

Institution: Keele University		
Unit of Assessment: UoA14 Geography and Environmental Studies		
Title of case study: Forensic Geoscience to Aid the Police and Community		
Period when the underpinning research was undertaken: 2006 - present		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr Jamie Pringle	Senior Lecturer	2006-present
Dr Ian Stimpson	Senior Lecturer	1987-present
Dr Nigel Cassidy	Reader	2001-2016
Dr Vivienne Heaton	Lecturer	2016-present
Dr Daniel Allen	Lecturer	2013-present
Dr Kristopher Wisniewski	Lecturer	2010-present
Dr Glenda Jones	Research & Teaching Fellow	2018-present
Period when the claimed impact occurred: 2014-present		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words)		
<p>The development and application of forensic geoscience techniques by researchers at Keele University have directly informed 'active' and 'cold case' missing persons police investigations in the UK and beyond. Such work has improved police search training in terms of its efficiency and effectiveness, reducing the time to conduct searches from several weeks to a number of days. The research has also helped to locate victims killed in natural disasters and genocides in other parts of the world, as well as shaping archaeological excavations and in the detection of illegal waste sites and wildlife crime, including deliberate badger sett tampering.</p>		
2. Underpinning research (indicative maximum 500 words)		
Identifying burial sites		
<p>The Keele Applied and Environmental Geophysics (KAEG) research group, led by Dr Pringle who is an Expert Search Advisor for the Major Crime Investigative Support of the National Crime Agency (NCA), worked with Dr Cassella (Staffordshire University) to establish a test site on Keele University campus in 2007. This involved the creation of simulated clandestine graves of murder victims containing pig carcasses located in different burial styles. Experimental studies were conducted to test the effectiveness of different geophysical techniques over time when searching for such burials (3.1), and to determine time since death (3.2). One study provided hitherto unrecognised insights into the importance of soil water conductivity in generating reliable burial date estimates and thereby important intelligence for police use in murder investigations (3.2). Research also highlighted how electrical resistivity geophysical surveys, a method for characterising near ground surface soil, rocks and other material in terms of their electrical properties, could be utilised in new ways to detect shallowly buried remains within the first four years of burial. It was also identified that the application of Ground Penetrating Radar (GPR) geophysical surveys could be used to detect burials up to 10 years (3.1). Important variables</p>		

affecting results were also recognised for the first-time including weather, body wrapping/clothing, length of time being buried, and season of surveying (3.1).

Revising police search strategies for active and unsolved cases

KAEG's research has provided police with new search strategies and utilising geophysical methods not commonly used in searches for missing persons. KAEG has produced innovative search strategies for locating objects beneath the ground and hidden in walls. The strategy consists of an intelligence gathering stage, including the use of maps, aerial photographs, interviews and walk-overs of surrounding areas before analysis using a range of geoscience / forensic methods, such as geophysics, LiDAR scanning, and search dogs (3.3, 3.4). These strategies were deployed to recover a murder victim buried under a concrete basement in Toronto, Canada (3.3) and to search for suspected murder victims in the UK (3.5). Electrical resistivity surveys have been innovatively applied by KAEG to a range of criminal investigations including missing persons (3.5) and environmental crime investigations (3.3). They are cited as being more effective when searching very large areas or sites with high clay content soils to pinpoint suspected locations for further investigation (3.5), taking days instead of several weeks, thereby saving police time.

Protecting the environment and forensic archaeology

KAEG's multi-technique geophysical search strategies have also supported the Northern Ireland Environment Agency (in conjunction with colleagues at Queen's University Belfast) to detect and characterise two illegal waste dumps (3.4), as well as to investigate deliberate badger sett tampering (5.9). Such techniques have also helped to facilitate archaeological investigations in confined urban spaces over short periods of time (3.6). During excavations in London in 2013 (3.6), 200 bodies dating from AD 1275–1485 were discovered, buried in individual graves, challenging contemporary historical accounts of victims buried in mass pits during the Black Death plague period (3.6).

3. References to the research (indicative maximum of six references)

Research underpinning this impact case study has been published as research articles in international peer-reviewed journals, including Scientific Reports, and, predominantly, in the Journal of Forensic Sciences and Forensic Science International, the leading global Forensic Science journals that are recognised internationally for their originality, significance and rigour.

