

**ENHANCING THE VALIDITY OF THE SAPS GOLD
FINGERPRINTING DATABASE THROUGH IMPROVED
SAMPLE-COLLECTION TECHNIQUES**

by

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submitted in part fulfilment of the requirements for the degree of

MAGISTER TECHNOLOGIAE

in the subject

Forensic Investigation

at the

UNIVERSITY OF SOUTH AFRICA

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APRIL 2008

Preface

This study's main focus was to analyse the methodology used by gold mines when obtaining reference samples required for gold fingerprinting analysis. Such methodology is also regulated by legislation in that in terms of the Precious Metals Act 37 of 2005 sect 22(1), "Any **producer** or any person who imports precious metals must submit to the Forensic Science Laboratory (FSL) of the South African Police Service (SAPS) such specimens of any precious metals produced or imported by him or her as may be prescribed". The gold mines are producers of precious metals, specifically gold, and they are therefore required to submit reference samples, which are then used by the SAPS FSL to maintain a database of gold samples. This database can then be used for comparison purposes during the forensic science of gold fingerprinting.

The supporting regulations of the Precious Metals Act, Section 19 stipulate seven requirements for the submission of reference samples and this study intends to give guidelines to security officials employed on the gold mines of South Africa to ensure that these requirements are met and that the validity of the SAPS gold fingerprint database is enhanced through improved sample-collection techniques.

The use of gold fingerprinting is part of the forensic investigation process used when trying to establish the origin of gold confiscated as an exhibit during police and mining security crime operations and recoveries, and this allows for victim identification in the resultant criminal trial and proper disposal of recovered gold-bearing materials that are recovered.

It is important for the mine security official responsible for reference sample collection to keep in mind that the methodology used when obtaining these samples could be challenged in court and that, therefore, definitive guidelines should be followed to ensure that the most representative samples are collected and that the collection and handing over of samples meet chain of evidence requirements.

Acknowledgements

I would like to take this opportunity to acknowledge the assistance given to me by my supervisor, Dr NJC Olivier. His guidance and support in setting me on the right track when times got tough were invaluable. I would also like to thank the various respondents and other individuals that assisted with completing questionnaires and discussing the subject and, specifically, my employer, Gold Fields Protection Services, for allowing me to use resources and time when conducting the interviews and drawing up the research report. A special word of thanks should also go to Professor Watling, for his patience and for the advice that he gave to me during the time he set aside to discuss my research while on a short visit to South Africa.

I also would like to thank my wife, Bonnie, and daughter Cherize for their understanding and sacrifice of valuable family time that had to be used for the dissertation, especially over weekends and public holidays.

My thesis is dedicated to the memory of my son, Oswald Rhodes Crundwell, who was tragically killed in a motor vehicle accident, during my first year of writing this dissertation.

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CHAPTER 1

GENERAL ORIENTATION

1.1 INTRODUCTION

One of the most significant advances in the fight against gold theft has been the development of a forensic scientific analysis technology to fingerprint gold, which was conceptualised in 1974 by Professor Roger John Watling, while he was working as Senior Research Officer, Applied Spectroscopy and Environmental Chemistry, at the National Physical Research Laboratory of the CSIR in Pretoria, South Africa. In 1992, Professor Watling conducted further research and published his findings in a plenary lecture, entitled “The Use of Laser Ablation-Inductively Coupled-Mass Spectrometry to Fingerprint Gold”, at the Third International Symposium on the Exploration Mining and Processing of Minerals in Johannesburg, South Africa (Watling, 1992). During an interview conducted by the researcher with Professor Watling on 7 December 2007, he stated that the methodology had become commonly known as gold fingerprinting and that he had, since 1992, refined his methodology with the assistance of Anglo American Research Laboratories and had established an initial gold reference sample database for South Africa. It was then realised by members of the South African Police Services (SAPS) and mining industry that in terms of legal compliance, that the body that managed the database and conducted the fingerprinting would have to be an independent body and, as the Anglo American Research Laboratories belonged to a mining company, the database should be transferred to the South African Police Services Forensic Science Laboratory (SAPS FSL), which transfer duly occurred in 1994 (Watling, 2007).

Professor Watling had left South Africa in 1986 and had continued his research into gold fingerprinting at the Curtin University of Technology and later at the University of Western Australia, both Universities in Australia. Professor Watling was requested in 2007 by the South African Chamber of Mines (COM) to review the SAPS FSL gold fingerprinting database and forensic methodology and

advise the COM of any shortages or improvement that could be made which would then allow the SAPS to present gold fingerprinting evidence in South African courts.

The researcher has been closely involved in the review of the SAPS FSL gold fingerprinting methodology by Professor Watling and has noted that the credibility of the gold fingerprinting reference sample database is reliant on the quality and representivity of reference samples collected from the various gold-producing mines in South Africa. The researcher has become concerned that the methodology used when obtaining such reference samples has intrinsic problems in that no definitive guidelines are in place for all mining houses to follow on how to ensure that reference samples that are taken to the FSL meet the requirements of chain of custody criteria and are representative of the ore bodies and metallurgical processes on the various mines in South Africa.

1.2 AIM OF THE RESEARCH

The aim of the research was to establish if improvements could be made to the sample-collection process and techniques, with the specific intent to:

- Ensure that the samples obtained are representative of the ore bodies, the metallurgical processes, and of refined gold; and
- Determine if the collection methodology used meets the legal requirements of natural justice as applied in South African courts

1.3 PURPOSE OF THE RESEARCH

In Denscombe (2002:27), it has been purported that there are various purposes for doing research and that one of the purposes is the desire to solve a practical problem or to improve on procedures. The first purpose of this research would be to evaluate the existing procedures followed for their strengths and weaknesses and then to consider how things should be improved.

A second purpose of the research was to explore national and international literature in the field to discover any new information and make recommendations on good practise (Denscombe, 2002:27).

The third purpose was to apply the new knowledge in the working place in an attempt to improving the validity of the SAPS gold fingerprinting reference database.

In light of the above, the main purpose of the current research was to enhance the researcher's own knowledge and that of other investigators by making recommendations on good practice procedures for the collection, handling and transporting of samples from the mines to the SAPS FSL and to make these recommendations available to others within the mining industry. To this end, the current Gold Fields Protection Services (GFPS) Quality Management procedure regarding the "Escorting of samples for fingerprinting" will be revised and will be made available to other mining houses, and proposals made regarding procedures relevant to the SAPS will be discussed with SAPS officers in an attempt to make suggestions about possible improvements to the current procedures.

1.4 RESEARCH QUESTIONS UNDER INVESTIGATION

Taking into account the topic of the research conducted, namely enhancing the validity of the SAPS gold fingerprint database through improved sample-collection techniques, the researcher identified the following questions that he felt would best be answered by the research study. In Vithal and Jansen (1997:10), it was proposed that a maximum of three questions be asked, as focusing on a limited number of issues would be a way of retaining a sharp focus on what the researcher intended to do. In terms of this research dissertation, the researcher felt that the following two questions would need to be answered:

- What does forensic investigation in the gold mining industry entail?
- What are the current sample-collection practices in the gold mining industry?

1.5 KEY THEORETICAL CONCEPTS

In any research dissertation, it is vitally important that the readers of such a document are fully educated about the terminology used so as to ensure that they have a background understanding of what the researcher is writing about. Terminology should be defined in an operational way, i.e. the definitions must be given as they are used in relation to the researcher's project (Leedy, 1980:60). The key concepts that relate to this research study are defined below.

1.5.1 Theft

A person commits theft if he or she unlawfully and intentionally appropriates movable corporeal property, which:

“(a) belongs to, and is in the possession of, another;
(b) belongs to another but is in the perpetrator's own possession; or
(c) belongs to the perpetrator but is in another's possession and such other person has a right to possess it which legally prevails against the perpetrator's own right of possession: provided that the intention to appropriate the property includes an intention to permanently deprive the person entitled to the possession of the property, of such property” (Snyman, 1995:445).

1.5.2 Gold fingerprinting

Moore (2004:1) reports that every piece of gold has a unique trace element make up, making it possible to identify the origin of each piece of gold that is refined. The metal make up of gold is often referred to as its profile, with each gold fingerprinting as individual to a piece of gold as a fingerprint is to a person.

1.5.3 Refined gold

Refined gold is gold made pure by an industrial refining process (Coetzee & Horn, 2006:62). The researcher is also aware that refined gold is commonly known as bullion or as the final product of the gold mining operation.

1.5.4 Gold-bearing material

According to Coetzee and Horn (2006:62), gold-bearing ore is ore in all forms as it is found during mining and processing until it is classified as refined gold.

1.5.5 Unrefined gold ore

According to Coetzee and Horn (2006:62), unrefined gold ore would consist of rock that has not been processed to remove impurities that contain trace elements of the required precious metal.

1.5.6 Extractive metallurgy

The New Book of Knowledge encyclopaedia (1992:229), defines extractive metallurgy as dealing with the extraction, or removal of the metal from its ore and the refining of the metal.

1.5.7 Mass spectrometry

According to Antolasic (2005:1), mass spectrometry is concerned with the separation of matter according to atomic and molecular mass.

Another definition, as given by James and Nordby (2002:640), is that mass spectrometry is the technique based on the detection of vaporised molecules and their ionised (charged fragments). The detection and display of the spectra are based on the mass to charge ratios of the ions.

1.6 DESIGN

In terms of an overview given by Maxfield and Babbie (2005:108), research design involves a set of decisions regarding what topic is to be studied, among what population it is to be studied, with what research methods, and for what purpose. The researcher made use of an empirical study design, in terms of which knowledge was based on observing what the strengths and weaknesses of existing procedures were through carrying out interviews, conducting a literature review, and physically observing the reference sample-collection techniques. Empirical research is the production of knowledge based on

experience or observation (Maxfield & Babbie, 2005:4). The design followed ensured that the respondents to the study were involved in the process of gold fingerprinting reference sample collection and their input was reliant on real life situations and experiences, which had made the results of the research applicable to the practice (Denscombe, 1998:27).

1.7 APPROACH

A qualitative approach was used, which is basically any type of research that produces findings not arrived at by statistical procedures or other means of quantification. Qualitative research can refer to research about peoples' lives, lived experiences, behaviours, emotions and feelings, as well as about organisational functioning, social movements, cultural phenomena, and interactions between nations (Strauss & Corbin, 1998:10). The reason that the qualitative approach was important to the researcher was that it would enable the researcher to establish what techniques were in place in practice so that he could then try to understand why the specific technique was being used. This should then enable the researcher to highlight possible shortfalls in the methodology and to make suggestions on improving the techniques used, in this way improving the validity of the SAPS gold fingerprint database.

1.7.1 Target population

In Graziano and Raulin (1993:194), the term "target population" is defined as the larger population in which the researcher is ultimately interested. In terms of this research, the target population was people who were aware of or had been exposed to the collection of reference samples for gold fingerprinting (and, therefore, have knowledge on the subject) and these individuals would include two members of the SAPS FSL, ten SAPS Organised Crime Precious Metals and Diamond Unit members, and 17 Mining Security members who were mainly involved in the investigation or management of gold theft from various mining houses, including Gold Fields, Harmony, Anglo Gold Ashanti, and Durban Roodepoort Deep. The total target population, therefore, consisted of 29 people

who were involved in varying degrees with reference sample collection for gold fingerprinting.

All the identified persons (respondents) who were identified in the target population were all active members of either the National Forum (NF) or the National Coordinating Committee (NCC), which are joint mining industry and SAPS initiatives to address gold theft in South Africa. The NF is a more strategically focused body, which develops strategy, and senior officials of both the SAPS and Mining Security divisions of several mining houses in South Africa are represented at the forum. The NCC is basically the operational body of the NF and operational strategies are implemented by this body. One of the strategic initiatives of these bodies was to assist the SAPS with the implementation of gold fingerprinting to being a recognised forensic methodology, which could be accepted in the South African courts.

Owing to the relatively small target population, the researcher thought it relevant to approach several subject experts through a process of purposive sampling (Maxfield & Babbie, 2000:238). These identified individuals would then complement the research by providing technical detail on gold fingerprinting, legislative requirements for chain of custody, and metallurgical and geological expertise. A total of five subject experts were identified and were approached to participate in either a structured questionnaire interview or an informal interview on specific technical aspects of the topic.

1.7.2 Sample population

Graziano and Raulin (2004:204) state that the definition of the sample population in research would be the subset of the target population on which measures are taken.

In identifying the sample population for the research, the researcher noted that, although various members of the target population were aware of the basic concepts involved in gold fingerprinting, very few of them had practical

experience in the actual reference sample-collection process. The researcher noted that, in the past, the collection of representative samples for the database had been conducted in a very unplanned and haphazard manner and that members of the SAPS FSL had not been happy with some of the samples received, as samples were often not in the correct format and the majority of mining houses did not have any written guidelines on how to submit the samples (Dixon, 2007). The researcher conducted several initial interviews and it was apparent that the best inputs were received from members of the SAPS FSL and then from only one or two individuals from the various mining houses that had actually been involved in the process. It was, however, still decided to use the process of random sampling (Blaickie, 2003:168) on all the people in the target population to allow for a larger sample population, albeit that it became quickly apparent that only a limited number of people responded well to specific questions on the previous process used.

1.7.2.1 Random sampling

The 29 people identified in the target population were subjected to a simple random sampling technique (Blaickie, 2003:168) to select the sample population from the target population. Random sampling involves a selection process that gives every possible sample of a particular size the same chance of selection (Blaickie, 2003:168). The 29 names were put into a hat by the researcher and names were drawn at random for participation. In some instances, people who were approached for participation indicated that they preferred not to complete a questionnaire as they felt that they did not have enough knowledge on the sample-collection process as they were not directly involved in the process and, in such instances, another name was drawn on a random basis for an interview. The researcher, however, ensured that people who had been involved in the actual collection process, i.e. members of the SAPS FSL and some of the mining security members, were included as part of the sample population.

The final sample population consisted of 11 people who were prepared to participate in the structured questionnaire, two members from the SAPS FSL,

three members from the SAPS Organised Crime Precious Metals and Diamond Unit and eight members from the various mining houses involved. The researcher noted that the sample population consisted of a very limited number of respondents and was concerned that this would affect the reliability of findings. As the research topic was inherently a topic that was still in its infancy in becoming a well-researched area, a further decision was taken to include the process of purposive sampling to ensure that the findings made were scientifically credible.

1.7.2.2 Purposive sampling

Occasionally it may be appropriate for researchers to select a sample on the basis of their own knowledge of the population and the nature of their research aims – in short on the basis of their judgement and the purpose of the study. Such a sample is called a purposive sample (Maxfield & Babbie, 2000:238). Purposive sampling allows researchers to choose a case because it illustrates some features or process in which they are interested (Silverman, 2000:104).

To further enhance the findings of the research it was also decided to approach specific subject experts, which included: the scientist responsible for developing gold fingerprinting as a forensic science; two practising advocates who were involved in the prosecution of gold theft incidents; a metallurgical consultant, and a geological expert. These subject experts were:

- Professor Watling: Professor Watling is a recognised international research scientist with extensive experience and expertise in problem-solving chemistry, particularly in the areas of analytical chemistry. He has pioneered research into the use of spectral distribution patterns (fingerprinting) to establish the provenance of forensic evidence. Professor Watling has also been contracted by the Western Australian Police to give gold fingerprinting evidence in at least 50 criminal cases and his testimony has been accepted in all the cases (Watling, 2007). As discussed in the introduction to this chapter, Professor Watling also researched and developed the forensic gold fingerprinting science

- Advocate Riana Janse van Rensburg and Senior Advocate Schnetler: It was decided to approach the senior public prosecutor of the Westonia Magistrates Court, Adv. Riana Janse Van Rensburg, as she was regularly involved in the prosecution of gold theft cases in her court. It was also decided to use the opinions of a retired deputy attorney general in the Witwatersrand local division, Senior Advocate Fanie Schnetler, who had been contracted by the Gold Fields Limited Group to assist with the prosecution of specific criminal cases within the courts. During initial research into gold fingerprinting it became apparent that no forensic gold fingerprinting cases had been presented in open court in South Africa and therefore, no case reference existed and no subject experts in this specific field were available. It was felt that both of these experts could comment on specific chain of custody and other legislative issues
- It was decided to interview the metallurgical consultant to the Gold Fields Limited Group, Mr Alwyn Smit, as he had been involved in discussions around gold fingerprinting and he would ensure the theoretical correctness of aspects relevant to the metallurgical process
- Mr Brouwer is the chief regional geologist for the Gold Fields Limited Group and he was approached to comment on issues surrounding the collection of underground reef samples

The second subset of the sample population identified through purposive sampling therefore consisted of five people.

