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# Forensic Traceable Liquid for Deterring Trafficking in Cultural Property: Pilot Implementation in Iraq

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**ABSTRACT**

This paper introduces and evaluates forensic traceable liquid technology as a potential deterrent for trafficking in cultural property, earlier employed in the UK to reduce heritage crime and recently implemented in Iraq to protect over 573,000 archaeological objects in five museums. The study suggests a theoretical framework and unveils novel qualitative and quantitative empirical datasets acquired through surveying and interviewing 42 law enforcement practitioners from 21 countries. The acquired data confirms the theoretical underpinnings and reveals that forensic traceable liquid, physically applied at the source, is viewed as an efficient deterrent on the market side, providing hard evidence of provenance, enhancing traceability, increasing the certainty of being convicted of dealing in illicit material, introducing risk, and invisibly guarding objects along the trafficking chain. Notably, source-country respondents appear more enthusiastic about this innovation than market-country ones, while the support for its wider implementation is unanimous.

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## Introduction. Trafficking in Cultural Property: Towards Proactive Crime Prevention

Global trade in cultural artifacts is a multi-billion-dollar industry, with a steadily increasing estimated value (FATF 2023). Entering market destinations, an archaeological object often bears a long criminal record, such as violation of national patrimony laws, theft, counterfeiting, illegal export, fraud, corruption, and handling proceeds of crime. Moreover, evidence exists on the links of cultural property trafficking to organized criminal groups, money laundering, and drugs and arms trafficking (Bogdanos 2005; UN 2015; FATF 2023). Terror groups like the Taliban and IS (Islamic State, also known as Daesh) have also used cultural heritage to finance their criminal activity (Barford 2013; UNODC 2016; Westcott 2020). Despite this multiple-level public security impact, international policy has largely taken a reactive stance, with little attention dedicated to crime prevention and deterrence activities aimed at a market reduction. The attention has mainly concentrated on return and recovery, with rare criminal prosecution (Brodie 2015), while investigators tend not to examine financial aspects or associated criminal networks, also due to privacy surrounding high-net-worth transactions (FATF 2023). Such a reactive policy does little to create deterrence both on the market, where the illicit chain is generated, and at the source, where it is fed. Against this background and "alarmed at the growing involvement of organized criminal groups in all forms and aspects of trafficking in cultural property," the Economic and Social Council adopted a resolution on "crime prevention and criminal justice responses to protect cultural property, especially with regard to its trafficking" (ECOSOC Res 2010/19 2010), followed by the United Nations resolutions 180 (UNGA Res /66/180 2012) and 186 (UNGA Res/66/186 2013) on the same issue. The urgent need to act proactively culminated in the adoption of "International Guidelines for Crime Prevention and Criminal Justice Responses with Respect to Trafficking in Cultural Property and Other Related Offences," calling Member States to strengthen crime prevention policies and underlining that cultural property trafficking is facilitated by modern and sophisticated technologies (ECOSOC 2014). Of note, the concepts of crime prevention and crime deterrence are often used interchangeably, yet they are not synonymous. To prevent is to keep something from happening, while deterrence lies at the heart of preventive aspirations of criminal justice and means discouraging someone from doing something by instilling doubt or fear of consequences and, therefore, inhibiting or reducing the likelihood of an event occurring (Kennedy 2009; Glynn 2022).

Consistent with the UN resolutions, this paper intends to contribute towards shaping pro-active, prevention-oriented policy approaches employing technological advancements and considers forensic traceable liquid as a potential deterrent in cultural property trafficking. Physically applied at the source, the technology is meant to holistically impact the trafficking chain by introducing major risk and traceability, deterring looting on the ground and illegal trade on the market. Thus, this paper provides a thorough background on forensic traceable liquid technology, its characteristics, use by law enforcement, and previous academic research. Then, having examined the successful deployment of forensic traceable liquid for deterring heritage crime in the UK, the paper focuses on its pioneering implementation for protecting over 573,000 archaeological objects in five museums in Iraq (British Council 2020), one of the most looting-affected countries (Stone 2015; Matthews et al. 2020). Further, the technology is scrutinized through the lens of three theoretical approaches emerging as a lever of three

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main deterrence elements: raising certainty of being convicted (Deterrence Theory), increasing risk in dealing in illicit material (Market Reduction Approach), and introducing invisible guardianship along the trafficking chain (Routine Activity Theory). To empirically verify the above theoretical assumptions, the study tackles the law enforcement perspective, operating with novel qualitative and quantitative datasets acquired through a digitally-delivered survey and semi-structured interviews with 42 specialized law enforcement practitioners from 21 source and market countries. The obtained results fully support the theoretical underpinnings disclosing a high perceived deterrence efficiency of forensic traceable liquid. Viewed as an instrument of strategic prevention and an efficient tool for providing hard evidence of provenance and enhanced traceability, forensic traceable liquid is seen as capable of increasing the certainty of being convicted of dealing in illicit material. The results also demonstrate that the wider the scale of implementation, the higher will be the risk and fear of being convicted along the trafficking chain, decreasing illegal transactions. Invisible guardianship and deterrence signage are also seen as contributing towards sending a powerful deterrent message. Moreover, the results reveal a higher confidence in deterrence efficiency of forensic traceable liquid on behalf of source-country respondents as compared to their market-country counterparts. However, despite this enthusiasm gap, all surveyed agents express a unanimous support for its wider implementation in curbing trafficking of cultural property. Challenges and recommendations for future deployment are also discussed.

Hence, this study extends our understanding of deterrence efficiency of forensic traceable liquid, adding a novel research element on the preventive side of the fight against cultural property trafficking. Increasingly facilitated by modern and sophisticated technologies, this criminal phenomenon likewise requires technologically enhanced prevention and deterrence: "If law enforcement does not stay up to date with technology, then it can be like trying to chase a Lamborghini car on a Vespa. Law enforcement must embrace the use of technology in order to be more efficient and effective and help us stay on top of the issue" (Respondent 40 [R40], Randolph J. Deaton, Supervisory Special Agent, FBI Art Crime Program Manager, FBI Art Crime Team, USA).

## Contextualizing Forensic Traceable Liquid Technology

### *Proof of ownership and crime deterrence*

Forensic property marking has been used as a preventive measure in reducing crime, deterring offenders and increasing levels of public confidence in policing, for decades (Hodgson et al. 2018). There are numerous terms to describe the technology subject of this paper, such as "forensic traceable liquid," "invisible forensic taggants," "SmartWater," and others, where "forensic" suggests laboratory analysis, "liquid" differentiates itself from microdots, "invisible" implies impossibility to detect by the naked eye, "taggants" refers to traceability, and "SmartWater" makes reference to the original product.[1] Here, the abovementioned terms are used interchangeably. Forensic traceable liquid was designed in the early 1990s by Phil Cleary, a former British police officer, and his brother, Mike Cleary, a Chartered Chemist (Evans 2012). By varying the chemical composition of liquid polymer manufactured from a selection of 24 rare elements and using a blend of microscopic additives to encrypt data, millions of formulations are available. Each specific formulation acts as a unique marker, providing a robust form of traceability to law enforcement and ensuring that provenance can be established in case of theft or pillage, containing data on the owner's identity, the location of the theft, and the date it was applied and by whom (Evans 2012; Cleary 2017a). A clear liquid at the point of application when brushed or sprayed on, it is completely undetectable by sight or feel when dry, except by a green UV light, under which it glows bright yellow (Dodd 2017). As an asset protection identifier, it is deemed to be superior to genetic fingerprinting DNA (Andrews 2005), is permanent under all conditions, and can stay on skin for months and clothing for years (Figure 1A). Any attempt by criminals to scrap or scrub it off risks simply transferring incriminating evidence —dust particles—to their tools, clothes, and location, adding to its deterrent value.

