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Initiative on Forensic Geology (IFG),
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Front cover photographs: IUGS-IFG training on the Geoforensic Search Strategy (GSS), at
Universidad Antonio Nariño, Sede Usme, Bogotá, Colombia (Source: Laurance Donnelly,
Carlos Molina, Rosa Maria Di Maggio and Matheus Pereira Nogueira e Silva).
Introduction

The ‘5th Iberoamerican Congress on Forensic Geology’, was held in Bogota, Colombia, on 26 to 28 October 2022 in collaboration with the: International Union of Geological Sciences, Initiative on Forensic Geology (IUGS-IFG); Universidad Antonio Nariño, Colombia; Unidad Científica para la Construcción de Paz UAN (UniPazUAN), Colombia; Red IberoAmerican Investigadores Forenses (RIIF); Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo (CYTED) and Geoscience Forensi, Italia.

There were 121,768 reported as forcibly missing people between 1985-2016 in Colombia according to data from the Truth Clarification Commission. The Colombian authorities have taken positive steps to resolve this problem, by searching to locate the graves of missing persons, undertaking positive identification and returning their remains to enable closure for many families. Since 2006 at least 6,746 graves have been found containing the remains of 8,311 people. Of these 4,744 individuals have been identified, and the bodies returned to family members. Indigenous people and children are particularly susceptible. However, there is debate over the actual number of missing persons in Colombia. These missing persons are associated with paramilitary and guerrilla groups, organised criminals and drug trafficking by cartels, as reported by the International Commission on Missing Persons (ICMP).

The ‘5th Iberoamerican Congress on Forensic Geology’, has a principal focus on the search for missing persons in Colombia and brought together experts from Colombia, Argentina, Brazil, Mexico, Chile, Guatemala, Spain, Italy and England. These included geologists, forensic geologists, geophysicists, remote sensing experts, palynologists, botanists, archaeologists, anthropologists, legal experts, police and law enforcement to discuss and consider strategies to search and locate unmarked homicide graves and mass graves in Colombia. There was also a poster session providing case histories on ground searches and search techniques. Abstracts for each presentation given are provided in this booklet of abstracts.

For the first time, family members of missing persons were invited to this event. They bravely and admirably provided detailed, first-hand, often distressing and emotional accounts of how, where and when their relatives ‘went missing’ or were abducted. A profound understanding of the subsequent years of pain and suffering was provided and the ongoing desire to locate their family members.

IUGS-IFG provided training on ground searches strategies, at a remote location to the south of Bogotá, at Universidad Antonio Nariño, Sede Usme. The training was based on the Geoforensic Search Strategy (GSS), which was developed over a 25 years period during the search for missing persons and homicide graves in the United Kingdom, and adopted internationally (Donnelly and Harrison, 2021).

The training included the use of a search drone, probing (augering), geophysics (ground penetrating radar and electrical conductivity) followed by the forensic recovery of items at simulated graves containing clothes and animal remains. Family members of victims were also provided with separate demonstrations on how the GSS could search for missing persons' graves. There were also workshops on forensic odontology and knowledge exchange with relatives of victims.

As part of this event IUGS-IFG members (Dr Laurance Donnelly, Prof Carlos Molina, Dr Rosa Maria Di Maggio and Mr Matheus Pereira Nogueira e Silva) were invited to the headquarters of the Colombian National Police and INTERPOL in Bogota. An invited presentation was given (Laurance Donnelly) on the Geoforensic Search Strategy (GSS), followed by an inspection of the forensic laboratories and facilities to exchange ideas. Presentations were also provided by the Colombian Police on the illegal mining of gold, coal and emeralds in Colombia.
Prof Molina was formally presented with two publications from the Geological Society of London; 'A Guide to Forensic Geology' and 'Special Publication on Forensic Geology and Soil Science.'

Laurance John Donnelly

**Dr Laurance Donnelly**

BSc (Hons), PhD (Geol), CGeol, CSci, EurGeol, FGS, FGSA, MIMMM

Forensic Geologist

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International Networks


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The objective of this presentation is to provide an account of the establishment of the Geological Society of London Forensic Geoscience Group (GSL-FGG) and the International Union of Geological Sciences, Initiative on Forensic Geology (IUGS-IFG).

Geologists have aided and assisted the police and law enforcement since the middle part of the 18th Century. However, before 2002, most geologists involved with police, and law enforcement investigations worked in relative isolation from other geologists. This was due in part to the often confidential, sensitive and high profile nature of their investigations. Furthermore, there was no formal, professional organisation aimed at promoting the interests of the applications of geology to criminal investigations. There was no or little formal research conducted. Operational cases were not commonly documented and discussed, and no conferences, workshops and publications specifically focussed on forensic geology.

By 2002, I had been working for six years on a high-profile case in the United Kingdom, known as ‘The Moors Murders’. Whereby, a number of children were abducted, murdered and buried in shallow, unmarked graves in the Pennines, a range of hills to the east of Manchester. The search for the last remaining grave applied conventional mineral exploration and engineering geology ground investigative methods to search for the body (ongoing) and other items. In 2005, this search evolved and included police search methods and tactics, in collaboration with British police search specialists.

In 2002, I was invited to speak on, ‘Forensic Geology and The Moors Murders’, at Westminster Palace, House of Commons, in London. An interview on BBC Radio 4 followed to discuss the applications of geology in searches for burials. These two events stimulated interests in forensic geology. Whereby other geologists, the police, media and politicians made approaches to consider the applications of geology to police investigations.

From 2002 to 2006, I made a case and discussed with the Geological Society of London my idea for establishment of a specialist forensic geology group. After three years, later in 2005 of persistence, permission was eventually granted by the Geological Society of London. At the start of 2006, I commenced the formation a committee, developed the structure and governance of the group. The committee consisted of British geologists that had either worked with the police or had methods and techniques that could potentially be applied to police investigations. The Geological Society of London (GSL), Forensic Geoscience Group (FGG) was formally established at an inaugural conference, held on 18 December 2006, at Burlington House, the headquarters of the Geological Society of London.

GSL-FGG predominantly had a UK focus, but attracted attention from international geologist
that were also working with the police and law enforcement agencies. I therefore set up the Geoforensic International Network (GIN), which was an international register to bring together geologists from around the world with forensic geology expertise or interests.

Following the success of GSL-FGG, in 2009 approached the International Union Geological Sciences (IUGS), and I was given permission to establish an international working group on forensic geology. The forensic geology working group was one of seven focus groups, within IUGS Geoenvironmental Management, which rapidly became successful attracting further international attention.

In 2011, IUGS promoted this forensic geology working group to the status of an Initiative. The IUGS, Initiative on Forensic Geology (IFG) was launched at the 62nd Executive Committee meeting of the IUGS, at UNESCO headquarters, in Paris, France, on 22 February 2011. The aim of IUGS-IFG is, ‘to develop forensic geology internationally and promote its applications’. Additionally, there are publications, outreach events, knowledge exchange, capacity building and training.

In 2020, IUGS-IFG diversified from the conventional 'scene-sample-search' focus, to include crimes in the minerals, mining and metals industries. IUGS-IFG were awarded a 'Special Project'. The principal aim of this project is to review and investigate the applications of geology to mitigate risks associated with these crimes, working in collaboration with international law enforcement agencies.

Also, in 2020, the IUGS-IFG Student Chapter was developed with students in Brazil to provide an opportunity to develop forensic geology during the COVID-19 global pandemic and to encourage and support the next generation of forensic geologists.

