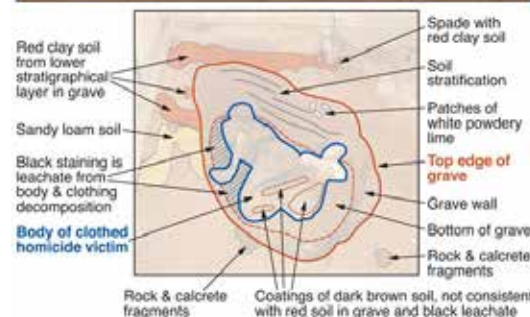




## Sexual Assault and Theft



www.csiro.au

# Morphology and mineralogy of sandy materials as significant trace evidence in a murder and drug investigation in Australia

**Rob Fitzpatrick<sup>1</sup> and Mark Raven<sup>2</sup>**

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<sup>1</sup>Deputy Chair, International Union of Geological Sciences, Commission on Forensic Geology

<sup>1</sup>Adjunct Professor, the University of Adelaide

<sup>2</sup>CSIRO Mineral Resources



# Centre for Australian Forensic Soil Science:

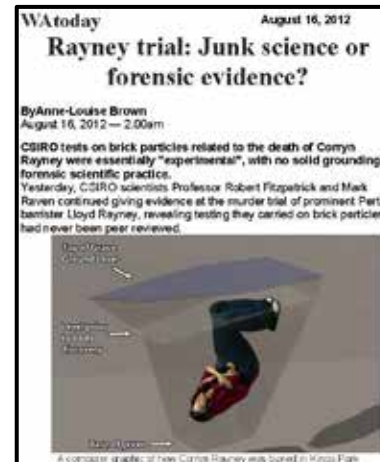
*Background: since 2001 have completed over 250 soil forensic cases*

Forensic soil science and geology assists law enforcement agencies on the use of both Natural & Human-made earth materials (geological & soils) with forensic investigations in:

**Trace evidence:** *Earth materials are a powerful contact trace.*

## Corryn Rayney murder 2007

- Body found in a grave in Kings Park
- Brick fragments + sand in bra straps
- Supreme Court, Perth, 2012 **Judge only**
- Significant media-hype in Perth



## Peter Falconio murder July 2001 on highway near Barrow Creek, Northern Territory

- Participated in search of body in 2008
- Bradley Murdoch convicted killer dies 15 July 2025
- Headline news The Guardian: Saturday 18 July 2025



# Origin of forensic soil science and geology

## First documented case study

- In April 1856, on a Prussian railroad, a barrel that contained silver coins was found on arrival at its destination to have been emptied and **refilled with sand!**
- Prof Christian Gottfried Ehrenburg of Berlin acquired samples of sand from all stations along lines of railway
- He then used light microscopy to match the sand in the barrel to the station from where the sand originated from



**Scientific American, April 1856**

*This is arguably the **very first documented case**, where forensic comparison of soils was used in help police solve a major crime*



# Case study examples: all vastly different in origin and complexity

**Two *real live* homicide and drug cases:** illustrating how **sandy earth materials** on clothing (shoes) were used as evidence in 2 forensic investigations selected from 250 cases conducted by Centre for Australian Forensic Soil Science (CAFSS):

**1. Sandy soil in 2 illegal cannabis plantations near Coonalpyn, AND recovered in lambswool covers on shoes seized from five men**

Six men arrested for cultivating controlled plants for sale in a large commercial quantity

**1,347 plants seized worth ~81 million \$ over 12 yrs**

District Court in Adelaide, South Australia, Jury

**2. Sandy soil under sea water on SA beach AND recovered in shoes seized from Rosebud Beach, Victoria (750 km apart) from 2 men**

Murder - Ladies Beach, Horseshoe Bay, South Australia

Supreme Court in Adelaide, South Australia, Jury

**Adelaide, South Australia**

**Coonalpyn, South Australia**

**Melbourne, Victoria**



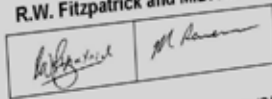
# Guidelines for conducting criminal and environmental soil forensic investigations



Centre for Australian  
Forensic Soil Science

## Guidelines for Conducting Criminal and Environmental Soil Forensic Investigations: Version 10.1

R.W. Fitzpatrick and M.D. Raven



Centre for Australian Forensic Soil Science (CAFSS)



Client Report: CAFSS\_076 (Version 10.1)

1<sup>st</sup> February, 2016

## Guidelines for Conducting Criminal and Environmental Soil Forensic Investigations: Version 10.1

by Fitzpatrick and Raven (2016)

Centre for Australian Forensic Soil Science

Report No. CAFSS\_076. 46pp.