Today, law enforcement in various countries makes use of forensic traceable liquid, and in the UK, there has been a successful wide-scale deployment of property marking schemes by police aimed to reduce and deter household burglary, catalytic converter theft, rail and telecoms cable theft, fuel and solar panels theft, cash-in-transit and ATM attacks, domestic violence, and other crimes (IFSEC 2008; Cleary 2022). Forensic traceable technology is used in a variety of specific products (liquid, powder, spray systems, etc.) as a part of comprehensive crime deterrence strategies including, but not limited to, covert operations, enhanced policing, liaison and education of second-hand dealers, and equipping police stations with detection equipment. Removing the anonymity of previously unidentifiable property, forensic traceable liquid "helps police find things that seem lost forever" (Metropolitan Police Service 2016), while deterrent signage plays a crucial role in informing criminals and the public about the enhanced protection (ADVANCE 2021; Portsmouth City Council 2023). In relation to household burglary, MetTrace partnership has been enforced by Metropolitan Police since 2015, aiming to change offender behavior through fear of increased identifiability and traceability of stolen property (Figure 1B). Over 440,000 homes have been protected so far, and 97.5% of those have not been targeted since, resulting in a 25% reduction in burglary in protected areas (Metropolitan Police Service 2018). Furthermore, in 2021, the National Infrastructure Crime Reduction Partnership was launched by the Home Office of the UK Government to share intelligence and track organized crime gangs to tackle all infrastructure-related crime (Doyle 2023). Forensic traceable liquid is at the core of this intelligence-led multi-agency initiative, aiding police to map out criminality and maximize the identification of offenders (London Assembly 2020; BSIA 2021). The technology was also adapted to tackle ATM gas attacks, ensuring that both criminals and stolen cash were forensically marked, regardless of how an ATM was attacked, whether that be an explosive force of gas, cutting attacks, or Black Box or Drag Out attacks using heavy plants (Mack 2017; Cleary 2018). The trial application resulted in an unprecedented 90% reduction in ATM attacks across the deployed areas and extension of the program's scope (Dodd 2017). Forensic


**Figure 1.** A) Forensic traceable marking under UV light and B) MetTrace deterrent signage. Image Courtesy of SmartWater Group Ltd©.

taggants are also used to prevent domestic abuse, enabling potential victims to mark perpetrators at the time of an incident, forensically linking them to the scene of crime, and reporting a 69% domestic violence reduction and a 94% reduction in harm from the reported incidents (ADVANCE 2021). The list of examples could be continued, but the common denominator is a steady increase in conviction rates for crimes otherwise hard to prove, mirrored by statistically proven crime reduction and deterrence rates. Regional and national media coverage of successful convictions due to forensic traceable liquid is vital for amplifying deterrent value within a criminal cohort both efficiently and cost-effectively.

## Previous academic research

While police have been making extensive use of forensic traceable liquid both as an investigative and crime prevention tool, limited empirical research has been carried out on its deterrence efficiency, showcasing a lack of agreement on the issue. Below, a comprehensive scrutiny of the existing research is provided, with a brief overview of earlier work and a specific focus on more recent and up-to-date research.

Thus, in 1975, a range of operation identification projects in the USA showcased 33% and 25% burglary reduction rates for participating areas due to property marking (Heller et al. 1975), though a study by the National Council for Crime Prevention in Sweden reported little crime deterrence effect of property marking on interviewed burglars (Knuttson 1984). Further, a 12-month postcode property marking demonstration project in South Wales reported a 40% burglary reduction in participating dwellings, with no reduction registered for non-participants. A crucial deterrent role of window/door stickers was underlined, and a significant reduction in markable goods' loss demonstrated the efficiency of property marking per se (Laycock 1985). Furthermore, a UK nationwide burglary reduction schemes' review included a minor property marking trial in Nottingham, noting a very low 1.4% burglary rate for marked households as compared to the 7.8% rate of non-participant ones (Tilley and Webb 1994). Tackling offenders' perspectives, a 2004 UK Home Office study concluded that only 25% of wrongdoers would be deterred by property marking (Hearnden and Magill 2004), and Sutton also suggested that offenders are largely unconcerned by property marking, recognizing, though, that it might increase detection rates (Sutton 1998, 2008).

Against this background of earlier research based on outdated marking and marketing techniques, three works deserve larger attention due to their focus on contemporary forensic marking technology, accurate methodology, and breadth of scale. Gill aimed to assess the effectiveness of forensic traceable liquid, tackling offenders' perspective through a sample of 101 interviews in a Doncaster prison in the UK (Gill 2008). The location was chosen due to the city-wide use of traceable technology by law enforcement within an overarching crime reduction strategy run from at least 2005, accompanied by sustained press and media awareness campaigns targeting criminal fraternities. By 2008, over 15,000 homes across Doncaster were protected with forensic traceable liquid and anti-intruder index sprays, along with routine UV scans at police stations, covert and overt operations resulting in high-profile convictions of well-known criminals, education of potential receiver/buyer communities, and extensive warning signage in the area. The results evidenced a high deterrence effect of forensic traceable liquids, with 74% of offenders declaring never to break into a building with such signage displayed. Interestingly, 17% of respondents who claimed not to be deterred by the signage alluded to not believing the technology would really be present on the site. Further, 91% of respondents demonstrated a good understanding of the functioning of forensic traceable liquid, recalling at least one distinct feature, such as invisibility, difficulty of removal, glowing under UV light, and a unique DNA-like code assigned. Moreover, 70% of respondents declared it would be "very difficult" to remove index spray from the body, while 45% of respondents thought it would not be possible to remove it from stolen property. Finally, forensic traceable liquid totaled the highest score—8.3/10—as compared to other deterrents, such as police patrols, access control systems, window grills, CCTV, and others (Gill 2008).

Upon request of West Mercia and Warwickshire Police, Hodgson evaluated the impact and cost effectiveness of burglary reduction strategies, focusing on two principal interventions: forensic traceable liquid marking and the "We

Don't Buy Crime" campaign utilizing UV marker pens, with similar deterrent publicity employed in both cases (Hodgson et al. 2018). The project evaluated the 2015–2017 trial period when three areas (A, B, and C) were treated with forensic traceable liquid technology and in area D, the "We Don't Buy Crime" campaign was implemented, while area E received no similar treatment. At the early stage of assessment, a drop of 15–41% in dwelling burglaries was reported in all deployed areas, A–D, as compared to untreated ones. Along with this, an estimated 6–46% increase in non-dwelling burglaries (not targeted by interventions) was recorded, indicating the shift towards easier targets. To test these figures across a larger area, forensic traceable liquid was deployed in 12 more areas (including the 3 initial ones). Similar burglary reduction rates were recorded across all treated sites, with an estimated drop of 18–52% in dwelling burglaries. Despite greater statistical power achieved by combining data across 14 sites, the study deemed it problematic to make causal connections between crime reduction rates and property marking interventions, reporting that it was not randomly allocated to sites and incidence of burglary in treated areas was too low. Albeit with the declared limitations, Superintendent of West Mercia Police Tom Harding stated that with burglary rates being 18–52% lower than expected, these conclusions are essential for proving forensic marking deterrence effectiveness and sparing people the trauma of having their homes broken into (Hodgson et al. 2018). The West Mercia Police continues to deploy forensic traceable liquid technology, registering consistent crime reduction rates (West Mercia Police 2022, 2023).

Finally, Raphael's study shed more light on assessing the deterrent impact of forensic traceable liquid property marking on residential burglary crime reduction (Raphael 2015). When conducting this research, Iain Raphael was a Detective Superintendent and organizational lead for crime prevention at the Metropolitan Police, with over 20 years of experience in conventional and covert techniques to deter and detect crime, and was led by intrinsic motivation to understand whether police were making the best use of technological advances. The study monitored levels of crime in 10 different trial areas in London, extending the observation coverage up to 750 m in 250 m intervals around trial areas, considerably widening the scale as compared to previous studies. Notably, 5000 London residential households were forensically marked, and key data was observed over a 12-month period against the previous year. Property marking was supported, as part of a comprehensive strategy, by extensive deterrent advertising in the deployed areas, covert operations, liaison with second-hand dealers, equipping police stations with detection equipment, and scanning of prisoners, as well as wide and targeted press media coverage and marketing of pro-active arrests and convictions (Harrison 2013). The obtained results demonstrated a 45% reduction in residential burglaries, a 21% reduction in robberies, no significant change in motor vehicle theft, and a 22% reduction of total notifiable offences within the 10 trial areas. Significantly, when widened to include 250 m, 500 m, and 750 m displacement zones, a 23% residential burglary reduction, a 15% robbery reduction, a 3% motor vehicle theft reduction, and a 9% total notifiable offence reduction were reported, evidencing no significant crime displacement and a clear diffusion of benefits effect. However, a light offence displacement was registered once offset against control area performance, with minor increases in less harmful offences, such as robbery (cumulatively a 5% increase found to 750 m), theft of motor vehicles (10% increase), theft from motor vehicles (15% increase), and total notifiable offences (1% increase), which could be minimized by maximizing deterrent advertising. Moreover, an online survey reported 51% of households feeling safer in their area and 52% in their home, with 33% registering an improved opinion of police, which is a considerable overall increase in public confidence. Based on firm statistical data, the study demonstrated that forensic traceable liquid protection can significantly reduce residential burglary, with a clear diffusion of benefit effects, reduced levels of offence displacement, and the identified power of psychological marketing in altering offender behavior and deterring crime. These results exercised significant impact on law enforcement, with the MetTrace partnership launched by the Metropolitan Police in 2015 applying the forensic traceability scheme to over 440,000 homes in London and resulting in the largest ever worldwide implementation of this form of situational crime prevention (Rowe 2016; London City Hall 2019; Moorhouse 2019).