In 2021, IUGS-IFG celebrated its 10th anniversary of globally advancing; (i) crime scene examination, (ii) geological trace evidence analysis, (iii) ground searches or burials, and (iv) illegal mining, and associated minerals and metals crimes.

**IberoAmerican Network of Forensic Researchers (RIIF)**

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The IberoAmerican Network of Forensic Researchers (RIIF) originated in 2022 following the Ibero-American Program of Science and Technology for Development (CYTED), created by the governments of Ibero-American countries to promote cooperation in science, technology and innovation for the harmonious, integrated and sustainable development of Ibero-America. The RIIF leads research related to 'Enforced disappearance, citizen search and forensic anthropology', and is constituted by both public and private institutions from the academic sector, civil organizations, public sector entities and private enterprise, which are part of nine countries including; Argentina, Brazil, Chile, Spain, Guatemala, Mexico, Peru, Portugal and Colombia as a coordinator, through the Scientific Unit for the Construction of Peace UniPAZUAN (https://www.cyted.org/es/riif).

The objective of the RIIF is the forensic development of search for missing persons through the applications of technical-scientific methods of forensic investigation. Furthermore, RIIF
seeks to find solutions for the families of thousands of missing persons in the Ibero-American countries. As such, RIIF applies the results of its research to facilitate the search for the missing persons.

RIIF also facilitates the pursuit of truth and justice, through documentation and outreach activities with the civil society, territorial authorities, NGO's (non-governmental organisations) governmental and judicial entities, the advancement of the sustainable development aims (ODS). This relates to judicial bodies, the advancement of SDG 16, 'Peace, Justice and Rule of Law' (UNDP, 2016; Chavarro et al., 2017, Government of Colombia - Colciencias, 2018), and the enactment of the universal declaration of human rights on access to justice and the rule of law (UNDP, 2016; Chavarro et al., 2017), and human rights on access to scientific and technological information (UN 1948, 1975).

**Euro-South America Criminology and Victimology Network**

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The Euro-South American Criminology Network emerged from the Erasmus Programme, European Union student exchange programme established in 1987, which seeks to represent a community for academic-professional collaboration and knowledge exchange in criminology. The network is composed of professors of criminology and related areas of knowledge, researchers in the field of public safety and criminal justice; government representatives from the Justice and Internal Affairs sectors; graduate students and experts in these and related topics. The members of the network contribute to the debate on the prevention, control, prosecution and treatment of crime, and the design of and security policies based on scientific evidence from Europe and South America. In Colombia, the network has promoted the design of graduate programs in Criminology, such as the ‘Master's Degree in Criminology and Conflict’ at Antonio Nariño University. This course was conceived as a high-level program that combines critical perspectives that emerge from different disciplines and social theories. In addition, to the dissemination of knowledge, and the inclusion of historically excluded communities.

**IUGS-IFG Student Chapter: A Global Initiative for the Next Generation of Forensic Geologists**

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The IUGS-IFG Student Chapters is directly related to, and set up with the support and endorsement of the International Union of Geological Sciences, Initiative on Forensic Geology (IUGS-IFG). The IUGS-IFG Students Chapters were established by students from the Federal University of Pelotas, with support and endorsement from the the IUGS-IFG Chair, during the 2020 global lockdown caused by COVID-19 pandemic. The aim was to disseminate and develop geoforensics among the students while providing an option of extracurricular remote
activities for the students. The establishment of the IUGS-IFG Student Chapters includes four countries (Brazil, Argentina, Chile and India), in 17 different universities, including 223 students, 22 forensic experts and 19 professors. The IUGS-IFG Student Chapters are responsible for developing activities related to all different subtopics of forensic geology, in a way that inspires and encourages the students to follow this career.

The IUGS-IFG Student Chapters was also established to encourage the next generation of forensic geologists. The Geoforensic International Network (GIN), which was developed by IUGS-IFG also incorporates members of the IUGS-IFG Student Chapters. Forensic geologists in South America are well placed to advance forensic geology because of all the challenges faced by these countries in terms of crimes in the mining, minerals and metals industry and environmental crimes.

A forensic geologist must have the ability to clearly communicate with people who do not have the same background as a forensic geologist. It is therefore recommended for all aspiring forensic geologists to develop the necessary interpersonal skills in addition to technical abilities.

**Disappearances in Colombia**

**Victims of Forced Disappearance in the Middle Magdalena Region, Colombia**

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The Magdalena Medio region of Colombia has been characterised as one of the territories historically most affected by Colombian armed conflicts. The communities have been victimised by multiple forms of violence. In this context, the Regional Corporation for the Defense of Human Rights (CREDHOS) originated in Barrancabermeja on 10 December 1987, as a civilian alternative to denounce the serious humanitarian crisis that was being experienced in the region and that continues 35 years later.

Among the victimising facts documented by the Corporation is the enforced disappearance. A systematic practice was implemented by illegal armed groups to impose social, political and territorial control. Consequently, there has been a serious violation of human rights and international humanitarian law, with heart-breaking and permanent effects on the victims and their families.

In order to contribute to the relief of the suffering CREDHOS has implemented a, 'Search Route for Victims of Enforced Disappearance' that integrates families, social leaders, community action boards and civil society organizations, joining efforts with the, Unit for the Search for Missing Persons (UBPD), from a humanitarian, psychosocial and forensic anthropology approach. The objectives include; the definition of strategies and techniques for the collection of information, the identification of the socio-political impacts on the communities, the creation of confidential and safe spaces for the free emotional and cognitive and behavioural expression of the victims' relatives. There are also plans to search for those
that have forcefully disappeared. Investigations are also implemented to search for graves and exhume the sites.

To meet the objectives, four methodological phases includes; (1) the collection and analysis of information, (2) determine the location of possible gravesites, (3) search, recovery and identification, and (4) the dignified return of bodies and associated items findings, conducted by a multidisciplinary team.

A regional search plan for missing persons in Magdalena Medio of the UBPD has been developed to achieve effectiveness, efficiency and the concentration of efforts. It is intended this approach will result in the timely fulfilment of the rights of the victims, truth and justice, and lead to social transformation. The search process also seeks to maintain the memory of the victims and survivors of the armed conflict in Colombia.

**Forced Disappearance in Santander: A Permanent Crime Against Humanity**

Suárez Pinzón, Ivonne, Ramos Martínez and Joel David
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The commitment to truth, justice and non-repetition of the horrific events that occurred in the context of violence in Colombia has led the establishment of AMOVI (Archive of Oral Memory of Victims), which focuses its efforts on the investigation and dissemination of information on the circumstances and reasons of people that have disappeared. In 2021, in compliance with this commitment the investigation, 'Forced Disappearance in Santander: Permanent Crime against Humanity' was initiated and presented to the Integral System of Truth, Justice, Reparation and Non-Repetition (SIVJRNR). In January 2011, there was the testimony of 35 people and records collected in the investigation on the genocide of the UNO (National Opposition Union), which took place between 1972 to 1982. As a result, 63 forced disappearances and a multitude of related crimes were documented between 1973 to 2019, which provided a sample of the victims in Santander that have disappeared. The findings show that 95% of the disappeared people were men and 5% were women. Regarding the alleged perpetrators, 25% of the disappearances were attributed to the National Army, 25% to paramilitary groups, 6% were unknown armed, 3% paramilitary cooperation with armed forces, 29% unidentified, 3% national police and 2% cooperation between army and national police.

