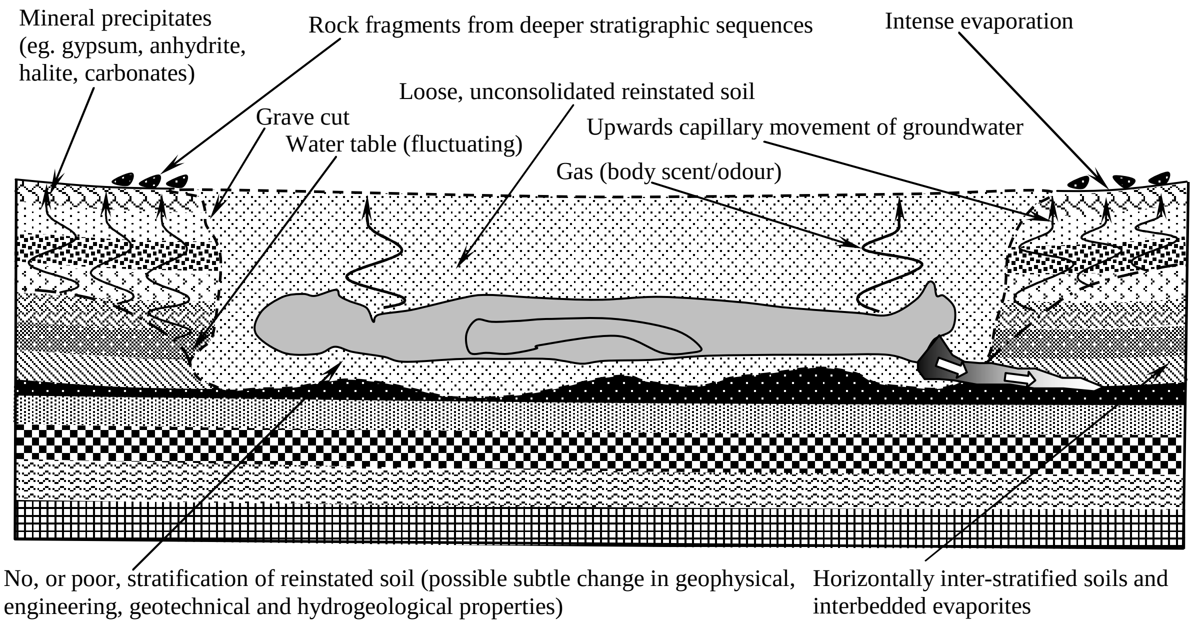

Fig. 2. Conceptual geological model for a shallow homicide grave in a desert playa, salina or sabkha. These may be characterised by ephemeral lakes (playas), or flat, vegetation free, topographic lows in pediment and alluvial plains (salinas), or on coastal plains (sabkhas). Fine-grained clastic, non-clastic sediments may accumulate from aeolin and fluvial processes or by groundwater flows caused by capillary rise. Groundwaters are often saline and upon evaporation deposit evaporite salts on the ground surface. These deposits, if containing silts and clays, also may be susceptible shrinkage and desiccation. Ground surface structures can be complex and these may be disturbed by digging during body disposal.