## Cultural heritage protection

### Religious heritage

Proven efficient in securing convictions in court and deterring crime, forensic traceable liquid bears profound implications for world cultural heritage protection (Antiquities Coalition 2017). Despite its still relatively limited deployment, proactive use of forensic marking can play a key role in preserving our shared memory. In the early 2000s, due to the so-called lead theft epidemics, unprecedented levels of metal theft from church roofs all over the UK were registered, causing multifold damage (Cooper 2013). With material devastation of church roofs and water ingress destroying interiors of high historic, artistic, and spiritual value, the economic burden of restoration was enormous (Gledhill 2007). Huge damage was also caused to local communities visiting churches for religious service and/or social assistance, "leaving holes not only in church roofs, but also in the hearts of people and especially their identity" (ITV 2020). In 2007, over 24,000 churches in the UK were protected with "high-tech holy liquid" and deterrent signage on church premises, allowing stolen metal to be forensically traced back with undeniable evidence (DeterTech 2013; Thomas 2023). The growing deployment of forensic traceable liquid resulted in a slow reduction of incidents, and by the end of 2011, a 67.4% reduction in theft claims was recorded (Barnes 2023). Since then, with some minor fluctuations and progressive increase in forensic traceable liquid deployment, church theft rates have been steadily reducing (Figure 2), while numerous churches received precious pieces of their historic structures back (Ecclesiastical 2012). Today, forensic traceable technology forms part of insurance protection toolkits for churches, deterring criminals and securing successful convictions, with a most recent conviction culminating in a 10-year imprisonment sentence thanks to forensic evidence (Thomas 2023; Wiggins 2023).

### War memorials

With an estimated 100,000 war memorials in the UK, ranging from crosses, bridges, and buildings to plaques and lighthouses, these also became an easy target for

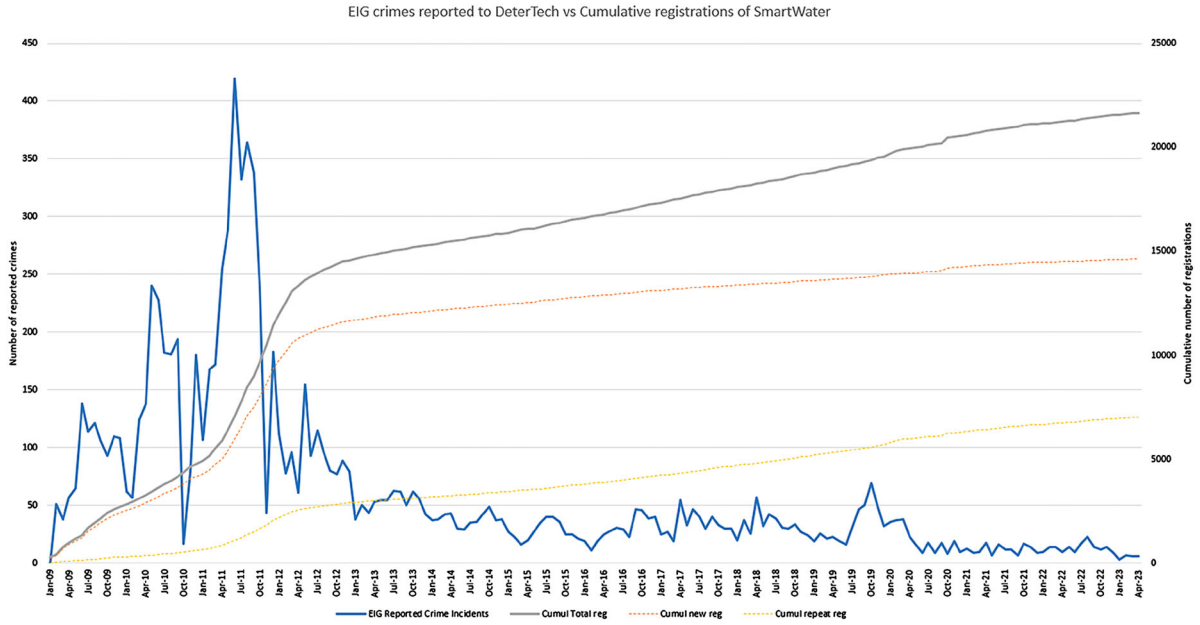


**Figure 2.** Crimes reported by Ecclesiastical vs. cumulative registrations of forensic traceable liquid. Image courtesy of DeterTech©.

perpetrators, with an average of one to three war memorials per week vandalized by thieves looking to illegally remove bronze, copper, and other metals to sell for scrap (War Memorials Trust 2012). In response to this and to coincide with the centenary of the First World War, the *In Memoriam 2014* initiative was launched in 2011 by the War Memorials Trust with the support of the Royal British Legion, Cadet Forces, and HRH Queen Camilla (War Memorials Trust 2011). The project aimed at employing forensic traceable liquid for deterring metal theft and providing greater protection to war memorials, rendering them uniquely identifiable and traceable by assigning each sculpture and plaque with a high-temperature state-of-the-art forensic signature guaranteed to withstand burning and melting, making it harder for criminals to dispose of stolen metals (English Heritage 2012). Moreover, the concept of *In Memoriam 2014* included an important awareness-raising component by encouraging local communities and youth to get involved by registering and forensically marking war memorials (English Heritage 2012). A year after the launch of the campaign, a two-thirds drop in metal theft on war sites across the UK was already reported (War Memorials Trust 2012). In subsequent years, statistics showcased a continuous drop in theft and vandalism, with the lowest number of incidents reported in 2021–2022—10 incidents as compared to 16 in the previous 2020–2021 period (War Memorials Trust 2021, 2022). Reportedly, the role of media is paramount in highlighting that war memorial theft is not only unacceptable but no longer a soft target, due to the heightened risk of prosecution (War Memorials Trust 2012).

### *Other heritage crimes*

Forensic marking is now part of the "Heritage Crime Prevention Guidelines" of Historic England (Figures 3A, 4), an executive agency of the British Government tasked with protecting historic environments (Historic England 2023). Among other examples, following the theft of lead piping from Hall's Croft, one of the five Shakespeare family homes in Stratford-upon-Avon, the Shakespeare Birthplace Trust implemented forensic traceable tagging on all five buildings, and no theft episodes have been registered since then (Tackett 2020). Forensic technology has also recently assured the first ever arrest and a six month jail sentence under the 1990 Indian Arts and Crafts Act for illegal sale of Native American jewelry (Tackett 2020), while the United Nations Educational, Scientific and Cultural Organization (UNESCO) has also launched the development of a forensic process to trace illegal trafficking of elephant tusks and rhino horn (Cleary 2017b).

## Deterring Trafficking in Cultural Property: Pilot Implementation in Iraq

Consistent with the ECOSOC Guidelines, efforts are being made worldwide to prevent trafficking in cultural property. In response to the growing threat of terrorism financing and money laundering, the EU has provided for a system of import licenses for cultural goods (EU 2019) and expanded the scope of its anti-money laundering legislation requiring the art market to comply with compulsory due diligence (5AMLD 2020; 6AMLD 2021). In Italy, new legislation was enacted criminalizing heritage crime with up to 16 years of imprisonment (LEGGE n. 22 2022). Specialist training programs are being held (UNIDROIT 2018), and the number of restitutions to affected countries is growing (Cascone 2021). Trafficking in cultural property is increasingly facilitated by modern and sophisticated technologies; here, we focus on forensic traceable liquid as a novel deterrent and evaluate its potential effectiveness, first, within a theoretical framework and, empirically, from a law enforcement perspective.

