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A MULTIDISCIPLINARY APPROACH BASED ON THE COOPERATION OF FORENSIC GEOLOGISTS, BOTANISTS, AND ENGINEERS: COMPUTED AXIAL TOMOGRAPHY APPLIED TO A CASE WORK

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ABSTRACT. The novel application of the Computed Axial Tomography technology to a forensic case work showed high potentialities in performing investigation on a pair of sandals belonging to a victim found in the countryside, at the scene of events. This technology allowed to crystallize the appearance, dimensions, and spatial orientation of eight thorns fixed in their soles, before their removal from the shoes for further geological and botanical analyses. Considered the shallowness of penetration, this investigation allowed to exclude the thorns, for being responsible for possible discomforts or injuries to the feet of the victim.

1. Introduction

A forensic expert in criminalistics, such as a forensic geologist, in addition to possess a solid knowledge of the principles and methods of geosciences, he/she also should have a general knowledge of the forensic sciences (Picozzi and Intini 2009; Pirrie 2009; Di Maggio *et al.* 2014; Saferstein 2017). These requirements are crucial in serious crimes occurring outdoor in the countryside, where a complex interaction between the actors of the crime scenes (victims and perpetrators) and the surrounding environment may occur. As a matter of facts, due to the principle of exchange of Locard, the contact between objects, subjects, or places may cause the transfer of physical traces, linking subjects, objects, and places. In such cases, traces of sediments, soils, and remains of plants (as well as other organisms, mainly insects) may transfer from the scene to the victim or suspect, during their moving on the sites (Murray and Tedrow 1975; Palenik 1982; Tindall 1994; Lombardi 1999; Bull *et al.* 2004; Murray 2004a,b; Pye and Croft 2004; Bull and Morgan 2005; Pye 2005; McKinley and Ruffell 2007; Morgan and Bull 2007; Pye 2007; Fitzpatrick, Raven, and Forrester 2009; Ruffell and McKinley 2009; Ruffell 2010; Ruffell and McKinley 2014; Pirrie, Dawson, and Graham 2017; Donnelly *et al.* 2021; Fitzpatrick and Donnelly 2021; Somma 2022). For this reason, in such circumstances, a multidisciplinary approach may be crucial for reconstructing the dynamics of the events. A team composed of geologists or soil scientists, botanists, and entomologists is the minimum requirement for allowing a complete examination of a complex system, such as the soil, due to the presence of different abiotic and biotic components. Nevertheless, in complex cases, where few are the available information, and evidence are difficult to extract for their peculiar location on the questioned items, every possible scientific technology must be explored and considered, in order to access to physical evidence and allow its successive analyses. Especially in the field of legal medicine, the technology of Computed Axial Tomography (CAT) proved to be crucial in the careful examination of the corpse. CAT is a radiological diagnostic imaging method, non-destructive and repetitive, widely used in biomedical and forensic sciences, but also applied in the field of industry (Thompson and Leach 2018). In legal medicine, CAT is used for reconstructing the two-dimensional (2D) and three-dimensional (3D) images of corpses, allowing to help in the differential analyses among natural-accidental-suicide-homicide diseases and what is recently known as virtual autopsy (virtopsy). Important results may be obtained also in the study of dismemberments (Baier *et al.* 2017), firearms injuries for reconstructing the trajectories of the bullets and distinguishing entry and exit wounds (Viero *et al.* 2014; Fais *et al.* 2015), the identification of the sphenoidal sinus (Souadih *et al.* 2020), and the realization of 3D printing of skeletal elements (Baier *et al.* 2021). It is evident that CAT may be useful also for other forensic purposes (Rutty *et al.* 2013; Kim 2020) in assisting investigators to better detect the presence of unknown objects inside others and characterize their spatial and dimensional features. Elements of significative investigative interest may be characterized and measured in the 3D virtual images obtained by means of CAT.

