



# Nuclear and related analytical techniques in archeological and ecological studies

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# Outline

1. Introduction
2. Methodology
3. Results and discussion
4. References
5. Acknowledgements

# 1. INTRODUCTION

## 1.1 History of Neutron Activation Analysis (1936)

George de Hevesey (1885-1966)

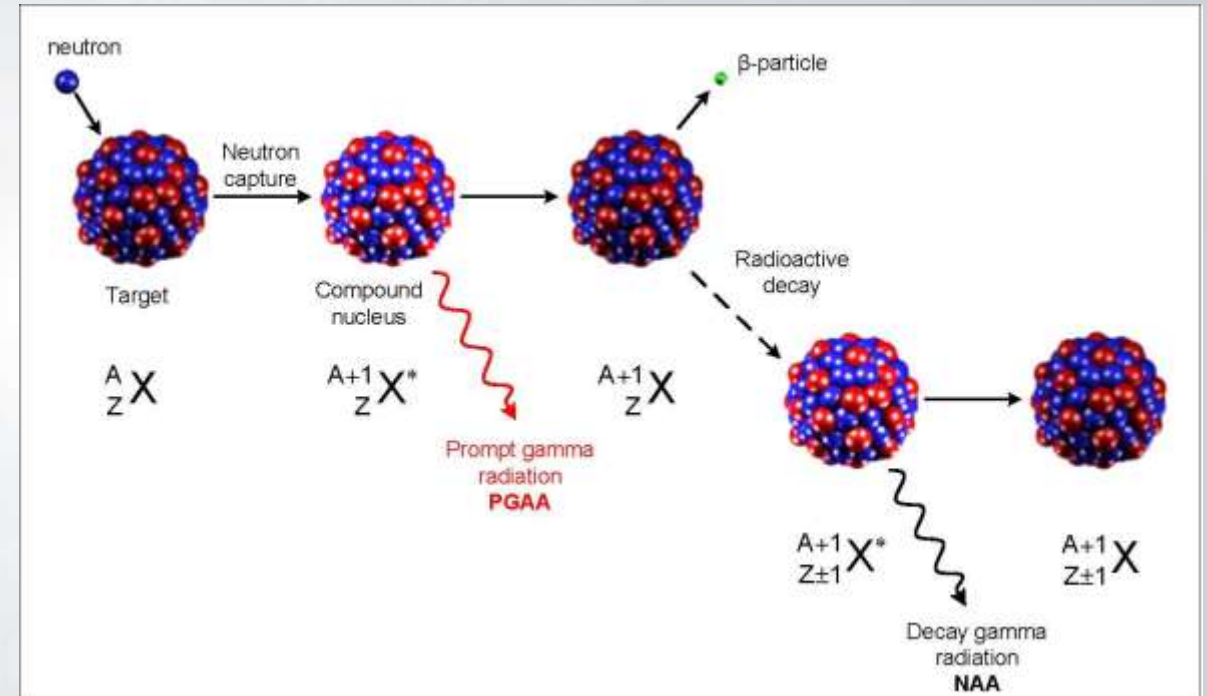
Hilde Levi (1909-2003)



# 1.2 Neutron Activation Analysis

## Principles of NAA

- Non-destructive analytical technique
- Irradiation by neutrons
- Detection of gamma rays



# 1.3 Applications of Neutron Activation Analysis

- Archaeology
- Forensics
- Soil science
- Geology
- Ecology





# 1.4 NAA Methods

- Relative Method

- usually performed by irradiating known amounts of the sample and element standards simultaneously followed by comparing their gamma ray spectrums counted under the same conditions.

- Absolute Method

- is a direct analysis of the irradiated samples without using any element standard reference.

# 1.5 Features of NAA

- The demand for a suitable irradiation source
- Working with radioactive materials
- Elemental detection limits (Some elements become very radioactive while others don't. Long half life VS short half life)

## 2. METHODOLOGY

### 2.1 Sample preparation

Ball mill



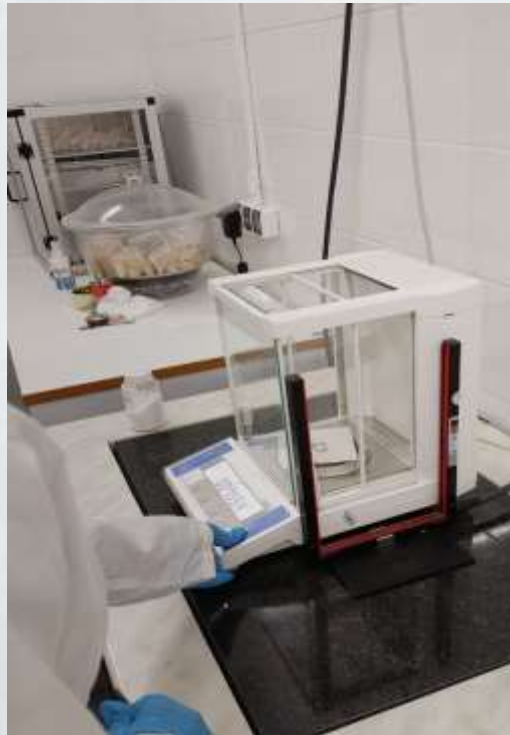
Drying cabinet





# 2. METHODOLOGY

## 2.1 Sample preparation



## 2.2 Irradiation

- IREN Facility – Intense Resonance Neutron Source
- REGATA – 2 ( Pneumatic transport system)
- HPGe Gamma spectrometer