<http://www.adelaide.edu.au/directory/robert.fitzpatrick?dsn=directory.file;field=data;id=35757;m=view>

## Soil collection and sampling

- **Questioned** soil samples  
whose origin is unknown
- **Known** soil samples:
  - Control** soil samples
  - Alibi** soil samples
  - Reference** soil samples

Sample chain-of-custody

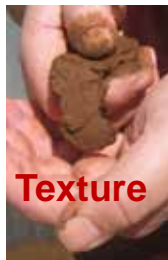
Soil characterization & evaluation

Guidelines for Expert Witnesses

# Systematic approach to discriminate earth materials in forensic examinations

## **STAGE 1. Initial characterisation of all samples** - Screening and sample selection

- Munsell soil colour, texture, structure (soil morphology)



## **STAGE 2. Semi-detailed characterisation of selected samples** - Mineral and organic matter composition - Size fractionation (< 50 µm)

- X-ray diffraction (XRD), chemical methods (e.g. pH)



## **STAGE 3. Detailed characterisation and quantification of minerals and organic matter in composite and individual soil particles following sample selection; size or magnetic or heavy mineral fractionation using advanced analytical methods**

- Detailed micro-X-ray-diffraction (synchrotron) and quantitative XRD
- Electron microscopy etc.

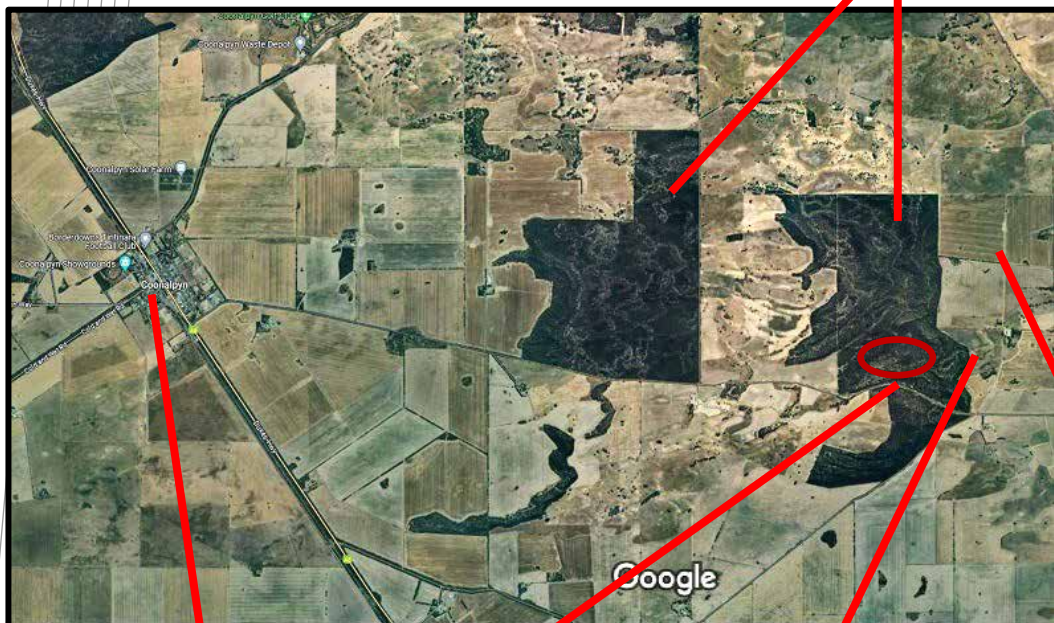
## **STAGE 4. Integration and extrapolation of soil information from one scale to next**

Sample grouping, soil classification; landform and soil mapping



# Cannabis plantations of commercial quantity near Coonalpyn: 1,347 plants seized, ~81 million \$ over 12 yrs

Google Earth image of areas around Coonalpyn and along the Dukes highway showing localities of 2 cannabis plantations in the uncleared native mallee vegetation on steep sand dunes



Imagery ©2024 Airbus, CNES / Airbus, Landsat / Copernicus, Maxar Technologies, Map data ©2024 Google 500 m