The present paper illustrates the results of a case study related to a forensic application of CAT carried out by the author, as expert of the judicial authority with the assistance of the auxiliary, Gabriella Epasto[1]. During investigation related to a subject found lifeless in the countryside, special attention was paid to the examination of a pair of sandals, among his belongings, because of a peculiarity: one of the sandals was found open, with the velcro straps closed on themselves, and outside the metallic buckle seats. The external inspection of the sandals revealed an intact appearance with soil traces and plant thorns fixed in the soles of the footwear. In order to assist the judicial authority in understanding the reason why one of the sandals was open in such peculiar way, or evaluate other investigative hypotheses, the footwears were carefully inspected by means of CAT for characterizing the spatial and dimensional features of the thorns fixed on the soles. A deep penetration of the thorns could have been responsible for discomforts or injuries to the foot, such a way to require the untying from the rings to allow a careful removal of the foot from the sandal. With this in mind, the dimensions, orientation, and depth of penetration of the thorns were characterized in order to understand if the penetration involved all the thickness of the sole, up to the insole. Moreover, CAT was also used to "crystallize" the state of the thorns before their extraction from the soles. In such a way, 3D preliminary images could have also reduced the consequences of possible damages suffered by the thorns during the delicate extraction phase and before the characterization of the extracted material by geologists and botanists.

[1]Epasto, G. and Somma, R. (2022). "On the application of Computed Tomography in Forensic Engineering: a case study". Book of Abstracts of the International Workshop on Advances and applications in geoforensics: unraveling crimes with geology (Messina, Italy, 26th September 2022), Accademia Peloritana dei Pericolanti, University of Messina, pp. 19-20.

2. Materials and methods

The material analysed was a pair of sandals with flexible soles in polymeric material, adjustable velcro straps, lining in leather, and steel buckles. Traces of soil and plant elements were recognized in the sandals through visual inspection, firstly by means of eye lens, and later by a stereomicroscope with workstation (Zeiss, model Stereodiscovery V20). Traces were observed on the soles, insole, and on the furrow between the insole. In particular, several mm-long thorns stuck in the rubber of the soles were found. Evidence of animal bites or blood traces were searched as required by the investigators but none was found. After preliminary visual inspection and before any analysis, the sandals were inspected by means of CAT, as useful tool for examining internal and external structures and inspecting highly absorbent materials by means the emission of X-ray. The technique provides transverse tomographic images able to depict with high accuracy the spatial distribution of low-dose tiny X-ray that traverses the examined material in an axial plane at many different angles (Ter-Pogossian 1977). During the measures realized by the tomographic station, the incident X-rays are directed towards the sample. The X-ray emitted by the material are recorded by detectors and processed by computer to produce axial 2D cross-section images (slice) of the investigated material. A series of such 2D images, arranged in parallel planes or around an axis, allows to evidence the characteristics and anomalies of the material according to the slice-by-slice method (Epasto and Somma 2022). The analyses are carried out by using a tomographic station consisting of a shielded cabin and a computerized station for data processing. The focal spot may be variable in the micro-macro range, allowing the diameter of the focal spot to be varied, usually from 250 to 800 μm, increasing in such a way the penetration capacity in materials with high absorption. The generation of X-rays takes place with an adjustable voltage usually up to a maximum of 225 kV. The X-ray beam emitted by the specimen is stored by a flat panel detector. The transmitted signal depends on the intensity of the incident X-rays. The sensors present in the panel convert the incident photons into electric charges, stored and amplified if necessary. During the scan, the X-ray tube emits a conical beam of radiation and simultaneously the specimen rotates around its axis. The system, by acquisition of numerous projections of each point of the sample, is able to provide a sinogram at the end of the scan, where each line corresponds to a projection. Subsequently, through special algorithms, the tool provides sequences of images of each section in gray scale and 3D reconstructions of the model. The instrument used for analysing the sandals was the Y.CT Vario model (Figure 1). Preliminary CAT tests were carried out on a pair of new sandals of the same model and measure with some thorns fixed on the soles for testing the optimum setting of the instrumentation. After having obtained a positive result by the test, the evidence was prepared, introducing each sandal in an envelope of radio transparent material (polyethylene) to further preserve the shoes and limit trace dispersion or contamination.