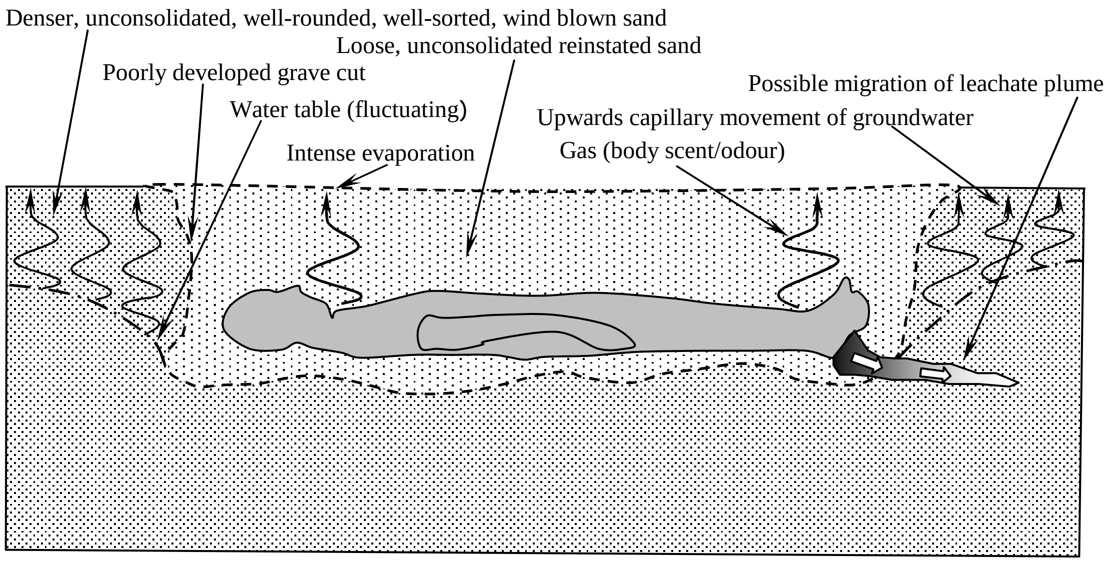

Fig. 3. Conceptual geological model for a shallow homicide grave in a desert sand dune (an area of wind-blown sand). Most dune material is composed of medium sized quartz (sand grains, c0.2 to c0.7 mm in diameter). Dunes are usually well-graded and well-sorted (similar sized grains) having particles of similar roundness. Sand dunes have a poor load bearing capacity and are difficult to compact. These loose to medium dense sands may undergo settlement and movement by erosion after burial has taken place. As a result of the engineering and geotechnical properties of the sand a distinct 'gave cut' may not develop. There may be little, if any, contrasting geophysical or geotechnical properties between the undisturbed sand dune and the sand which has been disturbed (by digging) and reinstated into the grave to conceal the body. This may make the detection of the body by geophysical methods more difficult (but not impossible).

Posters

Cutting it fine: blood pattern detection on grass

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Forensic natural science disciplines such as forensic soil science, forensic palynology, and forensic botany, often have to operate outdoors where the environment introduces a myriad of variables that can affect the post-depositional fate of trace evidence. In the case of bloodstain pattern analysis, little research has been carried out on the effects of the outdoor environment on the survival and degradation of bloodstains deposited on various natural surfaces. A review of research to date indicated that what has been done has been limited to the detection of blood patterns on the ground surface using luminol, a chemiluminescence reagent that, with iron in haemoglobin acting as a catalyst, reacts with an oxidising agent to produce a distinctive blue glow. Grass, despite being a vegetation cover commonly encountered at outdoor crime scenes, is a surface for which no previous research on the degradation and detection of bloodstains by these methods has been published. To study the preservation of bloodstains on grass, blood patterns were deposited on test plots and exposed to the weather (elements) for 2, 6 and 10 weeks. After these time intervals, the samples were tested with the successor to luminol, Bluestar® Forensic. The results show that although the visibility of the bloodstains was significantly affected by rainfall, a chemiluminescence reaction was detected with Bluestar® Forensic on all of the samples tested. As would be expected, the older the bloodstains the less intense this reaction became. However, cutting the grass back to a height of approximately 10 mm above the soil significantly enhanced most of the reactions (Fig. 1) as blood residues had been washed onto the lower parts of the blades and surface of the soil while broadly retaining the patterning of the original deposit. Furthermore, for some samples, a reaction was detected 20 mm down in the soil.

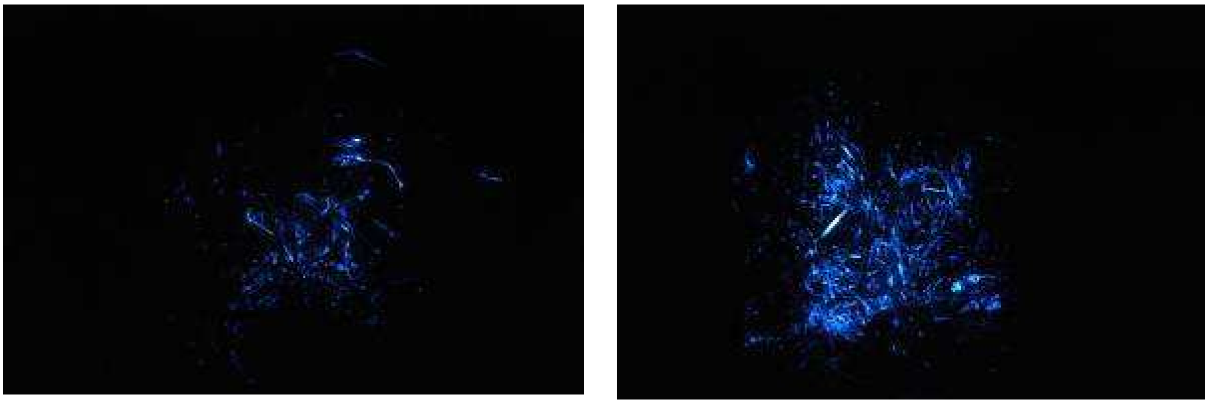

Fig. 1. (Left) chemiluminescence reaction from blood on grass, prior to and (right) after cutting the grass to a length of 10 mm (photographed with a Nikon D40 digital camera).