1.8 DATA COLLECTION

Strauss and Corbin (1998:29) have indicated that research is basically a flow of work that evolves over the entire course of the investigative project. Each of the types of work, for instance data collection, entails choices and decisions concerning the usefulness of various alternative procedures.

The researcher had collected data, which had consisted of answers and opinions expressed in response to questions, viewpoints in literature, and the practical

observation of the process of gold fingerprint sample collection. In this dissertation, the type of data used was primary data. The researcher who was responsible for the design of the study, and for the collection, analysis and reporting of the data generated the primary data. The new data was then used to answer specific questions. Primary data is usually characterised by the fact that it is the result of direct contact between the researcher and the source and is generated by the application of particular methods by the researcher, e.g. interviews (Blaickie, 2003:18).

1.8.1 Interviews

In terms of the qualitative research approach that was used and because of the small number of people involved in gold fingerprint reference sample collection, a structured questionnaire was developed to obtain the applicable information, which was then further expanded on during a face-to-face situation with one interviewer and one interviewee (Robson, 2000:88). The reason for using this approach was that it facilitated an environment that was exploratory in nature, as very little work had been conducted on the practical procedures required for reference sample collection for gold fingerprinting.

The researcher developed the questions by critically looking at what was currently used in practice and then allowed for interrogation of the respondent's knowledge on this aspect, as well as the respondent's knowledge of legislation that was promulgated while the research was being conducted. The initial questionnaire was then drawn up and the researcher used some of the subordinates working for him to review the questions. After a few minor changes, a final questionnaire was developed, which was used in the rest of the research.

With regard to administering the questionnaire process, the researcher found that, owing to time constraints, the majority of people to be interviewed could not be interviewed during normal office hours and were not available after hours, so the interview process was adapted to cater for this by the researcher forwarding a copy of the questions to the respondent (either electronically or by hand

delivery), which was then completed by the respondent and returned to the researcher. The researcher reviewed the answers given and would then contact the respondent for a face-to-face interview if further clarification and explanation was needed on any answer. Each person who completed a questionnaire was requested to sign a paragraph of consent in which the person was notified that the information given was to be used in a study into the specific research topic.

The majority of subject experts identified through purposive sampling were also required to complete the structured questionnaire and discussions with them were then held about details of relevant aspects of the topic through informal interviews. Where questions in the questionnaire were not relevant to the subject expert's frame of reference, the specific questions were ignored and in some instances specific questions on his or her subject area were asked instead and notes of the discussions were also included in the questionnaire document.

1.8.2 Literature

Very limited literature was found on the subject of gold fingerprinting apart from expert subject presentations and articles by pioneering experts found mainly in gold-producing countries, such as South Africa and Australia. No literature could be found on gold fingerprint reference sample-collection techniques; however, general procedures as used by the SAPS when handling exhibits could also be applicable to sample collection.

The research questions were divided into various areas of focus in an attempt to find a greater number of literature sources. The researcher identified the following areas of focus:

- Gold and metallurgical processes
- Gold fingerprinting
- Forensic investigation and criminal investigation
- Legislative aspects of sample collection with specific emphasis on the Precious Metals Act (Act 37 of 2005)
- Sample-collection techniques

- Chain of custody
- Representivity
- Identification and individualisation

This process allowed the researcher to obtain extra information on the areas of focus and, as each focus area is a topic in its own, the standard used was only to collect information that was relevant to the gold fingerprinting reference sample-collection process and information which could provide supporting criteria which were relevant to the topic question.

An organised approach was used when conducting the literature study and the researcher conducted a literature review at the Gold Fields Library of the UNISA Florida Campus; use was also made of the web-based OASIS site of UNISA; general searches were conducted on the Internet using the SOSIG website (Social Science Information Gateway); and research was also conducted through material that had been accumulated in files at Gold Fields Protection Services (documents were mainly academic of nature and were from presentations submitted by subject experts at various national and international forums). Literature found also related to the relevant methodology for conducting criminal and social research; general research methodology; and the technical aspects of spectrometry. Some literature made specific reference to gold fingerprinting.

Apart from a policy guideline at Gold Fields Protection Services (this document had been drafted as a quality management policy document and was very rudimentary in detail), no specific literature could be found on the techniques to use when gathering reference samples. The methodology employed when conducting an analysis of the literature was to use quotes from documents to substantiate a specific viewpoint and then to acknowledge the source of each quote.

1.8.3 Personal experience

The researcher has four years of experience in the SAPS and 21 years of experience in Gold Fields Protection Services (GFPS) respectively and for the past ten years has been a unit manager in the Special Investigations Department of GFPS. During the researcher's career in the SAPS he was mainly involved in crime prevention and similar uniform branch duties, which included responding to complaints and investigating motor vehicle accidents. Whilst employed by GFPS, he has spent the majority of his career in positions where he has been required to investigate a variety of criminal offences, ranging from theft of assets, theft of platinum and gold, fraud, corruption and other white collar crimes to other types of disciplinary infractions that occur in the mining industry.

The researcher also obtained his National Certificate in Police Administration whilst employed in the SAPS and, during his career in Gold Fields Protection Services, obtained a B: Tech Degree in Security Management. He has also attended various courses, including a joint SAPS/Mining Security Investigative Course and an in-house metallurgical security course and has also attended various national and international conferences on the investigation of crime and related topics.

The researcher is also an active member of the National Coordinating Committee, a joint initiative between the SAPS, the National Prosecuting Authority (NPA) and the mining industry, in which a national strategy is actualised and managed regarding the investigation of precious metal thefts.

Whilst employed by GFPS, the researcher has obtained extensive experience in the investigation of precious metals' theft in the role of investigator on Impala Platinum mine in the Rustenburg area and, later, as the manager of a specialist unit responsible for criminal investigations, including gold theft, occurring within the Gold Fields Limited group of mines, which has national and international operations in South Africa, Africa, Australia and South America.

The researcher became involved in an ongoing review of the SAPS FSL gold fingerprinting capability designed by Professor Watling during 2007, and is also assisting with the reviewing of current gold fingerprinting reference sample-collection procedures. At this stage the researcher has the most practical knowledge on the process among mining industry and SAPS members.

1.9 DATA ANALYSIS

In Leedy and Ormrod (2001:161), reference is made to the Creswell data analysis spiral as a basis from which to plan for data analysis. The spiral includes the steps outlined below:

Organising (identifying sources of data) the case files reports, literature, etc. – In the present study, various sources of data were identified and an arch lever file was used to file certain types of data in predetermined categories, such as legislation, case references, literature etc. The file then became the primary source for organisation. Sub-dividers were used to segregate the various chapters from each other and the interview questionnaires were also filed separately.

Interviewing the sample population by making use of random and purposive sampling to gather data – Interviews were only conducted with respondents who were in some manner involved in the reference sample-collection process or could be classified as subject experts, and the results obtained from the interviews were then integrated with the findings made during the literature review and through observing the procedure in use to gather samples.

Integrating the information – All answers to each question were then recorded under the specific question and the answers were then refined by checking for common wording. During further review, similar answers were grouped and précised together where duplication of answers had existed.

Perusing the integrated data and jotting down the preliminary interpretations – Preliminary interpretations were then drafted and questions ordered to follow a logical sense of sequence, which was not initially apparent when the questions were first drawn up.

Grouping the data into categories, looking for meaning in the data – Categories were then drawn up and each generic category was placed into a separate chapter and the area would determine the nature of the chapter. The chapters were structured around specific questions in the research questionnaire and, when processing the responses to questions, all the various responses were grouped together and from this certain deductions were made. Useless information was then also eliminated.

Drawing up hypotheses or propositions – At the end of each chapter certain conclusions were made and an initial hypothesis was made, which was mentioned in the individual chapter conclusions. The hypothesis would then relate to the research questions and the chapters of the dissertation were documented in such a way that all data could be reviewed and what appeared to be best practice was then categorised so that recommendations could be made.

Drafting the final report – The final report was then drafted and each draft was reviewed and corrected. After this process had been completed, the final chapter of conclusions and recommendations was written up.

The researcher also identified the phases of sample collection, which he described in detail. Conclusions could then be made on best practice for each phase. These conclusions were drafted into a GFPS quality management procedure document, the document circulated for comment, and the required improvements made so that a final procedure could be included in the official Quality Management System (QMS) system. Similarly, the researcher also completed his research report, which was then also circulated among the

respondents, who were then allowed to comment on the findings made, and all these were sanitised and included in the final dissertation.

1.10 METHODS TAKEN TO ENSURE VALIDITY

Validity concerns the accuracy of the questions asked, the data collected and the explanations offered. Generally it relates to the data and the analysis used in the research (Denscombe, 2002:100). In order to ensure validity as described by Mouton (2001:100) and Merriam (1991:167), the researcher used a variety of sources of data, which included interviews of both people involved in reference sample collection and various subject experts on specific aspects that came to light; relevant literature; and personal observation of the process. Literature was obtained from various sources, which included scientific publications, correspondence and articles that had been collected by GFPS over a period of time on gold fingerprinting and other source documents, which all came from reliable and valid sources. A standard questionnaire was also drawn up and questions were based on certain key concepts; the same list of questions was presented to each respondent. In cases where the respondent did not have knowledge on a specific question, the person was allowed to ignore the question. Every respondent answered the questions on the basis of his or her personal background and experience and respondents were requested to write the answers the questions in their own time. Should any additions have been made during face-to-face interviews, the response to a question was clarified with the respondent before he or she answered the specific question in the questionnaire. This was done to ensure that the researcher interpreted the response correctly as suggested in Lacey and Laff (2001:23-24).

Graziano and Raulin (2004:38) are also of the opinion that, when any theory is proposed, the concept must possess validity; that is, it must make specific testable predictions that are confirmed by observation. To ensure validity, the researcher used general control procedures as postulated in Graziano and Raulin (2004:194), which generally included:

- Environment – respondents were allowed to complete the interview schedule in their own environment, which allowed them to concentrate on giving answers that reflected their own experience and knowledge without being under threat of scrutiny by the researcher
- Response measurement – the researcher looked at all responses given by the respondents and attempted not to be put off by any specific answer that he, at first glance, would not tend to have agreed with
- Replication – the same process was used with all respondents to ensure that they all went through the same process in responding to the questionnaire

Data analysis was concluded by only using official documents that were identified during the literature review and, when reference was made to a specific literary reference, the researcher would ensure that the material had been only obtained from a pertinent scientific publication which was still current to the subject under research.

1.11 METHODS TAKEN TO ENSURE RELIABILITY

During the process of data collection by either literature reviews, questionnaire schedules or observations, the researcher described how data collection was done, how the data was analysed, and how random sampling was established, which sampling was conducted by following suggestions made by Mouton (2001:100). The respondents that were interviewed were either subject experts in a specific area or were members of the National Coordinating Committee who had been tasked specifically with ensuring that the gold fingerprinting methodology was enhanced and brought to such a stage that it could be used as evidence in open court. The respondents identified were also the most experienced in the field of gold fingerprinting.

As suggested by Vithal and Jansen (1997:34), reliability is used more in statistical studies and less frequently in qualitative studies where other standards of validation and consistency are typically sought. Bearing this in mind, it

became evident that the researcher would rely more on the validity of the responses that were received during the interviews, physical observations, and the results achieved when reviewing other literature. However, one manner of ensuring reliability would be to ensure that exactly the same questions were given to the respondents when interviews were conducted. It was also recognised that, in terms of Cresswell's (1994:159) definition, "reliability" also refers to the extent to which the researcher's conclusions can be replicated, albeit that, should the same research questionnaire be circulated at a later stage, respondents' responses could be significantly different as they may have obtained additional learning and knowledge, and especially responses on legislative requirements could have become more clear.

1.12 ETHICAL CONSIDERATIONS

According to Mouton (1996:10), one of the three worlds of research is that of the ethics of science, which aims to provide guidelines on what constitutes appropriate moral behaviour in the sphere of science. Mouton (1996:10) further postulates that the ethical conduct should be evident in the following distinctive features of research: the various disciplines (social), the various approaches (explanation approach), the methodologies (qualitative research), and finally the object of the research (to improve gold fingerprint reference sampling techniques).

In terms of ethical conduct, the following four major ethical considerations were made which is in line with recommendations made by Leedy and Ormrod (2005:101-102):

- **Sources consulted** – reference was made to all the sources consulted and these sources were included in the final list of references
- **Respondent requests** – the respondents in the random sampling subset all requested that their names should not be used and the researcher adhered to this request and referred to them as individually numbered respondents

- **Right to participate in the completion of the questionnaire** – the respondents were informed of the nature of the research and were given the choice of completing a questionnaire and, in instances where the person approached indicated that he/she preferred not to complete a questionnaire, another name was picked from the hat. Respondents who indicated that they were prepared to participate were also informed that they had the right to withdraw from the research at any stage
- **Data authenticity** – the researcher did not fabricate any data to support any finding or recommendation. The findings and recommendations were based on the facts as highlighted in the research

1.13 RESEARCH PLANNING (CHAPTERS AND LAYOUT)

The dissertation is divided into the following chapters, which allow the researcher to discuss the research questions and allow for documented design and interpretation:

- **Chapter 2 - Forensic investigation in the gold mining industry**
In this chapter the focus is on the topics of criminal and forensic investigation, and the importance of identification and individualisation. The chapter then concentrates on chain of custody requirements that are required for gold reference sample collection. Gold fingerprinting on both a macro and micro level is then be reviewed, and in the last section of this chapter the researcher focuses on the database itself
- **Chapter 3 – Best practice procedures for conducting sample collection**
This chapter initially focuses on the current collection practices in use, including some of the strengths and weaknesses; identifies the role-players involved in the gold fingerprinting reference sample-collection process; looks at specific legislation that impacts on gold fingerprinting; makes some comparisons between some of the issues involved in establishing a gold reference sample database and issues involved in

other forensic methodologies; discusses possible enhancements that could be made to the current practices; examines the representivity of the database; and lastly looks at other aspects that could improve the validity of the database

- **Chapter 4 - Findings and recommendations**

In the final chapter, the final findings and conclusions of every chapter are discussed

CHAPTER 2

FORENSIC INVESTIGATION IN THE GOLD MINING INDUSTRY

2.1 INTRODUCTION

Forensic investigation involves the lawful tracing of people and exhibits, which may, directly or indirectly, contribute to the reconstruction of a crime situation and supply information about the *modus operandi* and the persons involved in the crime for the purpose of bringing a criminal to justice (Dowling, 1997:1).

According to an article in the *Servamus* magazine entitled “Forensics: Environmental clues” (2007:42), forensic geology is the scientific application of earth science to legal matters. This means that a forensic geologist identifies, analyses and compares earth materials, such as soil, rocks, minerals and fossils found on or in a receptor (such as a suspect vehicle or other medium of transfer, such as water), to possible source areas (such as a crime scene, an alibi location and/or the point of disposal/release). The goal of these comparisons is to establish the degree of probability that the material was or was not derived from a particular location (“Forensics: Environmental clues” 2007:42).

In the gold mining industry, the various security companies accountable for the security function on the mining operations employ specialist investigators that are responsible for conducting forensic investigations and these individuals are further reliant on the assistance of the SAPS and the National Prosecuting Authority (NPA) for the appropriate investigation response and prosecution of offenders via criminal courts’ processes. In terms of cooperation, this has been one area in South Africa where public/policing partnerships have been necessitated because of the specialised field that investigators are required to operate in. Gold is the prime product of these mines and the theft of gold would obviously be a matter that these individuals would have to deal with on a regular basis. In order to conduct these services, the forensic investigator has to have a specialised knowledge of investigation, as purported by Van Niekerk (2000:12).

In light of the above, this chapter focuses firstly on some discussion around criminal and forensic investigation, then on the importance of identification and individualisation, and issues for chain of custody requirements. It then moves more specifically to the forensic methodology of gold fingerprinting, discussing the need for and purpose of gold fingerprinting in general and in South Africa in particular and finally looks at the gold fingerprinting database itself.

2.2 CRIMINAL INVESTIGATION

In terms of the Pocket Oxford English Dictionary (1993:39), the term “investigation” is defined as the action of investigating; the making of a search or enquiry; systematic examination; or careful and minute research. In terms of the investigation of crime various definitions have been given. Van der Westhuizen (1993:1) defines criminal investigation as a systematic search for the truth with the primary purpose of finding a positive solution to the crime with the help of objective and subjective clues.