The information provided by the seekers -who were mainly female (86%)-, and gathered from documentary evidence made it possible to produce a socio-demographic profile of the victims,. Furthermore, it was possible to address the material, physical and symbolic damage and develop a psychosocial analysis of the effects. One of the key aspects of the research was the inclusion of the spatial variability for the analysis of the context of the disappearance. This was necessary to achieve a broader understanding of the dynamics of forced disappearance in the territory. With this, it was possible to georeference the last known locations of the disappeared persons and/or the approximate placement of the facts, including related crimes and the presence of armed gangs, with a special emphasis on the tracing the routes of the forced displacement, which was followed by their relatives in an attempt to save their lives.

This investigation provides a contribution to the truth and memory of the victims and survivors of those that have disappeared. People who in the midst of their pain do not stop
searching for their loved ones or demanding justice for one of the most tortuous crimes with the highest levels of impunity, due to the denialism and inefficiency of the Colombian State entities.

Yesterday’s Pain is Today’s Strength

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In this city called of all and for all and where its refuge thousands and thousands of citizens called Colombians or foreigners are in search of a better tomorrow where you breathe aroma, perfume of rest and there is no one sufficiently lost that does not deserve our solidarity, our love and our forgiveness. Where this perspective is understood, then that a fault committed by one, calls us all, involves first of all the victim, and it is that call to take the initiative so that the one who did the damage responds.

We have learned that these paths of pacification, of the formation of reason over revenge, of the delicate harmony between politics and law, cannot guide people's processes, it is not enough with normative frameworks, and political or economic arrangements of good will and find the solution to the damage done between the parties.

In addition, it is always rich to incorporate in our peace processes, the experience of sectors that in many occasions have been made invisible so that they are precisely the communities with collective memory, the main sector of the people and their culture.

The deep wounds of history necessarily require instances where justice is done, the victims are given the opportunity to know the truth, and the damage is properly repaired so that there are clear actions and thus avoid the repetition of such crimes.

We are required to generate a cultural change, a change to the culture of death and violence, to respond with the culture of life and encounter. This is what our Colombian writer Gabriel García Márquez told us "THIS CULTURAL DISASTER WILL NOT BE REMEDIED WITH LEAD OR SILVER, BUT WITH AN EDUCATION FOR PEACE, BUILT WITH LOVE ON THE DEBRIS OF A PISSED-UP COUNTRY WHERE WE GET UP EARLY TO KILL EACH OTHER", a legitimate revolution of peace that channels towards the immense life, creative energy that almost two centuries we have used to destroy us the domain of imagination and how much we have omitted, we allowed barbarism to become flesh in the life of our peoples that how many times are normalized and live as normal is because of violence, social exclusion without our voice is raised.

In the encounter between us, we discover our rights, we recreate life so that it may become authentically human again, firmly condemning that which has put an end to so many lives that is maintained and sustained by unscrupulous men.

For this too we must be prepared, solidly grounded in principles of justice that in no way diminish charity. It is not possible to live in peace without doing anything about that which corrupts life and threatens it. In this regard, we remember all those who have courageously and tirelessly worked and even lost their lives, defending and protecting the rights of human beings and their dignity.

If Colombia wants a stable and lasting peace, it must urgently take a step in this direction, which is that of the common good, of equity, of justice, of respect for human nature and its demands.
Unipaz UAN integrates sciences and engineering, health sciences and social sciences, and carries out research, education, integration conducive to the pursuit of justice, reparation and the truth to the victims of the armed conflicts in Colombia. The objective is to structure the skills for the generation, application and administration of understanding to address social inconveniences and/or encourage optimization of quality of life, promote cooperation, union, visibility and academic, scientific and technological production, visibility and academic, academic, scientific and technological production that will have a positive effect on the scenario of civil society for its vast and advisory collaboration in the formation of tranquility processes. In addition, it promotes national and international cooperation and supports the Ibero-American Network of Forensic Investigators (RIIF).

The Geoforensic Search Strategy

A Blended Geological, Police and Law Enforcement Approach to Search the Ground for Graves and Burials Associated with Homicide, Serious and Organised Crime and Counter Terrorism

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The Geoforensic Search Strategy (GSS) is a method to search the ground for items and objects that have been buried as part of a criminal act. This includes shallow, unmarked, homicide graves, narcotics, weapons or items of value. GSS first started in 1994, during the search for the grave of a child who had been murdered and buried in an unknown location in the Pennies, a range of hills on the outskirts of Manchester, in northern England. Initially, this was based on mineral exploration and engineering geology methods, but became adopted in the 25 years that followed to incorporate police and law enforcement tactics.

GSS is based on a Conceptual Geological Model (CGM), evaluation of diggability and an assessment of the likely detectable items, to provide a High Assurance Search (HAS) for the presence or absence of a specified buried target being sought. This blend gives a pragmatic, proportionate and cost effective methodology to locate a buried target. The GSS should proceed from the macro to the micro (regional) to localised (site/scene) scale, and form the non-invasive to the invasive.

GSS comprises three phases; ‘pre-search’, ‘search’ and ‘post-search’, and sub-divided into 30 stages. In the pre-search phase, the focus is on the definition of the search type, a preliminary
geological assessment, planning and logistical considerations. The search phase involves the implementation of the search to locate the desired target. The post-search phase comprises validation, recovery, recording and reporting of the search. The GSS was originally designed for open area searches and could incorporate scenario based, feature focused and intelligence led searches, and for offensive (detective) and protective (defensive) searches, and searches of vast open spaces. GSS has been adopted and adapted for searches in Colombia.

**Ground Penetration Radar and its Contribution to Forensic Investigations in Colombia**

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The use of the ground penetrating radar (GPR) for forensic purposes in Colombia began in the Departamento Administrativo de Seguridad (DAS) in 2009, in support of the investigations of the Attorney General's Office. Since then, GPR has provided scientific and judicial support, diversifying the search methods used to date by the Prospecting and Exhumation groups of the Cuerpo Técnico de Investigación (CTI), of the Attorney General's Office, at the national level. These investigations are based on the foundations of forensic geoarchaeology.

The objective of this paper is to present the results obtained in surveys and the subsequent exhumations based on the use of GPR as a non-invasive technique. The applications geophysical methods are increasing in Colombia. The paper also discussed the technology available to the prosecution, its scope, forensic archaeological applications and projections in the search for missing persons in Colombia.

The introduction of GPR in forensic fields strengthens criminal investigation, with scientific support for the administration of justice, and for the verification of sites. This provides demonstrative evidence, in prosecuting perpetrators and locating bodies of disappeared persons. Furthermore, this generates confidence in the institutions that investigate these crimes in favour of justice and the fight for human rights and International Humanitarian Law (IHL).

GPR is a novel and effective alternative in cases where it is difficult search large and complex locations a timely manner. GPR works without destroying the sites because it is a non-invasive technique, reducing time and increasing efficiency in the search for mass graves.

GPR includes state-of-the-art equipment that employs non-invasive and therefore non-destructive geophysical and archaeological search methodologies of the sites it covers. The method saves time, resources and personnel. GPR has been used to search for victims of forced disappearances, and to verify scenes with scientific rigour in legal and clandestine cemeteries, in solitary places, such as including; graves, houses, caves, tunnels and others locations. The diagnostic possibilities and findings increase in the location and georeferencing of criminal events throughout the country, with reports of cases processed with positive results.
The GPR technique represents a state-of-the-art tool in the search for missing people, as a response to the victims, expanding the spectrum of possibilities in forensic investigations, contributing in reality to criminal and scientific inquiry, providing real-time information about the properties of the disappearance scenarios, including clandestine burials; such as their depth, size, shape and distribution of the sites that will be recovered, whether archaeological, historical or judicial.