Coonalpyn  
Along the  
Dukes  
highway

Cannabis  
plantations  
in uncleared  
mallee  
vegetation

1.2 km High  
density Poly Pipe  
tapped into  
welded steel  
mains pipeline



Wheat  
and  
Barley  
fields





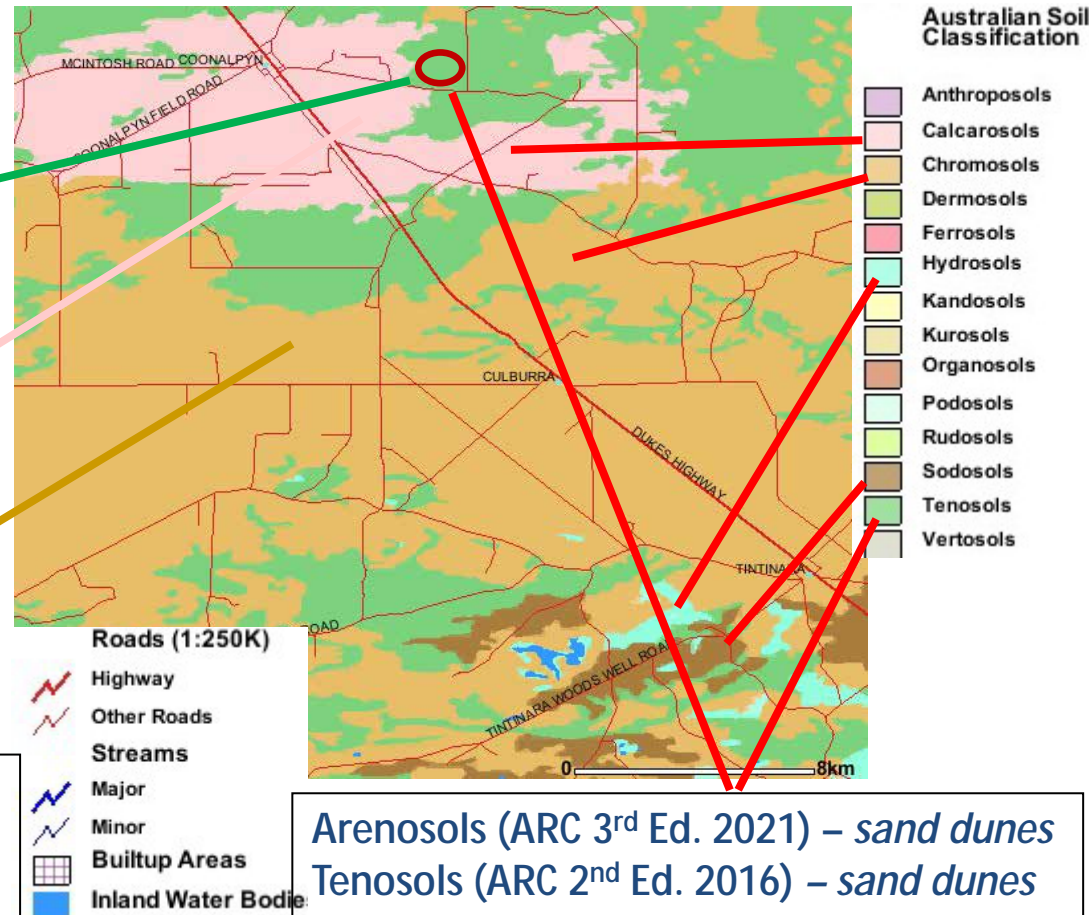
# Soil map near Coonalpyn around 2 cannabis plantations showing: Arenosols in steep sand dunes and adjacent flat lying landscapes with Chromosols and Calcarosols (sandy topsoils)

Control soils in Sites 1 & 2 classify into  
3 soil-landscape categories:

- (A) Sand dunes (Aeolian sands)  
with minor calcite:  
Natural deep sandy soil  
Hypocalcic Grey **Arenosol** (ASC)
- (B) Swales with high concentrations  
of calcite fragments:  
Natural calcareous shallow soil  
Pedal Supracalcic **Calcarosol** (ASC)
- (C) Fringe of plains & swales  
with minor calcite  
Natural grey sandy shallow soil  
Eutrophic Grey **Chromosol** (ASC)

The association of Arenosols (sand dunes)  
being very closely surrounded by:

- Calcarosols explains the occurrence of  
“calcite fragments” in the swales
- Chromosols explains the occurrence of  
“greyish brown clayey soil materials” at  
depth in the plains and swales



Soil map showing how the different soil types change  
across the landscapes around Coonalpyn and along the  
Dukes highway [Soil map downloaded from: Australian  
Soil Resources Information System (ASRIS) database]



# Sample Collection: Control bulk surface soils

## Sampled in 2 cannabis plantations near Coonalpyn



Photograph of the surface sandy soil sample (left photo) collected at the Site 2 cannabis plantation near Coonalpyn (right photo) showing of the nature of the undisturbed soil surface and tree canopy cover of the surface soil sample, which was sampled from the soil pit in the foreground with marker tape (cm); water tank can be seen in the background and adjacent irrigation pipes.