This research has demonstrated the value of Bluestar® Forensic to detect bloodstains that are up to 9 weeks old deposited on grass and soil, and the significance of cutting back the grass for to enhance detection, and the transport of blood residue into the soil profile. As well as extending the time intervals for this experiment, it is suggested that further work should look at blood pattern survival on a wider range of vegetation and soil types, on other natural surfaces (such as rock), together with investigating the rates of transport of blood residues into and through soil profiles, and how best to minimise destruction and maximise evidence recovery in such situations.

Diatoms: how useful are they in the recovery of human remains?

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This paper will examine the usefulness of diatoms in locating the deposition and/or recovery locations of human remains from waterways. Forensic scientists are constantly developing new techniques, many from within other scientific disciplines, to aid in answering questions previously thought too difficult to determine. This follows Locard's principle that every contact leaves a trace, even if detection methods are not at the time capable of discerning it. Trace evidence is at the forefront of these techniques being developed and includes the use of diatom analysis for tracing locations, perpetrators and weapons.

Diatoms are a large and ecologically important group of unicellular or colonial algae. They represent a major taxonomic division of phytoplankton and grow abundantly in rivers, colonising almost all suitable habitats. They are common and frequently dominate planktonic and benthic algal communities reacting to changes in limnological variables, such as pH, dissolved organic carbon, temperature, salinity and brine content and nutrients. Different species prefer different levels of these factors. This specificity makes them an ideal diagnostic tool in the world of forensic science, an as yet an under utilised research area of great potential forensic significance.

This study was undertaken to assess the viability of utilising diatom profiles, as each species is habitat specific, using quantitative microscopy, to locate the recovery area of human remains, too badly degraded to be assessed by pathology, and if possible the deposition area, which may enable investigators to gather more evidence, should it be required.

Control samples were collected from an area of a Lincolnshire river where a skull, used as the unknown sample in this study, was recovered. All samples were prepared using standard cleaning techniques applied in environmental and geological disciplines.

The observed data for the control samples was compared to the unknown skull sample. The number of control samples taken was small and further samples would be required to assess the usefulness of the technique.

This preliminary study raised many questions that need answering and as such a number of recommendations will be suggested to overcome these deficiencies in this method of forensic investigation. In addition, an attempt will be made to go some way to standardise operating procedures for the collection and identification of diatoms.

Analysis of simulated clandestine grave contents to assist search teams in the detection of clandestine burials

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Recent studies have reported that cadaver decomposition products have an important role in the detection of clandestine burials when utilising geophysical methods, they also have a use in 'time since death' determinations. Elevated conductivity, pH and certain element concentration levels have been observed in surface waters downstream of cemeteries. Initial work has also been undertaken to develop soil water chemical tests in an attempt to provide gravesite indicators.

In this study, simulated clandestine burials were created in a semi-rural environment using domestic pig cadavers as human proxys (due to the UK 2004 Human Tissue Act preventing the use of human tissue). Two 'graves', c2 m x c0.5 m were hand-excavated to c0.5m below ground level (bgl). One grave was backfilled with excavated material to act as an 'empty grave'. The second grave was filled with the c75 Kg, 1.5 m-long pig carcass, before backfilling and replacing overlying grass sods. Vertically oriented, water lysemeters were placed in both graves and in a 'control' position well away from the 'graves' to collect 'empty', 'grave' and 'background' soil-water respectively. Lysate samples were extracted on a fortnightly basis for 6 months post-burial and stored frozen for subsequent batch analysis. Collection is ongoing at monthly intervals. The nearby university campus weather station allowed for comparative measurements of rainfall, surface and 0.5m bgl temperature readings over the survey period.

Field investigations and, laboratory biochemical analyses have been undertaken to offer complimentary data. Samples have been analysed for conductivity and pH, and Merckoquant™ 'field test kits' have been used to offer semi-quantitatively determination of the presence of specific elements of interest. Conductivity measurements of the 'grave' showed linear increases over the time period of the study and it was found to be 50 times as conductive as background readings after 6 months (Fig. 1). The 'empty' grave demonstrated similar readings to background. A more complex pattern was found for the pH values, the grave showed an initial decrease up to 3 months post-burial, before increasing continually up to six months post-burial; the 'empty' and control grave pH levels were more variable (Fig. 2). Potassium ion concentrations from the grave showed increasing values when compared to background. Phosphate levels initially decreased up to week 6 and then became consistently lower than background values. Nitrate and Sulphate levels did not demonstrate elevated grave values in this study. ICP-OES analysis of the lysate showed increasing potassium, sodium and magnesium values 'post-burial', with other element ions showing a variable signature. Complex data from the FTIR trace element spectral analysis and GC-OES analysis is still ongoing.