Becker (2000:436) purports that during a criminal investigation answers must be found to the following questions: Who is related to this crime (for example, the perpetrator, the victim, and eye witnesses)? What was the crime? Where was the crime committed (description of the crime scene)? With what was the crime committed (which tools were used, such as weapons and disguises)? In what way was the crime committed (the *modus operandi*)? When was the crime committed? Why was the crime committed? How do you know what you know?

Gilbert (2004:34) highlights that criminal investigations are only as good as their adherence to the law. The researcher is of the opinion based on experience that the South African Constitution as contained in the Constitution of the Republic of South Africa Act 108 of 1996 (South Africa, 1996), serves as historical foundation and evolving contemporary guidelines for modern investigators, and this legislation, coupled with the legislation given in the Criminal Procedure Act 51 of 1977 (South Africa, 1997), will guide law

enforcement practitioners in the manner in which they need to conduct criminal investigations.

2.3 FORENSIC INVESTIGATION

According to Caldwell (1965:317), criminal investigation is a police activity directed towards the identification and apprehension of alleged criminals and the accumulation, preservation and presentation of evidence regarding their alleged crimes. The adjective “forensic” is defined by the Pocket Oxford Dictionary (1993:292) as “to be used in a court of law”. It is, therefore, apparent that in conjunction with the definition of investigation given in the proceeding paragraph, forensic investigation is a systematic enquiry into criminal activity, which results will be used in a court of law. Other authors, such as Marias (1992:1), also see forensic investigation as being a process where an attempt is made (a) to establish exactly what happened when the crime, for example gold theft, was committed in order to uncover the truth surrounding the events; (b) to prepare and present a *prima facie* case in a court of law; and (c) to submit the evidence required to reveal the unlawful action of the accused.

Forensic investigation (often shortened to forensics) is the application of a broad spectrum of sciences to answer questions of interest to the legal system. This may be in relation to a crime or to a civil action. The term “forensic” is derived from the Latin word *forum*, which means “the market place”. In early Roman society; justice was administered in the market place (Mogotsi, 2002:27).

The researcher is of the opinion, based on experience as criminal investigator and forensic investigator, that a criminal investigation and a forensic investigation are very similar and are basically the same thing except that, in a forensic investigation, the case is to be presented in a criminal trial or civil hearing, whereas a criminal investigation will not always necessarily result in a criminal trial.

2.4 AIM OF FORENSIC INVESTIGATION

As stated by Van der Westhuizen (1993:4), the aim of a criminal investigation can generally be described as an open-ended long-term purview, which is pursued within a specific sphere of achievement. The aim of forensic investigation would similarly be to ensure that the criminal, or an alleged criminal, will be present at the trial and to submit the evidence required to prove the unlawful action (Van der Westhuizen, 1996:1).

2.5 OBJECTIVES OF CRIMINAL/FORENSIC INVESTIGATION

Van der Westhuizen (1993) states that an objective describes more precisely a commitment, which must be achieved within an appointed time and according to a specific standard (Van der Westhuizen, 1993:4). Van der Westhuizen (1993:4) further suggests that the objectives for both forensic and criminal investigation are generally the same and that they are as follows:

- Identification of the crime
- Gathering of evidence
- Individualisation of the crime
- Arrest of the criminal
- Recovery of stolen property
- Involvement in the prosecution process

Similarly Swanson, Chamelin and Territo (2003:28) state that the objective of criminal investigation is to establish that a crime has actually been committed; to identify and apprehend the suspect(s); to recover stolen property; and to assist in the prosecution of the person(s) charged with the crime. Dowling (1997:1) agrees with the views expressed by Swanson et al. (2003:28) and adds that criminal investigation is a systematic, planned process, consisting of the above-mentioned components, as well as the gathering and safe keeping of evidence and evaluation. Van Rooyen (2001:50) further states that, in an investigation process, information is primarily derived from two sources: people and objects. It is clear that the science of gold fingerprinting involves using objects to identify to whom they belonged and to prove that a crime has been committed.

In terms of the specific objective of recovering stolen property, Van der Westhuizen (1993:7) argues that this objective has a two-fold nature: firstly, to restrict the victim's losses to a minimum and, secondly, to present the recovered property as evidential material at the trial (Van der Westhuizen, 1993:7). In terms of gold fingerprinting, both the above aspects of the objective of recovering stolen property would definitely be applicable as losses to the mining industry could be restricted and gold exhibits could be presented in a court at criminal proceedings.

Van Der Westhuizen (1993:4-7) states that the other objectives of criminal investigation; namely, identifying the crime (was gold theft committed?), gathering of evidence (gold samples required to prosecute the case), individualisation of the crime (who had stolen the gold and from whom was the gold stolen), arrest of the criminal (arrest of the person/s who were involved in the theft of the gold), and finally involvement in the prosecution process (presenting evidence of gold theft in court), are all equally applicable to forensic and criminal investigations conducted in the mining industry.

2.6 IDENTIFICATION AND INDIVIDUALISATION

The concepts of identification and individualisation are equally important to gold fingerprinting and are defined in the sections below.

2.6.1 Identification

"Identification" means to put something with other objects that have the same characteristics (Concise Oxford Dictionary, 2002:75). "Characteristics" mean the intentional or design features that would be common to a particular group or family of items (Doyle, 2003:2; Horswell, 2004:6; Gardner, 2005:24). An example of the process of identification would be the analysis of an exhibit on a mass spectrometer and, in terms of certain unique traits, the establishment of the exhibit as indeed gold, either in an unwrought or processed form.

2.6.2 Individualisation

Individualisation is completed when the object in dispute and the standard of comparison have the same origin (Van Rooyen, 2001:58). Van der Westhuizen (1993:6) further states that the process of individualisation takes place to determine individuality and that it normally consists of a series of identifications and comparisons, which have a two-fold aim:

- To individualise positively the various objects in dispute; and
- To conclusively determine the criminal involvement of the objective or person providing the standard of comparison

Van Heerden (1986:194-199) also argues that the overall aim of individualisation is to individualise the crime as an act of a particular person or persons based on unique features. There are various identification categories used during the investigation phase. These categories are as follows:

- Situation identification – identification of the unlawful nature of the crime
- Witness identification – identification of the part of the perpetrator from statements made by witnesses
- Victim identification – identification of the identification of the dead person
- Imprint identification – identification of the imprint of an alleged object by comparing it to a disputed object
- Origin identification – identification of whether organic samples have the same origin as the disputed sample
- Action identification – identification of the human acts that are directly related to the crime
- Culprit identification – identification of the possible offender involved in the unlawful conduct
- Cumulative identification – where the contributions of various different specialists are collectively considered within the framework of the history and relevant circumstances of the crime situation as a whole

This would mean that, should a gold exhibit be confiscated during an investigation, it would be possible to compare the exhibit to reference samples in the gold fingerprint database and establish the natural origin of such an exhibit.

2.6.3 Differences between identification and individualisation

The difference between identification and individualisation, therefore, is of great importance to criminal investigation, and Van Heerden (1985:11-12) further declares that the act of identification is merely concerned with the identification of something or somebody belonging to a specific category. In other words “A” is simply “A” and a hair is simply a hair. No comparisons are drawn. Individualisation, on the other hand, involves comparison of disputed objects found at the scene of crime with an object of known origin (Van der Westhuizen, 1993:6).

Individualisation is only possible if it is preceded by a series of identifications and is based on, and takes place through, comparison. It refers to the demonstration that a particular sample is unique even among members of the same class (Van Rooyen, 2004:12). It, therefore, follows that the concept of individualisation through a process of origin identification is of more importance to gold fingerprinting, as the methodology is very reliant on the ability to individualise the origin of an exhibit, which can then prove ownership and allow for successful recognition of the victim. The overall aim of gold fingerprinting is to compare a gold exhibit seized during a criminal investigation and to determine its origin by comparing certain trace elements with gold reference samples.

The researcher noted that the concept of individualisation would also be more relevant to gold fingerprinting as the methodology relies on being able to individualise the origin of an exhibit and not to only identify that the exhibit contains gold. The methodology would first determine that the exhibit is gold

and secondly, and more importantly, it would determine the place from which the gold was stolen.

2.7 CHAIN OF CUSTODY

The chain of custody is the witnessed, unbroken, written chronological history of who had the evidence when. It is also an account of changes in the evidence, noting, for example, if any portion had been used for laboratory analysis (Swanson et al., 2003:33). Similarly, Van Heerden (1982:213) refers to the chain of custody as the “chain of possession” and describes it as being the continuous safekeeping and identification of physical evidence, which is of cardinal importance in crime investigation. If the investigator is negligent regarding the proper identification of physical evidence or fails to maintain continuity of possession, the value of laboratory analyses is reduced to a minimum.

Lambrechts (2005:362) states that the continuity of possession begins as soon as the physical evidence has been found at the scene of the crime and persists until the article is produced as evidence or proof in court. Even if the physical evidence has been handled in accordance with the entire set of chain of custody general rules, any doubt that arises concerning the people who have handled it during the process of investigation will call the integrity of the evidence into serious question. The handling and handing over of samples and their return after scientific analysis must be confined to the smallest possible number of people in order to ensure the unassailable continuity of possession.

Miletich (2003:144) states that the chain of evidence, also called the “chain of custody,” is a record indicating the location of evidence from the time it is discovered, at the crime scene, until it is presented in court. The record should include the name of each person who handled the evidence. Record entries should be accurate and consistent, providing the correct sequence for evidence transferred from one person to another. The month, day, time of day, and year, noted besides the name of each person who possessed evidence for a specific

period, helps maintain the chain of custody. The chain is broken if, at any time, there is a gap in the record. This is when neither a person nor place can be located that accounts for the gap. When there is a gap, a defense attorney can argue the evidence was not properly handled, was tampered with, and therefore should not be admitted in court. This argument, if accepted by the court, could completely undermine the prosecution's case against the defendant.

In South African case law, the need for a maintaining a proper chain of custody was clearly stated in **S v Kaptein 1984 (3) SA 316 (CPD)**, where the court on appeal held that the chain of custody was compromised after a mix up with the mass of dagga which had been an exhibit in a case and of which it was later found that the expert witness (a pharmacist) who had analysed the dagga had been requested to reweigh the dagga in court and had found it to weigh 738 grams instead of 745,5 grams. Confusion then arose as to the exact handling of the exhibit, which could not be properly accounted for by the SAPS members, and some concern was also raised as to the marking of the exhibit. The three lessons to learn from this case are that:

- Usage must be made of expert witnesses
- As few people as possible must be allowed to handle an exhibit
- Exhibits should be properly marked

Van Rooyen (2004:12) states that, in order to preserve the integrity of physical evidence, adherence to the following guidelines is a prerequisite:

- Limit the number of individuals who handle the evidence from the time it is found to the time it is presented in court
- If the evidence leaves your possession, record in your notes to whom it was given, the time and date, the reason for it being given to another, and when and by whom it was returned
- Make sure the person handling the evidence affixes their names and assignment to the package
- Obtain a signed receipt from the person accepting the evidence

- When the evidence is returned, check for your identification mark and ensure that it is the same item. Determine if it is in the same condition as it was when recovered
- Any change to the physical appearance of the evidence should be brought to the attention of the court

Van Rooyen (2004:12) further states that, should a question arise as to the authenticity of an item offered as evidence, proof that the chain of custody will be demonstrated by proving that:

- The evidence offered is the same evidence found at the scene
- There has been no opportunity to replace or improperly alter the evidence, and
- Any change in the condition of the evidence can be explained

Marais (1992:8-17) feels that the following is the process to be adhered to when collecting physical evidence:

- Recognition – identifying what is to be collected
- Protection – ensuring the physical evidence is not contaminated
- Recording – taking photos or videos
- Collection and packaging – using proper containers for collection
- Labelling or marking – properly marking and recording each exhibit
- Preservation of integrity
- Submission for analysis
- Maintenance of chain of possession
- Presentation in court

2.8 GOLD FINGERPRINTING

In a report published in 1994 by John Watling entitled “Gold fingerprinting by laser ablation inductively coupled plasma mass spectrometry” it was pointed out that “LA-ICP-MS” had been applied to the characterisation of the trace elements composition “fingerprint” of selected samples from Western Australia and South Africa. By comparison of the elemental associations it was shown to be possible

to relate gold to a specific mineralising event, bullion pour and possibly the specific mine. This methodology facilitates identification of the provenance of stolen gold or gold used in salting activities and the technique has already been applied in 17 cases involving gold theft in Western Australia where it is estimated that up to 2% of gold production is relocated each year as a result of criminal activity (Watling 1994:205).

The researcher had the distinct privilege of meeting Professor Watling in 2007 in a professional work capacity, as the South African Chamber of Mines (COM) had invited Professor Watling to assist with reviewing the usage of gold fingerprinting methodology within the SAPS Forensic Science Laboratory and the South African mining industry. The SAPS FSL has been involved in gold fingerprinting for in excess of ten years and, in terms of a private/policing partnership, various role-players in the mining industry have donated equipment to assist the SAPS FSL to achieve its commitments. These donations also include the Chamber of Mines donating a mass spectrometer to the SAPS FSL laboratory. Efforts have been recently made in South Africa to ensure that gold fingerprinting becomes an accepted forensic methodology, which can be used as evidence in criminal trials, and efforts have been made to enhance the forensic methodology within the SAPS. An integral part of the process has been the collection of gold reference samples for the population of a gold database, which can be used to compare to the exhibits that are referred to the SAPS FSL through normal policing channels.

During an interview with Professor Watling (2007), he indicated that gold fingerprinting has been accepted as a forensic science in Australia and that the Australian judiciary have various criminal case law references but that, in such cases, a reference sample has to be collected from the specific mine identified during the investigation because they do not have an extensive reference database. The Australian Chamber of Mines feels that the cost of establishing a reference sample gold fingerprinting database in Australia is too costly as the risk of gold theft is reported to be fairly low in Australia. International gold

producers are looking at progress made in South Africa in the establishment a gold fingerprinting database and the expectation is that, once the methodology has been properly implemented, the SAPS FSL could become the international centre for a gold fingerprinting database.

In the field of gold fingerprinting the submission of samples from the various mining houses has two distinct purposes. Firstly, it allows the police to identify where a specific exhibit originated (from which mineralising event) and such evidence could be used in a court of law during the trial of a suspect to assist with proving who the victim was and, in this environment, potentially the specific mining operation from where the exhibit originated. Secondly, it provides information regarding the origin of gold recovered by the police during operations where a suspect is not arrested. It should, however, be noted that, where two mines are operating on the same mineralising event, it could be difficult to identify the exact mine from which the gold originated, although, through a process of controlled comparisons, a statistical estimation could be made of which mine would be the most likely owner (Watling, 2007).

It is, therefore, imperative that, in terms of establishing who the lawful owner is, the use of gold fingerprinting is recognised as a forensic investigative tool that could be used to the financial benefit and crime risk mitigation advantage of the various mining houses to ensure that proper individualisation and disposal is made of seized exhibits.

The validity of the SAPS FSL gold fingerprint database is clearly reliant on having a scientifically acceptable number of reference samples to ensure that proper individualisation can be made to the most probable mining operation from which the exhibit originates.

South Africa is also in the fortunate position of having had legislation passed; namely, the Precious Metals Act, Act 37 of 2005 (South Africa, 2005), which legislates the possession of wrought and unwrought precious metals.

Dixon, Head Materials Analysis, SAPS FSL (Dixon, 2007) notes that “the forensic analysts at the SAPS FSL can draw a conclusion that the sample and exhibit have the same origin due to the comparison of trace impurities in native gold that reflect the same geochemistry of the original mineralising event”. Dixon (2007) further believes that no two gold deposits are ever identical, even though some may share the same common characteristics. As a result any native gold carries a unique concentration distribution of all the naturally occurring elements and characteristics of that particular mineral deposit. Inevitably the concentration of all the impurities carried by gold will vary not only in the deposit but also on a microscopic scale; however, the presence or absence of certain elements at either high or low concentrations can still provide a relatively “unique fingerprint”.

In this research dissertation, it appears that the majority of respondents had a basic understanding of the concept of gold fingerprinting in that the respondents replied as follows to the question “What is your understanding of the concept of gold fingerprinting”?