# Sample Collection: Questioned soils

## Recovered from lambswool shoe covers

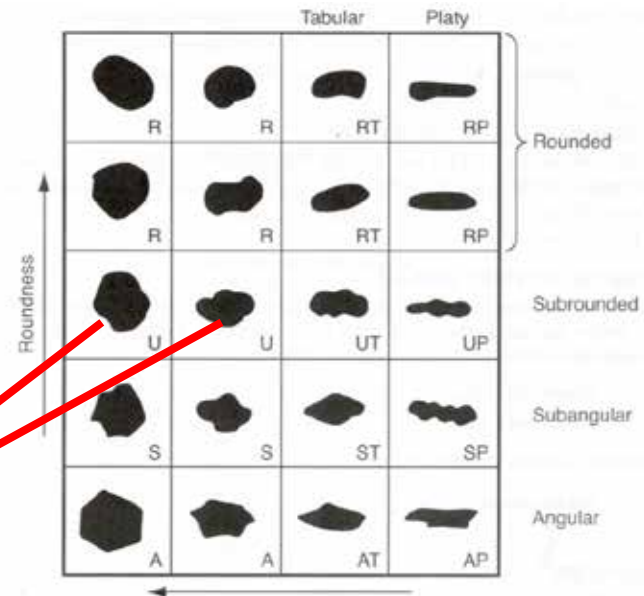
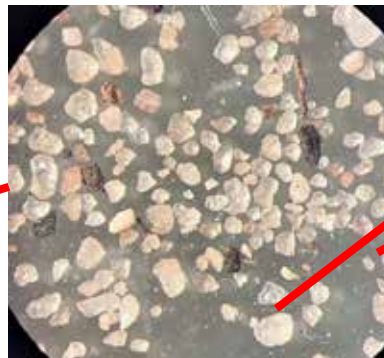


Photographs of questioned soil material (left photo's) recovered from the lambswool covers (right photo) used to cover the soles of shoes worn by suspect (CAFSS\_234.2)

# Visual description of 6 questioned soil samples from lambswool covers on soles of shoes

The 6 questioned soil samples from lambswool covers on soles of shoes have the following 9 out of 9 similar soil morphological features:

1. Greyish brown to Light brownish grey Munsell soil colours
2. Loose Consistence
3. Sandy texture
4. Single grain structure
5. Water repellent class
6. Slightly Effervescence Class (SL) to Strongly effervescent (ST)  
indicates carbonate minerals are present
7. Very few, fine carbonate fragments.
8. Common fine to medium Organic Materials
9. **Subrounded (U)** very many, fine quartz particles



Indicates: Extremely Strong degree of comparability between the 6 questioned samples



# STAGE 2 & 3: Semi-detailed and detailed characterization (X-ray diffraction - XRD)

Traditional X-ray diffraction (XRD) techniques using pressed powders are suitable because **large amounts of sample were available** (i.e. > 5 milligrams).



**Soils**  
**(< 50  $\mu\text{m}$  fraction)**



# Stages 2 & 3: Mineralogy of Questioned samples

CAFSS No	Bulk or Hand-picked samples <sup>1</sup>	Qz	Ct	Do Ak	Kn	Mi	Sm	Ab At	Or Mc	Ht Go	An	Ha	Gy
234.1	Bulk	D	M	T	T	M	M	M	M	T	T	T	T
234.2	Bulk	D	SD	M	T	M	M	M	M	T	T		
234.3	Bulk	D	M	M	T	M	T	M	M	T		T	
234.4	Bulk	D	SD	M	T	M	T	M	M	T	T	T	T
234.5	Bulk	D	M	M	T	M	T	M	M	T		T	T
234.6	Bulk	D	M	M	T	M	T	M	M	T	T		T

**D** - Dominant (>60%)

**CD** - Co-dominant  
(sum of components >60%)

**SD** – Sub-dominant (20-60%)

**M** – Minor (5-20%)

**T** – Trace (<5%)

Where: Qz = Quartz; Calcite = Ct, Do= Dolomite/ Ak=Ankerite; Kn = Kaolin; Mi=Mica, Sm= Smectite; Ab = Albite/ Anorthite = At; Or= Orthoclase/Microcline, Ht= Hematite/ Goethite = Go, An = Anatase; Ha = Halite; Gy = Gypsum, Am-Amphibole