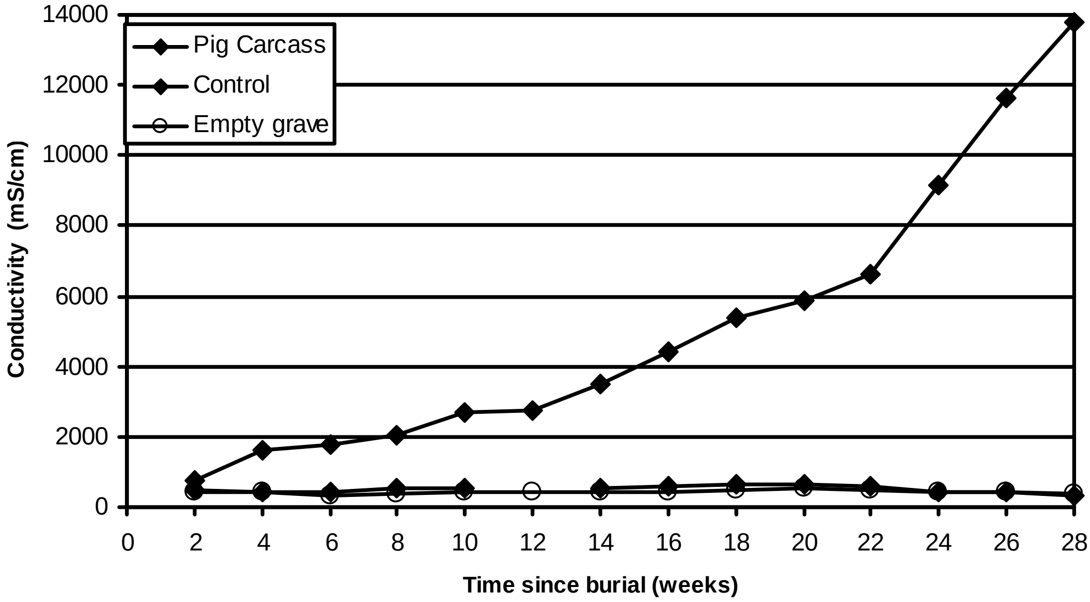

Fig. 1. Sample field measured conductivity values for the pig grave, empty grave and background control values.

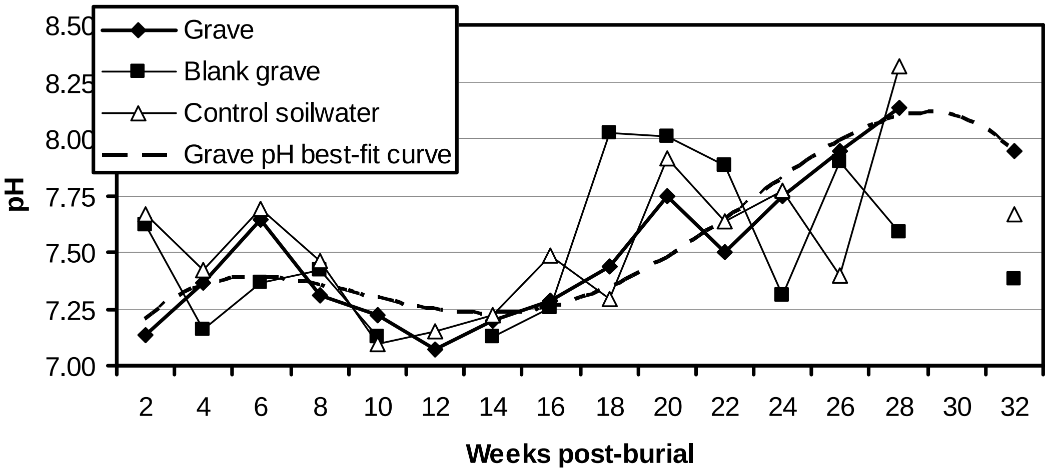

Fig. 2. Laboratory measured pH sample values for the pig grave (& best-fit curve), empty grave and background control values.

Forensic geophysics

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Forensic geophysics is not just about finding buried dead bodies. Shallow and deep geophysical measurements answer fundamental forensic questions; using science to discover what happened, when and how.