Following the murder of Khaled al-Assad, beheaded by IS in 2015 for refusing to disclose the location of hidden archaeological artifacts in Palmyra, Syria, the development of a special forensic product was initiated to protect cultural heritage in endangered contexts and conflict areas (British Council 2020). To alleviate concerns of conservators, the University of Reading led the development of unique chemical codes for inorganic artifacts that cause no damage to stone, ceramics, metal, or glass and are able to withstand explosive blasts, harsh solvents, and extreme environmental

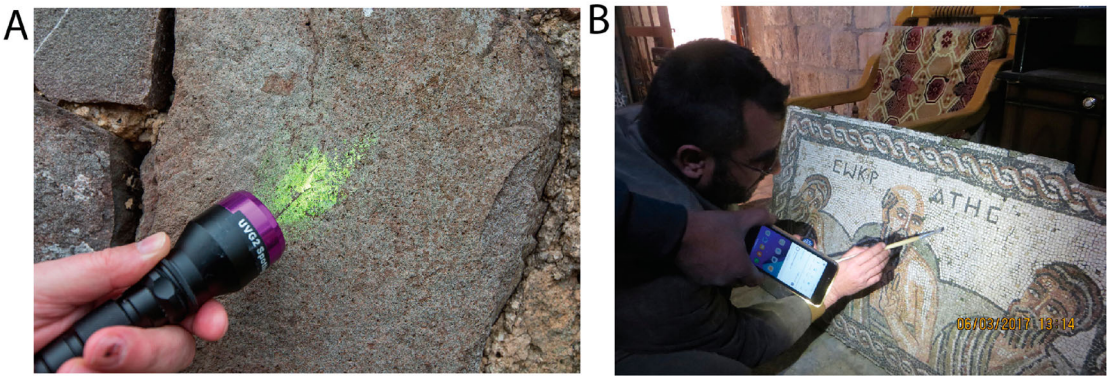


**Figure 3.** Forensic traceable liquid marking A) at the Hartshill Castle, UK and B) in Syria. Image Courtesy of SmartWater Group Ltd©.

conditions, while traceable liquid for organic materials is still under development (British Council 2020). The product was tested at universities in the UK and the USA and is guaranteed to last at least 30 years after application. The research culminated in a pilot project in Iraq, forensically protecting 206,000 objects in the Iraqi National Museum in Baghdad and 67,000 in the Slemani Museum in Sulaimani, Kurdistan Region of Iraq (Figure 5). In the second phase, a further 300,000 objects in three museums across Iraq were protected, and more initiatives in Iraq, Yemen, Libya, and other countries are in progress, while implementation in Syria is suspended for security reasons (Figure 3B). Museum staff training, enhanced cataloging, archiving, and photographing of collections were also carried out, along with deterrent signage and press releases both in Iraq and internationally (British Council 2020; Tackett 2020; University of Reading 2020).

The strategic objective of forensically marking archaeological heritage in Iraq and other source countries consists in holistically tackling the illegal trafficking chain: physically protecting objects on the ground and deterring illegal trade on the market. Similar to all the heritage crimes described above, once on the market, stolen pieces become totally anonymous, unidentifiable for police and impossible to trace back to the original structure. Likewise, the burden of proof is a critical obstacle in securing convictions for trafficking in archaeological artifacts, as, once taken off the land in a clandestine way, it remains close to impossible for police to prove their illegal origin. Helping to tackle this critical inability of police to identify illegal objects in their apparent anonymity, forensic traceable liquid changes this situation by making offenders reconsider the risks and deterring crime. More specifically, with millions of datasets available, forensic traceable liquid is meant to provide hard, indelible proof of provenance to objects, aiding law enforcement in overcoming the burden of proof and guaranteeing traceability. Such enhanced protection means that, in the event of a repeat of the 1991 or 2003 events in Iraq, there would be a realistic chance of recovering marked objects by tracing them back to their museum of origin and facilitating repatriation. Finally and most importantly, by proactively introducing an additional element of risk within the supply chain, forensic traceable liquid is meant to create a powerful deterrent to the first-world buyers in market destinations (British Council 2020; Cleary 2020; Fobbe and Koush 2021).

## Methods and Materials: Evaluating Deterrence Efficiency

### *Theoretical framework*

To evaluate the potential crime deterrence efficiency of forensic traceable liquid, we first scrutinize it through the lens


**Figure 4.** Forensic traceable liquid deterrent signage, Ironbridge Gorge Museums, UK. Image Courtesy of SmartWater Group Ltd©.

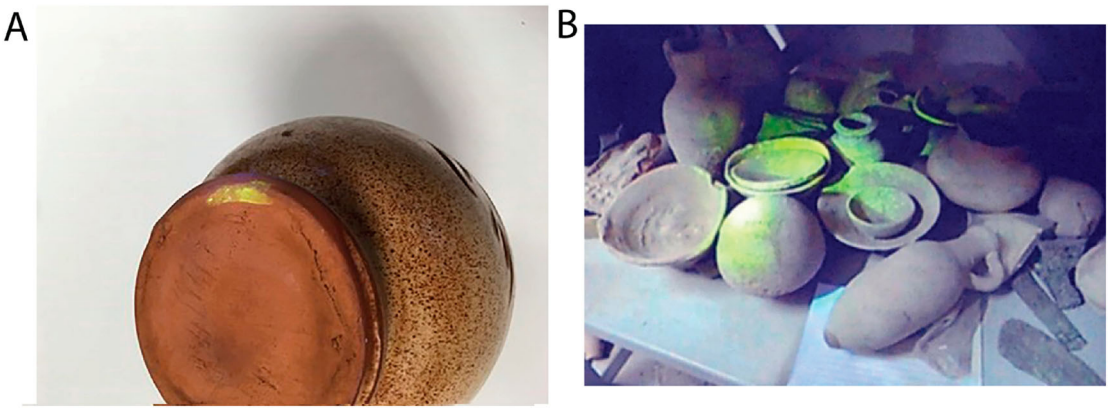


**Figure 5.** Forensic marking on archaeological objects A) under UV light and B) at the Iraqi National Museum, Baghdad. Image courtesy of Roger Matthews and Ali Al-Makhzoomi 2020©.

of three theoretical approaches, namely Deterrence Theory, Market Reduction Approach, and Routine Activity Theory.

Deterrence Theory is based on the assumption that offenders are rational actors willfully engaging in crime and guided by a cost-benefit analysis: a crime occurs when respective rewards outweigh anticipated risks and, therefore, increasing risks can deter most crimes in most circumstances (Jacobs 2010). More specifically, Deterrence Theory operates through three main concepts: certainty, celerity, and severity. Certainty represents the likelihood of being caught, celerity denotes the speed of imposed punishment, and severity alludes to the fact that punishment should be significant enough to project a message of unacceptability. The three should work together to deter crime by increasing the cost of action over its benefits (Johnson 2019), but evidence demonstrates that the deterrence effect of the certainty of punishment is far more consistent than that of severity or celerity (Nagin 2013). In other words, when criminals believe there is a high risk and a certainty to be caught, they are less likely to commit crimes, especially those that require a certain degree of planning, which is the case for the illicit antiquities trade. Moreover, Kennedy assigns a fundamental role to the communication of information to potential offenders, viewing it as a form of advertising (Zimring and Hawkins 1973; Kennedy 2009), a deliberate process influencing behavior and forming sanction risk perception (Nagin 1998). Indeed, deterrent advertising plays a crucial role in reducing and preventing burglary, domestic violence, lead theft, and other crimes. Thus, within Deterrence Theory, forensic traceable liquid tackles the most effective element, deterrence-wise. Applied physically at the source, with proper advertising, it increases the traceability and detectability of cultural property, increasing the certainty of being caught dealing in illicit material on the market side.