**The 6 questioned soil samples associated with soil trapped in lambswool covers on shoes have the following 12 out of 12 similar amounts of mineral components:**

**Dominant:** quartz

**Subdominant:** calcite, dolomite/ankerite, mica, orthoclase/microcline, albite/anorthite,

**Minor to trace:** smectite,

**Trace :** kaolin, hematite/goethite, halite, anatase and gypsum

**Indicates:** Extremely Strong degree of comparability between the 6 questioned samples

# Stages 2 & 3: Mineralogy of Bulk control surface samples

CAFSS No	Bulk or Hand-picked samples <sup>1</sup>	Qz	Ct	Do Ak	Kn	Mi	Sm	Ab At	Or Mc	Ht Go	An	Gy	Am
234.7	Bulk	D	T	T	M	M	M	M	M	T	T		
234.8	Bulk	D	T	T	T	M	M	M	M	T		T	
234.10-2	Bulk	M	T		M	T	D	T	T	M	T		
234.10-3	Bulk	M	SD		M	T	D	T	T	M	T		
234.13	Bulk	SD	T		M	T	SD	T	T	T	T		T

**D** - Dominant (>60%)

**CD** - Co-dominant  
(sum of components >60%)

**SD** - Sub-dominant (20-60%)

**M** - Minor (5-20%)

**T** - Trace (<5%)

Where: Qz = Quartz; Calcite = Ct, Do= Dolomite/ Ak=Ankerite; Kn = Kaolin; Mi=Mica, Sm= Smectite; Ab = Albite/ Anorthite = At; Or= Orthoclase/Microcline, Ht= Hematite/ Goethite = Go, An = Anatase; Ha = Halite; Gy = Gypsum, Am-Amphibole

The 5 control bulk soil samples have the following 9 out of 12 similar amounts of mineral components:

**Dominant to minor:** quartz, smectite

**Subdominant to trace:** calcite

**Minor to trace:** mica, orthoclase/microcline, albite/anorthite, kaolin, hematite/goethite, anatase

**Trace :** dolomite/ankerite, gypsum and amphibole (*occurrences in 3 samples*)

**Indicates:** Very Strong degree of comparability between the 5 control bulk surface samples



# Stages 2 & 3: Mineralogical comparisons between the 6 questioned soils AND 5 known control bulk soil samples

The 6 questioned soil samples associated with soil trapped in the lambswool covers on shoes and 5 control bulk soil samples collected at Sites 1 and 2 cannabis plantations have the following 9 out of 12 similar amounts of mineral components:

**Dominant to minor:** quartz, smectite;

**Subdominant:** calcite,

**Minor to trace:** mica, orthoclase/microcline, albite/anorthite, kaolin, hematite/goethite, anatase

*Minor & trace:* dolomite/ankerite & gypsum & halite in the lambswool covers is likely due to “accidental spillage” during process of applying “commercial agricultural dolomitic lime”

**Indicates:**

**Extremely Strong degree of comparability** between XRD patterns of the 6 questioned soil samples and 5 control samples

**It is extremely likely that the questioned soil associated with soil trapped in the lambswool covers on shoes all originated from either Site 1 and/or Site 2 cannabis plantations near Coonalpyn.**

# STAGE 4: Comparisons between 6 questioned and 5 control samples

The 6 questioned soils trapped in the lambswool covers on shoes

AND

The 5 known control bulk samples collected from both cannabis plantations

have a ***Strong degree of comparability***

**Indicates:** that the 6 questioned samples in the lambswool covers on shoes and 5 known bulk samples from both cannabis plantations have identical origins

# Conviction and Sentencing

**One man (mafia member) admitted guilt & extradited to Italy**  
**Five men were found guilty by way of jury verdict for:**

*Cultivating controlled plants for sale in a large commercial quantity*

- This is a significant seizure of cannabis plants
- The manner in which they were grown and concealed required a significant level of planning, preparation and organisation

**Sentencing: August 2025:**

**Anyone who trafficks illicit drugs can face penalties of:**

- Up to \$500,000 fine
- or
- Life imprisonment and can forfeit assets such as houses and cars



