Nuclear Trafficking: In Pursuit of Evidence

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Background

- With the end of the Cold War and the break up of the Soviet Union there were a rash of incidents involving the smuggling of nuclear material.

- Especially worrying were those involving HEU and Pu – both nuclear weapons usable materials.
Podolsk, Russia
1.5 kg HEU

Andreeva Guba, Russia
1.8 kg HEU (36%)

St. Petersburg, Russia
3.0 kg HEU (90%)

Munich, Germany
400 g Pu (87% Pu-239)

Murmansk, Russia
4.5 kg HEU (20%)

Tengen, Germany
6 g Pu (99.75% Pu-239)

Landshut, Germany
0.8 g HEU (87.8%)

Prague, Czech Republic (2)
0.415 g + 17 g HEU (87.8%)

Moscow, Russia
1.7 kg HEU (20%) - Electrostal Diversion

Vilnius, Lithuania
100g HEU (50%)

NOTE: enrichments have not been independently verified for all seizures
Effect of 11/9 (or 9/11 according to US colleagues)

- Following the terrorist attacks on the Twin Towers a fear was generated about the implications of if terrorists got hold of such smuggled materials
- A lot of emphasis on detecting such material in illicit transit
- Next stage was to consider what could be learnt from analysis of seized material
- One response was to set up international “Round Robin” exercises to look at the practical aspects of the problem
Constraints of exercise

- The exercise was set up to mimic production of evidence to meet court requirements
- Reports at:
  - 1 day – to hold
  - 1 week – to charge
  - 2 months – to prosecute
Scenario

- On a Monday in the country of Texmex, two seizures of nuclear materials occurred.
- The first seizure occurred at a border crossing when an Elvis (“The King”) Presley look-a-like, who had been out of the US for two weeks celebrating Elvis’ 75th birthday, was returning via the country of Texmex. A routine customs check yielded a suspicious piece of metal.
- The radiation protection specialist arrived on site with appropriate equipment and determined the presence of uranium-235.
- The Texmex larger customs area perimeter was closed down. Authorities scrutinized the names of travelers within the perimeter and found one Mr. Remoisy, who had been previously prosecuted for illicit trafficking.
- Closer inspection of Mr. Remoisy’s effects also resulted in seizure of a suspicious piece of metal (now designated as material B) that looked similar to the material found with Elvis (designated material A).
Questions to be answered

- (1) Do the measurements of sample A as well as sample B materials indicate that the law was broken in Texmex? (Possession of greater than 1 g of HEU is illegal)
- (2) Given the characteristics of the materials can it be reasonably determined that the two seized materials (sample A and sample B) are from the same source?
- (3) Using the above, are the two seizures related?
- (4) Is there more material at large?
Samples provided to Laboratories

- Two samples, (an A and B) of less than 10 g each were supplied to each laboratory
- Analysis plans were drawn up to maximise the information that could be gained from each sample to allow the questions to be answered
- A wide variety of analytical techniques were to be employed
Plan of Action

Analysis provided by other facilities

1. **SPME headspace** sampling for organics analysis (24h)
2. Open package Dose rate (24h)
3. **Take photos** (24h)
4. Weigh sample, dimensions, density (24h)
5. **Micro focus XRF** alloy determination (24h)
6. **Superheadprobe** (24h)
7. **Gamma count** on solid U isos, rough assay, daughters (24h)

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**Surface organics** (1wk)

**24hr REPORT DUE**
Plan of Action

8 Subsample (next day)

9 gamma spec (1 wk) 2 x 0.8g

10 assay solid (1wk/month) 2 x 0.2g

11 C, S solid (1 wk) 2 x 0.5g

12 ONH solid (1wk) 2 x 0.5g

Characterisation solid (2 month) 5g total

13 1g
goal microscopy
SEM
Grain structure
Origin of material?

14 TIMS iso, Pu & U ug (1 week)

15 ICP-MS 2 x 50mg full suite (1 week)

16 Pu, Am, Np, Th, Pa 2 x 0.2g equiv (2 month)

17 Si by spec 0.1g equiv if enough (1 wk)

18 intermediate ICPMS solution

19 TIMS Pu ug (2 month)
Analytical techniques used (i)

- Gamma spectrometry (including U-232)
- Assay by potentiometric titration
- Carbon analyser
- Isotopics by TIMS
- Trace Pu analysis
Analytical techniques used (ii)

- HR-ICPMS
- ONH and S analysis
- Organics analysis
- μ-focus EDXRF
- Raman
- Solid sample modelling by gamma spectrometry
- Age dating
- Solid characterisation techniques such as SEM and optical microscopy
1 Day Analyses

Open package/ Dose rate → Photographs → Weigh/ Dimensions

Digital microscope/ Raman superhead probe → Micro focus XRF

Gamma count solid → 1 Day report
1 Week Analyses

Subsample

Carbon/Sulphur

Oxygen/Nitrogen

Gamma count (known geometry)

ICPMS

TIMS

Si by spectrophotometry

1 Week report
Analytical techniques used: ICPMS

- Glove box contained Thermo Scientific Element 2
- Instrument used routinely to ensure trace elements meet material specifications
- Also developed methods to analyse for additional elements
- LODs typically ppb-ppt
# 1 Week- ICPMS Elements

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2 Month Analyses

Uranium Assay → SEM/EDX → Gamma fraction U-232 → Transuranics (Pu) → TIMS (Pu) → Th (age dating) → ICPMS

2 Month report
# 2 Month- ICPMS Elements

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**1 week elements**

**2 month elements**
Analytical techniques used: Age dating

- Candidate ratios for age dating:
  - $^{234}\text{U}/^{230}\text{Th}$
  - $^{235}\text{U}/^{231}\text{Pa}$
  - $^{234}\text{U}/^{214}\text{Bi}$
  - $^{236}\text{U}/^{232}\text{Th}$
- U-234 by TIMS
- Th-230 by gamma spectrometry
Key Analytical Methods in Decision Making

- Only few differences noted between the samples
- TIMS main discriminator between the samples - small uncertainty associated with this technique. Weight% significantly different for all isotopes
- Carbon analysis- results significantly different at coverage factor 2
- Trace element analysis- only two metals, Zr and Re, significantly different in material at coverage factor 3
Answers to Questions

- (1) Do the measurements of sample A as well as sample B materials indicate that the law was broken in Texmex?

- (2) Given the characteristics of the materials can it be reasonably determined that the two seized materials (sample A and sample B) are from the same source?

- (3) Using the above, are the two seizures related?

- (4) Is there more material at large?

(1) Yes as both samples were over 5 grammes

(2) It was concluded that the samples were not the same but were different batches made by the same process

(3) Yes

(4) Analysis can not answer. There is more material, but it may not be at large