## 2.2 Irradiation

REGATA-2 (Pneumatic transport system)



## 2.3 Detection

# Gamma spectrometry

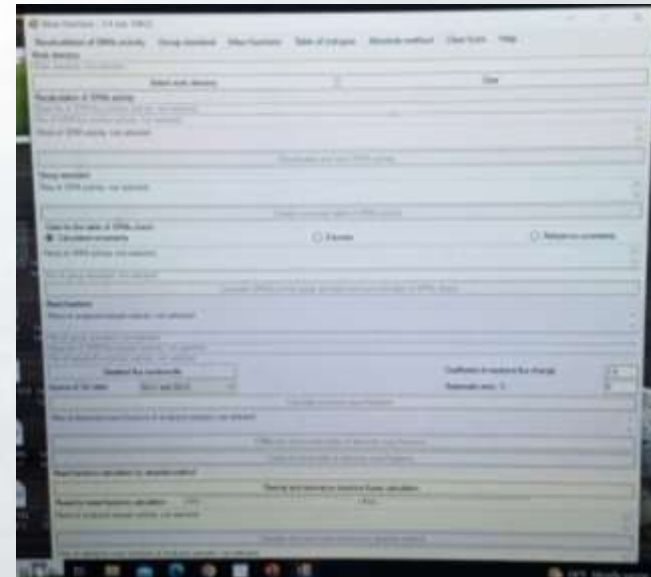
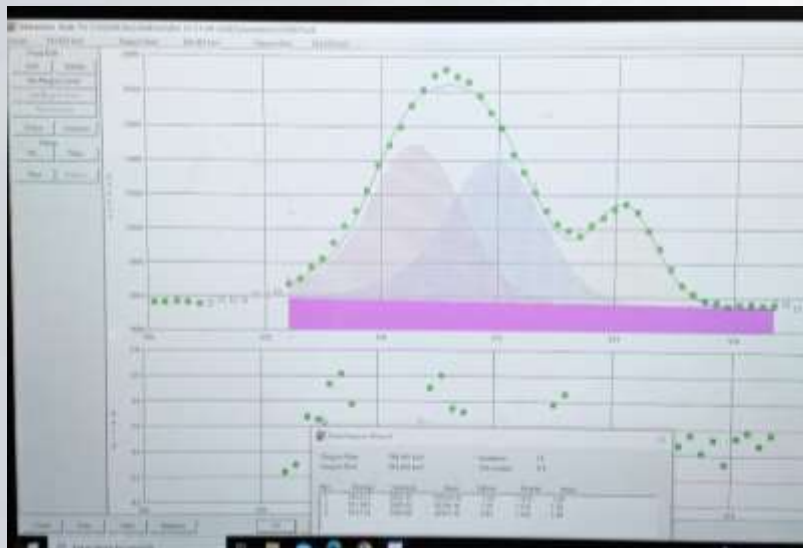
- Non-destructive technique
- Determination of the type and intensity of a radionuclide
- Very accurate in quantitative and qualitative analysis
- High Purity Germanium (HPGe) Gamma spectrometer



## 2.4 Analysis

### Genie 2000

- A basic spectroscopy software that is suitable for data acquisition, display and analysis of gamma and alpha spectrometry data.
  - Gamma Acquisition analysis and CalcConc





# 3. Results and Discussion

- 35 elements found as a result

The final table of concentration.

| sample | SL1-1 | SL1-2 | LL1-1       | LL1-2       | Na mg/kg | %   | MDC, mg/kg | K mg/kg | % | MDC, mg/kg | Ca mg/kg |
|--------|-------|-------|-------------|-------------|----------|-----|------------|---------|---|------------|----------|
| i-01   |       |       | 5100180.CON | 5200093.CON | 1690     | 3.3 | 1.94       | 17      |   | 79.1       | 12000    |

The final table of concentration.

| sample | MDC, mg/kg | Cd mg/kg | %  | MDC, mg/kg | Sn mg/kg | %  | MDC, mg/kg | Sb mg/kg | %  | MDC, mg/kg | Ba mg/kg | %   |
|--------|------------|----------|----|------------|----------|----|------------|----------|----|------------|----------|-----|
| i-01   | 0.0806     | 0.139    | 25 | 0.218      | 8.27     | 31 | 0.156      | 0.22     | 11 | 0.0263     | 288      | 5.6 |



## 4. References

- <http://flnph.jinr.ru/en/facilities/iren>
- <http://depni.sinp.msu.ru/~hatta/canberra/Genie%202000%20Operations%20Manual.pdf>
- <https://pubmed.ncbi.nlm.nih.gov/36049442/>
- [https://www.theremino.com/wp-content/uploads/files/GammaSpec\\_ENG.pdf](https://www.theremino.com/wp-content/uploads/files/GammaSpec_ENG.pdf)

# 5. Acknowledgements

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Thank you  
Спасибо