- One respondent indicated that it is based on impurities found in gold and concentrates and shows where the gold was mined
- One respondent indicated that it is a process where a forensic laboratory analyses gold-bearing samples in a scientific manner using sophisticated equipment in order to identify the origin of the gold in the sample
- Four respondents said that it was used to identify traces in gold to trace back to certain ore bodies, which enables ownership of gold recovered
- One respondent indicated that it is by taking suspect gold and analysing it for a range of analytes; it is possible to build up a profile or “fingerprint” of that gold that can then be compared to a database and/or other samples in the same case
- One respondent indicated that it is like DNA; the state would be able to prove ownership and identify the illegal mining process
- One respondent indicated that it is the ability to identify the origin of gold by scientific base to establish ownership without any doubt

- One respondent indicated that it shows the chemical differences of each site
- One respondent indicated that it is the method of analysing specific samples relating to the mining site, identifying recovered prime product by means of a composite sample taken that links specific processes and chemicals to that mining site

Respondents' answers vary from reasonably scientific explanations to explanations by laymen who do not have the same scientific background as some of the respondents. This is understandable as respondents varied from highly qualified persons who were employed in the SAPS FSL to police and security officers who had been made aware of the technology in the general course of their employment duties.

2.9 THE NEED FOR GOLD FINGERPRINTING

The possession of unwrought precious metal, which includes gold, is legislated in South Africa in terms of Section 4 of the Precious Metals Act (Act 37 of 2005).

Section 4 (1) Prohibitions relating to acquisition, possession or disposal of unwrought precious metal:

- (1) Save as is otherwise provided in this Act, no person may acquire, possess or dispose of, either as a principal or as agent, any unwrought precious metal, unless –*
- a. he or she is the holder of a refining license and acts in accordance with the terms and conditions of his or her license;*
 - b. he or she is an authorized dealer;*
 - c. he or she is a producer who has won or recovered such unwrought precious metal;*
 - d. he or she has obtained a certificate from the Regulator authorizing him or her to acquire or to dispose of such of unwrought precious metal;*

- e. such unwrought precious metal does not exceed a prescribed mass and is acquired in accordance with a special permit issued by the Regulator for scientific or beneficiation purposes or to make jewellery; or*
- f. he or she is the holder of a precious metal beneficiation license and acts in accordance with the terms and conditions of his or her license.*

Further in the Precious Metals Act (Act 37 of 2005), the following sections also relate:

- Section 7 regulates the issue and renewal of a refining licence
- Section 8 regulates the issue and renewal of a precious metal beneficiation licence
- Section 9 regulates the issue and renewal of jewellers' permits

The possession of unwrought precious metals without a valid refining or metal beneficiation licence or jewellers' permit is in itself a criminal offence and in such instances where a person is found to be in unlawful possession of a precious metal (gold), gold fingerprinting will be used to determine the origin for return of the exhibit to its lawful owner. The criteria used for the return of an exhibit would be in terms of the relevant section in the Criminal Procedure Act and is based on the balance of probability of the identification of to whom the gold must be returned. The researcher noted that in terms of the South African Criminal Procedure Act No 51 of 1977, section 31 regulates the disposal of exhibits that are seized by the police in instances where no criminal proceedings are instituted. Further in the Criminal Procedure Act, section 32 regulates the disposal where criminal proceedings are instituted and an admission of guilt is entered and, in section 34, the Act regulates the disposal of an article where criminal proceedings have been implemented and the judge or presiding officer has to make a decision on the disposal of a seized article. In all instances, it has to be determined who may lawfully possess the article and

the article is to be returned to such person or alternatively, the article will be forfeited to the state.

During discussions with Dixon (2007), it was pointed out that, in terms of current legislation, there are distinct areas which have been viewed as potential loopholes and which aid the laundering of stolen gold. These are detailed below.

2.9.1 Precious Metal Act – Refining licences (Previously regulated as a recovery works licence under the old Mining Rights – Act 20 of 1967)

The mining industry has been exposed to instances where unwrought gold has been recovered in possession of people who are authorised to be in possession of unwrought gold in terms of them having a recovery works' licence or the new refining licence. (All recovery works' licences are valid for a period of two years after the Precious Metals Act (Act 37 of 2005) was promulgated on 1 July 2007). The licence is usually issued to an individual who has a stake in a small mining operation and in terms of his licence is allowed to mine and to transport the "production". In such instances, the mining operation is a smoke screen with limited production and the person purchases illegal gold from theft syndicates who have infiltrated the major gold producers who have registered mines.

Gold fingerprinting would, therefore, be most relevant to determine ownership in instances where a recovery works' licence holder alleges that he or she has obtained gold from a site for which he or she has a licence to mine. Comparison of his/her gold fingerprint from his/her mine would confirm whether the allegation was truthful or, alternatively, comparison can establish from which legitimate mining operation the gold has been stolen.

2.9.2 Precious Metals Act (Act 37 of 2005) – Licensed jewellery manufacturers /dealers

In a similar vein, the mining industry has also become aware of another loop hole in that certain people are registered to be in possession of unwrought gold because they need the raw product to manufacture jewellery. Certain unscrupulous manufacturers are buying up stolen gold and are then using such gold to manufacture jewellery.

The researcher feels that gold fingerprinting is an invaluable forensic tool, as the exact composition of gold found at a jewellery manufacturer can be determined and the analysis can also highlight whether the exhibit has undergone an illegal smelting process, which would be common to stolen gold. Gold fingerprinting can clearly distinguish between gold processed in a refinery and the illegal smelting process, which would traditionally have compositions of high quantities of certain minerals, which are usually released in the illegal smelting process. During the illegal smelting process, the process is reliant on mercury for amalgamation and several elements of mercury, e.g. high quantities of lead, are then identifiable when exposed to mass spectrometry.

2.9.3 Second Hand Goods Act (Act 23 of 1955)

Another scam that the mining industry is being exposed to is a *modus operandi* used by people who are registered to trade in second-hand materials and who then buy up second-hand jewellery or gold recovered from scrapped computers and other electrical equipment. This has become an active and lucrative business as, in many instances, the people who are buying up the jewellery and other recycled gold are actually also buying up stolen gold, which is then spiked by the addition of commodities, such as brass padlocks or brazing rods during the smelting process and this is then mixed with actual scrap jewellery and the gold then processed and resold into the legitimate system. The reason for spiking the gold is to bring down the gold percentage to reflect gold percentages common to second-hand jewellery or recycled gold, i.e. 9 carat gold, which has a gold percentage of around 75%.

Similar to the reasons for gold fingerprinting provided in the proceeding chapter, this forensic tool is critical for identifying recovered exhibits, which can then determine if the gold originates from second-hand jewellery or recycled scrap gold or whether the illegal refining process is evident.

2.10 PURPOSE OF GOLD FINGERPRINTING

As stated by John Watling (2007), “the biggest application of gold fingerprinting is to cut down on gold theft at source and therefore improve the profitability of mines”. This rather simplified explanation, however, gets to the crux of the importance of gold fingerprinting to the mining industry, which in reality operates as a business and needs to generate profits. It is the researcher’s opinion that Professor Watling made this simplified statement, as at the time he was battling to get the mining industry in Australia to support and fund the formation of a centralised database for specimen samples, and hence the specific reference to profit.

It was, however noted in an article in the Australian media that “the Western Australian peak mining group says the industry does not need to establish a database using gold fingerprinting technology” and further that the Australian Chamber of Minerals and Energy’s comment was “For now there is no business case” and that the mines subsequently decided not to fund the project (Gold fingerprinting technology snub puzzles scientist, 2006).

During an informal interview with Professor Watling (2007), by the researcher, he further reiterated that the major reason for the stance taken by the Australian Chamber of Minerals and Energy had been that there was a perception that gold theft is not prevalent enough in Australia to make the establishment of a database a worthwhile enterprise. Professor Watling indicated that as a result of the different crime risk in South Africa, specifically with gold theft, the prevalence of the theft of gold was a lot higher and it made sense that the South African Police Service and South African Chamber of Mines had strategically decided to establish a specimen database.

In his interview, Dixon (2007) mentioned that much suspected stolen gold is thought to be laundered by syndicates who sell scrap gold to refineries, on the basis that this is jewellery scrap and gold reclaimed from electrical equipment such as computers etc. Gold fingerprinting has been used as an empirical method for discriminating between genuine scrap and illegally smelted gold. While this has remained as a goal, in order to return stolen property to its rightful owners, the rapid identification of a particular batch of gold as stolen or legal is a very important screening process.

The respondents gave a further myriad of purposes for gold fingerprinting, which highlights the purposes that gold fingerprinting is used for in the macro environment. In response to the question “What is the purpose of gold fingerprinting?” the respondents replied as follows:

- One respondent stated it is a tool that is applied to stop the theft, processing and illegal black market trade in gold-bearing material
- One respondent stated that, from a policing perspective, it is a forensic tool to establish the provenance of gold with the view to prosecution. Through a traceable process it reveals how gold was laundered to the point where the stolen concentrate was legalised
- One respondent stated that the purpose was to populate a database with a representative number of samples from as wide a range of gold mining operations as possible, in order to be able to accurately identify the origin of a gold-bearing sample in cases where the origin is not known
- Four respondents said it was a tool to determine origin of gold and to prove or disprove legality of ownership and origin, i.e. whether this was melted jewellery or mine gold
- Two respondents said that it was to establish a fingerprint of the various mining houses gold, enabling them to detect, recover and calculate the theft of gold from our premises

- One respondent stated that it is used to determine whether a specific piece of gold is either stolen mine gold or whether it originates from jewellery scrap or coins
- One respondent stated that it is used to identify a unique print or identification of the specific mine operation relating to ore, sludge, carbon, eluted solution and bullion cathode sludge

The researcher noted that some of the respondents did not fully comprehend the question and therefore gave a myriad of answers, which highlighted some of the uses of gold fingerprinting. In terms of Professor Watling's view (2007), the researcher agrees that the ultimate purpose of gold fingerprinting is to prevent the theft of gold at the gold mines and for this reason it is very important that this purpose is mentioned when off setting the submission of samples against the cost involved. The submission of samples can be a very costly process to follow but, if these costs are set off against the fact that gold fingerprinting can prevent gold theft, the return of investment will be come evident to the mine houses that are being required to submit samples.

2.11 BENEFITS OF USING GOLD FINGERPRINTING IN SA

It is apparent that various purposes for gold fingerprinting have been given in both the micro (workplace) and macro (country wide) environments in the preceding paragraph and that such purpose are seen in many instances in both the micro and macro environments. The researcher noted that the macro environment also extends to other countries in Africa and to other continents where gold is produced. One of the greatest challenges facing the gold fingerprinting technology will be to get samples from all places in the world where gold is produced so as to counter any argument put forward in defence during a trial where the defence advocate tries to insinuate that the gold came from another country.

All respondents that participated in answering the questionnaire in the mining and police environments indicated that they were involved in some manner with

gold fingerprinting to a lesser or greater degree. A clear distinction could be made between the benefits of using gold fingerprinting for the mining industry and for the SAPS.

2.11.1 The benefit of using gold fingerprinting in the South African mining industry

The respondents gave a myriad of benefits, which highlight the various roles in the micro environment that the respondents play in the sample-collection process. Some of the additional benefits included:

- Identifying the origin of stolen gold
- Identifying various sources of gold-bearing material, which could be fingerprinted
- Determining the origin of gold and proving or disproving the legality of ownership and origin, i.e. whether this was melted jewellery or mine gold
- Enabling the mines to detect, recover and calculate the theft of gold from their premises
- Enabling the mines to identify a unique print or identification of the specific mine operation relating to ore, sludge, carbon, eluted solution and bullion cathode sludge

The golden thread that ran through all answers was mention that, in the mining micro environment, the main benefit of gold fingerprinting is the identification of the origin of gold.

2.11.2 The benefit of using gold fingerprinting in the SAPS

The respondents from the SAPS also gave a myriad of benefits, which highlight the various roles in the micro environment and the macro environment that the respondents play in gold fingerprinting. The various benefits given were:

- Identifying the origin of stolen gold
- Allowing for the establishment of a gold fingerprinting database
- Comparing exhibits against samples in the database

- Involvement in developing the methodology and ensuring continuous improvement
- Indicating whether exhibits originated from stolen gold, jewellery gold or mining processes
- Focusing on where gold is imported and produced from a foreign country mining process, whether that is scientifically correct, and whether the said gold has not originated from South Africa
- Allowing for the prosecution of crimes related to the theft of gold and the following repatriation of the said gold
- Stopping the theft, processing and illegal black market trade in gold-bearing material
- From a policing perspective, establishing the provenance of gold with the view to prosecution. Through a traceable process it reveals how gold was laundered to the point where the stolen concentrate was legalised
- Determining whether a specific piece of gold is stolen mine gold or originates from jewellery scrap or coins

It is apparent to the researcher that the members in the SAPS are focused on the policing aspect of gold fingerprinting, while members of the mining industry understand the policing role but are more focused on the sample-collection role. This finding is in line with current logistical arrangements for gold fingerprinting, where the mining industry is required to obtain and submit reference samples.

2.12 GOLD FINGERPRINTING DATABASE

The researcher noted that, in terms of case law, reference is made to a database and that any database is as strong, valid and reliable as the information that is received when it is used as a tool. The Honourable Judge Willis made mention of the following in his judgement in the case *S v R2000 (1) SASV 33 (W) 39D*: “In my view there are substantial benefits to be derived from harnessing the advances in modern science to the law. When it comes to rape cases DNA testing can be specifically helpful. (See *S v. Matlhane 2000 (2) SACR 515 (SCA) 520 d.*) The testing process – like all other scientific processes – must be

executed and recorded with such care that it can later be verified by any objective scientist and *a fortiori* also a Court of Law” (See S v. Maqhina 2001 (1) SACR 241 (T).)

Gold fingerprinting is a forensic science and, similar to any forensic evidence that can be given in a criminal trial, the value of such evidence is explained by a specific forensic expert who relies on his ability to be able to scientifically account for and explain how a specific evidentiary object is relevant to the case under dispute. Dixon (2007) has pointed out that the SAPS FSL has been involved in gold fingerprinting since 1994 and at the heart of the methodology has been the fingerprint database which has been populated with samples from the mining industry and from other donations made by universities and the Reserve Bank.

According to Mr RJ Roberts (2007), PhD student and consultant to the SAPS FSL, at the basic level of gold fingerprinting, the method involves the collection of a variety of analytical data from gold samples and the data comprises both quantitative data from dissolved gold and qualitative data obtained from the ablation of solid samples of gold by laser. The results of such analysis allow one to present the data as a profile, which allows the comparison of two pieces of gold. It, therefore, follows that, should a sufficient number of reference samples be analysed, then progress can be made on tracing the source of illegal gold by comparing disputed exhibits with reference samples. Roberts (2007) further stated that an analyst bases current data analysis on interpretation and the discrimination between legal and illegal gold must be made without bias. These requirements have resulted in the use of a number of statistical techniques to reach a finding.

Roberts (2007) also stated that the gold database was generated by using three methodologies for the profiling. Firstly, a sample from each exhibit is dissolved in aqua regia and analysed using an ICP-OES for all elements. Secondly, a portion of the aqua regia solution is diluted and analysed using an ICP-MS that has lower detection limits than the ICP-OES and can measure to much lower levels.

Thirdly, a portion of the sample is mounted on a Perspex block and ablated by means of a laser for analysis using an ICP-TOF-MS. The Perspex blocks and data would then be kept, and form the basis of the gold fingerprint database.

Roberts (2007) further alluded to the fact that the gold fingerprint of a specific mine could differ over a period of time, depending on changes in the geological event that was being mined and that, therefore, the submission of reference samples would be an ongoing exercise.

2.13 SUMMARY

This chapter initially looked in general at the definitions of criminal and forensic investigation and research found that both investigation purposes are very similar, with forensic investigation being more court directed. It was also found that forensic investigation methodologies are being used in the mining industries and that a prime example of this would be the use of gold fingerprinting.

Some evidentiary aspects, such as the difference between identification and individualisation and requirement for chain of custody, were also researched, where it became very apparent that gold fingerprinting relies specifically on individualisation as the basis of the methodology.

Research then focused specifically on what gold fingerprinting is and it was also determined that the main purpose of gold fingerprinting is to prevent gold theft. Several other benefits were then also identified, which included the main benefit of identifying the origin of disputed gold exhibits. It was also found that the mining industry is the main role player in ensuring that reference samples are submitted, and the benefits of submitting such samples and assisting the SAPS FSL became quite obvious as industry could then try to curb the significant problem of gold theft from the mines' operations. This would result in financial gain when the mines receive stolen material back after the police have concluded their investigations, and the loss of product could also be minimised.