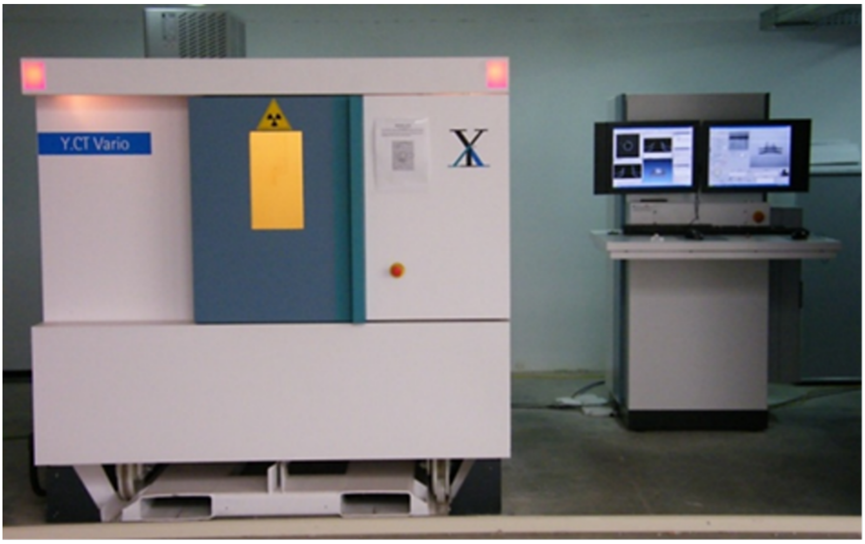

FIGURE 1. CAT workstation related to the instrument Y.CT Vario located at the Department of Engineering of the Messina University. The analyses were performed by Gabriella Epasto (Epasto and Somma 2022).

3. Results

The CAT scans, carried out slice by slice on both sandals, allowed to obtain 2D and 3D reconstructions of the study material crossing at least eight thorns within the soles. The shape, length, inclination with respect to the tangent to the sole, and penetration depth of the thorns were detected (Table 1, Figure 2).

TABLE 1. Characteristics of the thorns detected in the soles by CAT.

Thorn ID	Lenght [mm]	Depth [mm]	Inclination [°]
1	5.19	1.54	27.54
2	6.76	3.33	104.94
3	5.53	2.27	50.33
4	-	4.06	50.21
5	3.21	0.93	77.63
6	5.93	1.74	119.31
7	5.33	2.47	61.40
8	3.38	1.63	94.50

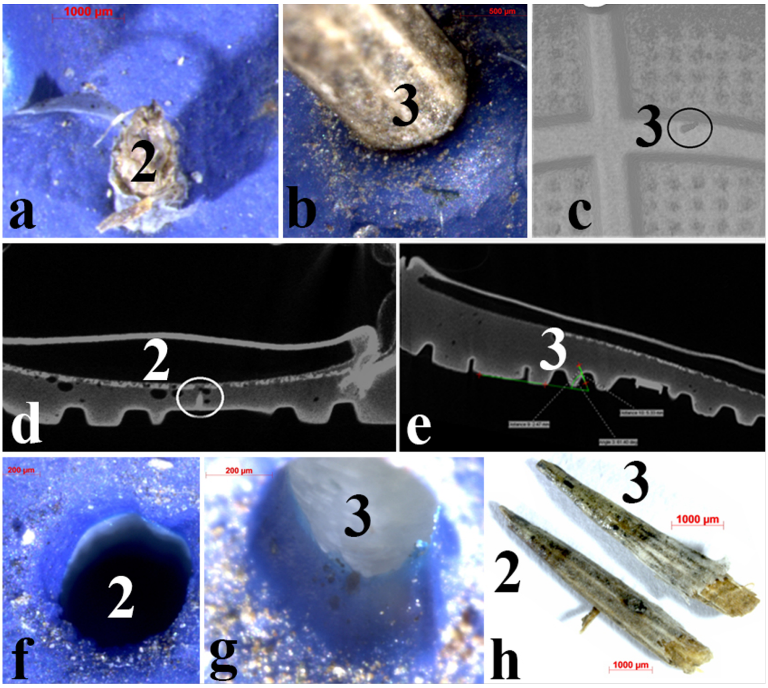

FIGURE 2. Sandals of the victim: a) Photography under stereomicroscope of the thorn n. 2 fixed in the sole. b) Photography under stereomicroscope of the thorn n. 3 fixed in the sole. c) CAT 3D reconstruction of the sole where the thorns n. 3 was detected by means CAT. d) CAT image showing a section orthogonal to the sole with the thorn n.2 highlighted. e) CAT image showing a section orthogonal to the sole with the thorn n. 3 highlighted. f) Photography under stereomicroscope of the hole in the sole left by the thorn n. 2, after its removal. g) Photography under stereomicroscope of the hole in the sole left by the thorn n. 3, after its removal. h) Photography under stereomicroscope of the thorns n. 2-3, after the removal from the sole. The thorns were determined as belonging to the thorny plant *Cytisus infestus* (Morabito, Mondello, and Somma 2023).