Seismic data have been used since the First World War when the German Army used refraction to predict where heavy artillery guns were located, allowing return fire without direct observation. Seismic monitoring has allowed the study of bombings/large explosions such as; nuclear weapons tests, nuclear reactor accidents, chemical explosions (from terrorist attack to industrial accidents and mining/quarrying blasts), airplane and train crashes, landslides (for example, mine spoil heaps) and major tunnel collapses.

Electrical resistivity, induced polarity, self-potential magnetic & electromagnetic methods all have a major role to play in forensic studies, including the burial locations of murder victims and the assessment of toxic waste sites.

Magnetometers have been used to find a truck, used in a hijack and buried in a sand pit.

Ground-penetrating radar (GPR) has become one of the main geophysical tools for those involved in the search for buried organic remains such as the victims of homicide and genocide.

Radiometrics have been used for fly-over and sometimes walk-over surveys of radioactive mine-waste. In the future, GIS-linked multi-sensor platforms and software advances will make many shallow geophysical applications even more relevant to forensic science.

A modelling/inverse-scattering approach to investigate the potential of GPR for the location of archaeological human remains

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Ground-penetrating radar (GPR) has been used to detect buried human remains in forensic investigations. However, in archaeological prospecting GPR has been used mainly to locate tombs, burial chambers and coffins, rather than the body itself, since the decomposition process makes very difficult the detection of small-sized skeletal remains especially if buried in heterogeneous, conductive soils.

Previous papers have demonstrated the usefulness of finite-difference modelling to assess the detectability of human remains for forensic investigations. Numerical simulations can indeed investigate the ability of GPR to resolve diagnostic features of the human body under various subsurface conditions and survey parameters. The modelling results can assist in planning the acquisition of real data and provide test data for evaluating the performance of data processing algorithms.

In this paper, we present the results of a feasibility study for the use of GPR to locate human remains in archaeological contexts, and to investigate its resolution capabilities. We exploit a novel approach based on the integration of modelling and tomographic inversion. GPR responses for the usual monostatic or bistatic survey configuration are simulated for various body cross-sections (Fig. 1A) using either a 2D frequency-domain electromagnetic forward solver or 2D and 3D finite-difference time-domain (FDTD) algorithms. The inversion is performed through an innovative frequency-domain tomographic technique based on the solution of a linear inverse-scattering problem under the Born approximation.

Our results show that, although a proper reconstruction of the distribution of the subsoil electromagnetic parameters cannot be achieved in complex realistic situations, this technique allows a better location of buried human remains than conventional GPR processing (Fig. 1B).

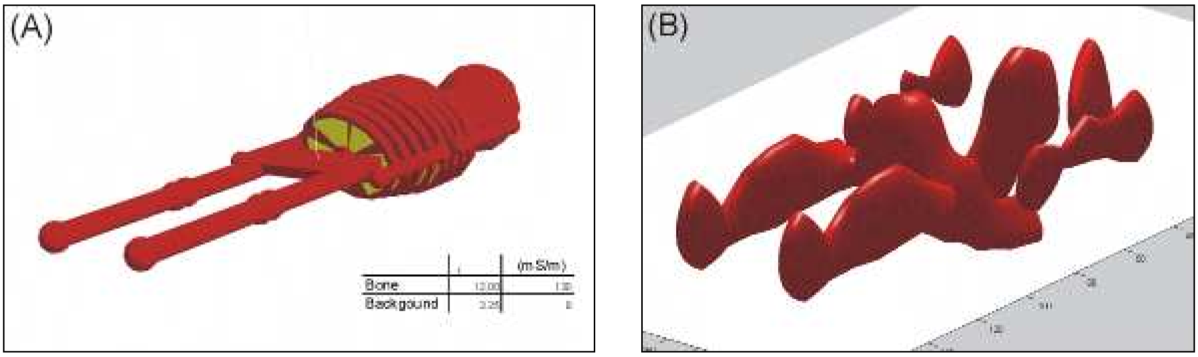

Fig 1. (A) Numerical skeleton model placed 0.5m below ground level with GPR attenuation factors with; (B) resulting 3D numerical inversion from synthetic 900 MHz 2D profiles, set 20 mm apart and 20 mm trace interval.

Source apportionment of nuisance dust with directional collection and multi-element fingerprints

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Local sources of nuisance dust are widespread in most societies, be they industrial or agricultural, urban or rural. Attempts to contain emissions are directed by legislation and informed by statutory guidance, within the overall context of national and international air quality strategies. In many cases, local monitoring is a prerequisite for efficient development of dust suppression. In cases of dispute or particular concern, it is often necessary to confidently attribute problem dust to one or more local source(s); in effect to answer the fundamental question: whose dust is it? This contribution describes a method of dust source attribution developed by DustScan Ltd, which combines a simple and cost-effective technique for collecting ambient dust by direction, with multi-element analysis by plasma spectrometry.