The last part of this chapter then reviewed the actual gold fingerprinting database and highlighted what procedures were required to populate the database. In the next chapter the researcher reviews current reference sample-collection practices to establish if the practices meet judicial process and then comments on possible areas of improvement.

CHAPTER 3

SAMPLE-COLLECTION PRACTICES IN THE GOLD MINING INDUSTRY

3.1 INTRODUCTION

In Coetzee and Horn (2006:3), it is stated that the achievements of the mining industry and its contribution to the South African economy are truly remarkable. It is a crucial foreign exchange earner and a substantial contributor to economic production. The mining industry remains a leading employer and a leader in the field of scientific technological research, to the benefit of all South Africans. It is with this in mind that we need to protect the perceived rampant theft of product from precious metal producers. In a report published by Peter Gastrow of the Institute of Security Studies in 2001, it was estimated that 35 tons of gold was stolen and unrecovered per year for the period 1994 to 1998, and that the annual loss experienced by the country was in excess of R1,9 billion per year (Gastrow 2001:67).

In a subsequent report published by Coetzee and Horn (2006:58), the authors indicated that they estimated that syndicates were selling unwrought gold in excess of R1,836 billion a year. At this stage the average gold price was R119 a gram (Coetzee & Horn, 2006:61). It is apparent that this figure was very similar to the study findings made by Gastrow, and the major concern would be that, should volumes of stolen gold remain constant, the recent increase in the gold price to over R150 a gram would result in a financial loss, which is significantly higher, as the average London gold price used by Gastrow (2001) was only R53.39 per gram. It is, however, further mentioned in both reports that the estimated figures used are not based on scientific calculations or exact reporting figures of the mines, and the industry cannot determine the exact loss of product from underground operations and during the processing phase.

The above scenario brings the physical and technological fight against gold theft into perspective; it is apparent that any effort to enable law enforcement

agencies to curb gold theft and protect this natural resource should be supported and that this gives good reason for ensuring the successful application of gold fingerprinting as a recognised forensic science.

This chapter focuses on the current reference sample-collection practices and identifies the perceived strengths and weaknesses of the practices. The chapter further focuses on the role-players involved in the process, and on legislation that impacts on the process, and then looks at possible practical enhancements that would be required to include in a written collection procedure. The chapter concludes with some other issues that were identified during research, which could also be pursued to further enhance the validity of the reference sample database.

For the purpose of clarity, the researcher defined the collection process as including the extended process, i.e. from the actual preparations for sample collection, through the physical sample collection and transport process, until the inclusion of the sample in the gold fingerprinting database at the SAPS FSL.

3.2 CURRENT SAMPLE-COLLECTION PRACTICES

The researcher could only find one written procedure, which related to the collection of samples for gold fingerprinting and that was a procedure obtained from the quality management system of Gold Fields Protection Services (GFPS QMS – Bullion sample escort – dated 01/01/2005). However, perusal of the procedure indicated that it was out of date, as no reference was made to the newly published Precious Metals Act, (Act 37 of 2005) and procedures related more to the physical security escorting procedures than to any guidelines on what samples and from where and how samples were to be collected. In addition, the only reference to chain of custody was to indicate that the sample was to be transported in a sealed and numbered “intervoid” bag (an off the shelf bag that has a unique serial number and which can be sealed to avoid tampering with the contents).

The Precious Metals Act (Act 37 of 2005), and specifically section 29, was promulgated during the research and this assisted a great deal in documenting some of the more practical aspects relevant to the actual physical sample in terms of size, origin, format and frequency of submission. The Act did not, however, detail more practical aspects of the actual physical sample-collection process and it was these practical aspects that required further research to try to establish a generic written procedure which would ensure that all mining houses supplied samples, which met evidentiary criteria to support chain of custody and other material aspects of the sample-collection process.

It was further noted that the gold fingerprinting methodology was still being refined by members of the SAPS FSL, and that these members were also causing some confusion as they would constantly be requesting different sample sizes, origins and formats as they were using samples for academic purposes. As they were still in a research phase, they would request different forms of samples from different mining groups, depending on what they were researching at a specific time.

During physical observation within the researcher's normal work, the basic sample-collection practice was that security members would inform members in the metallurgical plants that samples were required and the samples would then be collected and placed into containers by the various metallurgical managers for sample from the metallurgical plants and by the mine laboratory manager for samples collected from the shafts. These managers would place the containers in "intervoid bags". In most instances, the security members would arrive at the managers' offices and would then have to complete the SAPS FSL form MLS0087F. The sealed "intervoid" bags would then be placed into a Perspex box and the samples would be recorded in an exhibit register; the metallurgical and security official would sign in the register and the serial number of the "intervoid" bag would also be included in the exhibit register. The samples would then be moved to a safe at the security offices and once all the samples had been obtained from all the mine operations, arrangements would be made

to deliver the samples to the SAPS FSL. The samples would then be handed to a SAPS FSL Material Analysis member who would sign in acknowledgement of receipt of the sample in the exhibit register.

The following elements of the sample-collection process were further noted in the Gold Fields operational process:

- The Metallurgical Plant Management had relied on security staff to complete the requisite SAPS FSL form MLS0087F
- The Metallurgical Plant Management was not always aware of what sample size was required and what type of sample was to be collected, i.e. bullion, concentrates, carbon in pulp etc. Some managers were under the impression that samples had to be given of product in various stages of refining, which would include concentrates and carbon in pulp samples
- The Metallurgical Management gave individual waybills to the security member transporting the samples. This was a positive aspect as it ensured some form of paper trail
- The samples were also written in an exhibit register (commonly called the FPR Found Property Register), which is used by the security department and is similar to the SAPS 13 register, which is also used to record and manage the receipt and disposal of properties
- A see-through Perspex box was used to transport the samples and the keys to a padlock used on this box were kept at the SAPS FSL laboratories. The padlock would be opened at the SAPS FSL when the samples were delivered and only once the Metallurgical Plant had put the samples into the Perspex box would the padlock be locked. This arrangement was impractical, as the padlock would sometimes be locked by mistake before samples had been placed in the box and it would become a logistical nightmare to ensure that the only copies of the key were kept at the SAPS FSL
- Each mine had its own Perspex sample transport box and this further exacerbated the logistics regarding key control

- In some instances the samples had also been placed into bottles and were marked and then a group of bottles were placed in an “intervoid” seal bag
- The samples’ collection and transport was left to a designated person who would collect all samples from the various mines of the Gold Fields Group. This was actually a good move as this allowed for some consistency regarding the proper completion of the SAPS FSL form and the type of sample collected
- The mass of samples was recorded on the sample packaging by metallurgical staff and in the exhibit register and sometimes on the waybill.
- Samples would then be transported after obtaining the required transport permit from the SAPS Gold and Diamond Branch. This was an additional administrative red tape process that actually served no purpose
- Delivery to the SAPS FSL was conducted after arranging telephonically for delivery to the SAPS FSL with the Senior Superintendent in charge; he would then on arrival at the SAPS FSL, collect the samples and sign for them in the FPR (exhibit register)

Attempts were made to review the practices at other mines but as the samples are only submitted infrequently, only the Gold Fields practice was reviewed. However, discussions were held with respondents from both Harmony and Anglo Gold security divisions and they confirmed that similar practices were conducted at their operations when samples were submitted to the SAPS FSL. It was also found that some of the smaller mining houses, such as Durban Roodepoort Deep and Metorex had not been submitting samples and they were accordingly informed of the new legislation in the Precious Metals Act (Act 37 of 2005).

In an attempt to determine the strengths and weaknesses of the current collection practices and to identify possible improvements that should be included in a written procedure, the researcher introduced two specific questions into the questionnaire.

3.2.1 Strengths of the current sample-collection practices

To the question “What do you foresee as being the strengths of the current specimen-collection process?” the various strengths given, sometimes by more than one respondent or where one respondent gave several strengths, were as follows:

- Nine respondents felt that the current chain of custody met legal requirements
- One respondent also indicated that tamper proof bags bearing a unique serial number are used
- Two respondents said that major mining producers have bought into the concept
- One respondent also indicated that requirement for submission of samples had been included into legislation and that this was a positive aspect
- One respondent also indicated that good cooperation exists between the SAPS and COM
- One respondent also indicated that information has improved
- One respondent also indicated that industry has enforced the usage of a standardised form to administer the information required when reference samples are submitted
- One respondent also indicated that clear sampling procedures are contained in legislation
- One respondent also indicated that a strength was the single management structure for collection and dispatch, as well as documentation and record keeping
- One respondent also indicated that collection of gold samples from relatively pure gold sources – bullion – was a strength
- One respondent also indicated that recording the details of specimens is well controlled and accurate
- One respondent also indicated that samples are taken from a fairly wide range of sampling points, presumably resulting in an accurate database
- One respondent also indicated that data collection occurred through the complete spectrum where gold/concentrate is being mined

- One respondent indicated that efforts are being made to establish a database that is as near to comprehensive as possible
- One respondent indicated that samples enhance the power of the database and allow for a continuous record of changes in a mine's source areas and processing techniques
- One respondent indicated that sample submission forms are a distinct strength
- One respondent indicated that the process would assist investigators to successfully prosecute licence holders who are currently committing crime by receiving stolen property, specifically some refiners and recovery licence holders

It became evident that the respondents identified various strengths and that several of these strengths were not necessarily a direct strength of the sample-collection process but more of the positive impact of using gold fingerprinting. It also became very apparent to the researcher that all role-players were committed to improving collection practices and this would overall significantly improve the validity of the gold fingerprinting database.

3.2.2 Weaknesses of the current sample-collection practices

To the question "What do you foresee as being the weaknesses of the current sample-collection practice?" various perceived weaknesses were identified and these comments have been grouped under common themes. The various weaknesses given, sometimes by more than one respondent or where one respondent gave several weaknesses, were as follows:

- One respondent stated that individual mines change ownership and shafts change names, which leads to some confusion
- Two respondents said that some mines that are possibly not as involved in national forums between the SAPS and COM do not submit samples. These are usually the smaller mining houses that do not have the same security infrastructure as the larger mining houses. A specific problem area is the South Rand. Not all producers in gold mining participate and

the samples are being contaminated through a poorly regulated administrative process. Insufficient native gold samples, specifically from the Barberton area, exist and there is a lack of cooperation of mine employees

- One respondent stated that the gold database is only populated with legal gold; more illegal gold samples from disruptive operations are needed. Samples have not been retained of seized gold as they are returned to the mines without the SAPS FSL receiving a sample
- One respondent also stated that limited gold samples from the rest of Africa are received. To cover the whole world is virtually impossible and it is also very difficult to keep track of new prospecting areas
- One respondent stated that problems are experienced with the shortage of manpower and qualified personnel at the SAPS FSL. Once personnel obtain qualifications they become an attractive product for the market and get other job offers. SAPS red tape and manpower competency are also problems, which result in time delays at the SAPS FSL
- One respondent stated that samples also need to be obtained from collection points underground, e.g. on conveyor belts and that more than one sample is needed to ensure statistical representivity. It may also be necessary to include other forms of samples, such as gold spillages etc. Repeatability of samples is a problem. A cocktail of gold-bearing material needs to be sampled
- One respondent also stated that the SAPS FSL also needs data regarding the specific metallurgical process that is used
- One respondent stated that the Mineral Resource Department is not involved in the taking of samples underground, which would ensure that samples are representative of the ore body
- One respondent indicated that the chain of custody with sample collection was a problem and did not meet legal requirements
- One respondent stated that the process has not been tested in an open court of law, thus not proving reliability and validity

It became evident that the respondents also identified various weaknesses and again that several of these weaknesses were not necessarily a direct weakness of the sample-collection process but more of the gold fingerprinting methodology.

During physical observation of the sample-collection process at Gold Fields Mines during the course of the researcher's work and visits to the SAPS FSL, it was noted that great confusion existed as to what samples and what mass of sample was to be collected and who was to complete the SAPS FSL documentation. It was also found that people were unsure about the required format for the samples to be collected and no specific process was followed to identify when samples were to be collected. It also became apparent that the mining houses did not always understand terminology used by legislatures in the Precious Metal Act 37 of 2005, as the wording used could be open to more than one interpretation. An example of this was the use of the term "concentrate", as "concentrate" is a generic term, and concentrates occur in a variety of processes in metallurgical plants.

It was also found that mine shaft names and metallurgical plant names had changed and the SAPS FSL staff members were very confused as to this aspect as they had not been informed of the changes. An example of this was the old Oryx mine shaft and metallurgical plant, which had been incorporated into Beatrix Mine, and the shaft was now called Beatrix No. 4 Shaft and the metallurgical plant renamed to Beatrix No. 2 Plant. Another example of this was the renaming of shafts at Driefontein mine, where a shaft which had previously been known as No. 1 Shaft was renamed Masakhane Shaft to more fairly reflect the cultural diversity of the mine.

It is apparent from the above list that several perceived weaknesses are evident in the current sample-collection practices used. It could, however, be argued that the majority of weaknesses were not true weaknesses and in some instances

might actually be classed as being merely shortcomings as they could be corrected with limited intervention.

It was also further noted that some weaknesses were also administrative in nature and that in other cases concern was raised about the sustainability of the SAPS FSL to properly administer the sample-collection process. This concern was the result of various perceptions of problems in the SAPS FSL with regard to manpower retention and other perceived problems that are inherent to state institutions.

The researcher is, however, of the opinion that the majority of weaknesses stem from the lack of any written procedures; that, further, no specific body is forced to take accountability for the whole process; and that the roles, specifically of the geologists and metallurgical staff, are not clearly defined.

Another definite weakness that was identified was that the SAPS FSL was not communicating with the people who were actually responsible for obtaining the samples. In practice, the samples were being collected by security members and they would instruct the metallurgists on what samples to collect and from where the samples were to be gathered. As these security members were not experts in the field, the samples submitted would not always confirm to the SAPS FSL requirements.

According to Mr Dixon (2007), another weakness was that information and documentation (SAPS FSL MLS0087F) arriving at SAPS FSL is not always complete; specifically those filling in the form are not specifying from which reef the sample originates and samples are not always properly labelled; the language usage on the documentation does not always make sense to the SAPS FSL personnel as those completing the documentation use mine slang.

During a purposive interview conducted by the researcher with Ms Janse van Rensburg AC (2007), Senior Public Prosecutor Westonia Magistrates Court,

she indicated that she felt that a definite weakness was evident in the chain of custody with regard to gold reference sample collection in that the requisite statements supporting the handling of exhibits were not completed. It was, however, apparent that the justice respondent was basing her perception on her experience of cases where chain of custody had been challenged in cases where samples had originated from a crime scene and not from a source that could be re-sampled should the origin be taken into dispute. Re-sampling would mean that another sample could be taken from the same mine to prove that the exhibit sample originated from the specific mine.

The practice of re-sampling possible areas of origin was discussed with Watling (2007) and he confirmed that, as Australia did not have an extensive database, in all instances where evidence was to be led in court, Australian police would get him to sample and resample the possible area of origin.

3.3 ROLE PLAYERS IN GOLD FINGERPRINTING SAMPLE COLLECTION

The researcher then decided to establish what roles each respondent played in the sample-collection process and to use this to look for duplication and for a proper segregation of functions.

To the question “What is the role you play in the sample-collection process?” the respondents obviously took cognisance of the fact that they each have a specific role to play; however, it was noted that each specific category felt they had a common role.

The roles that were identified by the metallurgical consultant were as follows:

- Setting up of procedures
- Coordination of activities between operations

The roles that were identified by the majority of security officers were as follows:

- Coordinate sample collection from the mines to the SAPS FSL
- Ensure that all sample documentation is properly completed

- Ensure that the correct masses of samples are submitted
- Assist with collecting samples from mines which have not submitted samples (two respondents)

The roles that were identified by the majority of SAPS officials were as follows:

- Act as end custodian of all samples
- Submit exhibits to the SAPS FSL

It had become apparent that the submission of samples was a role that was being left to security members from the mining industry and that the metallurgical member and SAPS members had no direct role to play in the physical process of sample collection and submission. The police only started playing a role when the samples were delivered to the SAPS FSL Laboratories.

The researcher feels that this conclusion is extremely important as this clearly indicates that, as one of the aspects of enhancing the validity of the SAPS gold fingerprint database is through improved sample-collection techniques, the main responsibility for this improvement lies with members of the mining industry.