Market Reduction Approach (MRA) is a routine problem solving framework tackling the roots of theft, suggesting that demand affects supply and that reducing dealing in stolen goods will downscale motivation to steal (Sutton, Schneider, and Hetherington 2001). Reiterating Deterrence Theory, MRA suggests the strategy of risk projection and assumes that raising risk along the illegal chain will reduce motivation to steal and, as a consequence, illicit dealings on the market (Mackenzie 2011). To do so, MRA propones instilling an appreciation that transporting, storing, and selling stolen goods is at least as risky as stealing itself, which, consequently, renders buying, dealing, and consuming appreciably riskier for all stakeholders. Strategically, MRA recommends enforcing interagency partnerships and seeking to implement local legislation requiring traders to provide proof of sellers' identities, use test-selling on dealers' compliance, conducting media campaigns, arresting fences, providing hot lines for reporting illicit dealings, and raising awareness of increased risks of being caught (Sutton, Schneider, and Hetherington 2001). Proven useful for tackling other stolen goods markets, MRA is an acknowledged strategy for engaging with the global antiquities market, where multi-decade impunity has actually rendered its participants fearless of being caught (Mackenzie and Green 2009; Brodie 2015). Thus, within the MRA framework, forensic marking of cultural heritage at the supply end renders dealings riskier for all stakeholders by introducing the necessity of making additional checks against indelible tags and having the potential to deter middlemen, dealers, and final consumers. Combined with extensive deterrent campaigning at both ends of the chain, forensic marking is capable of sending a powerful message of a new, earlier unheard of, risk of being caught red-handed within an overall riskier market environment.

The third theory chosen here for analyzing antiquities trade is Routine Activity Theory (RAT), which argues that for a crime to occur, the convergence of three factors should take place: motivated offenders, suitable targets, and absence of capable guardians, the latter two creating opportunities for crime. The theory assumes that crime can be deterred by restricting opportunities for it to occur and rendering targets less suitable (Coomber et al. 2015). Applying RAT to the antiquities trade, it appears that its first two components are hard to impact. Offenders are highly motivated, as profits along the chain grow exponentially (Koush 2011a; Mackenzie 2011), while archaeological objects are extremely suitable targets due to their size-for-value convenience or orphanage practices of splitting larger artifacts into pieces for better transportation and sale (Watson and Todeschini 2006; Koush 2011b; Leventhal and Daniels 2013). The third RAT element, lack of capable guardians, is also a big issue in source countries due to insufficient law enforcement resources to protect innumerable archaeological heritage sites, often exacerbated by detrimental economic conditions, conflict or post-conflict contexts, or terror groups controlling archaeologically rich areas (Mackenzie and Davis 2014; Kathem et al. 2020). In this apparently hopeless triangle, forensic marking introduces an ever-present yet invisible-to-

the-naked-eye guardian to objects at the source, extending this guardianship further along the illicit chain and indelibly accompanying them up to the market. Such guardianship of previously unguarded areas, along with deterrent signage, would render targets less suitable, reducing opportunities for crime and deterring offenders.

Thus, the above theoretical framework provides a fundamental lens for understanding crime deterrence leverage mechanisms in the context of trafficking in cultural property. Scrutinized through this lens, forensic traceable liquid emerges as a powerful deterrent, acting through three main elements: raising certainty of being caught by providing indelible evidence of provenance (Deterrence Theory), increasing risk along the whole illicit chain up to the final consumer (MRA), and introducing an invisible yet capable guardianship accompanying objects from supply end to market scaffolding (RAT)—all this inseparable from effective deterrent communication. Indubitably, the scope of application and advertising should be expanded to a consistent scale to obtain the desired deterrence effect.

## Research design and participants

To render the above theoretically sound reasoning empirically substantiated, this study tackles a law enforcement perspective, building on novel empirical datasets obtained through a survey and semi-structured interviews with 42 specialized formal and informal law enforcement officers in 21 source and market countries. The research design (performed in accordance with the relevant regulations and approved by the Research Ethics Commission of the School of Archaeology, Geography and Environmental Science, University of Reading, UK) consisted of a two-step engagement process, with a questionnaire-based survey delivered via email followed by semi-structured active online interviews (Fossey et al. 2002). As a result, two types of data were obtained, analyzed, and interpreted: qualitative, gathered from non-numerical entries of questionnaires and interviews, and quantitative, derived from numerical responses to Likert scale questionnaire items. Initially, the UK antiquities market was envisaged to be the main target group for data collection, accompanied by insight from a few distinguished law enforcement respondents. However, a perhaps unsurprisingly low engagement of market stakeholders rendered impossible the inclusion of the respective data into statistical analysis. Specifically, we contacted 37 stakeholders in the UK antiquities trade sector, representing 10 specialized art and antiquities associations, four auction houses, and seven galleries, altogether registering a response rate of 10% with only two full participations, one questionnaire, and one interview completed. The Antiquities Dealers' Association (ADA) Chairwoman provided the only commentary to the questionnaire items without giving numerical Likert scale values. From these comments, it emerged that, in order to reduce illegal antiquities trade, it is necessary to provide "a robust site protection as proposed by article 5 of the UNESCO Convention" and to "treat the antiquities trade as an equal and valued partner rather than as a problem to 'deal' with, encouraging open dialogue between the legitimate antiquities trade and law enforcement as well as academics and museums." While "the legitimate market is well aware of risks associated with selling antiquities and has spent years working with government bodies and the police," it is also necessary to "educate the trade and collectors on how to buy responsibly while supporting the existence of a well-run and responsible antiquities trade" (Joanna van der Lande, ADA Chairwoman). The International Association of Dealers in Ancient Art's (IADAA) Chairman refused to take part in the survey. The British Art Market Federation (BAMF) also declined to engage, inviting us to reference ADA, while no response was received from the British Numismatic Trade Association (BNTA), Association of Art & Antiques Dealers (LAPADA), British Antique Dealers' Association (BADA), Cotswolds Antiques Dealers' Association (CADA), Petworth Art and Antique Dealers Association (PAADA), Portobello Antiques Dealers Association (PADA), and Kensington Church Street Antiques Dealers Association (KCSADA). In spite of such a low response on behalf of umbrella organizations, we still attempted to approach their single members. We contacted four major auction houses, repeatedly directing emails to different representatives: one auction house fully completed the survey, and one participated in the interview. A total of seven galleries were contacted, with only one full participation. Art Loss Register was contacted numerous times, but no participation followed. Thus, despite the reported need for an open dialogue with the antiquities trade, the attempt to do so within this project, aimed at discussing novel technological advancements in heritage protection, did not find the expected response. The only two questionnaires with numerical values do not provide a significant sample for statistical analysis of the group. However, it is interesting and necessary to report the highest possible scores granted to all the items related to forensic traceable liquids' effectiveness by one of the market respondents: "We are always looking for ways to ensure illicit antiquities do not enter the legitimate market and this could help. It would also increase the value and marketability of legitimate antiquities. Therefore, they need to be used more widely, and the awareness of them needs to be greater" (an auction house employee). The other respondent also strongly agreed that a wide application of forensic traceable liquids will make a positive impact on the antiquities trade (Item 18 [I18] on the survey), suggesting also that "unscrupulous dealers will not change their modes of operating. Better security at archaeological sites is needed: if your apartment is continually being flooded from the flat above, you don't make it more waterproof, you go to the plumbing and stop the leak. Same process with illicit digging. But if it [forensic traceable technology] is thought to be effective and doesn't damage the artefacts, then go for it" (a gallery owner).

In sharp contrast to the low response from the trade, the law enforcement (LE) population demonstrated an evident interest and willingness to collaborate, becoming the main target group with an excellent response rate of 68% and a total of 42 participants (age $50 \pm 10$, six female) from 21 countries (Supplemental Material 1). Among those, 40 participants completed both phases (questionnaire and interview), while two participants took part only in the interview and therefore were excluded from statistical analysis. The LE group included formal agents (currently in charge; $n = 24$; age $46 \pm 10$, six female) and informal ones (retired or private investigators; $n = 16$; age $54 \pm 8$, no female) originating from source ($n = 18$; age $46 \pm 9$, two female) and market ($n = 22$; age $52 \pm 10$, four female) countries. Each participant was free to disclose their name

(n = 24) or choose anonymity (n = 18). Notably, the challenge of targeting the LE group was the unavailability of contact details for specialized offices. INTERPOL does possess lists of countries' hot points for cultural crime, but this sensitive data is not public (R9, Corrado Catesi, Co-ordinator, Works of Art Unit, INTERPOL). UNESCO also provides a list of selected Specialized Police Forces on its website, but it is incomplete, and oftentimes contact details are not reported. Academic literature of regional overviews of art crime policing also do not provide contact details (Oosterman 2019). To cope with this inaccessibility of contact information, the stream of contacts was built by accessing pre-existing first-level contacts of the investigator in law enforcement and heritage fields, with a request for further introductions to specialized agents. This process resulted in accessing second-, third-, and further levels of contacts in different countries up to the eighth (see Supplemental Figure 1). No outsider emails were sent to LE agencies, confirming that relationship-building dynamics do not just happen but are the outcome of negotiation between the researcher and actors in the field (Kersel 2006).

