

**Trace Element Analysis  
of Geological, Biological &  
Environmental Materials  
By Neutron Activation Analysis:  
An Exposure**

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1



# **SESSION 1**

## **January 03, 2005**

- **Introduction**
- **Neutron Activation Analysis Principles**

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**2**



# INTRODUCTION

The key words in the title of the course are:

- **Biological, Environmental and Geological Materials**
- **Trace Element Analysis**
- **Neutron Activation Analysis**
- **Exposure**

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3 □



## **INTRODUCTION ...**

- **Materials and Matrices**
- **What is the need to do Trace Element Analysis?**
- **What are the Trace Element Analytical Techniques ?**

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4 □



# Materials and Matrices

- Biological Materials
- Environmental Materials
- Geological Materials

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5



## Materials and Matrices ...

- Biological Materials  
Hair samples, Nails, Blood samples ...
- Environmental Materials  
River, Lake, Beach sediments, Atmospheric Dust ...
- Geological Materials  
Ocean floor cores, Volcanic lava rocks, Mountain  
Rocks, Lunar rocks, Mars soils...



## Materials and Matrices ...

- Matrix of a material
  - Major Elements
  - Minor Elements
  - Trace Elements

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7 □

# Major, Minor & Trace Element Composition of Materials

Conventionally:

**Major:** Concentrations exceeding 1% by mass

**Minor:** Concentrations in the range 0.1% to 1.0% by mass

**Trace :** Concentrations less than 0.1% by mass

Different trace levels

ppm	mg/g	(micro gram/gram)	$10^{-6}$	gm/gm
ppb	ng/g	(nano gram/gram)	$10^{-9}$	gm/gm
ppt	pg/g	(pico gram/gram)	$10^{-12}$	gm/gm
ppf	fg/g	(femto gram/gram)	$10^{-15}$	gm/gm
ppa	ag/g	(atto gram/ gram)	$10^{-18}$	gm/gm

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8

Reference:

Chapter 1: What a geochemical analysis means , p 1-3

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Addison Wesley Longman Ltd. 1997





## What is the need to do Trace Element Analysis?

- Need for
  - Environmental: Pollution studies, Monitoring statutory values ...
  - Biological: Nutrition studies, forensic analyses
  - Geological: Trace element geochemistry of terrestrial and extra terrestrial matters

.....

## Trace Element Analysis – Needs

Analysis means to determine the composition of a material.

In the context of trace element analysis by neutron activation analysis – measurement of concentration (abundance) of certain elements in the material, or relative amounts of two or more isotopes in a material.

Trace element analyses are carried out on terrestrial and extra-terrestrial materials.

Terrestrial materials – air, volcanic lavas, rocks, gas, water, atmospheric dust, soil or rock, or processed materials like sewage sludge or industrial effluent

Extra-terrestrial materials – lunar rocks, martian soils, meteorites ....

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10

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## Trace Element Analysis – Needs ...

### Needs (or applications):

**Compositional characterization** of a completely unknown material.

**Quality control/Quality assurance** of manufactured products monitoring/testing statutory or recommended limits in contaminated materials

**Geothermobarometric** details of a sample's composition to understand anthropogenic history

## Trace Element Analysis – Needs ...

**Temporal details** of materials for archaeological and forensic applications

**Temporal compositional variation** – industrial spills, power plant accident ...

**Compositional spatial distribution** mapping of elements to identify sources – of river pollution, location of exposed ore deposits in stream sediments, wells

**Efficiency monitoring** to optimize the conditions of experiments or industrial processes.

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12 □

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## Different types of Analyses - Concepts

- **Qualitative & Quantitative analysis**
- **Major, Minor & Trace element analysis**
- **Bulk & Spatial analysis**
- **Isotopic composition analysis**
- **Speciation & Spectroscopic analysis**  
**(Cannot be done by Neutron Activation Analysis)**

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13 □

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## Different types of Analyses – Concepts ...

- **Qualitative & Quantitative analysis**

Qualitative means identification of an element at detectable level – preliminary investigations

Quantitative means measurement of the values of concentrations

- **Major, Minor & Trace element analysis**

Major: Concentrations exceeding 1% by mass

Minor: Concentrations in the range 0.1% to 1.0% by mass

Trace :Concentrations less than 0.1% by mass

ppm	mg/g	(micro gram/gram)	$10^{-6}$ gm/gm
ppb	ng/g	(nano gram/gram)	$10^{-9}$ gm/gm
ppt	pg/g	(pico gram/gram)	$10^{-12}$ gm/gm
ppf	fg/g	(femto gram/gram)	$10^{-15}$ gm/gm
ppa	ag/g	(atto gram/ gram)	$10^{-18}$ gm/gm

## Different types of Analyses - Concepts

- **Bulk & Spatial analysis:**

**Bulk analysis is performed on a homogeneous material like rock powder.**

**Spatially resolved analysis is performed on a heterogeneous material.**

- **Isotopic composition analysis**

**Isotopic analysis is performed to determine the atomic abundance ratio of two or more**

**isotopes of the same element.**

**Example:  $^{143}\text{Nd}/^{144}\text{Nd}$  ,  $^{18}\text{O}/^{16}\text{O}$  by Mass Spectrometry**

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15 □

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## Different types of Analyses - Concepts

- Speciation & Spectroscopic analysis

**Speciation analysis** is performed to determine the existence of different chemical forms of an element in a material, or the relative ratios of different forms of an element in a material.

Example: Determination of the element Sulphur in the form of Sulphide, Sulphate, Sulphite etc by AAS, GSMS.

**Spectroscopic analysis** is performed to measure slight differences in spectral wavelengths to understand the electronic bonding and the atomic environment. Such knowledge is useful to a structural chemist or a mineralogist.

(Cannot be done by Neutron Activation Analysis).

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16 □

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## What are the Trace Element Analytical Techniques ?

- Neutron Activation Analysis (NAA)
- Inductively Coupled Plasma Mass Spectrometry (ICPMS)
- Mass Spectrometry (MS)
- X-Ray Fluorescence (XRF)
- and more ....

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17 □



## Milestones

- 1932 Discovery of neutrons
- 1936 Neutron Activation Analysis
- 1940 – 50 Research Reactors
- 1960 Neutron Activation  
Analysis Technique

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18 □



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19 □