The Application of Ground Penetrating Radar (GPR) in the Search for Missing People at the Forensic Anthropology Foundation of Guatemala

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There is no doubt that every day advances in technology are applicable to a wide variety of scientific practices, the current needs of forensic studies given the global conditions of some countries, both in armed conflicts (wars and terrorism), as well as criminal actions (gangs and drug trafficking), have encouraged professionals related to this use cutting-edge techniques that give effective applications of new technologies.

The Guatemalan Forensic Anthropology Foundation has succeeded in incorporating new technologies into the work process to provide greater efficiency, reliability and accuracy in the search for and identification of missing persons.

The application of Ground Penetrating Radar (GPR) to forensic archaeological practices seeks to improve the capabilities and effectiveness of searches by providing a cost-effective process, saving human and economic resources. The objective of this presentation is to share cases examples of the applications of GPR in Guatemala in the search for graves.

Ground Penetrating Radar and Electrical Resistivity Tomography in Simulated Pits

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In this project, we used Ground Penetrating Radar (GPR) and Electrical Resistivity Tomography (ERT) in a simulated test field, to characterise the temporal response associated with the different stages of decomposition of bodies, in different seasons and soil type. The test site is located in the facilities of the Attorney General of the Mexican Republic, in the municipality of Galindo, Qro. This site has a semi-arid climate and consists of 12 individual graves in which nine bodies were buried at three different depths for a period of one year. Measurements were made prior to burial and in three subsequent stages. For the GPR surveys, a 400MHz antenna was used and surveys were carried out on a south-north oriented grid. In the first two stages the traverses were 1 m apart and in the next two stages, each traverse was 0.5 m apart. In addition to the line-by-line comparison, pseudo 3D models were built that allow better interpretation and can be compared with the geoelectric method. ERT was carried out
in its 3D modality, using a methodology recently designed by the Geophysical Exploration group of the Universidad Nacional Autónoma de México (UNAM), which allows measurements to be taken at points inside the traverses. The electrodes are placed every metre, in an area 14 x 29 m and we present 3D models for each stage.

Seismic Identification of Disturbed Soils Associated with Clandestine Graves

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There are a variety of geophysical techniques that could be used to locate a clandestine grave. However, before starting detailed physical investigations, it is first necessary to define the study area and the soil characteristics. The success depends on the size of the area, the time of year, and even the condition of integrity and decomposition of the body that alters the soil conditions. The Ambient Noise Tomography (ANT) method is a quick and non-invasive way to determine the extent and mechanical properties of an area where the ground has been disturbed. In this study, we applied ANT in a test field consisting of 11 individual graves where nine bodies were buried at three different depths. The objective was to identify the zones of disturbing material and the subsurface conditions in two periods (three months apart). For this, we used a quadrangular array of 72 vertical geophones of 4.5 Hz that covered an area of 231 m². The results show that the subsoil is composed of an irregular layer of 3 m thick that includes a filling of weathered materials. These materials are partially saturated during the first experiment, which makes it challenging to define the location of the excavations. In the second experiment, the saturation decreases, and it is possible to identify the velocity variations produced by the excavations of greater depth (1.2 m), which have the most significant amount of body mass. The comparison with other geophysical results shows that ANT is a non-invasive and non-destructive complementary method for decision-making in the search for clandestine sepulchres.

Application of Hydroinformatic Tools to Search for Deceased Human Bodies in Rivers

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This paper presents the advances in the development of a comprehensive methodology that facilitates the search for people reported missing in rivers. The methodology is made up of three components: forensic, hydroinformatic and archaeological. For its development, testimonial information, hydroinformatic techniques for the characterisation of rivers, and computational models were used to represent the dynamics of the river and of the bodies that are transported by it. Finally, heat maps with potential search locations are presented. The presentation culminates by presenting the actions that are currently being developed and the challenges encountered in the search for bodies of people reported missing in rivers.
Identification of Volatile Organic Compounds (VOCs) Present in Cadaveric Decomposition for Later Use in Canine Olfactory Training

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In the last decades, Chile has been strongly affected by the increase in missing persons. As such, it has become necessary to implement several scientific disciplines to detect decomposed human remains. One of the police techniques used in the search for missing persons is by means of trained canines; because they have olfactory perception and are able to detect dead bodies through the detection of specific odours.

As for the disciplines of science involved in this technique, several scientists have dedicated themselves to study the characteristics of the chemical components present in decomposing bodies. It is for this reason that it has been investigated that volatile organic compounds' (VOCs) released during the decomposition of human bodies are detected by trained canines.

VOCs are highly volatile chemicals. When released during the process of cadaveric decomposition, they provoke an effective response in canines, facilitating the search for individuals. An efficient technique for the identification of VOCs present in human remains is solid-phase microfiber micro extraction (SPME) in conjunction with gas chromatography-mass spectroscopy (GC-MS). For this purpose, different cadaver samples have been used, using different adsorbent materials under various conditions, to correlate the VOC profile with the cadaveric decomposition process. It has been found that several of these compounds are produced in different parts of the human body, and that they even share some similarities and qualitative differences, opening the way to a possible identification of the chemical profile associated with odours that can be used for the training of canines in victim recovery.

Application of the Canine Component in the Search for Missing People

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Chile is one of many countries that includes a canine capability (also known as K9), for drug and explosives detection. To date, the use of canines has grown gradually in forensic investigations, the activities in which the canine has been included in recent decades is the detection of people, including both live and dead bodies. Currently, two lines of investigation are being developed in the area of criminalistics; the detection of living persons and human remains.

There is no entity in Chile that is in charge of regularising the breeding of canines. Consequently, the owners of these dogs train them independently or in the best of cases are governed by other breeders with a longer trajectory, the most used method is the KIM method. Some of the most popular breeds are the Belgian Malinois, Labrador, Classic German Shepherd, Black Solid and Sable, all belonging to the same family of German Shepherds.
The use of canines offers great advantages when searching for people, since they are trained from puppies to obey commands. They also wear vests with accessories, which can be used to carry basic first aid kits, cameras and GPS.

The early inclusion of the canine capability gives an advantage to a search for missing persons and to the police investigation, by significantly increasing the percentage of successful cases in the field and having the possibility of locating the number of deceased missing persons.

Geologist in the Court and Forensic Context, the role of the Forensic Geologist in a Judicial Context Workshop: Daubert Standard and Expert Report

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In the sense that science is a method to prove arguable facts in any judicial process, its theoretical-practical relevance is constantly growing and changing. This is achieved with the application of certain or probable rational knowledge, methodically obtained in various disciplines of knowledge.

In judicial matters and the forensic field, since 1993, the Supreme Court of Justice of the United States of America has adopted a series of criteria and recommendations to appreciate and evaluate the scientific nature, trustworthiness and validity of this evidence, in what is known as, 'The Daubert case.

This workshop will address the plot behind the Collipulli kidnapping, in a city located in the south of Chile, that ended in tortures, a homicide, and twelve defendants in preventive detention. It will be presented in a way that the expert reports were composed based on the Daubert standard of a crime scene examination and the monitoring of the evidence from collection until the lab analyses.