4. Discussion and conclusions

In the present case work, CAT allowed to crystallize the appearance of the thorns before their extraction from the sole (Figure 2c-e). It was possible to ascertain the presence in the soles of at least eight thorns, from 3 to 7 mm long, superficially fixed on the soles, being the depth lower than 4 mm, never crossing the rubber completely from one side to the other one of the sole (Table 1). This investigation allowed to exclude the thorns, found on the soles, for being responsible for discomforts or injuries to the foot, such a way to require the untying from the rings to allow a careful removal of the foot from the sandal. Images obtained by CAT assisted geologists and botanists to strongly reduce the consequences of possible damages suffered by the thorns during the delicate extraction phase by means of dental and surgical instruments, before to analyse thorns and the soil adhering on them (Figure 2). Once the thorns were extracted, botanists were able to analyse and identify them as *Cytisus infestus* (C. Presl) Gussone (Figure 2a-b-h), *Cynara cardunculus* L., *Smilax aspera* L., *Rosa sempervirens* L., or *Rubus ulmifolius* Schott. In addition, the relationships between the distribution of soil traces found inside the holes and in the surrounding damaged area by the thorn penetration (Figure 2 f-g) allowed to reconstruct the chronology of transfer of soil and thorns contained therein or in the thorny plants growing on the ground, from the site to the sandals. In outdoor crime scenes occurring in the countryside, the probability that a transfer of organic traces of plants (Caccianiga and Compostella 2009; Caccianiga *et al.* 2021), insects (Byrd and Sutton 2023; Somma, Sutton, and Byrd 2023), mineral grains (Somma 2023a,b; Somma *et al.* 2023d; Spoto 2023), fossils (Marra, Di Silvestro, and Somma 2023; Somma and Maniscalco 2023) from the scene to the victims or perpetrators is very high (Ruffell and McKinley 2009). Consequently, a holistic approach in the study of traces deriving from the ecosystems of the scene of events is of paramount importance. In such cases, especially involving serious crimes, the application of physics, legal medicine (Tagliabue *et al.* 2023a; Tagliabue *et al.* 2023b), engineering (Somma *et al.* 2018; Baldino *et al.* 2023; Somma 2023a,b; Somma *et al.* 2023a,b,c; Somma and Costa 2023), botany (Morabito and Somma 2023), palaeontology (Marra 2023), geography (Ruffell and McKinley 2005; Somma and Costa 2022) among many others (Spoto, Somma, and Crea 2021; Somma 2022; Somma 2023b; Somma *et al.* 2023a,b,c,d; Spoto 2023; Spoto, Barone, and Somma 2023) may be crucial to detect all evidence possible, as demonstrated in the present research. In this regard, the novel application of the CAT technology to the presented case work showed high potentialities in performing forensic investigation of items found in the scene of events. The cross-reading of the findings obtained by CAT, to carry out before to apply other investigations, demonstrated to be a successful approach to realize in such a circumstance.

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References

Baier, W., Norman, D. G., Donnelly, M. J., and Williams, M. A. (2021). "Forensic 3D printing from micro-CT for court use-process validation". *Forensic Science International* **318**, 110560. DOI: 10.1016/j.forsciint.2020.110560.

Baier, W., Norman, D. G., Warnett, J. M., Payne, M., Harrison, N. P., Hunt, N. C. A., Burnett, B. A., and Williams, M. A. (2017). "Novel application of three-dimensional technologies in a case of dismemberment". *Forensic science international* **270**, 139–145. DOI: 10.1016/j.forsciint.2016.11.040.