### *Research tools and data analysis*

The questionnaire "Towards the safety of the antiquities market: securing the stakeholders from unforeseen risks" was drafted for conducting the survey and was accompanied by a Participant Information Sheet, Consent Form, and Respondent Data Sheet. The questionnaire contained 25 items, 20 of which were 1–10 Likert scale statements and questions, four yes/no questions, and one open-ended question. Thematically, items related to several categories: A) value of cultural heritage for humanity and human rights implications (I1, I6, I9, I19, I23, and I25); B) threats and links to terrorism (I4 and I7); justification techniques (I2, I3, and I5); C) market regulation (I10, I11, and I12); D) reverse of the burden of proof (I20); E) crime deterrence strategies (I8); and, F) forensic traceable liquid technology (I13, I14, I15, I16, I17, I18, I21, I22, and I24). The order of questions was randomized so as not to condition potential responses. Each item invited respondents to briefly state the reasons for the expressed numerical choice (Supplemental Material 2). Of note, the empirical data for categories A–E is part of a separate research project focused on creating a reference framework of crime deterrence strategies for the illegal antiquities trade (under review).

Each questionnaire submission was followed by a request for an online semi-structured interview, with a total of 42 interviews conducted. No uniform interview guide was used; instead, interview questions were prepared based on the respective questionnaire responses of participants. Interviews normally lasted from 1–2 hours, in some cases up to 3 hours, depending on the interviewee's availability. Interviews were conducted on the Microsoft Teams platform and in some cases, due to institutional, technical, or organizational reasons, via phone, WhatsApp, or Zoom. Video and audio recordings were transcribed and safely stored according to the relevant data management policy (University of Reading 2023). All participants received written instructions describing the study and gave written informed consent to participate in it.

To uncover the perceived crime deterrence efficiency of forensic traceable liquid, we analyzed quantitative and qualitative data obtained from responses to questionnaire items of the F category and interviews. All the F category items were conceived on the basis of the theoretical framework described above and aimed to scrutinize the technology through perceived levels of certainty, risk, and invisible guardianship—the main leverage mechanisms of crime deterrence, according to Deterrence Theory, Market Reduction Approach, and Routine Activity Theory, respectively. To facilitate the interpretation of scores and their comparison to the neutral response, the 1–10 scale was converted to a -4.5–4.5 one (-4.5 denotes strongly disagree, 4.5 denotes strongly agree, and a neutral response corresponds to 0), which does not affect the statistical estimates in comparison to the original scale range (for details, see Supplemental Material 3).

## Results and Discussion: a Law Enforcement Perspective

The acquired data demonstrates a high confidence of participants in responding to all F category items, as indicated by significantly positive scores (Supplemental Materials 4–6). We found a number of significant differences between the respective scores from source (n = 18) and market (n = 22) country respondents (see Supplemental Material 5), while we did not observe any significant difference between responses of formal (n = 24) and informal (n = 16) groups (all p-values > 0.5). Overall, we found that respondents are aware of forensic taggants used to protect heritage (I13; average score $0.7 \pm 0.5$; $z = 5.3$, $p < 0.001$), while only half of respondents had heard about their application in Iraq (I16; average score $0.5 \pm 0.5$; $z = 4.3$, $p < 0.001$), showcasing a relatively high level of awareness. However, most respondents declared they had never come across forensically marked archaeological objects (I14; average score $0.1 \pm 0.3$; $z = 2.1$, $p < 0.037$), a predictable response due to only recent and circumscribed implementation. Regarding potential deterrence effectiveness, respondents highlighted several ways forensic technology can impact the illicit trade, fully confirming the assumptions of the adopted theoretical framework.

### *Increasing certainty: traceability of provenance and hard evidence*

The obtained results showcase a high potential of forensic traceable liquid in overcoming evidential difficulties and, by doing so, increasing the certainty of being caught red-handed, the main lever of Deterrence Theory. As the illegal antiquities trade aims at ensuring that the exact origin of objects cannot be determined, police "have to be constantly teasing out what is illegal and legal, not the same with other types of smuggling" (R2), as "false provenance is very often used for obfuscation" (R11). Therefore, forensic traceable liquid is perceived as "a complete game-changer" (R2) that "would make this impossible, or at least many times more difficult" (R11). Indeed, respondents agreed that forensic technology is an excellent tool for documenting the provenance of an antiquity (I15, see Supplemental Materials 2, 4) providing "an undeniable proof for police" (R20 Jean-Luc Boyer, Vice Director, OCBC Central Office for the Fight against Trafficking in Cultural Goods, Judicial Police, France) and being "very effective in providing evidence in court and enabling law enforcement to establish with

certainty where a particular piece was and when it was last in its country of origin without the need for lengthy international enquiries to authorities, increasing thus the prospect of criminal conviction" (R2). Moreover, due to the enhanced traceability of provenance, forensic technology is deemed "particularly useful for marking pieces at risk in remote rural areas, to which public has unsupervised access, such as religious buildings. It would be a deterrent, and may lead to the identification of stolen material where the theft has not yet been noticed/circulated" (R2).

### Introducing risk and raising fear along the trafficking chain

Within the lens of both Deterrence Theory and MRA, introduction of additional risk into the trafficking chain by marking objects at the source can act as a potential deterrent, raising fear at the consumer end. The acquired results confirm this assumption, with respondents significantly agreeing that awareness about invisible forensic taggants will raise the fear of being caught dealing in illicit material (I21, see Supplemental Materials 2, 4). Indeed, awareness about forensic taggants on the market side, guaranteed by extensive advertising, is meant to raise fear along the entire chain, rendering business riskier for all participants. Regarding buyers, "the danger of being caught and thereby destroy reputation in antiquities field is definitely a deterrent, as they attach great importance to their inviolable reputation" (R11). Dealers and middlemen along the chain will also inevitably perceive additional risk, as "when we could detect people trafficking with illicit goods and be able to arrest them, there will be an extended knowledge of risk and people will start stopping these actions" (R15). Along with this, to be effective in deterring theft on the ground, "deterrent signs should be in the language that potential thieves will understand" (R41 Colonel Matthew Bogdanos, U.S. Marine and Chief of the Antiquities Trafficking Unit, Manhattan District Attorney's Office, New York, USA). Mirroring the perception of increased risk, respondents also assumed that invisible forensic taggants applied in Iraq will decrease transactions in Mesopotamian artifacts (I17), thus recognizing a potential diffusion of benefits on reducing suspicious transactions in objects coming from the historic Mesopotamia region, which extends beyond the geographical borders of contemporary Iraq. However, one must be cautious about interpreting the perceived transactions' decrease, as it might also mean that "marked objects have been driven underground" (R1 Michael McNeir, Former Accredited Financial Investigator and Detective, Organized Crime Command—Homicide and Serious Crime Command, Metropolitan Police Service, UK). Further, similar to I17, respondents agreed that a wide application of invisible forensic taggants will make a positive impact on the antiquities trade (I18), "contributing to its transparency and making trade representatives think more than twice before dealing in illicit or unprovenanced antiquities" (R4 Christos Tsirogiannis, Forensic Archaeologist, formerly at the Greek Ministries of Culture, Justice and Public Order; Greek Police Art Squad, Greece). Interestingly, a correlation between I17 and I18 was observed (Figure 6A; see Supplemental Material 6), suggesting that a positive impact of a wider application of forensic technology (I18) will trigger a further reduction in transactions in Mesopotamian artifacts (I17). Furthermore, the results revealed that items I17 and I18 are consistently correlated to I21 and related to fear of being caught (Figure 6B–C). This cross-correlation indicates that, following the pilot Iraqi implementation (I17), the wider the scale of forensic liquid application in other source countries (I18), the higher the fear of being caught dealing in illicit material will be (I21). The perceived risk will be accrued, leveraging the expected deterrence effect and confirming the underpinnings of Deterrence Theory and MRA.