The above, in order to support the prosecutor’s theory, who pretends to sentence those who kidnapped two men, 28 and 46 years old, in a police story marked by levels of violence never seen before, which was triggered by a drug and weapons robbery. The details of this case include the capture of both victims in a makeshift shelter and almost ten days of confinement.

An oversight allowed the younger victim to escape, while the other was killed and his remains burned in a bonfire.

The end of this workshop included the live testimony of a chemical expert before a judge, where she has the duty to present a series of evidence that will allow the court to reach a conclusion. To do so, she will have to be cross-examined, and the judge will have to decide according to scientifically proven knowledge and evidence, her years of experience and the principles of logic.

Identification of Missing People: Anthropology, Odontology, Genetics and Taphonomy
Research on Forensic Odontology for the Process of Human Identification

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The Anthropology and Forensic Odontology Oral Health Research Group, at Antonio Nariño University in Colombia, contribute to the process of human identification, and the clarification of violent acts. Investigations have been undertaken to produce Colombian forensic standards, including; sex, age, height and biological ancestry. For the estimation of age, methods and formulas were established based on the physiological changes in the dental tissue and the maxillo dental complex, such as the reduction of the pulp chamber and bone wear and loss. Similarly, for children, the pattern of dental formation and calcification has been studied. For the estimation of the sex, the sexual dimorphism of the cranial base, the diameter of the teeth and the proportion of the upper and lower anterior incisors were determined. For height, standards were built associated with cranial and cephalometric measurements, and in conjunction with teeth and height. For the ancestor factors, investigations focused on documenting the dental and cranial characteristics of different mestizo and Afro-Colombian groups. Research is also being carried out on the characteristics of teeth when subjected to high temperatures, and on the location of bodies in unmarked graves using computed tomography.

Calcined Skeletons: Use of Spectroscopic Techniques in the Search for Missing People

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In Chile, there have been political problems and changes in the economy, coupled with the increase in kidnappings in recent years. There has been violent crimes, including dismemberment and the incineration of bodies. Therefore, it is important to identify skeletal remains and whether they belong to missing persons.

Bones become calcined at different temperatures, either in oxidative or reducing conditions, and can be identified by spectroscopic techniques such as; Fourier transform infrared (FTIR), Raman spectroscopy and inelastic neutron scattering (INS), which allow differentiating the vibrational signals in the spectra. The effect of heat on skeletal remains in different environmental conditions can also determine the temperature reached by the bodies and establish whether an oven was used to ensure the incineration of a person.

Research was conducted on human bones (femur and humerus) burned in aerobic or anaerobic conditions at different temperatures (400 to 1000°C). Three sets of experiments were conducted on the bone samples; (i) burned aerobically (oxidising conditions), (ii) burned anaerobically (reducing conditions) in an unsealed container, and (iii) burned anaerobically in a sealed chamber. They have shown that, with INS, there are differences in the types of samples, to establish the absence of vibrational bands of hydroxyapatite OH in anaerobically burned bones in unsealed containers (reductive conditions), followed by the presence of
cyanamide (NCNH₂) and portlandite (Ca(OH)₂), in reductive conditions.

The spectroscopic techniques showed the identification of human skeletons calcined at different temperatures and oxygen availability, allows the reconstruction of forensic scenarios and, consequently, the generation of scientific evidence to be evaluated by the courts.

**DNA Analysis of Burnt Bone for the Identification of Victims of Forced Disappearances at Different Times History**

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Chile is one of the Latin American countries where forced disappearances have been committed. In this sense, the first cases were verified after 11 September 1973 and the current list of the number of victims has been defined in reports of the National Commission for Truth and Reconciliation and the National Corporation for Reparation and Reconciliation. Accordingly, the figure amounts to a total of 1,469 missing persons recognised up to 10 March 1990.

Scientific research is essential to support the search for victims of enforced disappearances through the identification of human remains in forensic cases and the analysis of skeletons, especially those that were incinerated. The severe rise in temperature can generate the denaturation of DNA in soft tissues. However, it can be preserved in dense tissues that provide physical protection against damage including; teeth, tarsal and carpal bones or in the petrous portion of the temporal bone, since these have higher bone density.

To recover DNA from burned bones, it was necessary to consider; (i) the impact of the burn on the bone, (ii) difficulties in preparing burned samples for DNA extraction, and (iii) protocols for bone decalcification.

The skeletal sample was immersed in a chelating solution, such as; EDTA (Ethylenediaminetetraacetic Acid) to remove the inorganic component of the bone. Followed by DNA recovery through solid phase extraction using a silica-based binding. A collection of burned skeletal remains for genetic studies could be an alternative method for the identification of missing persons.

**Utility of Taphonomy in Forensic Studies**

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Taphonomy is the study of the modifications that biological organisms pass through following death. The decomposition of the human body and the postmortem processes suffered to
understand the sample of the study of the taphonomic analysis. By analysing the modifications that the cadaveric remains present, it is possible to interpret the taphonomic processes that occurred post mortem. Forensic taphonomy as a discipline appeared in the 1980s, when it began to be applied in cases of Forensic Anthropology, with the aim of contributing to the reconstruction and interpretation of the death events. With the implementation of experimental facilities on the decomposition of human and non-human models, and the continuous contribution of retrospective research, the studies on forensic taphonomy has significantly development in recent years. In particular, regional studies have gained special relevance. Despite the fact that burial includes one of the most used methods of hiding corpses, and also one of the oldest and most current main funerary models, taphonomic research on buried bodies is not common.

The inhumation of the body limits the observations of the human remains and therefore the assessment and progression of the decomposition process. In 2018, the first experimental facility in Europe was inaugurated: the Amsterdam Research Initiative for Subsurface Taphonomy and Anthropology (ARISTA). Nonetheless, in Spain, projects prior to ARISTA include the Thapos-m experimental project in collaboration with the Universitat Autònoma de Barcelona (UAB) and the Finca Experimental la Higueruela del Museo Nacional de Ciencias Naturales (MNCN-CSIC), among others. Thanks to taphonomic studies that are being carried out in those kind of facilities and from different specialities (e.g. palaeontology, archaeology, anthropology) it is possible to recognise if they are primary or secondary burials, determine the type of funerary structure that was used originally (i.e. buried bodies in direct contact with the sediment or the coffins). Also, to differentiate posthumous modifications from those that occurred in life, caused by illness or traumatisms. Furthermore, the studies provide information on determining the time elapsed since death to study moment (post mortem range). The research provides details on mortuary practices carried out in each case and the order of burial in multiple burials. In this sense, taphonomic analysis adds value to anthropological studies, giving more information about the context and reconstructing the taphonomic history of the burials.

The cadaveric state of bodies varies depending on different factors and taphonomic agents. These include simple or multiple burials, bodies buried or in exposition, limited access of entomofauna or anaerobic environment depending on the type of soil or artefacts present, temperature, humidity, biological features of the individual and wrapping. In addition, in mass burials, microenvironments are created by the interaction between the bodies and the relative position of each one of them. In this sense, experimental research is more limited since the simulation of a mass burial requires a homogeneous and relatively large sample of individuals, and is even more restrictive when working with human models. On the other hand, retrospective studies with solved forensic cases contribute to generate references in a concrete context and under real conditions.