Simulated graves research

3.1. Pringle JK, Stimpson IG, Wisniewski KD, Heaton V, Davenward B, Mirosch N, Spencer F & Jervis JR. 2020. Geophysical monitoring of simulated homicide burials for forensic investigations. *Scientific Reports*, **10**, 1-12. <http://dx.doi.org/10.1038/s41598-020-64262-3>

3.2. Pringle JK, Cassella JP, Jervis JR, Williams A, Cross P & Cassidy NJ. 2015. Soilwater conductivity analysis to date & locate clandestine graves of homicide victims. *Journal of Forensic Sciences*, **60**, pp. 1052-1060. <http://dx.doi.org/10.1111/1556-4029.12802>

'Active' and 'cold case' geoforensic studies

3.3. Ruffell A, Pringle JK & Forbes S. 2014. Search protocols for hidden forensic objects beneath floors and within walls. *Forensic Science International*, **237**, pp.137-145. <http://dx.doi.org/10.1016/j.forsciint.2013.12.036>

3.4. Ruffell A, Pringle JK, Graham C, Langton M, & Jones GM. 2018. Geophysical assessment of illegally buried toxic waste for a legal enquiry: A case study in Northern Ireland (UK). *Environmental Forensics*, **19**, pp. 239-252. <https://doi.org/10.1080/15275922.2018.1519740>

3.5. Pringle JK & Jervis JR. 2010. Electrical resistivity survey to search for a recent clandestine burial of a homicide victim, UK. *Forensic Science International*, **202**, pp. e1-e7. <http://dx.doi.org/10.1016/j.forsciint.2010.04.023>

3.6. Dick HC, Pringle JK, Sloane B, Carver J, Haffenden A, Porter S, Wisniewski KD, Roberts D, & Cassidy NJ. 2015. Detecting and characterising of Black Death burials by multi-proxy geophysical methods. *Journal of Archaeological Science*, **59**, pp. 132-141. <http://dx.doi.org/10.1016/j.jas.2015.04.010>

4. Details of the impact (indicative maximum 750 words)

Supporting searches for UK missing persons

In 2016-17, England and Wales police forces recorded 102,404 missing people, a proportion of whom will have been murdered (NCA, 2019 report). In this context, Pringle and Heaton are part of the Search Technologies Research Team (START), a police and academic collaboration that improves police search effectiveness (5.1). Pringle has provided expert support to the last three National Search Advisers at the NCA, each seconded from Regional Police for five years, searching for 350 UK missing persons (5.2). KAEG has raised police awareness and knowledge through publications in the Police Professional practitioner magazine, and workshop training with UK Police crime scene investigation managers and officers in 2014, 2016 and 2018 (5.2). Research findings (3.1, 3.4) have informed police search training at the National College of Policing (5.2). Evidenced-based research and details concerning geoforensic challenges were also presented at the 2018 House of Lords Forensic Science enquiry (5.3).

Pringle's expertise has informed decisions about the appropriateness of geophysical techniques/equipment for searches, and accurate interpretation of forensic search datasets collected, essential for key decision making and operational success (5.2). Since October 2014, KAEG has directly contributed to 16 UK missing persons cases undertaken by the NCA and Police Forces, providing operational advice and conducting geophysical surveys (5.4). This has saved UK Forces £141,291.31 of police time (5.4). Many cases, with intelligence or witnesses' reports of bodies buried, were closed with either human remains found, or the absence of human remains confirmed. One involved searching for a missing person in North Wales, where a geophysical survey was undertaken within a rural area and a body discovered and identified (3.5).

Supporting searches for international missing persons

Internationally, KAEG has given expert advice on 12 cases, conducting geophysics searches for missing persons in Brazil, Canada, Colombia, Pakistan, Romania, USA, UAE and Vietnam (5.4). Search strategies (3.5) have located victims killed in natural disasters, genocides and murders (5.4). For example, in April 2014, the Cienfuegos family contacted an international geoforensics research team, involving Pringle, requesting help to locate their grandfather's grave, shot and buried in the Lena mountains, northern Spain, during the civil war. The team conducted GPR surveys of two witness-identified sites, discovering 26 victims buried in a mass grave. Closure was provided for affected communities, including the Cienfuegos family, whose grandfather's remains were found (5.5). The team has also advised Columbian authorities in searching for 240 people killed by a landslide in Mocoa, Colombia, in 2017, and assisted the International Commission on Missing Persons (Colombia Programme) to locate 51,000 missing persons (5.4).