DustScan is a passive system for monitoring fugitive dust 360° around a replaceable sampling head. It uses a transparent, permanent adhesive, 'sticky pad' on a 70 mm diameter cylindrical monitoring head. The dust monitoring head is mounted on a stand and fixed approximately 2 m from the ground. The sticky pads are manufactured by specialist suppliers from stock material and comprise three principal layers: a transparent PVC film, a permanent, cross-linked polymer acrylic adhesive and a silicone-coated paper liner that is removed at the start of monitoring. Measurement of dust coverage on the sticky pads after monitoring uses a computer-based scanning system and specific software. The pattern of dusting on the sticky pad indicates the direction and scale of potential dust nuisance by direction. Given this information, samples may be taken according to suspected dust source, and subjected to a range of geochemical analyses including acid dissolution (HF-HNO3) prior to analysis by ICPAES or ICP-MS. Rigorous blank correction procedures are essential to account for metallic components of the sticky pads themselves, but good results are obtained for a range of elements including Cu, As, Cd and Pb. Careful assessment of the data often allows source-specific elemental criteria to be established; the elemental fingerprints of dust type. In the simplest of cases, this is sufficient to identify the source of a problem dust, but more commonly some form of mixture deconvolution is required. Various intuitive graphical techniques have been successful in small-scale studies, but multivariate statistics provide a powerful tool as the site database increases. Studies based on such techniques have been undertaken at a variety of industrial sites including landfills and quarries, packaging warehouses and solid fuel handling depots, marinas and harbours. Examples of these are described in order to give an overview of the potential offered by low-cost dust sampling equipment when combined with sophisticated but now standard analytical capability.

Commercial displays and exhibitors

Geoscan Research Ltd

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Geoscan Research Ltd designs and manufactures geophysical instrumentation for both professional and amateur use. Although primarily for archaeological use, our products are also used increasingly in other areas including; environmental, forensics, geological, civil engineering and peace-time military applications.

The product range at present comprises earth resistance meters, fluxgate gradiometers, mobile sensor platforms and associated computer software, with new measurement techniques currently under development. Our products are low cost, user-friendly, light-weight and have proven reliability. Our equipment has appeared frequently on archaeological and historical television programmes (Fig. 1).

Fig 1. (Left) FM256 Fluxgate Gradiometer and (right) MSP40 Mobile Sensor Platform with FM256 for combined resistance and magnetic surveys.

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Website: www.bartington.com

Bartington Instruments Ltd is a leader in the design and manufacture of high precision fluxgate magnetometers and magnetic susceptibility instruments. Our equipment is used worldwide for archaeological exploration, UXO location, geophysical investigations and many other applications that involve detection of buried magnetic anomalies.

The Grad601 Gradiometer is an ideal instrument for magnetometry surveys in archaeology and for pipe and cable location. Since its introduction in 2004, it has rapidly gained an enviable reputation for its ease of use, automatic set-up and excellent stability. With a 1m vertical sensor separation, and a recently enhanced 0.03nT resolution, recorded data is of a very high quality, whilst fluxgate technology ensures the Grad601 is one of the lightest instruments available. The MS2 Magnetic Susceptibility system has become an industry-standard for the susceptibility measurement of soils and other geological samples. With a wide range of sensors and probes, it can be used for both laboratory and field work. The instrument has a very wide variety of applications including archaeological prospection, mineral identification, nanoparticle analysis and Curie temperature determination. Bartington Instruments also designs and manufacturers a range of single and three-axis fluxgate magnetometers and gradiometers, along with associated data acquisition systems. Our products are supplied to users involved in physics, medical physics, geosciences, industry and defence. (Fig. 1).

Fig. 1. (Left) the Grad601-2 and (right) the MS2 with MS2D Field Loop.

Allied Associates Geophysical Ltd

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Allied Associates Geophysical Ltd are a supplier of geophysical and Non Destructive Technology (NTD) equipment with offices in Belgium, Germany, and the UK. Having established in 1988 we have seen a dramatic change in the traditional use of geophysics partially due to equipment development and partially due to acceptance by previously non geophysical users. Equipment designed 20 years ago with a dedicated geophysical use can be seen in use today within a host of fringe disciplines including forensics. The use of magnetics for locating ferrous objects is well known, but recently Ground probing radar (GPR) has been employed to aid location of shallow burials be this shallow graves in earth or under concrete slabs/patios. On a wider 'forensic' remit GPR has played its part in 'Advance Search' situations with Government agencies and Specialist Armed Forces units deploying GPR in a number of conflict zones around the world (Fig. 1 & 2).