As mentioned above, one of the most determining taphonomic agents is the type of soil. Knowing how decomposition progresses specifically in each soil will make it easier to approximate the final cadaveric state of the remains to be exhumed, without disregarding the other factors involved (e.g. geographical location, depth, compaction and the presence of plastic artefacts). The importance of an initial taphonomic evaluation in forensic anthropology cases has been discussed, since knowing the different possibilities in which the bodies can be found according to the depositional and biogeographical context, allows adapting the methodological approach and ensuring the necessary human and material resources. However, a decomposing body will cause changes in the properties of the surrounding soil, related to the release of fluids. Knowing and characterising these alterations can also facilitate the process of searching for and locating clandestine burials by chemical or physical means.
Forensic geologists deal with different types of crimes (against people, environment, cultural and heritage), which can require the use of a range of techniques and involve different geological materials. Regardless of the type of crime and its narrative, the forensic geologists' approach to the scene of the crime is based on the same fundamental principles that are to study, to recognise, to analyse, and to interpret the geographical, physical and geological features of the environment where the crime had been placed. Forensic geologists have to be able to search and to collect suitable information from the environment to put them in the specific criminal context.

The judicial site survey and soil collection are sensitive tasks that forensic geologists carry out during their investigations. During these stages, the probative validity of soil evidence could depend on: (i) the way the sample was gathered and preserved; (ii) all those activity carried out from the seizure and preservation of items, to the collection of soil from them; (iii) undervaluation of the potentiality of soil analyses during the firsts stage of investigation and no knowledge of the requirements of their application. For these reasons, the optimal judicial soil survey and gathering of soil samples are possible when those who perform the collection of evidence are highly specialised in forensic geology techniques, and are perfectly informed of the crime, so that they are aware of what, where and how to collect soil evidence.

When collecting and successively studying soil for forensic purposes a multidisciplinary approach is necessary and should be normal practice adopted in forensic science departments.

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Traceability of Soils in Northern Chile: Contributions of Geology to Cases of Forced Disappearance

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Given the increasing number of kidnappings and disappearances in northern Chile in recent years, geological characterisation and traceability of the soils in the Chilean provinces bordering Peru and Bolivia is necessary.

Two cases of kidnapping with homicide were simulated, both victims were last seen in Putre, Chile. Two months later the body of a woman was found near Ilo, Peru and three months later
the body of a teenager was found in the town of San Andres, Bolivia. Soil samples were collected from the soles of the victims' shoes and fingernails, along with soil from the site of the find and another general sample of the soils and rocks in the area. The samples were mineralogically analysed using Raman spectroscopy, to later standardise the results with X-Ray Diffraction and geological soil charts.

The results reveal that the samples from the woman's body have three different types of soil, and those from the adolescent have four different types. The samples from the woman correspond mostly to fragments of rhyolites and pumice, and to a lesser extent, limestone and quartz microcrystals. The samples collected from the adolescent have a higher content of very fine-grained sandy gravels and silts, with traces of slags and dacitic lavas.

It was suggested that the woman was possibly from Visviri and the adolescent from Arica, and was abducted by a criminal organisation in Putre. With the geological characterisation of soils it was possible to conduct traceability studies at the time of the reported disappearance, to narrow down places of possible abduction and to focus the search for missing persons only by knowing the sedimentological characteristics of the last whereabouts and the scene of the crime.

Fungi: Biological Micro-vestiges in a Case of Crime?

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Forensic mycology is a term used to describe the study of the fungal species potentially useful in establishing biological evidence to recognise the place where a human cadaver decomposition occurred, and to link the crime scene with a suspect. The different fungal groups have been postulated as tools for recognising human burial sites and to estimate the burial time. The authors established two large groups called 'ammonia fungi' and 'post putrefaction fungi' to determine burial times. More recently, this discipline was used to relate a suspect with the location where the body was found, by noting the presence of fungal species as trace evidence or biological micro-vestiges. The case studied in this work, showed the possibility to use mycology as biological evidence due to the presence of Bipolaris Cynodontis, as representative species in the soil collected at the crime scene and from the shoes of suspects. Bipolaris Cynodontis belongs to the ammonia fungal group, because it is an Ascomycota Teleomorph that appears in the soil samples at the beginnings of cadaver decomposition (i.e. less than 30 days). The cadaver found in this study was reported missing in the Buenos Aires province, in Argentina, 25 days before its discovery. Therefore, the presence of Bipolaris Cynodontis in the soil sample aligned with results obtained by previous researchers. In addition, its presence from a sample obtained from the suspect's shoes, relate him with the crime scene, and along with other evidence.

Analysis of Skeletal Fragments: A View from Microanthropology

Daniela Andrea García Padilla.
In recent years, there has been an exponential increase in the concealment of corpses related to acts of forced disappearance, mainly by organised groups. This violence has resulted in different forms of concealment of corpses such as; calcination and bone fragmentation, practices rarely previously seen in Chile. For this reason, it is essential to search for accessible and reliable tools that allow us to discern the nature of the bones found in this type of clandestine burials and crime scenes.

Forensic micro anthropology is defined as an area of study of forensic sciences that combines forensic anthropology and histology, with the objective of analysing small fragments of evidence that at first, a forensic anthropologist or other expert in the identification of human remains cannot determine whether it corresponds to a human fragment or not. Therefore, it is necessary for the microscopic analysis of the evidence to determine, through forensic micro anthropology, whether or not it is human or non-human.

This paper describes the instrumental methods, including the equipment used and the treatment of the samples for their qualitative and quantitative identification from a forensic micro anthropology perspective. Additionally, information is provided on the context bone and its main functions.

Micro vestiges, Silent Witnesses of a Crime: Cynodon Dactylon DNA Links Suspect to Homicide

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An elderly woman was attacked and strangled in her bedroom. Police found a shoe print next to the body. With the support of witnesses they arrested a suspect and recovered her shoes. The shoe print from the crime scene matched the recovered shoes of the suspect. In addition, a fresh plant fragment was discovered in one of these shoes. The victim lived in a neighbourhood with different types of vegetation, such as trees, ferns, grasses, wild grasses and various medicinal herbs. To identify the species from the botanical evidence, DNA was isolated from the fragment and sequenced by high-resolution melting (HRM) analysis with internal transcribed spacer (ITS) primers. The ITS sequence was aligned using MEGA 5 software and compared with the GenBank database for plants, animals and microorganisms. The plant fragment was identified as Cynodon dactylon, commonly known as bermudagrass and used in gardens for decorative purposes.

Based on this information, the area surrounding the crime scene was searched again and the same type of grass was found only on the property of the victim's neighbour. It was concluded that the attacker fled after committing the crime, crossing the neighbour's garden, where the shoe collected the aforementioned botanical evidence. These findings were presented at trial, and the court sentenced the defendant to 13 years imprisonment. This case illustrates the importance of botanical micro evidence in connecting a suspect to a crime scene.
Enforced disappearance is a worldwide problem that violates fundamental human rights and has become a crime against humanity. It has gained particular notoriety in Latin American countries, especially in Colombia and Mexico, which, in terms of disappearances, occupy the first and second place respectively.

Enforced disappearance is understood as a practice used to spread terror and gain control of a territory with the acquiescence of different governmental entities, public servants, illegal armed groups and organised crime. This consists of the arrest, kidnapping or any deprivation of liberty against the person's will, continued by concealment of the occurrence of the event and finally, by the refusal of the perpetrators to reveal the location of the missing person.