3.4 LEGISLATIVE ASPECTS

In terms of the recently promulgated Precious Metals Act (Act No. 37 of 2005), the South African legislature promulgated regulation 29, which deals specifically with the submission of gold specimens to the SAPS FSL for gold fingerprinting purposes. The Precious Metals Act (Act 37 of 2005) was originally published in the Government Gazette No. 28764 on 21 April 2006. In terms of section 25 of the Act, the Department of Minerals and Energy indicated that the section would take effect on a date to be fixed by the State President by proclamation in the Government Gazette. In terms of the proclamation No. 17 of 12 July 2007, the State President determined that the Act came into operation on 1 July 2007. Government Notice R570, which appeared in Government Gazette No 30061 of 9 July 2007, sets out regulations made under section 23 of the Precious Metals Act (Act 37 of 2005). At the time that the research questions were being

answered, the draft regulations were published and, as part of the exploratory research into the subject choice that this research study should make, it was thought that it would be prudent to try to establish what the practical implications of the regulations would be in line with the requirements of the police, the mining industry, and justice.

Regulation 29 of the regulations relevant to the Precious Metals Act (Act No. 37 of 2005) reads as follows:

“Manner and forms of specimens

29. (1) *A producer of precious metals must submit specimens of such precious metals to the Forensic Science Laboratory of the South African Police Service every six months: Provided that a new mine must submit its first specimen within the first month of production.*

(2) *All specimens submitted to the Forensic Science Laboratory must be accompanied by a fully completed Form MLS0087F, which is obtainable from the Forensic Science Laboratory.*

(4) *A mine with several shafts must submit specimens of the relevant precious metal extracted from each shaft.*

(5) *Specimens of gold submitted by producing mines must be of raw, unprocessed gold in nugget form or of gold retrieved from concentrate, as well as processed gold (dore metal), whereas specimens of the platinum group of metals must be of furnace matte, converter matte and refinery feed.*

(6) *Metal specimens must consist of at least 2 grams of the relevant precious metal, while ore or concentrate specimens must be representative and must consist of at least 100 grams of the relevant ore or concentrate.*

(7) Specimens submitted for inclusion in profiling database shall remain part of the database and be retained by the Forensic Science Laboratory.”

(In terms of the regulations it was noticed that there was no sub-section 3 and it is suspected that this was purely an administrative oversight).

The definition of precious metals in the Precious Metals Act (Act No. 37 of 2005) includes both gold and platinum and the definition reads as follows:

“Precious metals means –

- (a) the metal gold, any metal of the platinum group and the ores of such metals.*
- (b) any other metal that the Minister has declared by notice in the Gazette to be a precious metal for the purpose of this Act, and the ores of any such metals.”*

In an attempt to measure the respondents' knowledge of the legislation, certain questions were asked to try to ascertain if the respondents were aware of the specific Act that governs sample collection.

To the question “What legislation requires that samples must be collected and forwarded to the SAPS FSL?” the respondents replied as follows:

- Eight respondents gave the correct Act, i.e. Precious Metals Act (Act No. 37 of 2005)
- Three respondents did not know that an Act had been promulgated

It became apparent to the researcher that 72% of the respondents knew that an Act partially legislates the collection of samples and this was thought to be indicative of the fact that the legislation regulations were only formally published in the Government Gazette by the time that the research was already under way. One of the most important aspects of conducting research is to learn and it was specifically evident that all respondents were made aware that legislation covers

this vital aspect and that now all respondents know what specific Act and regulation covers sample collection.

To the question “Which organisations/bodies have to collect specimens that have to be sent to the SAPS FSL Laboratories?” The various responses given, sometimes by more than one respondent or where one respondent gave several answers, were as follows:

- All 11 respondents said that this included all producers of gold
- Three respondents further stated that it also includes any person who imports/exports precious metals/unwrought gold
- One respondent further suggested that it also included all benefactors and jewellers
- Four respondents further stated that refineries also have to submit samples

The respondents identified all the various organisations/bodies that are required to submit samples, albeit that it was quite evident that this was dependent on the role they played in the collection process. All the mining industry respondents realised that they were required to submit samples from both their mining operations and from their metallurgical processes. Members of the SAPS also quite correctly identified that refineries and importers and exporters were to also submit samples. One respondent also felt that benefactors and jewellers were also to submit samples, but it was realised that this would only be when they imported or exported unwrought gold.

It should be noted that the initial draft legislation specifically stated that all importers and exporters of precious metals were to submit samples but that in the final draft these parties had been excluded. As far as the researcher could establish, this had been as a result of pending legislation that would focus specifically on the import and export of precious metals.

To the question “How often should specimens have to be collected?” The various responses given, sometimes by more than one respondent or where one respondent gave several answers, were as follows:

- Nine respondents correctly stated every six months
- Two respondents further said on importing and exporting
- One respondent thought it was every four months
- One respondent said as determined by the Mineral Resource Management Department

The majority of respondents (nine) correctly identified the period for sample collection as being every six months, which is also the period prescribed in regulation 29 of the Precious Metals Act (Act No. 37 of 2005).

One respondent indicated that the Mineral Resource Management Department should determine the period for submission of samples. This response was pursued further and in terms of possible changes could make sense as people in this department are aware of the exact geological make up of the ore bodies and they would be best suited to identify if there had been possible changes to the geological profile of the reef being mined which could cause a change in the fingerprint profile of gold.

Two respondents also further identified that any person who imports or exports precious metals must also submit samples when they import or export product, but it should be noted that this requirement was dropped from the final promulgated regulation.

To the question “What specimen size has to be collected expressed in grams?” the respondents replied as follows:

- One respondent said 1,5 grams for bullion and that concentrates should be 200 grams
- One respondent said bullion samples should be 1 gram and concentrate should be 1 kg

- Five respondents said bullion should be 3 grams
- One respondent said samples should be a minimum of 5 grams and concentrate should be 1 kg
- Three respondents said concentrate should be 100 grams

The majority of respondents (eight) indicated that the sample size for bullion would be between 1 gram and 5 grams. In terms of the Precious Metals Act (Act No. 37 of 2005), the required sample size for the relevant precious metal is given as 2 grams.

Six respondents recognised that sample sizes for other material, which includes gold concentrates and underground reef samples, would have to have significantly larger sample sizes, anything from 100 grams to one kilogram. In terms of the Precious Metals Act (Act No. 37 of 2005), concentrates and ore samples size will need to be 100 grams.

To the question “Do you have any comment on the specimen size?” the respondents replied as follows:

- One respondent said it should be sufficient for SAPS FSL to obtain adequate information for the database
- The SAPS FSL respondent indicated that 3 grams is a bit big but good for future analysis and re-analysis
- Seven respondents had no comment
- One respondent felt that a 1-gram sample was sufficient for analysis
- One respondent stated that samples collected should be representative of the material

From the various responses given by the respondents, it was apparent that the sample size would be determined by the material to be collected. This makes good sense as it is logical that a bullion sample, which contains 90% and more pure gold, would only need a relatively small sample, i.e. 2 grams as determined by the regulations. In the interview with Dixon (2007), he indicated that only

1 gram of bullion was required for actual fingerprinting and that the further 2 grams would be used for further reference samples should a dispute arise in court and more analysis have to be conducted.

In terms of the sample size for other material, which includes concentrates and underground samples, it quickly became apparent to the researcher that the methodology stills need to be refined in this area and that no definitive sample size can be given as the sample needs to be congruent with the amount of gold in the sample. In terms of collection procedures, mining industry staff collecting samples are not aware of the exact gold content of such materials, and this makes it very difficult to determine what sample size is to be collected. Until further advances are made in refining the fingerprinting technology, the researcher feels that a 100-gram sample should suffice and will make the mining group that submitted samples compliant with the Precious Metal Act regulations.

To the question “From where in the mining operations must samples be collected?” The various responses given, sometimes by more than one respondent or where one respondent gave several answers, were as follows:

- All 11 respondents indicated the reef coming out of the shafts
- Two respondents also indicated native gold (nuggets)
- All 11 respondents said the metallurgical plants – bullion
- One respondent also suggested collecting samples from all stolen gold and also samples of gold found abandoned outside mine areas and which had been taken through an illegal smelt process
- One respondent also suggested following advice from the Mineral Resource Management Department
- Two respondents also said from conveyer belts
- One respondent also said at any stage before chemical treatment

It was noted that the majority of respondents had a good understanding of from which general areas samples should be taken (in the metallurgical plants and from the underground workings) but that this is where a lot of the practical

confusion arises as it is from these areas that there are various commodities from which the samples could be taken.

The suggestion made by one of the respondents that the Mineral Resource Management Department should determine where the ore samples should be taken is an excellent suggestion as persons employed in this department are experts on geology and they have a better understanding of the geological events that could affect the fingerprint of gold. Similarly the researcher is also aware that the metallurgy experts should identify the areas and commodities within the metallurgical plants from where samples should be taken.

In terms of the Precious Metals Act (Act 37 of 2005) regulation 29 (5) requires that: "Specimens of gold submitted by producing mines must be of raw, unprocessed gold in nugget form or of gold retrieved from concentrate, as well as processed gold (dore metal)". This definition is not very clear as, in the practical collection observation with the SAPS FSL, during a meeting with Roger Dixon on 11 September 2007, he requested that underground samples could be in the form of reef prills and the metallurgical plant samples should be samples drilled from the bullion bars. Dixon further stated that he would be refining the wording in the regulation as the requirement could change pending advances in gold fingerprinting methodology, which was constantly evolving. During the researcher's discussion with Professor Watling (2007), the Professor indicated that in Australia persons collecting reference samples collect a 3-gram dip sample from the smelt pot; they collect a 100 - gram sample from the gravity concentrates; they collect a 1 - gram sample from bullion bar drillings; and they also try to collect a sample from the over pour in the smelt house. In terms of the underground samples, Watling further indicated that in Australia they use GPS readings to identify from where the sample was taken and that they collect samples from all the different reefs and fascies in the reefs. Bulk samples are collected and then put through a jaw crusher and a sample of approximately 100 grams is obtained. A rock sample of approximately 1 kilogram is also collected, which contains native gold. The underground samples are then

subjected to a Screening Electron Morphology (SEM) process and then the gold is subjected to an Energy Dispersal X Ray Analysis (EDXRA) process, which allows analysts to prepare the gold for fingerprinting.

The researcher found that no definitive guidelines were available to describe exactly from where and from what commodities samples have to be collected and, therefore, specific recommendations will be made to try to address this issue in the final chapter.

3.5 COLLECTION COMPARISONS WITH OTHER FORENSIC METHODOLOGIES

A lot has been written in criminal investigation literature on how evidence is collected at the crime scene and what procedures are to be followed when ensuring the presentation of such evidence at a criminal trial. The researcher noted that no literature was available that specified how to collect gold fingerprinting reference samples, and it was then decided to read up on how samples are gathered for other forensic sciences.

The closest type of forensic methodology to gold fingerprinting is the use of forensic soil comparisons (e.g. a murder scene is linked to a perpetrator from soil found on his person who can be linked to the crime scene) as, similarly, the methodology is based on analysing the exhibit by using examination of the mineral composition of the soil. In James and Nordby (2002:272) it is stated that:

Soils are very complex mixtures of materials of minerals, animal and vegetable origin at various levels of change and decay. Many of the components are common and natural forces have deposited some while others have been delivered by the intervention of man. The great variations of these combinations lead some to believe that the soil has a unique composition in any given area and changes detectably every few feet.

Similarly gold fingerprinting relies on the ability to profile certain unique minerals occurring within the soil (a specific gold reef) and, therefore, the same complex mixture of minerals will identify the specific reef of which a sample is representative. It is, however, evident that forensic soil samples are collected from say the underside of a shoe and, after comparison with an actual crime scene, a link can be made that puts the shoe on the specific crime scene. In gold theft, the gold can be traced to a specific reef but the exact crime scene cannot be identified to within a few feet. In such instances, the forensic scientist has to base his answer on a probability analysis of comparisons of samples from the same reef.

The researcher is aware that typically the majority of gold mined in South Africa is contained in underground operations, where the underground reefs are accessed through a system of vertical shafts which enable man and machinery to reach the reefs which have been covered by the earth following geological and volcanic events many millions of years ago. The gold particles are contained in bands of compressed rock, which is commonly called the reef, and the various reefs could continue at various depths for many kilometres and various mines could access a specific reef. Examples of reefs would be the Ventersdorp Contact Reef, the Middlevlei Reef and Carbon Leader Reef, which are found in the West Wits area in and around Carletonville.

The second forensic methodology examined by the researcher for comparison with gold fingerprinting is DNA profiling (in Kobilinsky, Liotti, and Oeser-Sweat, 2005:xiii), where a sample database is kept of DNA profiles. Some reading was done in this area to see if any parallels could be drawn. It was mentioned that recently developed techniques that permit human identification by analysis of specific regions of DNA within the human genome have emerged as powerful evidentiary tools for the criminal justice system after the realisation that a person can be "individualized" by analysing his or her DNA and that this has been heralded as one of the greatest revelations for the twentieth century. It was noted that this science also uses mass spectrometry to conduct the

profiling and that a centralised database is also maintained in various countries for comparison purposes. Further, in Kobilinsky et al. (2005:163), it is mentioned that the DNA profiles of criminals are being retained in an “offender” database so that, in the future, biological evidence can be compared with DNA profiles in a national database. It is, however, noted that samples submitted to the database originate from offenders and that again a direct link can be made to a specific offender and a determined crime scene.

It is obvious from the above two comparisons that gold fingerprinting does not have a precise crime scene, and profiling will have to be conducted against the ability of the forensic scientist to draw profiled links to a specific reef on the basis of statistical analysis. For this reason the mining industry has a major role to play in ensuring the submission of representative samples for the gold fingerprint database. It follows that collection procedures will have to accommodate these unique requirements. As the crime scene is not an exact location but could be representative of a theft from anywhere in the reef, the collection of representative samples should preferably follow specific chain of custody procedures to ensure their legal integrity, as reefs change slightly and it will be very difficult to obtain a 100% match to the exact location in the reef from which the actual theft occurred.

In a study guide for a course titled “mining for non miners,” which is presented at the Gold Fields Business Leadership Academy (2008:8) it is stated that the origin of gold can be traced back to mountains that were eroded and rivers carried sand and gravel into a huge lake. Over a long period of time, layer upon layer was deposited one over the other, and they were compacted and cemented together. Compression and heat transformed the layers of sand into quartzite and the occasional layer of mud into shale. Sometimes gold veins in these mountains were also eroded and the fine particles of gold were mixed with sand and deposited in the lake. Such a layer, which contains gold, is called a reef. The presence of gold is sometimes very difficult to establish as gold theft occurs in various stages of the refining process and it is not always possible to

see the bright yellow colour that is usually associated with gold. Gold in its refined form is dense, soft, shiny and the most malleable and ductile of the known metals. Gold dissolves in mercury, forming amalgam alloys, and this is one of the most common ways of processing stolen gold. In this stage it remains very difficult to see as the gold takes on a silvery colour. Gold is insoluble in nitric acid and this acid has been used to determine the presence of gold through a process commonly known to the researcher as the “acid test”. In general, stolen gold is processed into nuggets of various sizes and shapes, depending on the crucible used to process the stolen product, and these nuggets are then sold on the black market. Stolen gold in this form is easily identifiable as it looks very similar to the final product and is recognisable in that the metal looks like gold found in jewellery.

3.6 PROPOSALS FOR ENHANCING THE COLLECTION OF SAMPLES

The researcher then researched practical proposals on how to enhance the reference sample-collection process. The initial part of the research was to establish how important was the chain of custody to the process and then to obtain the respondents’ views on how to enhance the process with a few practical suggestions, which could later be refined into best practice, and could be included in the written procedure.

Van der Westhuizen (1993:154–155) suggests that the following points be considered when taking samples:

- What is the best sample type to take for ease of analysis?
- What sample type will result in optimal interpretation of results that may be forthcoming for the laboratory?
- What sample size is required by the laboratory?
- Should the sample be preserved or not?
- What type of container should be used?
- Is the sample container sufficiently sealed?
- How should the sample be transferred to the laboratory?

It is apparent from the above points made by van der Westhuizen (1993) that these are generic points to consider when collecting samples, but the practical question would still remain as to whether chain of custody criteria should apply to reference sample collection.