### Invisible guardianship

Consistent with the results for I17, I18, and I21, the respondents significantly agreed to a more directly formulated statement that invisible forensic taggants are effective in deterring transactions in illicit antiquities (I22). Indeed, the presence of invisible taggant, together with deterrent signage at the source and advertising campaigns at the consumption end, contributes towards announcing that objects are no longer unattended, the target is no longer so suitable, and guardianship is enhanced (RAT). Thus, forensic marking introduces an ever-present yet invisible-to-the-naked-eye guardian to the objects along the illicit chain up to the market, and this is "the beauty of it being invisible!" (R30). Forensic traceable liquid is seen as "a target-hardening strategy which makes illegal trade less attractive. Market should know that the target is getting harder whether they like it or not, therefore the success strongly relies on a successful communication strategy" (R34 Tim Hanley, former Head of Serious Crime Branch, Police Service of Northern Ireland, UK). Notably, a significant correlation between I22 and I21 was also detected (Figure 6D), implying that the higher the fear of being caught dealing in invisibly guarded material (I21), the higher crime deterrence efficiency it will generate (I22). Similar to the triangulation of I17, I18, and I21, a significant positive cross-correlation between items I17, I18, and I22 was also found (Figure 6E–F). The latter clearly indicates that the deterrence efficiency of forensic taggants (I22) will depend on its wider-scale implementation for protecting archaeological heritage (I18), following the positive impact of the pilot project in Iraq (I17). Undoubtedly, "antique dealers have lived in a murky world where they have got away with many things over the years, and now the tide is turning" (R1 Michael McNeir).

### Source and market-country respondents: an enthusiasm gap

Tellingly, source-country respondents showcase significantly higher scores in evaluating crime deterrence efficiency of forensic taggants than their market-country counterparts (Supplemental Material 5), revealing their higher enthusiasm and confidence about the technology and suggesting a number of possible interpretations.

Such a comparatively lower enthusiasm of market-country respondents may be explained by their in-depth knowledge of the on-the-ground realities in market environments where "purposeful indifference renders provenance checks more optical than intrusive" (R34 Tim Hanley). Moreover, in market states, the art and antiquities trade constitutes an important part of national GDP, rendering imperative the protection of trade industry interests, which explains the apparent lack of attention to the problem, scarce

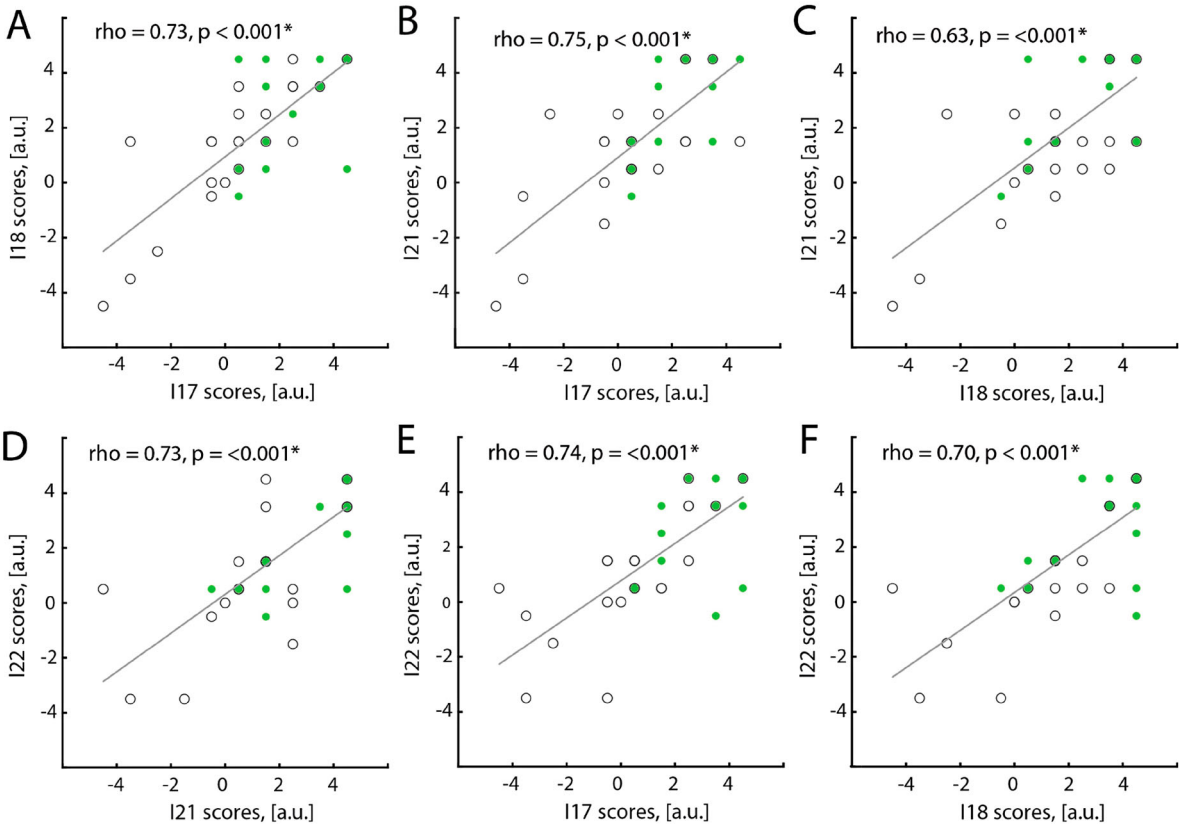


**Figure 6.** Cross-correlations for item pairs with significant difference between respondents in source (n = 18) and market (n = 22) countries. Of note, some responses overlapped; correlation between I2 and I3 is discussed in a separate research project (under review).

resources of police units (if any), and lack of political will to resolve it. The views of conservators and curators are also not to be underestimated in this regard. In first-world market countries, they are predominantly reluctant to apply any substance directly on cultural objects, deeming it invasive despite the laboratorial work conducted to demonstrate no harm is done to the object, consistent with contemporary conservation practice. By contrast, in source countries, especially those in conflict or post-conflict contexts, the attention is rather on physical preservation of an object at risk than on potential minor damage to its surface, if ever that would be incurred, despite the guarantees of the product. Therefore, it would be imperative to respect the views of the latter when the former exercise their power of decision-making in (dis)approving this kind of project for source countries within first-world funding bodies. Furthermore, market-country respondents suggest that forensic traceable liquid might act as a deterrent only for licit dealers but not for illicit ones, who would find an infinity of ways to overcome it. "Unscrupulous dealers are most likely to just elect not to sell an item rather than inform law enforcement if they are offered illicit material for sale, as they would rather seek to avoid handling material than run the risk of being caught" (R2). Alternatively, they would "allow it back into the market via a separate route instead of reporting it, remove the tag or get rid of an object" (R37 Vernon Rapley, Former Head of Art and Antiques Unit, Metropolitan Police, London; former member of Interpol Tracking Task Force). The reported lower enthusiasm could also be attributed to challenges of combatting "the world of organized crime. For them illicit material, tagged or well-known, is a commodity and interchangeable with goods like weapons, drugs or other things with value. Illegally obtained cultural property can be used to negotiate with authorities about a lower sentence when returned to rightful owner, and then taggant will only work in their favour" (R7 Dick Drent, Former Detective Chief Inspector, Netherlands National Police Force, Netherlands). Finally, this overall lower confidence in forensic technology can be explained by its limited scope of application, as market-country respondents dealing directly with trade representatives are well aware that until marking becomes the industry standard worldwide, it is unlikely that dealers will engage with it (R37 Vernon Rapley and R12). Agreeing "this is a good start" (R14 Richard Bronswijk, Leader of Art crime unit in Zoetermeer, Netherlands National Police Force, Netherlands), the respondents from market countries underlined that "to be effective, a widespread issue of SmartWater or similar tech is needed, as only a small amount of coverage exists so far, and it would work as deterrent in both source and market countries, and an investigative tool for law enforcement" (R2).