Fig.1. (Left) military search application and (right) weapons location using GPR.

Fig. 2. Mass grave location Bosnia using GSSI Sir-3000 radar system (GPR).

Geomatrix Earth Science Ltd

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Geomatrix Earth Science Ltd is a dedicated instrument supply company specialising in geophysical instrumentation for the investigation of near surface ground conditions for many applications including archaeological prospection and forensic investigations.

Our portfolio includes:

- The Pro-Ex and X3M range of ground probing radar (GPR) from Mala Geoscience. The Pro-Ex range includes the ability to use a variety of antenna frequencies to enable you to tailor your system to the task at hand, be it detection of man-made or natural voids, buried artefacts and man-made, built, or excavated structures, metallic and non-metallic services, culverts and depth to bedrock studies. The Pro-Ex stores data digitally, so it can be downloaded to PC and digitally enhanced. Mapped or grid surveys can be performed so areas can be viewed in plan form, with depth slices at operator selected depths enabling complex structures to be resolved.
- EM conductivity instruments, which are suitable for metallic object location and electrical conductivity mapping of large areas.
- Caesium vapour and fluxgate magnetometers and gradiometer systems, which can map man-made features, obstructions and buried ferrous objects.
- Electrical resistivity tomography and Seismic systems, which are ideally suited to depth to bedrock determination and Geo-archaeology studies.

Unique to Geomatrix is the Geophysical Exploration Equipment Platform (GEEP) system, which allows multiple instruments to be mounted on a single platform which is then towed over the ground using a small tractor at speeds of 2-3 m/sec depending on terrain. Positional accuracy is ensured by use of a differential or RTK GPS system depending on the desired accuracy of the finished survey. The GEEP allows large areas to be surveyed in great detail and at high speeds whilst ensuring high data quality (Fig. 1). All instruments are available on a sale or rental basis.

Fig. 1. (Left) Geophysical Exploration Equipment Platform (GEEP) multi-sensor platform from Geomatrix showing configurations with 4 caesium vapour magnetometers EM38 installed and (right) Dual-EM, multi-depth system.

STATS Ltd

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A member of the RSK Group, STATS Ltd is a leading consultancy practice with allied technical resources providing specialist support services to the property, infrastructure, land development, construction and construction materials sectors.

Our principal services cover:

- Environmental.
- Ground engineering and remediation.
- Materials in buildings.
- Civil engineering materials.
- Structural investigation.
- Construction quality assurance.
- Laboratory services.

The deployment of the latest equipment, coupled with the field application of the latest processing and visualisation software can provide key information not available through other means. Geophysical surveying techniques provide a toolbox of rapid, discrete and cost effective methods for the location and identification of subsurface features. STATS Geophysical provides expertise, survey design and site investigation services. We routinely apply state of the art geophysical instrumentation to the identification of subsurface variations associated with man-made and natural phenomena. Our senior staff have international research profiles through their work in geophysical data collection and interpretation, with work ongoing into new equipment and data processing software. STATS Geophysical provides expert witness, survey design and site investigation services. Our experience across many industry sectors allows us to recognise and distinguish objects concealed within the ground or structures. We offer rapid, high quality, efficient, professional non-destructive mapping searches worldwide.

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Founded in 1807, John Wiley & Sons, has been a valued source of information and understanding for 200 years, helping people around the world meet their needs and fulfill their aspirations. Since 1901, Wiley and its acquired companies have published the works of more than 350 Nobel laureates in all categories: Literature, Economics, Physiology or Medicine, Physics, Chemistry and Peace. Our core businesses publish scientific, technical, medical and scholarly journals, encyclopedias, books, and online products and services; professional/trade books, subscription products, training materials, and online applications and websites; and educational materials for undergraduate and graduate students and lifelong learners. Wiley's global headquarters are located in Hoboken, New Jersey, with operations in the USA, Europe, Asia, Canada, and Australia. The Company is listed on the New York Stock Exchange under the symbols JWa and JWb. Wiley-Blackwell was formed in February 2007 as a result of the acquisition of Blackwell Publishing Ltd, by John Wiley & Sons, and its merger with Wileys Scientific, Technical, and Medical business. Together, the companies have created a global publishing business with deep strength in every major academic and professional field. Wiley-Blackwell publishes approximately 1,400 scholarly peer-reviewed journals and an extensive collection of books with global appeal.