This crime has caused social, economic and cultural problems, both for governments and for the families who are constantly searching for their missing relatives. Among these problems is the difficulty of establishing an exact number of missing persons and skeletonised bodies found in different clandestine graves. With the highest figures for Colombia and Mexico, in the regions of Antioquia and the State of Tamaulipas, respectively, which has significant internal violence in these territories. Faced with these situations, government agencies, the different groups created by the families of victims of this scourge and the different non-governmental organisations have resorted to the multidisciplinary nature of forensic sciences to carry out the investigation in order to clarify the facts. Without ignoring that each country has different legislation and regulations to proceed in the field, the multidisciplinary teams in charge of this investigation have or should always have forensic professionals in anthropology, medicine and dentistry and a criminal expert, who is in charge of carrying out the preliminary field search work, under the guidance of the forensic anthropologist. It is for this reason that the different formation strategies for criminalists and criminologists must have sufficient competencies required to support forensic anthropological investigations for the search and collection of human remains in the field, especially in cases of enforced disappearance.

Therefore, it is necessary to train students to solve problems in a current and regional context, and in this case in Latin America; generating virtual tools that allow the integration of academic skills, according to the needs and functions that criminalists and criminologists in Mexico and Colombia must acquire support from forensic anthropological investigations for the search and collection of human remains in the field, especially in cases of enforced disappearance.
Geographic Information Systems and Remote Sensing Applied to the Search for Missing People

A Case Study of Two-Way Learning of Search Collectives in Mexico and Geospatial Information Sciences

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Mexico is currently experiencing a crisis of violence and disappearance of persons, the official data register more than 330,000 intentional homicides, more than 100,000 missing and disappeared persons and approximately 4,800 mass and clandestine graves found. Since 2007, these types of discoveries have increased due to the so-called 'war against drug trafficking'. The relatives of the disappeared were the first to organise themselves to carry out searches in spite of the insecurity they face. In October 2021, at least 160 collectives participated in the VI National Search Brigade for Missing Persons. These collectives require multiple supports, as well as the knowledge and use of geospatial information sciences. This work shows that the link between collectives and academia has a high potential for a more efficient and safe development of field work. It is the exchange of knowledge and experiences through the study of three cases in the states of Nuevo León, Morelos and Puebla. This includes the delivery of workshops on the use of geospatial information sciences for the search of missing persons.

Spectral Analysis of Soils Contaminated with Substances Associated with the Disappearance of People in Mexico

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Preliminary results of a study on the spectral monitoring of soils contaminated with substances known to be used in the disappearance of people in Mexico are presented. In a field test, 15 areas, each measuring 1x2 metres, were prepared with substances, including animal tissues dissolved in caustic soda boiled with water, hydrochloric acid, diesel, lime, blood and animal remains with various treatments, buried or on the ground surface. The objective was to determine the detectability of these substances in soils by means of multi and hyperspectral images from the analysis of spectral reflectance signatures measured by means of a field spectroradiometer in the range of 350 to 2500 nanometres with a resolution...
of one nanometre. Observations suggest that it is possible to design multispectral indices (around 100 nm bandwidth) to detect lime, blood, soda ash, and ash, but that hyperspectral sensors (less than 10 nm bandwidth) are required to detect acid, diesel, and burnt remains on the surface. Others, such as burnt remains in shallow burials, could not be detected during the monitoring period. Examples of cases where these techniques could be used with the use of satellite or aerial images taken with drones are provided.

Remote Sensing for the Detection of Clandestine Graves in Colombia

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This research is part of the project, ‘Application of geophysical methods and identification of environmental variables for the search of graves corresponding to burials related to acts of human rights violations. The objective is to monitor a burial site using remote sensing, before and after the digging of the graves. This monitoring was carried out using a Parrot Bluegrass unmanned aircraft, equipped with a Sequoia multispectral camera. This contained four sensors with green, red, red edge and near infrared (NIR) wavelengths. The sensors enable the detection of different vegetation indices for the analysis of vegetation dynamics.

Before, during and after the burial of the remains. The vegetation indices use NIR and red or green information, due to the capacity of these lengths to reflect and absorb light, highlighting the information of photosynthetic activity or temporal dynamics of the biomass of the vegetation cover. Different vegetation indices such as NDVI, GNDVI and GCI were constructed to observe the dynamics of vegetation cover over time.

Finally, the monitoring with different vegetation indices before, during and after in the experimental area made it possible to identify the degree of anthropic intervention associated with each of the 'common pits' since the decomposition of organic matter evidences a greater growth in these small areas.

Case Studies of Geophysical Methods and Remote Sensing for Missing Persons Searches in Colombia

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Since 2020, the Unidad de Búsqueda dasdpor Desaparecidas (UBPD) has carried out several humanitarian searches for missing persons’ bodies using geophysical methods and remote sensing as field procedures. Those methods include, for instance: georadar, electromagnetic profiler, resistivity metre and magnetic gradiometer, which were used to find individual and collective graves in cemeteries, open-field areas and landfills. Those areas are diverse in topography and vegetation cover throughout the Colombian territory. Simultaneously, the Remotely Piloted Aircraft System (RPAS), with multispectral sensors has contributed as an invaluable prospecting tool in the search for graves. This systematic use of geophysical and remote sensing methods is one of the first documented attempts for the search of graves in
the world with these non-intrusive tools, which have several benefits such as fast coverage rate, conservation of the archaeological context, and even non-disturbing procedures during searches. These experiences and challenges, including successful cases and lessons learned are provided in relation to missing person searches.

Satellite Imagery as a Tool for Searching for Missing Persons

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On 17 February 2021, in the sector of Caripilún, in the Biobío region, Chile, Tomas Bravo, a boy of 3 years and 7 months, was reported missing. That day, he went out with his great-uncle to look for some cows in the family property in the sector, leaving the boy alone for 15 minutes after the cattle escaped and when he returned the boy was no longer there. An exhaustive search began to find the whereabouts of Tomas. After nine days, despite all attempts to find him alive, the police found his body located approximately two kilometres from the place where he had disappeared. One of the methods used to locate the child was the application of remote sensing, analysing satellite images from the Chilean satellite FASat-Charlie. The images were integrated with combinations of bands, which indicated variations in topography, vegetation or other anomalies within the sector. These images were superimposed with photos from the FACh (Chilean Air Force) aircraft when a location of interest for the investigation was found, they obtained a higher resolution. The search was focused on these suspicious areas, to find some indication to the whereabouts of the child. This was finally achieved and proved to be a decisive tool in finding the child's body. The search proved to be complicated due to the presence of dense wooded areas, which made it difficult to analyse the images. To this day there is no certainty as to what happened that afternoon, the case is still open and there is no one to blame for what happened, leaving several questions unanswered.

Geospatial Evidence of Environmental Affectations in the Pajaral Swamp in the Municipality of Cantagallo, Colombia, 2017 - 2022: A Practical Case of Forensic Geology Using Satellite Imagery

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Detailed knowledge about the scene or space where an environmental crime has been committed is the fundamental basis for implementing justice. In this forensic research, Geospatial Information Technologies (GIT) and the fundamental principles of environmental geology were implemented as scientific support to the lawsuit filed by the Afro-Colombian Federation of Artisanal Fishermen of the Municipality of Cantagallo (FAPAMUCAN) with the objective to prove the actions carried out by a civil third party at the Riparian forest buffer of the Pajaral swamp complex and the Cimitarra River, constitute a series of crimes typified under the Law 2111, (2021). The offenses comprise deforestation, trespassing or invasion of lands of special ecological importance, environmental contamination, destruction of natural
resources, and, ecocide. Furthermore, it is worth noting that these crimes represent punitive aggravation since the affected land has promoted historical occupation by Afro communities whose sociocultural and economic foundations depend on the swamp complex.

