Chapter 18
End User Commentary on The Application of Forensic Soil Science in Case Work and Legal Considerations

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This chapter by Dawson, Parratt and Auchie covers the application of soil science in forensic case work and presents a full discussion of the use of soil traces in criminal law enforcement. It describes the legal context one has to be aware of, the many characteristics of soil that can be examined, and the presentation of the obtained results in reports and courts in the UK with its common law and adversarial legal system. This chapter showcases what has been achieved in the development of approaches and methods used in forensic soil science up to the current times. It discusses some anticipated or desired future developments, including outlining the necessary considerations for use of such new approaches in case work. It importantly outlines the main legal aspects, of relevance for any novel approach or new method of analysis being tested and validated for use in case work, as described in this and the other chapters of the book.

As such, Chap. 17 does not describe a(n) individual (emerging) analytical technique, but, rather, it importantly discusses the current and future use of this type of trace and as well as making considerations for the adoption of any new emerging technique in the forensic science.

Therefore, when asked to write a commentary as an "end user", this reading puts one in a reflective mode about soil traces in forensics. After several decades of soil forensics (or somewhat broader: geoforensics), what has been achieved and what may be expected? Just how useful has geoforensics been, and will it be needed more in the future? Are there factors that prohibit the full forensic use of soil traces and if so, can anything be done about that and is it worth the effort? These questions are difficult to fully answer, but some considerations come to mind.

Using soil traces in criminal investigations did not become as self-evident as the examination of many other types of traces. The book that is often seen as the first systematic description of geo- and soil forensics (*Forensic geology* by R. C. Murray and C. F. Tedrow) dates 1975. Now, over 40 years later, in some recent publications

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soil is still being described as something with "forensic potential". So far, soil in the forensic community has not become an obvious addition to the suite of traces to be examined in criminal cases.

To the soil scientist, the forensic potential of soil is clear enough: soil is everywhere and hugely varied from place to place, it is picked up by people and objects and therefore soil easily becomes a trace as in Locard's "every contact leaves a trace". As a trace it contains information related to a (criminal) activity. Traces of soil can help find answers, as the chapter rightly describes, to two important questions: finding an unknown crime scene from soil traces left on objects like tools or clothing when a crime is suspected (most often places of burial of people or items like firearms or bomb components), and determining if traces of soil on evidential objects originate from a particular and known location (such as a crime scene or an *alibi* location). Of these two questions, the former is not often asked, but when such a question arises, it is important to highlight that a soil trace does contain direct information about the very location one is looking for, as is clearly reported by Dawson et al.

The second question (association of a soil trace and a known location), is much more frequently asked. If it can be established that a soil trace was picked up at a crime scene, this can lead to the trace being crucial evidence in a crime. Its role however may also be more modest. From my own experience, a case comes to mind where the question was whether one or two shovels were used to dig the grave in which three murdered people were found buried. For the investigating police, the answer to this question was meaningful to help decide if more people than the one known suspect were involved in the murders. Since the soil on only one of the shovels was similar to the grave soil, the police decided (of course in combination with other intelligence) not to pursue the search for a conspirator. This way the soil helped clarify the crime scenario and soil traces can very frequently do that in many ways.

However, as indeed the chapter shows very well, it takes quite a lot of facilities and expertise to examine soil traces. No one person can ever manage the complete investigation of soil traces from sampling to final interpretation. Soil forensics depends critically on input from forensic practitioners and scientists of different backgrounds, working as a team. It also takes special facilities like GIS (Geographic Information Systems) and relevant soil databases, which need yet more expertise in applying or take long periods to become fully available. This means that the actual examination of soil traces is difficult to practically organise for a single forensic institute or agency without making huge investments. When such investments are not being made, the soil trace will not be used, experience is not gathered, innovative developments will not take place and eventually the soil trace will not increase its importance as evidence and its adoption in forensic case work. This dilemma needs a managerial resolve to keep soil forensics alive and an organisational solution for the proper conducting of soil trace examinations.