DW Consulting

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DW Consulting produces software for acquiring, assembling, processing, visualizing and publishing geophysical data. The programs have been specifically designed to meet the needs of archaeologists and continue to be developed in close co-operation with many instrument manufacturers and users (Fig.1).

The two main programs are:

- ArcheoSurveyor, this targets 2 dimensional data such as that created by Magnetometers & Resistivity meters.
- ArcheoSurveyor3D was developed to display volumetric data from Magnetic Susceptibility down-hole probes. However it can also handle other 3D datasets such as pre-processed GPR data.

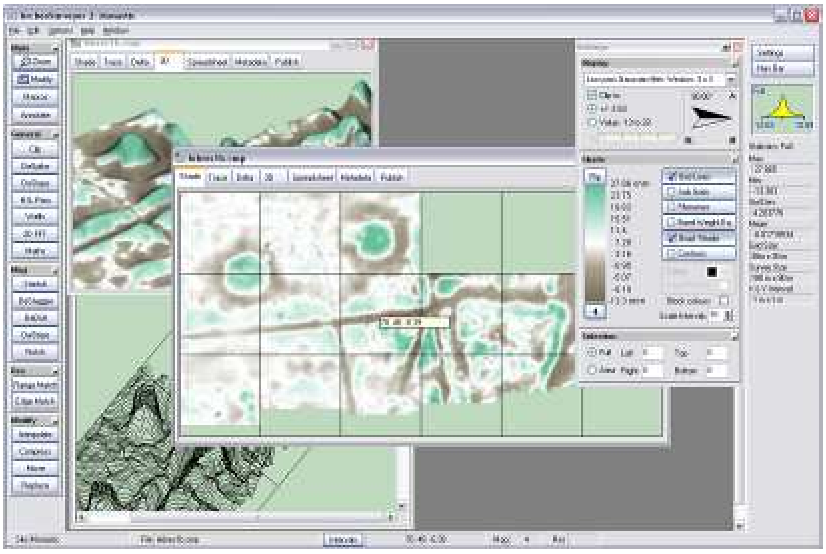
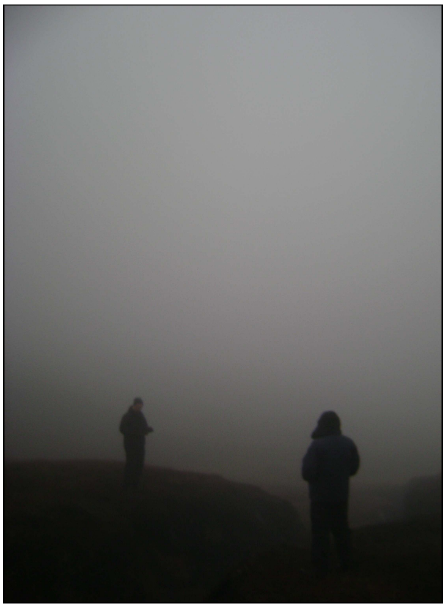


Fig. 1. ArcheoSurveyor Software.



Back cover:
A police officer and a forensic geologist conduct a search for a murder victim’s grave in a remote mountainous part of Eastern Europe.
Photograph © Laurance Donnelly

The Geological Society

Forensic Geoscience Group

FGG 2008

Geoscientific Equipment & Techniques at Crime Scenes

Programme and Abstracts of the 2nd FGG Conference
The Geological Society, Forensic Geoscience Group
Burlington House, London, 17 December 2008
Edited by Laurance Donnelly

The aims of The Geological Society, Forensic Geoscience Group (FGG) are:

To develop and promote the study and understanding of forensic geoscience (geoforensics), by creating a network for geoscientists and related specialists to; share knowledge, review and disseminate information, facilitate multi-disciplinary collaboration, promote best practice, discuss case histories, share geoforensic experiences, develop national and international contacts, stimulate discussions and debates. This is achieve by; the circulation of emails, organisation of meetings, conferences, seminars, workshops and field visits, collaboration with related forensic and other specialist groups, promoting world-wide research, training and teaching in the field of geoforensics. FGG has a growing network of contacts and brings together forensic geoscientists and related experts from; academia, industry, consultancy, government, police, law enforcement and the military, both nationally and internationally throughout; Australia, Austria, Belgium, Canada, Colombia, France, Germany, Italy, Japan, New Zealand, Northern Ireland, Portugal, Republic of Ireland, Romania, Russia, Sicily, South Africa, Spain, Switzerland, The Netherlands, United Kingdom and United States of America.

For further information on:

The Geological Society, Forensic Geoscience Group

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