Baldino, G., Ventura Spagnolo, E., Fodale, V., Pennisi, C., Mondello, C., Altadonna, A., Raffaele, M., Salmeri, F., Somma, R., Asmundo, A., and Sapienza, D. (2023). "The application of 3D virtual models in the judicial inspection of indoor and outdoor crime scenes". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A17. DOI: 10.1478/AAPP.101S1A17.

Bull, P. A. and Morgan, R. M. (2005). "Forensic Geoscience: Principles, Techniques and Applications". *Science and Justice* **45**(3), 169–170. DOI: 10.1016/S1355-0306(05)71658-0.

Bull, P. A., Morgan, R. M., Dunkerley, S., and Wilson, H. (2004). "Multi-technique comparison of source and primary transfer soil samples: an experimental investigation by D Croft and K Pye. A comment." *Science & Justice: Journal of the Forensic Science Society* **44**(3), 173–6.

Byrd, J. H. and Sutton, L. (2023). "The Use of Forensic Entomology within Clandestine Gravesite Investigations". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A7. DOI: 10.1478/AAPP.101S1A7.

Caccianiga, M. and Compostella, C. (2009). "Botanica e zoologia forense". In: *Scienze forensi: teoria e prassi dell'investigazione scientifica*. UTET giuridica, pp. 243–254.

Caccianiga, M., Compostella, C., Caccia, G., and Cattaneo, C. (2021). "Contribution of plant anatomy to forensic investigation: Tree bark morphology". *Forensic Science International* **318**, 110598. DOI: 10.1016/j.forsciint.2020.110598.

Di Maggio, R. M., Barone, P. M., Pettinelli, E., Mattei, E., Lauro, S. E., and Banchelli, A. (2014). *Geologia Forense: Introduzione alle geoscienze applicate alle indagini giudiziarie*. Dario Flaccovio Editore.

Donnelly, L. J., Pirrie, D., Harrison, M., Ruffell, A., and Dawson, L. A. (2021). "A guide to forensic geology". In: Geological Society of London. DOI: https://doi.org/10.1144/GFG.

Fais, P., Giraudo, C., Viero, A., Amagliani, A., Viel, G., Montisci, M., Miotto, D., and Cecchetto, G. (2015). "Identification of bullet entrance in different type of intermediate firearm wounds through micro-computed tomography analysis". *Journal of Forensic Radiology and Imaging* **3**(3), 147–152. DOI: 10.1016/j.jofri.2015.07.004.

Fitzpatrick, R. W. and Donnelly, L. J. (2021). *An introduction to forensic soil science and forensic geology: a synthesis*. DOI: 10.1144/SP492-2021-8.

Fitzpatrick, R. W., Raven, M. D., and Forrester, S. T. (2009). "A systematic approach to soil forensics: criminal case studies involving transference from crime scene to forensic evidence". *Criminal and environmental soil forensics* **105**. DOI: 10.1007/978-1-4020-9204-6_8.

Kim, E. S. (2020). "Accident Reconstruction of Damaged Human Body Using MDCT and Computer Numerical Analysis". *Applied Sciences* **10**(9), 3059. DOI: 10.3390/app10093059.

Lombardi, G. (1999). "The contribution of forensic geology and other trace evidence analysis to the investigation of the killing of Italian Prime Minister Aldo Moro." *Journal of forensic sciences* **44**(3), 634–642. DOI: 10.1520/JFS14523J.

Marra, A. C. (2023). "Taphonomical investigation applied to clandestine graves". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A6. DOI: 10.1478/AAPP.101S1A6.

Marra, A. C., Di Silvestro, G., and Somma, R. (2023). "Palaeontology applied to criminal investigation". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A4. DOI: 10.1478/AAPP.101S1A4.

McKinley, J. and Ruffell, A. (2007). "Contemporaneous spatial sampling at scenes of crime: advantages and disadvantages". *Forensic Science International* **172**(2-3), 196–202. DOI: 10.1016/j.forsciint.2006.09.006.

Morabito, M., Mondello, F., and Somma, R. (2023). "Macrobotanic data implementing Forensic Geology investigations". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A13. DOI: 10.1478/AAPP.101S1A13.

Morabito, M. and Somma, R. (2023). "The crucial role of Forensic Botany in the solution of judicial cases". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A11. DOI: 10.1478/AAPP.101S1A11.