Fortunately, to break this cycle, some good initiatives exist. One approach (for example from Australia) is an explicit partnering between forensic practitioners and soil scientists in research institutes. Traces are first evaluated carefully by forensic technicians employing techniques they also use when examining other traces

(mostly spectrometry). If worthwhile, the traces are given to specialist soil scientists in research institutes, who then employ their full range of instrumentation for analysis and apply their specialist knowledge for further examination. Also, in the last decade in for example the UK and Italy, groups of geoscientists or archaeologists together explore the forensic application of their expertise and offer their services to police organisations directly. This is the case in Scotland, where the development of soil forensics has arisen also through a direct partnership between the scientists at the James Hutton Institute, Scottish Police Authority (SPA) and Police Scotland. Another possibility is to do more than just soil trace examination. Within the Netherlands Forensic Institute (NFI) three teams examine soil: in addition to soil traces, soil samples for pollution crime cases are examined, and archaeologists that perform exhumations study soil as the environment of decaying processes to answer questions about, for example, time of death. This broader application of soil science in case work makes certain investments (such as GIS and databases) more justified.

However, insufficient facilities, expertise and awareness of soil as relevant for criminal investigations are not the only factors that still prohibit the full use of soil in forensics. There are still some knowledge gaps that limit the interpretation of the measurement results of soil examinations. It is for example important to have insight in the transference and integrity of a soil trace. Is the soil on a shoe really from one place or is it a mixture that is acquired by walking around as people do? As mentioned in the chapter, it is better to examine lumpy, coherent, aggregates of soil, but they are not always available. Examining the pollen content of the trace might help, since pollen reflects vegetation and it is known which species of plants can be found together or not, so the total assemblage of pollen in a trace can demonstrate that a soil trace is of mixed composition. Of course this can only be done when it is safe to (finally) destroy the trace, since palynology is a destructive method of examination. So unfortunately, often the integrity of a soil trace, especially small ones, is still very unclear. This limited understanding of the trace, prohibits the use of databases that contain information from much bigger samples, and it makes interpretations uncertain.

Also, appropriate methods to interpret measurement results of soil trace examinations still need further development. After the examination, an inference must be made with the measurement results to decide about the provenance or association of the trace. For this, much information is needed, both about the occurrence of different soils and each characteristic in it and of statistical analysis. This is not a simple task, but good developments may come from the use of GIS, that has possibilities for statistical inference built in.

As for the legal aspects of the applications of soil science in forensics, this chapter rightly draws attention to forensic reporting and presentation in court. Dawson et al. focus on the current situation in the UK, that is, the common law and adversarial procedures, “one of the most challenging environments for any expert evidence”. However, from a Dutch perspective, for a country with an inquisitorial system and only professional judges, it is clear that a lot of the legal considerations about forensic contributions to cases given in the chapter are as valid in an inquisitorial as in an adversarial system. Reporting clearly (professional judges are laypersons too), integrity

in work, and scientific robustness are all equally necessary. Moreover, lawyers in an inquisitorial system do not refrain from asking critical questions and can (and do) involve defence experts. Defence lawyers can always ask the judge who oversees the investigative process leading to a trial to involve a defence expert and the request is usually granted. An important difference between the adversarial and inquisitorial system with regards to forensic work is perhaps the fact that in the inquisitorial system much of the challenge is dealt with beforehand and not during the trial in court. Forensic scientists are either registered and evaluated regularly or are appointed by the judge who oversees the investigative process based on qualifications that must be made clear at the beginning of the examinations. Standards and regulations are everywhere. In any case, all forensic work needs to meet the strictest of criteria for good scientific practice. If the work done satisfies this criterion, it should pass adversarial as well as inquisitorial challenge.

It is clear that a small trace of soil takes a big investment in expertise and facilities. But, seeing the soil trace as a valuable addition to the suite of forensic traces, as I do, it is worth the effort to maintain and further develop soil forensics. Necessary for this are at least the simultaneous availability of expertise in soil science and geology, analytical chemistry (both organic and inorganic), biology (of pollen and fungi, plants and animals), facilities with standardised instruments for analysis, GIS, large enough collections of good data on soils, and (not the smallest problem) well developed methods to interpret the measurement results in such a way that appropriate conclusions can be drawn. Within the forensic world it will take a managerial resolve, and (preferably) the establishment of partnerships with academia, research institutes and stakeholders in public prosecution and police organisations, to achieve this and keep soil a valued part of forensics. Moreover it is clear that to achieve this goal good communication between all parties involved is vital and therefore it is a promising development that, as I can observe, this communication is improving and increasing in many places around the world.