By contrast, in source countries, the never-won battle against the despoliation of cultural heritage makes LE respondents more enthusiastic to embrace anything that renders their policing work more effective. They are largely convinced that forensic taggants constitute "a very important beginning" (R23), "a very important chapter for managing risk areas and risk implementation" (R33 Michalis Gabrielides, Head of the Office for Combating Illegal Possession and Trafficking of Antiquities, Cyprus Police, Cyprus), and "a step towards the liquidation of any form of illicit trade" (R16). This reliance on the effectiveness of forensic technology is also explained by a deeper empirical knowledge of the links of antiquities trafficking to other criminal activities: "Simply we need to stop buying and selling because this money will be used to finance terrorism and killing people"

(R26 Ali A. Alysauay, criminal investigator and intelligence officer, Head of Special Unit for Cultural Heritage, Anti-Illicit Antiquities Unit, IMOI/AIFI Iraqi Ministry of Interior, Agency of Intelligence and Federal Investigations, Iraqi Police). Interestingly, yet not surprisingly, source-country respondents perceive more clearly the deterrence potential of forensic technology in spite of their extensive knowledge of the illegal excavation problem, realizing that, applied at the source, it is meant to deter the market end. This perspicacious understanding could be best summarized through the words of R26 Ali A. Alysauay: "You cannot deter at the source, deterrence should work only at the market side, and we need not a drop but a stream of forensic technology. We try the best at the source, but it feels like it's our own problem, with no international support, and lack of collaboration for political reasons. But we can only stop the virus by controlling it on the market side." This greater enthusiasm could also be seen through the prism of a fundamentally different approach to the antiquities trade as such. Source-country agents clearly recognize the intrinsic links between archaeological heritage and communities of origin, which is in conflict with market-state models of heritage consumption: "There are no antiquities that have no owner, because they are not the property of one person, but rather the ownership of the entire community. Any trade in antiquities in any country is harmful to the culture of the country. As every society has the right to preserve its heritage and culture inherited through generations, no one can take this right away from them. There are no legitimate antiquities for sale or disposal in all parts of the world, but all of them are illegal and traded by illegal dealers, merchants, gangs and outlaws that exploit antiquities at the expense of poverty of people" (R27 Abdulrahman Alhajjar, Responsible for Heritage Department, SBAH State Board of Antiquities and Heritage, Mosul, Iraq).

### *Clandestine excavation*

Forensic marking is not seen as a panacea of cultural property trafficking, as a vast majority of illegally commercialized pieces are clandestinely excavated with no tagging ever applied. Undoubtedly, forensic marking would be most efficient if applied to documented antiquities from a museum or archaeological dig (R2 and R10). However, "unfortunately most of looted archaeological objects have been directly removed from the ground, and if dealers have the proof that the object comes directly from the ground, they will not be afraid" (R22). Indeed, burden of proof being an important obstacle, identification of the provenance of illegally excavated material remains a challenge for law enforcement. "If sprayed on archaeological sites, forensic traceable liquid could be one tool among many. But its value is limited in the same way an Art Loss Register search is limited: the database is small and the tool has a risk of being misused by dealers, who will say that if there is no marker material on the object, then it must be legal" (R41 Matthew Bogdanos). For the moment, no such spray exists, and its technological development and implementation would require wide endorsement of international organizations like UNESCO in strict collaboration with local authorities, law enforcement, and communities. Various respondents also suggested that newly excavated finds should be marked right after their discovery to allow tracking them in case of theft (R10, R22, and R21 Corinne Chartrelle, Former Deputy Head of Service, OCBC Central Office for the Fight against Trafficking in Cultural Goods, Central Directorate of the Judicial Police, France). Such treatment of legally excavated sites is seen as "a good deterrent, that will definitely raise fear also in relation to illegally excavated objects" (R10). Indeed, the introduction of risk and the deterrence success of forensic traceable liquid in reducing other heritage crimes is telling and triggers the expansion of its use to illegal excavation.

### *A unanimous endorsement: wider implementation and recommendations*

Despite various operational difficulties discussed, a unanimous endorsement was expressed by all the agents to applying invisible taggants to as many archaeological objects as possible (I24), with no significant difference between source and market country respondents and numerous approval comments: "The more the easier to detect and react, as one marked piece is easy to get away with, but with 10 pieces it becomes more difficult" (R7 Dick Drent). In relation to the market, "the more forensic technology is used, the more likely it is for dealers to test for it, as buyers, collectors and investors will demand tests before purchasing. If this could be made a requirement for Defective Title, then it could significantly increase the number of tests and detections" (R37 Vernon Rapley). Globally, "comprehensive tagging would facilitate authorities to share information, surveille, monitor, trace and intercept illicit trafficking" (R35).

Moreover, the endorsement of forensic technology was accompanied by several recommendations. First of all, it should be "applicable for long term, there should be no deterioration on antiquities, and evidence should be trusted and accepted in judicial process" (R36), all conditions fully satisfied. It was also underlined that the database should be secure and well maintained, implementation properly monitored, intelligence-led, and supported by solid infrastructure with appropriate detection tools, specialized training, parameters of deployment, controls, and sanction packages provided to law enforcement and customs, as well as UV checks at customs and massive awareness-raising campaigns among dealers and the general public, with impact statements and deterrent advertising for both sides of the trafficking chain (R1 Michael McNeir, R2, R34 Tim Hanley, R37 Vernon Rapley, and R41 Matthew Bogdanos). Finally, as "there is a lot of money to earn in the world of illicit trafficking so enough reason for organized crime to undermine the system," the successful implementation will "depend on the integrity of the taggant, database, organizations and people implementing them" (R7 Dick Drent). The "culture of checking" should be developed to render it functional for the antiquities trade (R2), accompanied by long-term research on its impact and effectiveness (R4 Christos Tsirogiannis). Moreover, "a solid precedence in a criminal case tried in a court where the technology is challenged but not defeated" will be crucial for creating deterrence (R40 Randolph J. Deaton), as happened with church metal theft. Like any innovation, forensic traceable liquid will require time and consistency to become widely effective in deterring trafficking in cultural property, but the voice of law enforcement makes it clear: "I need

this mark" (R16) and "the more the better, as it will bring about publicity and psychological deterrence" (R26 Ali A. Alysauay).

## Conclusion

Mass depredation of archaeological heritage in cradles of civilization like Iraq and Syria renders imperative a change in international policy towards a more proactive approach. In line with recent UN resolutions, this study contributes to developing technologically-advanced crime prevention and deterrence strategies for tackling trafficking in cultural property. It analyzes forensic traceable liquid technology as a potential deterrent, successfully employed in the UK for reducing heritage crime and recently implemented to protect over 573,000 archaeological objects in five museums in Iraq. Scrutinized through the lens of three theoretical approaches, forensic traceable liquid emerges as a powerful deterrent leveraging three main deterrence elements: raising the certainty of being caught (Deterrence Theory), rendering the market environment appreciably riskier (Market Reduction Approach), and providing invisible guardianship to objects (Routine Activity Theory). Tackling the law enforcement perspective, the study provides empirical data that fully supports the above theoretical underpinnings. First, "a complete game-changer," forensic traceable liquid is viewed as an efficient tool for providing hard evidence of provenance, enhancing traceability and, therefore, increasing the certainty of being caught dealing in illicit material. Secondly, the results highlight that the wider the scale of application of forensic traceable liquid in source countries, the higher the risk and fear of being caught dealing in illicit objects on the market will be, decreasing illegal transactions. Third, invisibly guarding the objects thanks to forensic marking and deterrent signage, forensic traceable liquid is seen as a target-hardening strategy. Further, albeit evenly agreeing that forensic traceable liquid is effective in deterring transactions in illicit cultural property, source-country respondents showcase a greater enthusiasm about the innovation than their market-country counterparts. However, despite this enthusiasm gap, the support for its wider application for curbing trafficking in cultural property is unanimous. Unquestionably, implementation of high-tech preventive measures in source countries, with direct repercussions of risk projection on the market side, will constitute an important step towards a holistic proactive crime control policy, sending a powerful deterrent message to antiquities market environments. Truly, "each archaeological object is like a human being with its own soul, and forensic traceable technology is an incredibly innovative system which gives each antiquity its ID" (R13 Roberto Lai, Former Police Officer, Carabinieri TPC Unit for Cultural Heritage Protection, Italy).

## Endnotes

1. SmartWater Ltd, now DeterTech, is an official police-accredited organization in the UK and a member of the British Security Industry Association. Each unique forensic identification number is maintained on the UK National Security Register certified to ISO 27001 with the highest levels of data security. It is the only forensic marking company compliant with the Government Forensic Science Regulators Code of Practice and received the Prince of Wales Award for innovation and the Millennium Product Status of the UK Government (Portsmouth City Council 2023).

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