In terms of South African legislation, and specifically the Precious Metals Act (Act 37 of 2005), section 5 of the Act stipulates that the mere unauthorised possession of unwrought precious metals, which includes unwrought gold, is an offence and the value of the gold fingerprinting evidence will be to ensure that, in terms of the Criminal Procedure Act (Act 51 of 1977), the recovered exhibit is returned to its lawful owner, either in terms of section 31 "Disposal of article where no criminal proceedings are instituted or where it is not required for criminal proceedings" or in terms of section 32 "Disposal of article where criminal proceedings are instituted and admission of guilt fine is paid", or lastly section 34 "Disposal of article after commencement of trial." The chain of custody of the actual exhibit before court could be disputed but it is felt that, as the accused would in all probability not try to dispute the actual origin of the gold as he has already committed an offence, the defence would not dispute the actual chain of custody relating to the reference sample-collection methodology.

It is, however, common cause and the researcher is aware that gold theft syndicates have evolved considerably and that they can afford to pay for the best defence attorneys that are available. It is also common cause that several syndicates have found perceived loopholes in the current legislation and that one of the loopholes is to obtain their own licences for being in possession of unwrought gold or second-hand jewellery gold. They then use these licenses to launder stolen gold obtained from the gold mining industry. In cases such as these, the actual origin of the gold then comes into dispute as the people arrested could allege that they obtained the exhibit from a premises or instance where they are entitled to have such an item in their possession in terms of their licence. It is then that the forensic scientist has to prove the true origin of the exhibit and for this to occur he has to refer to scientific analysis and probability

predictions based on the reference samples he has at his disposal, which are then compared to the actual exhibits that were confiscated. This would then subject the gold fingerprinting database to an attack by the defence advocate, where he could attempt to discredit the chain of custody used for collecting such reference samples.

The researcher has, therefore, realised that one of the most important criteria for ensuring the validity of the gold fingerprinting database would be ensuring that the proper chain of custody of reference samples is maintained and can be proven should the gold fingerprinting sample-collection methodology be tested in open court. The question that has become evident is whether the chain of custody requirements as followed when collecting an evidentiary exhibit from a crime scene should also be applied to the collection of reference samples for gold fingerprinting.

The question “How should samples be collected?” was asked. The various responses given, sometimes by more than one respondent or where one respondent gave several answers, were as follows:

- One respondent stated that a sample procedure for that specific type of material should be followed
- One respondent stated that sample procedures would be dependent on the content and distribution of the sample to be collected
- One respondent stated that an independent witness should be involved
- One respondent stated that sample collection was to be done by a designated person who would be responsible to ensure that the prescribed procedures are complied with
- One respondent stated that experts, both metallurgical and in mineral resource management, should specify the sample-taking procedure
- Eleven respondents stated that sample collection should take place in terms of chain of custody requirements
- One respondent stated that utilising a sample cutter (composite) would ensure a true reflection of product

- Three respondents indicated that they were not involved in the sample-collection process
- One respondent stated that samples should be sealed in uncontaminated holders
- One respondent stated that samples should be clearly marked
- One respondent stated that samples should be dated, with time and place where they were collected included
- One respondent stated that the name and signature of the person who collected the sample must be recorded for future reference
- Three respondents suggested the use of tamper-free security bags (“intervoid” bags)
- One respondent stated that the sample should be accompanied by paper work
- One respondent said that the chain of custody regarding the collection and handling of the samples is necessary for both court and civil purposes
- One respondent felt that the chain of custody and recording currently implemented by investigators connect either the evidence to the crime scene or suspect; in this regard the same procedures should be used and the point of sample collection should be considered to be the crime scene as during a formal investigation
- Four respondents felt that only one person should collect all samples and that a witness should accompany him
- Two respondents felt that good sample preparation was important
- One respondent said that the weight of the sample must be obtained as soon as it is taken
- One respondent said it was important to note comprehensively where the samples were obtained
- Six respondents said that samples should be sealed in separate intervoid bags and marked clearly
- One respondent said that the chain of custody regarding the collection and handling of the samples is necessary for court and civic purposes

- Four respondents felt that samples should be representative of all ore bodies
- Five respondents said that the correct documentation must be used
- One respondent stated that the sample should not be contaminated
- Two respondents highlighted the usage of the correct sampling equipment
- One respondent suggested that, when samples are stored, they are stored in a safe
- Two respondents suggested that the chain of custody should be kept as short as possible
- Two respondents suggested that security member's should also ensure that a section 212 statement is also submitted (proof of certain facts by affidavit or certificate – Section 212 of the Criminal Procedure Act, Act 51 of 1977)
- One respondent suggested that security members should ensure that a chain of custody is followed each time someone else takes over possession of a sample
- One respondent said that samples must reflect when, where, how and by whom the samples were gathered before being transported to the SAPS FSL
- One respondent suggested that during analysis a new seal number should be given
- One respondent stated that criminal evidence provided in courts must be well presented by complainants and witnesses, as the chain of custody in court must be specific and to the letter
- One respondent felt that proper training and preparation of witnesses must become a must in giving evidence

Respondents submitted several practical suggestions on how the samples were to be collected. From these suggestions it is apparent that a practical process should be followed, which will enhance the chain of custody and allow the process to be subject to scrutiny by any defence advocate during trial.

During an interview with Mr F Schnetler (2007), Senior Advocate in private practice, who was part of the purposive sample of experts consulted, he indicated that the validity of the information on the SAPS gold fingerprinting database would depend on the following factors:

- The institutions that are part of the process
- That samples taken at least conform with the basic guidelines as set out in the Precious Metals Act (Act 37 of 2005)
- The proper sending and handling of the specific samples
- Whether the chain of custody is properly documented
- Whether the percentage change that naturally occurs with samples from time to time can be properly clarified
- Whether the samples taken in a specific area of a shaft are representative of other sections of the same shaft

In terms of Advocate Schnetler's concern regarding the percentage change that naturally occurs with samples, it was noted that, in Watling's 1994 research into gold fingerprinting by laser ablation inductively coupled plasma mass spectrometry, he had confirmed that two reference samples of gold held in the State's Mineral Collection in Australia, which were taken from bars poured at the same mine two years apart, were also obtained and analysed and that the spectra obtained were almost identical and strongly indicated that the signature of the two samples remained almost identical over this period (Watling 1994:217).

On the website of the Environmental Protection Agency of the United States, available on the Internet at: <http://www.epa.gov:IntroCOC/page0600.html> (accessed 30 September 2007), the agency details the steps involved in chain of custody procedure, and the researcher has related each step to that required for chain of custody for reference sample collection, as shown below.

Step 1 Sampling preparation: – The step where materials used are prepared. In this step the gold reference sample should be identified and prepared for

collection by either the metallurgical or geological member responsible for this function. This official should complete the prerequisite SAPS FSL document.

Step 2 Sample collection: – In this step the gold reference sample is collected by the security official responsible for transporting the sample and he ensures that the sample is properly sealed and then documented in the requisite exhibit registers that are maintained for this purpose. The individual description and serial number of the “intervoid” tamper-proof bag will also be recorded in the register and the person handing over the sample will be required to sign in the register. The security official will also sign on receipt of the sample.

Step 3 Sample transport: - The step where the sample is transported from the field to the laboratory. In this step the gold reference sample is transported by the security official to the SAPS FSL and the necessary arrangements should be made to ensure his safety en route to Pretoria.

Step 4 Receipt storage and transfer: – The step where the sample is received and stored in the laboratory until it is transferred to a chemist who will analyse it. In this step prior arrangements are made with members of the SAPS FSL Material Analysis Section for an appointment and, on arrival, the security officer is met by the designated SAPS FSL member and he then hands over the samples, confirming that the sample bags are intact and sealed and that serial numbers correspond to the numbers recorded in the exhibit register. The designated SAPS FSL member then signs for receipt of the sample in the exhibit register.

Step 5 Sample analysis: – The step where the sample undergoes the appropriate analysis as requested by the field sampler. The designated SAPS FSL member will then ensure that the appropriate documents and registers are completed in the laboratory and, when able, the required analysis will be conducted.

Step 6 Sample data recording: – The step where the data forms, records and reports relating to the sample (and sometimes the remaining sample) are stored for safekeeping. The SAPS FSL member will then ensure that the database register is updated with the required information, and the gold reference sample will be secured for possible further analysis should the sample origin be disputed.

The researcher, based on his operational experience, concurred with the above additional proposals and it was felt that, should one follow the basics for chain of custody coupled with these recommendations, the requirements would suffice.

3.7 REPRESENTIVITY OF SAMPLES

One issue that the researcher considered to be an aspect that required further clarification within the sphere of gold fingerprint sample collection was the concern that there was a disjoint between scientific research conducted on gold fingerprinting and the representivity of samples obtained for the database during the sample-collection process. From various responses by respondents it was apparent that no specific guidelines had been given regarding which department in a mine would be responsible for the collection of shaft ore body samples. During observation conducted it was noted that, traditionally, security departments had relied on the metallurgical departments to collect both samples of processed gold (bullion samples) and samples from the ore bodies at the shafts, as the metallurgical employees worked in close liaison with the mine laboratories, which could assist with the submission of ore samples and bullion samples. The Precious Metals Act (Act 37 of 2005) section 29(5) stipulates that specimens of gold submitted by producing mines must be of raw unprocessed gold in nugget form or of gold retrieved from concentrate as well as processed gold (dore metal).

The researcher then asked a specific question to respondents to get a feeling for whether the respondents felt that the current samples collected were representative enough of the mine they were working for. It was realised that the respondents were not specialists in this field, but it was felt that their general

understanding would assist in improving at least the sample-collection process and that this could be used as a basis for further scientific study by researchers in gold fingerprinting methodology. The question that was asked was, in the opinion of the respondent, “Are samples collected representative of all parts of the mining process and are therefore of value when being used for gold fingerprint analysis?” The answers were as follows:

- Two respondents felt that the current samples collected were not totally representative of the mines’ gold production but still felt that samples collected were of value
- Four respondents felt that the samples were representative of the gold production
- One respondent said that the SAPS FSL gold database would only be a success if samples were received from all the stages of the process and from all the gold mines, refineries and recovery works. Samples would also have to be taken continuously in order to keep the database up to date
- Three respondents indicated that they felt that the Mineral Resource Department was better suited to collect shaft samples/samples that were representative of the ore bodies
- At least three respondents also suggested that, in practical terms, the Mineral Resource Department was better suited to collecting samples from the shafts as this department was responsible for studying the geology of the ore bodies, was more aware of the geological changes that had affected the formation of the gold deposits, and could therefore give a better opinion on what and from where samples were to be collected

The intention of this question was not to try to research the scientific basis of which sample representativity was best for gold fingerprinting methodology, but to try to arrive at some answer which was relevant to only the gold fingerprinting sample-collection process and to identify who was best suited to assist with the collection process.

In an attempt to further explore the representativity of samples, Mr H Brouwer, (2007) Regional Chief Geologist, Gold Fields Limited, an identified specialist in the purposive sample group, was questioned in an informal interview regarding the representivity of underground samples. During the interview he agreed that the geological nature of reefs could differ significantly between facies in a specific reef that was mined at a specific shaft and that members of the mineral resource discipline were better suited to determine where shaft samples should be taken as they were more aware of the geological formation, which ultimately affects the composite study for gold fingerprinting. It was then also agreed that further research would be conducted into the submission of shaft samples in that the Gold Fields Mineral Resource Management (MRM) department would assist the SAPS FSL by submitting various samples from a specific shaft and the SAPS FSL could then determine if the various samples differed so significantly that it would necessitate that samples from every facies in a reef would have to be collected from a specific shaft to be able to conduct gold fingerprinting. At the time of writing this research report, this exercise was still being conducted and, in terms of current sample-collection methodology and legislative requirements, the SAPS FSL only requires one sample per shaft.

According to Mr A Smit (2007), Senior Metallurgical Consultant to the Gold Fields Limited Group, improvement could be made to the sampling of concentrate samples in the metallurgical plants, as various forms of concentrates are evident within the many stages of processing within a gold plant. Sampling improvement would also further enhance the representivity of the gold fingerprinting database.

3.8 OTHER ASPECTS THAT COULD IMPROVE THE VALIDITY OF THE GOLD FINGERPRINTING DATABASE

In terms of validity improvements on the part of the SAPS FSL was concerned, the following question was asked to respondents – “Are there any other aspects that you feel require attention that will enable the SAPS to improve the validity of the gold fingerprint database?” The various responses given, sometimes by more than one respondent or where one respondent gave several answers, were as follows:

- Three respondents were concerned about personnel shortages at the SAPS FSL and that this could have an inhibiting result on the usability of gold fingerprinting methodology
- Two respondents felt there was a backlog of samples at the SAPS FSL
- One respondent raised a concern that the SAPS FSL is compiling a database from gold samples received from various areas in the RSA and the question to be asked was whether the SAPS FSL was able to determine where the gold derives from should gold from various areas be combined
- One respondent suggested that the SAPS FSL should be more dedicated and business like in their approach to gold fingerprinting
- One respondent stated that it would be imperative for the SAPS FSL to maintain standards to ensure that the database is kept alive and updated as prescribed
- One respondent felt that the results of data from SAPS FSL database need to be synchronised against the other precious metals databases of precious metals-producing countries of the world, so that the data and its unique results might be accepted as valid in any court of law
- Four respondents chose not to comment

From the above responses it became evident that there were a few other areas of perceived shortages regarding the sample-collection process but that the majority of perceived and actual shortages concerned the SAPS FSL rather than being directly related to the collection process itself. These responses will be shared with the management of the SAPS FSL. The only two major shortages which became apparent were, firstly, the need for an international database, which is a valid point but whose formation is hindered by the logistical nightmare of obtaining such samples coupled with political and ideological issues. The second concern that, should gold be mixed from different mines, fingerprinting would not be able to separate the different origins was a valid concern but was a question to be addressed by looking into the gold fingerprinting methodology and is not a collection issue.

3.9 SUMMARY

The current reference sample-collection practices used for gold fingerprinting appear to have caused various misunderstandings regarding how and from where samples are to be collected. It also became evident from the research that a concern existed regarding the application of chain of custody requirements. Recent legislation in terms of the Precious Metals Act (Act 37 of 2005) has given very basic guidelines on what and when samples are to be sent to the SAPS FSL and, in terms of the mining industry's role as being responsible citizens, it would be in the interests of all the mining houses to ensure that the prerequisite samples are submitted. It is apparent from this research that basic collection practices are in place but that these need to be properly documented in a generic document, which can be made available to and applied by the whole gold mining industry.

It also became apparent that a few mining houses still need to come on board as far as sample submission is concerned. Several strengths and weaknesses were identified which should be kept in mind when a written procedure is drawn up. The mining industry has the biggest role to play in the sample-collection process. The industry has previously responded well to initiatives by the SAPS, and the researcher is confident that significant improvements can be made with a little bit of initiative and commitment.

Concerns were raised as to the sustainability of the SAPS to administer the database owing to the possible red tape within what is effectively a state body, but the researcher is confident that this is an aspect that is perceived to be generic to any government department and that, should issues be addressed at the appropriate level, the required results could still be achieved.

CHAPTER 4

FINDINGS AND CONCLUSIONS

4.1 INTRODUCTION

The decision to conduct research on this specific topic was born out of necessity, after the researcher had noted that there was a perceived disjoint between the SAPS FSL and operational mine security personnel, regarding the collection of gold fingerprinting samples required for the gold database, which was being kept at the SAPS FSL. It was noted that members of the SAPS FSL were requesting samples for the database and it was apparent that the collection of samples on the various gold mines had become the responsibility of the various security departments that were deployed on the various mines. It was also noted that, every time samples had to be collected, security members became apprehensive as no definitive written procedures were in place and not everyone had realised the importance of the collection and submission of such samples. Much debate would then be entered into about what samples were to be collected and from which areas the samples should originate, and the majority of the discussions centred on the representivity of samples. This was further exacerbated by the fact that new legislation had been published while research into the matter was being conducted and various rumours started doing the rounds of what was and what was not required.

It was further noted that the forensic science of gold fingerprinting had been around for almost a decade and that no definitive research had been conducted to establish if current collection practices were optimal and if they met legislative requirements.

In an attempt to address these shortcomings, the aim of the research was to make suggestions regarding what was important for a written procedure that would ensure that samples were representative of their operations and that such a procedure could be used when submitting samples. The secondary aim was to establish whether chain of custody requirements was being followed

when samples were submitted. To deal with this aim, two research questions were asked:

- What does forensic investigation in the gold mining industry entail?
- What are the current sample-collection practices in the gold mining industry?