Morgan, R. M. and Bull, P. A. (2007). "The philosophy, nature and practice of forensic sediment analysis". *Progress in Physical Geography* **31**(1), 43–58. DOI: 10.1177/0309133307073881.

Murray, R. C. (2004a). *Evidence from the earth: forensic geology and criminal investigation*.

Murray, R. C. (2004b). "Forensic geology: yesterday, today and tomorrow". *Geological Society, London, Special Publications* **232**(1), 7–9. DOI: 10.1144/GSL.SP.2004.232.01.02.
Murray, R. C. and Tedrow, J. C. F. (1975). *Forensic geology: Earth sciences and criminal investigation*. Rutgers University Press New Brunswick, NJ.
Palenik, S. (1982). "Microscopic trace evidence-the overlooked clue. 1. Schneider, Albert looks at some string". *Microscope* **30**(2), 93–100.
Picozzi, M. and Intini, A. (2009). *Scienze forensi: teoria e prassi dell'investigazione scientifica*. UTET giuridica.
Pirrie, D., Dawson, L. A., and Graham, G. (2017). "Predictive geolocation: Forensic soil analysis for provenance determination". *Episodes Journal of International Geoscience* **40**(2), 141–147. DOI: 10.18814/epiiugs/2017/v40i2/017016.
Pirrie, D. (2009). "Forensic geology in serious crime investigation". *Geology Today* **25**(5), 188–192. DOI: 10.1111/j.1365-2451.2009.00729.x.
Pye, K. (2005). "Forensic geology". In: *Encyclopedia of Geology*. Ed. by R. C. Selley, L. R. M. Cocks, and I. R. Plimer. Vol. 2. Topics in Current Physics. Oxford, UK: Elsevier Academic, pp. 261–273.
Pye, K. and Croft, D. J. (2004). "Forensic geoscience: principles, techniques and applications". In: Geological Society of London. DOI: 10.1144/GSL.SP.2004.232.
Pye, K. (2007). *Geological and soil evidence: forensic applications*. CRC press.
Ruffell, A. and McKinley, J. (2009). *Geoforensics*. John Wiley & Sons Ltd.
Ruffell, A. (2010). "Forensic pedology, forensic geology, forensic geoscience, geoforensics and soil forensics". *Forensic Science International* **202**(1-3), 9–12. DOI: 10.1016/j.forsciint.2010.03.044.
Ruffell, A. and McKinley, J. (2005). "Forensic geoscience: applications of geology, geomorphology and geophysics to criminal investigations". *Earth-Science Reviews* **69**(3-4), 235–247. DOI: 10.1016/j.earscirev.2004.08.002.
Ruffell, A. and McKinley, J. (2014). "Forensic geomorphology". *Geomorphology* **206**, 14–22. DOI: 10.1016/j.geomorph.2013.12.020.
Rutty, G. N., Brough, A., Biggs, M. J. P., Robinson, C., Lawes, S. D. A., and Hainsworth, S. V. (2013). "The role of micro-computed tomography in forensic investigations". *Forensic science international* **225**(1-3), 60–66. DOI: 10.1016/j.forsciint.2012.10.030.
Saferstein, R. (2017). *Criminalistics: An introduction to forensic science*.
Somma, R. (2023a). "The space and time dimensions in the criminal behaviour of lust murderers". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A19. DOI: 10.1478/AAPP.101S1A19.
Somma, R. (2023b). "Unraveling crimes with geosciences". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A2. DOI: 10.1478/AAPP.101S1A2.
Somma, R., Altadonna, A., Cucinotta, F., Raffaele, M., Salmeri, F., Baldino, G., Ventura Spagnolo, E., and Sapienza, D. (2023a). "The technologies of Laser Scanning and Structured Blue Light Scanning applied to criminal investigation: case studies". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A15. DOI: 10.1478/AAPP.101S1A15.
Somma, R., Baldino, G., Altadonna, A., Asmundo, A., Fodale, V., Gualniera P. abd Mondello, C., Pennisi, C., Raffaele, M., Salmeri, F., Ventura Spagnolo, E., and Sapienza, D. (2023b). "Education and training activities in forensic and biomedical sciences: The Laser scanner technology". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A16. DOI: 10.1478/AAPP.101S1A16.
Somma, R., Cascio, M., Cucinotta, F., Mondello, F., and Morabito, M. (2023c). "Recent advances in forensic geology and botany for the reconstruction of event dynamics in outdoor crime scenes: a case study". *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A10. DOI: 10.1478/AAPP.101S1A10.