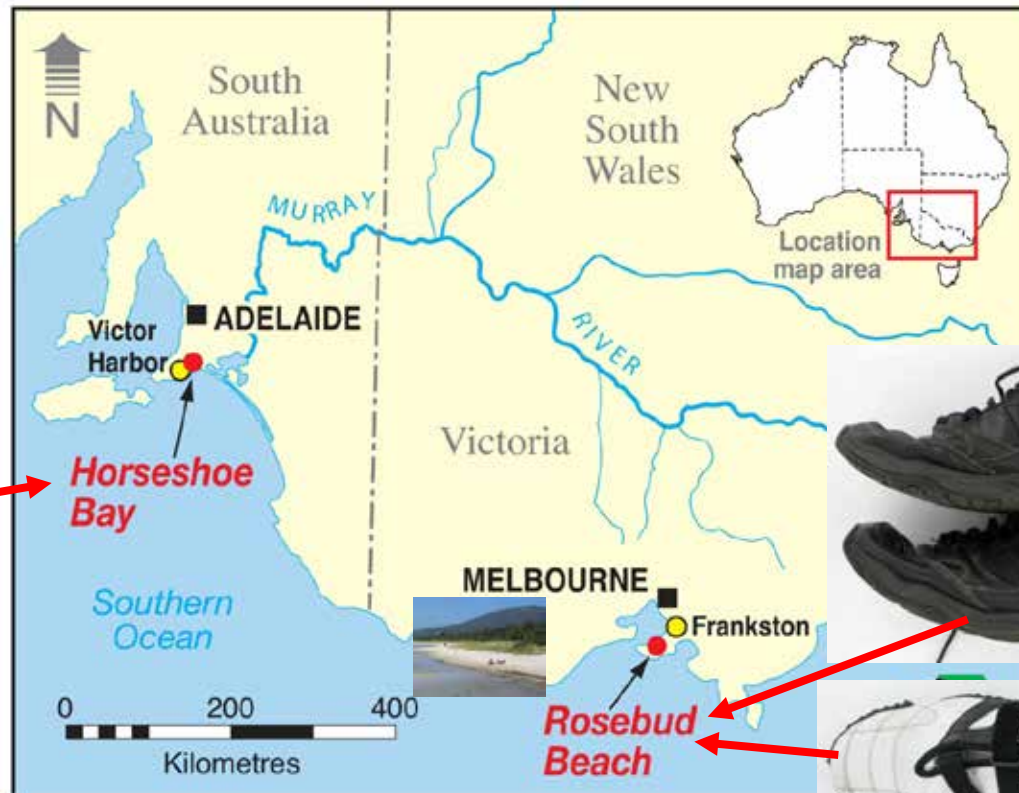
# Murder - Ladies Beach, Horseshoe Bay, South Australia

## Shoes seized on: Rosebud Beach, Victoria (750 km apart)

Carly Ryan body located in shallow water on main beach in 2007



New balance shoes and OMI sandals located on Rosebud beach in VICTORIA



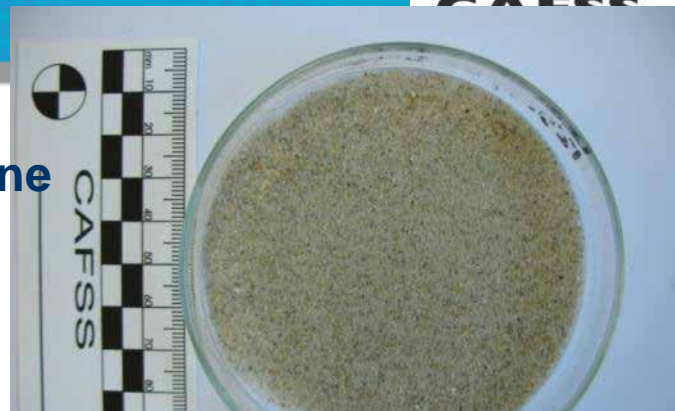
Alleged site of murder scene  
Ladies Beach  
Control samples (C)

Rosebud Beach +  
Inside shoes  
Questioned samples (Q)

# Sand from Rosebud beach (Control soil samples)



**Upper beach  
sample**



**In tidal zone  
sample**



**Greyish brown**

**6.3X magnification**



**20X magnification**





## Sand from Ladies Beach (C)

## Sand in New Balance shoes (Q)

Both Yellowish brown

Very strong degree  
of comparability!

6.3X magnification

20X magnification





## Sand inside OMNI shoes

## Sand from Rosebud beach

Questioned samples

Control samples

Yellowish brown

Greyish brown

Limited degree  
of comparability!