Through the processing, analysis, and interpretation of images that were obtained from multiple satellites (Landsat 5 - 8, Sentinel - 2, World Imagery, Planet, Lidar) provided information, evidence and historical details. The outcomes were used for the visual and space-multitemporal reconstruction of the crime scene based on the calculation of spectral indices (NDVI, NBR, NDWI, and BSI), vectorial measurements (area and/or length of coverage), estimation of spectral signatures of water and generalised hydrological schemes. The studies were analysed taking into account the state of the crime scene before, during, and after the execution of the aforementioned offenses. As a result, this study provided the material evidence, digital evidence, and electronic evidence (EDiPE) to the Attorney General’s Office to demonstrate the channelling of the Cimitarra River, the drying up of Poza Los Mangos (from 34ha to 0ha), the increase in the turbidity of the water and the reduction of the area of the Pajaral swamp (from 267ha to 65ha). This resulted as a consequence of the intervention in the processes of flow and storage of water, transport, deposition, accumulation of sediments and edaphization, to take advantage of the land to implement buffalo ranching and oil palm crops.

Illegal Mining and Minerals Crimes

Current Status and Future Prospects of Forensic Geosciences in Brazil

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Over the past few years, Forensic Geosciences in Brazil faced a significant boost, led mostly by students and forensic professionals. Amongst many lines of research, three major fields have stood out as promising initiatives: (i) the conceptualisation of projects related to geological trace evidence analysis throughout multiple Brazilian crime labs, especially regarding the collection, processing, and interpretation of soil evidence found at crime scenes; (ii) the strengthening of the fight against illegal gold mining in Amazon rainforest by creating a gold database in the nationwide 'Ouro Alvo' (Clean Gold) Program; and (iii) the establishment of stable isotope analysis to aid in the identification of human remains, under the project 'Fim do Luto'. The former initiative, regarding soil evidence, is currently being held
in three institutions simultaneously: Paraná State Scientific Police, Civil Police of Rio de Janeiro State, and the National Institute of Criminalistics. These efforts aim to set official protocols for sampling, analysing and evaluating soil traces seized by investigators, especially in body disposal sites. While still preliminary, authorities expect that these methods will help elucidate many violent crimes. Meanwhile, Brazil faces an environmental crisis due to the massive growth of illegal gold mining in Amazon, increasing the affected area in 632% for the past decade, reaching the milestone of 200,000 hectares of degradation, while much of this mined gold is melted into plates and smuggled out of the country. The Ouro Alvo (Clean Gold) Program, aims to build and maintain a gold database containing chemical, mineralogical and isotope ratio signatures of gold deposits found in Brazil for provenancing purposes. When it comes to missing people, nearly 200 reports are filed everyday in the country. Combining it to the thousands of stored and unidentified human remains, the ‘Fim do Luto’ project will construct a bone tissue isotope ratio database to assist forensic anthropologists.

**Development of a High Assurance Strategy to Determine the Provenance of Legitimate, Illegal and Illicit Minerals in the Global Supply Chain**

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There has been a reported increase in illegal and illicit mining over the past few years, following the increase in prices for precious minerals such as gold. This is particularly prevalent in Colombia and other Latin American countries, and this problem is foreseen to continue in the years ahead. The beneficiaries are often well-organised syndicates, criminal gangs, cartels or terrorist organisations. These crimes include; illegal mining beyond regulatory control, fraud, theft, adulteration of mineral concentrates or processed metals, the substitution of samples ahead of assaying, the mining and trading of conflict minerals, mineral smuggling and fakery. This presentation provides an overview of the modus operandi and associated operations and patterns of criminal activities associated with illegal mining and minerals trading, and their associated impacts. Importantly, options will be presented to develop a high assurance strategy to reasonably, practicably and cost-effectively manage and mitigate risks associated with questioned samples and materials that might be associated with illegal or illicit mining. These options may include covert and overt operations, blockchain technology, international collaboration, policy reforms, guidance, codes, national regulations, chain of custody, sample security, improved sample management procedures, bagging, tagging and certificate of origin, due diligence audits, registry of minerals producers and traders, elemental and isotope analysis and automated mineralogical profiling. An overview of these methods will be provided supported with operational case examples. Also provided is an overview of a project being undertaken in Europe on use of artificial micro taggant particles, which could also potentially be used to track and trace mineral commodities through the global supply chain and to verify the responsible sourcing of minerals. A second project is also outlined, commissioned by the IUGS Initiative on Forensic Geology, which is investigating crimes in the global minerals, mining and metals industries.
Appendix: Selected IUGS-IFG Photographs

5th Iberoamerican Conference on Forensic Geology, Bogotá, Colombia (source: IUGS-IFG).

Delegates at the 5th Iberoamerican Conference on Forensic Geology, Bogotá, Colombia (source: Mr Carlos Molina and Dr Laurance Donnelly).

Training in searches for shallow, unmarked, homicide graves, Bogotá Colombia (source: Mr Carlos Molina and Dr Laurance Donnelly).
IUGS-IFG training in searches for shallow, unmarked, homicide graves. Dr Rosa Maria Di Maggio recovering buried clothes (top left and top right), Dr Laurance Donnelly and Dr Carlos Molina conducting a geophysical survey over a simulated grave (bottom left), and Dr Rosa Maria Di Maggio and Dr Laurance Donnelly with the victim's family members (bottom right), Bogotá Colombia (source: Dr Laurance Donnelly).

Geophysical survey over a simulated grave and the recovery of a boot (source: Dr Laurance Donnelly).
Mr Matheus Pereira Nogueira e Silva, Dr Carlos Molina and Dr Laurance Donnelly demonstrating the applications of ground penetrating radar (left), drones (center) and soil probes (right) during the search for missing person’s graves, Bogota, Colombia (source: Dr Laurance Donnelly).

Dr Carlos Molina, Dr Rosa Maria Di Maggio, Mr Matheus Pereira Nogueira e Silva and Dr Laurance Donnelly with representatives from the Colombian National Police and INTERPOL, Bogotá, Colombia (source: Dr Laurance Donnelly).
Dr Rosa Maria Di Maggio, Mr Matheus Pereira Nogueira e Silva, Dr Carlos Molina and Dr Laurance Donnelly with representatives from the Colombian National Police, Bogota, Colombia (source: Dr Laurance Donnelly).

Dr Laurance Donnelly presenting a copy of 'A Guide to Forensic Geology', and giving a presentation on illegal mining and the IUGS-IFG Special Project, Bogota, Colombia (source: Dr Laurance Donnelly).
IUGS-IFG at the 5th IberoAmerican Congress on Forensic Geology, Bogotá, Colombia. Including Mr Matheus Pereira Nogueira e Silva, Dr Carlos Molina, Dr Rosa Maria Di Maggio, Dr Laurance Donnelly and Marcelo Tortelero (source: Dr Carlos Molina and Dr Laurance Donnelly).

Dr Laurance Donnelly presenting the Geoforesenic Search Strategy to the Colombian National Police and Interpol, Bogota, Colombia (left) and examining the skeleton of a victim found in an unmarked grave, Colombian National Police Forensic Laboratory (right) (source: Dr Carlos Molina and Dr Laurance Donnelly).