Supporting searches for archaeological targets

KAEG expertise has been innovatively applied during Crossrail excavations, discovering a 15th Century Black Death plague cemetery (3.6). This work, filmed for a Channel 4 documentary entitled 'Return of the Black death: Secret History' (5.6), used multi-technique geophysical detection, characterising the site and evidencing individual burials, challenging medieval testimonies of mass grave burials for plague victims (3.6). This was reported in the national and international press, reaching an audience of over 7.5 million, including BBC, Daily Mail, the Sun, the Times, Der Spiegel, and specialist magazines (5.7). KAEG also investigated World War II archaeological sites, including allied and axis prisoner of war camp tunnel escapes, and British Resistance Auxiliary Unit bunkers; these were also reported by the BBC and Telegraph (5.7).

Supporting legal enforcement to protect the environment

KAEG has supported policing of environmental crimes by conducting geophysics investigations to garner prosecution evidence (5.8). Search strategies have been applied in legal cases where waste was illegally buried, and badger setts tampered with.

A Northern Ireland Environment Agency (NIEA) environmental statistics report stated that between 2016-2018, 306 illegal waste sites required remediation, costing taxpayers £500,000. In this context, KAEG located two coastal buried waste dumps in Newtownards in 2016. Geoforensic evidence assisted the successful prosecution and determined sentence severity (3.4). The guilty defendant had to pay £250,000 clean-up costs, with the fine calculated using waste volumes and submergence under the water, as identified by KAEG. Proof of resultant marine pollution enabled a higher court sentence (5.8).

Badger persecution is a UK Wildlife Crime Priority, with 50% of incidents recorded by Scottish Badgers and Badger Trust related to badger sett interference. KAEG has worked with rural and wildlife crime officers (Staffordshire Police) to investigate deliberate badger sett tampering. GPR survey investigations, led by Wisniewski, found five of twelve badger sett tunnel entrances blocked; the resulting scientific report provided important evidence to the Crown Prosecution Service to charge the perpetrator (5.9, 5.10).

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 Testimonial of Nicola West, Home Office, Centre of Applied Science and Technology.

5.2 Testimonial of Inspector Murray Haynes, National Search Advisor within the Major Crime Investigative Support (MCIS) team, of the National Crime Agency.

5.3. Written evidence for 2019 House of Lords Science and Technology Committee Forensic science and the criminal justice system: a blueprint for change. <http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee-lords/forensic-science/written/88716.pdf>

5.4 Summary tables showing KAEG involvement in UK and international missing persons cases.

5.5 Fernandez-Alvarez J-P, Rubio-Melendi D, Martinez-Velasco A, Pringle JK & Aguilera D. 2016. Discovery of a mass grave from the Spanish Civil War using GPR and forensic archaeology. *Forensic Science International*, **267**, e10-e17. <http://dx.doi.org/10.1016/j.forsciint.2016.05.040>.

5.6 Channel 4, (April 6, 2014, 19:30), 'Return of the Black death: Secret History'. <https://www.dailymotion.com/video/x4s3xnr>.

5.7 Summary tables showing KAEG geoforensic media engagements.

5.8 Northern Ireland Illegal waste dumping judiciary decision: <https://judiciaryni.uk/judicial-decisions/2016-nica-95/>.

5.9 Wisniewski K, Pringle JK, Allen D & Wilson G. 2019. Wildlife crime: use of geoscience surveys and geophysics to assist badger sett investigations. *Forensic Science International*, **294**, e11-e18. <https://doi.org/10.1016/j.forsciint.2018.10.026>.

5.10 Wisniewski K, Pringle JK, Allen D & Wilson G. 2019. Hidden evidence. *Police Professional*, 24 January, p.22-23. <https://www.policeprofessional.com/?s=pringle+wisniewski>