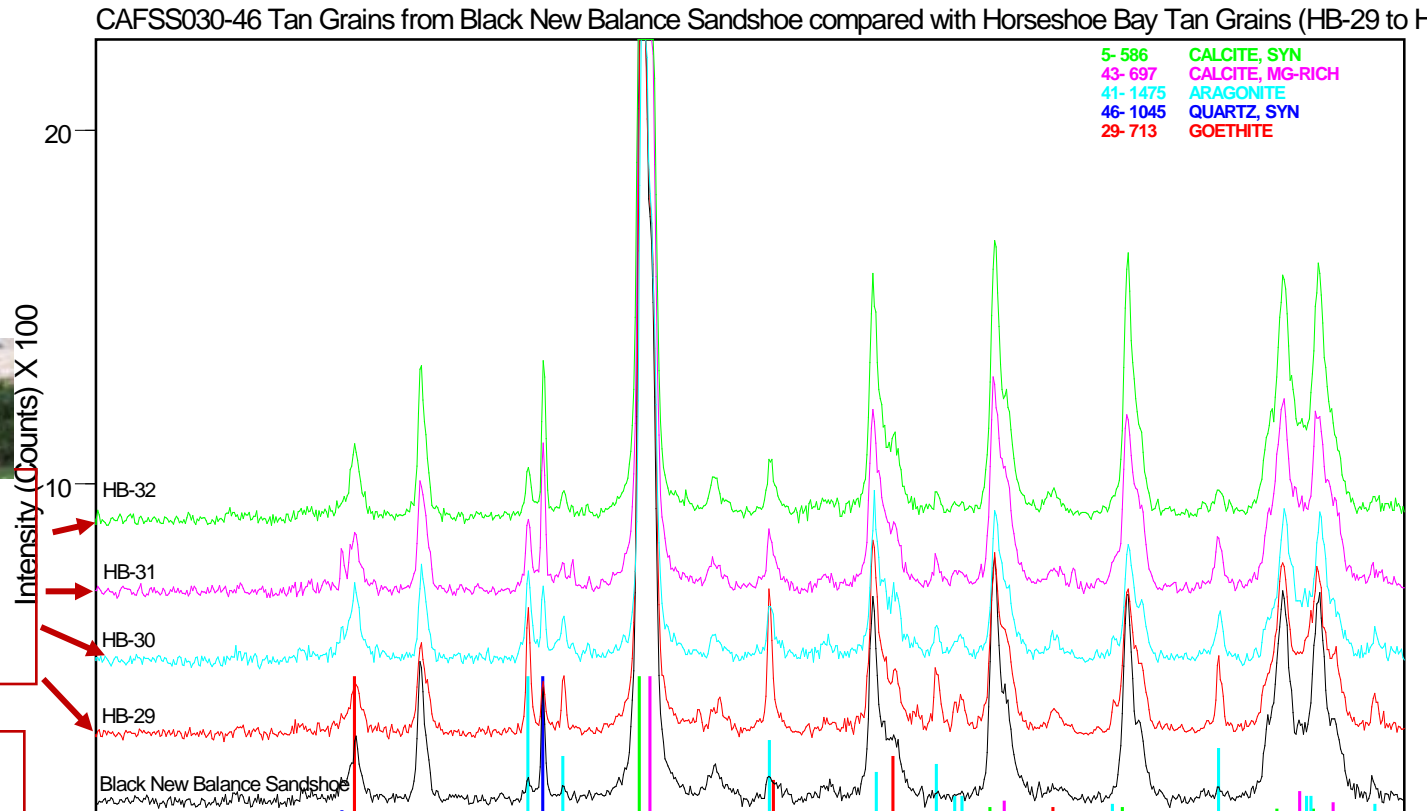
6.3X magnification

20X magnification

# Mineralogy of tan coloured shell grains from Ladies Beach (crime scene) & New Balance Shoes (Q sample)



**Crime scene  
samples  
Ladies Beach**



**Very strong degree of comparability!**

# Comparisons:

## Sand from “inside” both shoes and Sand on Ladies Beach, South Australia



Sand inside both shoes found on Rosebud Beach, Victoria were **significantly similar** in:

**Soil morphology:** colour, texture and **tan grains**

**Soil mineralogy:** X-ray diffraction of tan grains:

Calcite, Mg-calcite, aragonite, quartz, goethite and no feldspar

Compared to sand on Ladies Beach (crime scene) indicating:

**Very strong degree of comparability – that sand inside both shoes are derived from a common origin in Ladies Bay, SA**



## **Sentencing: Garry Francis Newman** is found guilty of: Assaulting and suffocating 15-year-old Carly Ryan on Horseshoe Bay beach

**Jury** revealed Carly Ryan had been bashed,  
suffocated and placed in the water where she drowned  
**Set non-parole term of 29 years**