Somma, R. and Costa, N. (2022). “Unraveling Crimes with Geology: As Geological and Geographical Evidence Related to Clandestine Graves May Assist the Judicial System”. *Geosciences* **12**(9), 339. DOI: 10.3390/geosciences12090339.

Somma, R. and Costa, N. (2023). “GIS-based RAG-coded search priority scenarios for predictive maps to prevent future serial serious crimes: the case study of the Florence Monster”. *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A18. DOI: 10.1478/AAPP.101S1A18.

Somma, R. and Maniscalco, R. (2023). “Forensic geology applied to criminal investigation: a case report”. *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A9. DOI: 10.1478/AAPP.101S1A9.

Somma, R., Spoto, S. E., Raffaele, M., and Salmeri, F. (2023d). “Measuring color techniques for forensic comparative analyses of geological evidence”. *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A14. DOI: 10.1478/AAPP.101S1A14.

Somma, R., Sutton, L., and Byrd, J. H. (2023). “Forensic geology applied to the search for homicide graves”. *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A5. DOI: 10.1478/AAPP.101S1A5.

Somma, R. (2022). “Advances in Flipped Classrooms for Teaching and Learning Forensic Geology”. *Education Sciences* **12**(6), 403. DOI: 10.3390/educsci12060403.

Somma, R., Cascio, M., Silvestro, M., and Torre, E. (2018). “A GIS-based quantitative approach for the search of clandestine graves, Italy”. *Journal of forensic sciences* **63**(3), 882–898. DOI: 10.1111/1556-4029.13677.

Souadih, K., Belaid, A., Ben Salem, D., and Conze, P.-H. (2020). “Automatic forensic identification using 3D sphenoid sinus segmentation and deep characterization”. *Medical & Biological Engineering & Computing* **58**, 291–306. DOI: 10.1007/s11517-019-02050-6.

Spoto, S. E. (2023). “Illicit trafficking of diamonds: new frontiers”. *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A3. DOI: 10.1478/AAPP.101S1A3.

Spoto, S. E., Barone, S., and Somma, R. (2023). “An introduction to forensic geosciences”. *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A1. DOI: 10.1478/AAPP.101S1A1.

Spoto, S. E., Somma, R., and Crea, F. (2021). “Using a forensic-based learning approach to teach geochemistry”. *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **99**(S1), A31. DOI: 10.1478/AAPP.99S1A31.

Tagliabue, G., Masseroli, A., Mattia, M., Sala, C., Belgiovine, E., Capuzzo, D., Galimberti, P., Slavazzi, F., Cattaneo, C., and Trombino, L. (2023a). “Thanatogenic Anthrosols: a geoforensic approach to the exploration of the Sepolcreto of the Ca’ Granda (Milan)”. *Atti della Accademia Peloritana dei Pericolanti. Classe di Scienze Fisiche, Matematiche e Naturali* **101**(S1), A8. DOI: 10.1478/AAPP.101S1A8.

Tagliabue, G., Masseroli, A., Ern, S. I. E., Comolli, R., Tambone, F., Cattaneo, C., and Trombino, L. (2023b). “The Fate of Phosphorus in Experimental Burials: Chemical and Ultramicroscopic Characterization and Environmental Control of Its Persistency”. *Geosciences* **13**(2), 24. DOI: 10.3390/geosciences13020024.

Thompson, A. and Leach, R. (2018). “Introduction to industrial X-ray computed tomography”. *Industrial X-ray computed tomography*, 1–23. DOI: 10.1007/978-3-319-59573-3_1.

Tindall, C. G. (1994). “Forensic Geology”. *Soil Science* **157**(2), 128.

Viero, A., Giraudo, C., Cecchetto, G., Muscovich, C., Favretto, D., Puglisi, M., Fais, P., and Viel, G. (2014). “An unusual case of “dyadic-death” with a single gunshot”. *Forensic science international* **244**, e1–e5. DOI: 10.1016/j.forsciint.2014.08.001.

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