A structured methodology was then used in an attempt to answer the research questions, by gathering information from as wide a variety of sources as possible, both local and international literature, and then also engage the opinions of people who are involved in the research topic in the real world. Denscombe (2002:14) supports scientific investigation as he sees methods of scientific investigation involving:

- Precise observations of the
- real world using an
- explicit and systematic method to produce
- theories that have
- verifiable results.

Denscombe (2002:3) further goes on to state that there is no such thing as perfect research and that one cannot please all the people all the time when it comes to doing social research. However, an awareness of the ground rules can help the project researcher to do a competent job that can be defended and justified to those who judge the quality of the end product.

Bearing this in mind, the researcher realises that his end product could be verified in that there should be a significant improvement in the validity of the SAPS FSL gold fingerprinting database and that the significance of chain of custody used in sample-collection processes will be probably tested in open court within the near future once this forensic science is used in court.

4.2 FINDINGS REGARDING THE RESEARCH QUESTIONS

The researcher decided on two specific research questions, which he felt would need to be answered, to get to the crux of the research topic.

4.2.1 Research Question One: What does forensic investigation in the gold mining industry entail?

4.2.1.1 Primary finding

In the research it was found that forensic investigation relates to a process where an attempt is made:

- To establish exactly what happened when a crime, for example gold theft, was committed, in order to uncover the truth surrounding the events;
- To prepare and present a *prima facie* case in a court of law; and
- To submit the evidence required to reveal the unlawful action of the accused.

It was further found that forensic investigation was used in the mining industry in the investigation of gold theft and that these investigations included the use of gold fingerprinting to identify the origin of gold that had been handed in as an exhibit. Such evidence could then be presented in court.

4.2.1.2 Secondary findings

Criminal investigation

It was established that criminal investigation has the same end result as forensic investigation and is also conducted in the form of research and that the basis of conducting a criminal investigation is to search in a systematic manner for the truth, with the primary purpose of finding a positive solution to the crime with the help of both objective and subjective clues and to identify and apprehend criminals in order to hold them accountable in a court of law.

Purpose of forensic investigation

The researcher found that the purpose of forensic investigation is to ensure that a criminal or an alleged criminal will be present at the trial and to submit the evidence required to prove the unlawful action. It, therefore, follows that the principle purpose of forensic investigation is to resolve and prove the elements of a crime.

It was noted that both the purpose of forensic investigation and the purpose of gold fingerprinting have at their heart the resolving of crime.

Objectives of forensic investigation

The researcher established that the objectives of forensic investigation are to establish that a crime has actually been committed; to identify and apprehend the suspect(s); to recover stolen property; and to assist in the prosecution of the person(s) charged with the crime.

It could therefore be argued that gold fingerprinting is also a form of forensic investigation as it has very similar objectives.

The objectives of forensic investigation are also found in the objectives of gold fingerprinting; namely, to establish that a crime has actually been committed, to identify and apprehend the suspect(s), to recover stolen property, and to assist in the prosecution of the person(s) charged with the crime.

Identification and individualisation

The researcher established that both the above terms played an important role in forensic investigation and specifically in gold fingerprinting. Research indicated that “identification” relates to identifying something or somebody and assigning it to a specific category while “individualisation” involves comparisons of disputed objects found at the scene of crime with an object of known origin.

It became evident to the researcher that individualisation was at the crux of gold fingerprinting in that an exhibit is recovered and it can then be compared to the gold database reference samples to enable the discovery of where the sample originated.

Chain of custody

The researcher determined that the most relevant definition of chain of custody is the witnessed, unbroken, written chronological history of who had evidence and when.

Gold Fingerprinting

In this research it was established that gold fingerprinting was the science of using laser technology, which can be applied to the characterisation of the trace element composition “fingerprint” of gold and that by comparison of the elemental association patterns of these minerals it is possible to relate samples back to a specific mineralising event, possible mine, and ultimately country of origin.

All of the research respondents had a basic understanding of the nature of gold fingerprinting and were unanimous in agreeing that some work needed to be done to improve sample-collection procedures, as such improvements would improve the validity of the SAPS FSL gold fingerprinting database, which would be of benefit to the gold mining industry and to the SAPS.

The purpose of gold fingerprinting

The researcher noted that in terms of the research conducted by Professor John Watling, the biggest application of gold fingerprinting is to cut down on gold theft at source and, therefore, improve the profitability of mines.

Respondents were of the opinion that the most important objectives of gold fingerprinting were similar to the objectives of forensic investigation in that they were:

- The determination of the origin of stolen or recovered gold
- The allowing for the return of such gold to its lawful owner
- The identification and arrest of offenders
- The prosecution of offenders
- The creation of intelligence that could be obtained from the use of the gold fingerprinting, which in turn could be used to determine security risk mitigating strategies
- The compliance by the mining industry with legislative requirements of the Precious Metals Act (Act 37 of 2005)

Role players in gold fingerprinting sample collection

The research identified the various role players as being:

- **Geological experts** who would be required to identify and obtain reference samples that reflect the composition of the various reefs and fascies of the underground operations of a mine and who would complete requisite documentation required for chain of custody requirements;
- **Metallurgical experts** who would be required to identify and obtain reference samples of refined gold bullion and concentrates within the metallurgical plants and who would complete requisite documentation required for chain of custody requirements;
- **Security Officers** that are required to seal reference samples in tamper-proof seal bags and to transport such samples to the SAPS FSL;
- **SAPS officials at the SAPS FSL** who are the end recipients and custodians of the reference samples and are required to manage and administer the gold sample reference database and to conduct analysis of samples to identify their origin. These officials would also be required to give evidence in a criminal court of law.

The findings of this research dissertation will be discussed with the relevant role-players and clearly defined roles may be identified, which will be to the benefit of all: the SAPS, the mining industry and the judicial system.

4.2.2 Research Question Two: What are the current sample-collection practices in the gold mining industry?

4.2.2.1 Primary finding

The current collection practices would meet the legal requirements of natural justice as applied in South African courts as, should there be any dispute as to the chain of custody requirement of reference samples, the most probable area of origin of the gold exhibit could be re-sampled and a more definitive result could then be obtained.

The basic practice was that security members would inform personnel in the metallurgical plants that samples were required, and the samples would then be collected and placed in containers by the various metallurgical managers for samples from the metallurgical plants and by the mine laboratory manager for samples collected from the shafts. These managers would place the containers in “intervoid” bags. In most instances, the security members would arrive at the manager’s office and would then have to complete the SAPS FSL form. The sealed “intervoid” bags would then be placed in a Perspex box and the samples would be recorded in an exhibit register. The metallurgical and security officials would both sign the register and the serial number of the “intervoid” bag would also be included in the exhibit register. The samples would then be moved to a safe at the security offices and, once all the samples had been obtained from all the mine operations, arrangements would be made to deliver the samples to the SAPS FSL. There the samples would be handed to an SAPS FSL Material Analysis member, who would sign on receipt of the sample in the exhibit register.

The current reference sample-collection practices used were found to have various strengths and weaknesses, and it was discovered that several practical enhancements could be included which would improve the validity of the gold fingerprint database.

The most recognised strengths of the sample-collection process were that:

- All role players were committed to supporting the SAPS FSL with their endeavours and to seeing that the collection of samples resulted in:
 - Determining the origin of stolen or recovered gold
 - Allowing for the return of such gold to its lawful owner
 - Identifying and arresting offenders
 - Prosecuting offenders
 - Intelligence could be obtained from the use of the gold fingerprinting, which in turn could be used to determine security risk mitigating strategies
 - The process allowed the mines to commit themselves to the legislative requirements of the Precious Metals Act (Act 37 of 2005)
 - Standardised documentation had been implemented which assisted with the collection of additional information as required by the SAPS FSL
 - Samples allow for a continuous record of changes in mines' source areas and in the processing techniques that are used

Various weaknesses were identified in the sample-collection process and the most significant of these were that:

- The mining disciplines of Mineral Resource Management and Metallurgy departments should be more involved in determining where samples should be collected and they should also be responsible for completing and signing the SAPS FSL form
- Generic written procedures which would allow all role-players to submit samples in a coordinated process were not in place. Once a written procedure was in place, this procedure could then also be rolled out to some of the smaller mines or bodies that had to submit samples, as not all these institutions were part of current mining industry and SAPS initiatives

- Samples that were arriving at the SAPS FSL were in some instances of no value as the samples had not been submitted in a standardised manner and the required documentation (SAPS FSL MLS0087F) had not been completed properly
- Not all the gold mines or producers in South Africa were part of industry initiatives and they were not submitting requisite samples
- For the database to be fully effective, samples should ideally be submitted from all gold-producing countries in the world
- The SAPS FSL had some logistical and manpower issues that would require attention as these were resulting in time delays
- The database had only been populated with legal gold and the database would be of more value if illegal gold that had been recovered by the SAPS and the mining houses was also submitted as reference samples
- Additional information was required by the SAPS regarding the metallurgical process

From the above schedule of strengths and weaknesses it became evident that what some people felt was a strength was a weakness for other respondents. This was indicative that there was a lot of room for improvement and standardisation.

4.2.2.2 Secondary findings

Chain of custody for gold fingerprinting sample collection

Respondents were divided on this issue, with some of them saying that current sample-collection methodology does meet chain of custody requirements and others stating that it does not.

It was also noted that the chain of custody requirements required for sample collection would not be as stringent as those required for the evidentiary movement of an exhibit from a crime scene to the SAPS FSL. It was also noted that, should a specific gold database sample be disputed in a court of law,

further confirmation of the sample individualisation could be done again by obtaining a second sample from the disputed origin and further analysis could be conducted.

The chain of custody would meet the legal requirements of natural justice as applied in South African courts if the basic requirements were included in the written procedure.

The basics requirements for ensuring that a good chain of custody is maintained would include:

- Keep the number of people involved in collecting and handling samples to a minimum and keep the chain of custody as short as possible
- Only allow people associated with the process to handle samples
- Document the transfers of samples with specific sample chain of custody forms
- Give the samples and data positive identification at all times and see to it that it is legible and written with permanent ink

Legislative aspects

The research highlighted that the Precious Metals Act (Act 37 of 2005) compelled all miners and producers of gold to submit reference samples to the SAPS FSL.

The regulations included with the precious Metals Act (Act 37 of 2005) were not descriptive enough to act as a written procedure for the submission of samples to the SAPS FSL.

Representivity of samples

The research concluded that samples were not representative enough of all commodities found in underground operations and metallurgical plants and that,

in instances where only one sample was submitted from a specific area, this could affect the statistical representivity of the database.

The current samples that were collected and included into the SAPS gold fingerprinting database were representative of the ore bodies from where they originated but the submission of further samples from various fascies in the ore bodies would allow for a larger pool of reference samples, which could then be double checked by taking additional samples from identified areas.

Collection comparisons to other forensic methodologies

The most similar forensic sciences that compared to gold fingerprinting were that of soil comparisons (comparing soil elements to a crime scene) and that of DNA profiling, where a mass spectrometer was also used when doing analysis.

Various similar processes were used in gold fingerprinting as in the other methodologies used, such as the use of mass spectrometry. In the determination of DNA profiling, the origin of the exhibit could be individualised by identifying a possible source in a database and then re-sampling the closest match to the exhibit. This same method could be used in gold fingerprinting.

4.3 RECOMMENDATIONS

The initial research concern that a certain amount of disjoint existed between the SAPS FSL and the various mining houses was found to exist to a certain degree and it was further concluded that much of the perceived apprehension existed as a result of people not properly understanding the specific process that was to be followed in submitting a sample.

The researcher therefore recommends that, in order to enhance the process, the following improvements be made, which will at the same time develop the validity of the SAPS FSL gold fingerprinting database:

- A generic procedure should be drawn up which explains in detail the process to use when collecting and submitting samples to the SAPS

FSL. This procedure should also be shared with mines and producers that are not involved in current industry initiatives. The procedure should also ensure that specific responsibilities are given to Mineral Resource Management Department members for the collection of shaft/reef samples and completion of proforma forms; Metallurgical Process Department members for collection of bullion samples and completion of proforma forms; and Security Department members for the transport and delivery of samples to the SAPS FSL

- Companies that have mines or strategic influence with mines in other gold-mining areas in the world should attempt to facilitate the collection of samples from these areas for inclusion as reference samples in the gold database
- Chain of custody requirements should be enhanced to ensure that they meet minimum requirements that have been identified. This will also include the mandatory use of “intervoid” sealed bags for the collection of all samples. The most important improvements to the chain of custody would include improving the documentation trail, ensuring the proper labelling of samples, requiring that the requisite expert (either metallurgical or geological) should complete the SAPS FSL MLS0087F form, and ensuring that security members are only responsible for the transporting and safe keeping of samples to the SAPS FSL
- The SAPS FSL form that is used is to be refined to ensure that it also can accommodate the name of the person who collected the sample and the person who transported the sample, and also the name of the SAPS FSL laboratory official who is to analyse the sample
- A decision should be taken on how to identify various shafts and plants on the various mining operations. One proposal was that, instead of only using the name of the premises, the sample-collection process in addition records the GPS reading, which can then be used as an identifier when name changes do occur
- Further representivity research should be conducted by members of the SAPS FSL and the various mining houses’ mineral resource

management departments to ensure that clarity can be obtained regarding from which areas, reefs and fasces representative samples must be collected from the various shafts

- The representivity of samples should be researched further in an effort to bolster the gold-profiling methodology

4.4 CONCLUSION

The ultimate aim of the research was to improve the validity of the SAPS FSL gold fingerprinting database and the researcher is of the opinion that, with a written procedure, some understanding and a bit of commitment and further research as recommended, significant improvements can be achieved which will be to the benefit of both the SAPS and to the mining industry as a whole. Other precious metal producers, e.g. platinum, could then similarly use the same methodologies, and with a few customised adjustments similar procedures could be tailor made for specific environments.

The researcher also hopes that this research report will provide both Mining Security and SAPS Organised Crime Unit members with some insight into the forensic world of gold fingerprinting, with specific reference to sample collection and some of the other issues that were identified as secondary findings. The concepts discussed in this research report are important to the enhanced knowledge that is required by crime fighters to ensure that we remain abreast of the crime threat within our democratic and beautiful country.

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Annexure A: Interview Schedule

Enhancing the validity of the SAPS gold fingerprinting database through improved sample collection techniques

Research questions

- What does forensic investigation in the gold mining industry entail?
- What are the current sample-collection procedures in the gold mining industry?

Historical information

1. In terms of your designation, what are the main responsibilities with your current employer?
2. How long have you been employed with your current employer?
3. Do you have previous experience with another employer that is related to your current designation?
4. Describe your investigative experience relating to the theft of gold?
5. What specific courses / seminars have you attended that are related to your current responsibilities?

Forensic gold fingerprinting

6. What is your understanding of the concept gold fingerprinting?
7. Is gold fingerprinting used by your current employer?
8. For what purpose is gold fingerprinting used in your current workplace?
9. What is the purpose of gold fingerprinting?
10. Are you involved in the sample collection process?
11. If your answer to question 11 was yes, please describe the role you play in the sample collection process.
12. What do you foresee as being the strengths of the current sample collection process?
13. What do you foresee as being the weaknesses of the current sample collection process?

14. What legislation requires that samples must be collected and forwarded to the SAPS Forensic Science Laboratories?
15. Which organisations / bodies have to collect samples that have to be sent to the SAPS Forensic Science Laboratories?
16. Why do you think the samples have to be collected?
17. How often should samples have to be collected?
18. How should samples be collected?
19. What sample size has to be collected, expressed in grams?
20. Do you have any comment on the sample size that has to be collected?
21. From where in the mining operations must samples be collected?
22. What would you say are the phases involved when collecting samples for gold fingerprinting?
23. Do you feel that the current collection techniques used meet the legal requirements of natural justice as applied in South African Courts?

Sample collection best practice procedures

24. What according to your experience would you suggest is the best practice procedures used to collect samples?
25. In your opinion, are samples collected representative of all parts of the mining process and are therefore of value when being used for gold fingerprint analysis?
26. Is there any aspect of the current legislation, the Act and regulations that you feel inhibits procedures used for the collection of samples?
27. What is your opinion regarding chain of evidence with specific regard to sample collection procedures?

Increasing the validity of the SAPS gold fingerprinting database

28. Express your opinion on whether enhanced sample collection techniques will increase the validity of the SAPS Gold Forensic Database?
29. Are there any other aspects that you feel require attention that will enable the SAPS to improve the validity of the gold fingerprint database?