**Before sentencing, Newman admits guilt**

Newman denied at trial having had anything to do with the murder, but after he was found guilty he confessed and said he “never intended killing the girl”



**Loses appeal 29<sup>th</sup> April 2011**

The appeal court was told Newman was sexually infatuated with the teenager and **had given dishonest evidence during his trial** (ABC News)

### **Journal reference to case study:**

Fitzpatrick, RW, Raven, MD. and Self PG. (2017). The role of pedology and mineralogy in providing evidence for 5 crime investigations involving a wide range of earth materials. *Episodes (Journal of International Geoscience)*. 40 (2) 148-156. <http://dx.doi.org/10.18814/epiiugs/2017/v40i2/017017>

# Carly's Law

Carly's Law was passed in 2017 and enshrined in legislation in 2018 making it a crime to plan to harm children under age 16

## Slain Carly inspires shake-up of US law

Saturday October 7, 2023 The Advertiser

Rebecca Whitfield-Baker

An Adelaide teenager who was brutally murdered more than a decade ago is inspiring a law change across the US.

At 15, Carly Ryan died after being lured to a meeting by a 50-year-old serial pedophile who pretended online he was an 18-year-old boy.

Gary Francis Newman killed the youngster at Horneshebe Bay Beach, Port Elliot, in 2007.

In the wake of the tragedy, her mum and cybersecurity trailblazer, Sonya Ryan, campaigned tirelessly for stronger laws to protect young people online.

Carly's Law was passed a decade after the schoolgirl died and enshrined in legislation in Australia the following year, making it a crime to plan to harm a child under 16.

It is particularly targeted at predators who misrepresent their age.

Similar legislation, also referred to as Carly's Law, has now been drafted in the US with several major states, including: Minnesota, Florida, Texas, Washington State, Indiana, North Carolina, moving closer to enacting it.

Ms Ryan, chief executive of Adelaide-based online safety program provider the Carly Ryan Foundation which now also has an offshoot in the US, said she had long been driven to fight for change beyond Australia.

She has worked internationally as an adviser for online safety with strong interest previously from Texas police in the US as well as New Zealand.

"When Carly's Law passed in Australia, the United Nations contacted me and wanted to help support me to ...



Murder victim Carly Ryan

Carly's Law into the criminal codes of as many countries as possible," the former South Australian of the Year said.

"For me, children everywhere are important ... this crime type is borderless.

"There are children all over the world suffering ... in the US alone there have been over 30 million reports of online child exploitation in one year.

"I have always felt that Carly's legacy needs to go beyond Australian shores, that it needs to potentially impact the lives of millions of children ... that remains my hope."

Ms Ryan, with support of the Australian Embassy in Washington, DC, and federal Attorney-General Mark Dreyfus has met with governors and politicians across the US.

"We are really moving forward towards getting Carly's Law introduced in several states," she said.

"We now have it in draft form and are working on the wording ... the fact that it is now in draft is a huge step forward ... we are very close to getting Carly's Law enacted here."

"I have worked so hard to change the online safety landscape in Australia and wanted to bring all the things I have worked so hard for, here to the US," she said.



Evil Gary Francis Newman was sentenced to 29 years jail for Carly Ryan's brutal murder.

Saturday October 7, 2023 The Advertiser

Carly's legacy needs ... to potentially impact the lives of millions of children

Sonya Ryan, left, whose daughter Carly was killed by a pedophile. Ms Ryan has worked to have cyber security laws changed in Australia and, now, the US. Story, Page 4

In 2023, similar legislation also referred to as "Carly's Law" has been drafted in the USA for: Minnesota, Florida, Texas, Washington State, Indiana, North Carolina

# Conclusions

## Soil is a Powerful Contact Trace

### Advantages of X-ray techniques are:

- Non-destructive
- Rapid
- Very little or no sample preparation required
- Large samples
- Small fragments

**Centre for Australian Forensic Soil Science (CAFSS)** – since 2001 have completed over 250 soil forensic cases in Australia and overseas

### Contributions/linkages to bestselling :

- True crime novels – Liz Porter (Australia)
- Fictional crime novels – Stephen Hunter (USA)
- Textbooks & Encyclopedias - Forensic science, Soil science & Geology







## Acknowledgements

**Centre for Australian Forensic Soil Science (CAFSS)**  
**CAFSS Board (Chair Prof Hilton Kobus)**

**Peter Self & Mark Raven (CSIRO Mineral Resources)**

www.csiro.au

# Thank You

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