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Instrumental Neutron Activation Analysis (INAA) – Practice and Potential Forensic Applications

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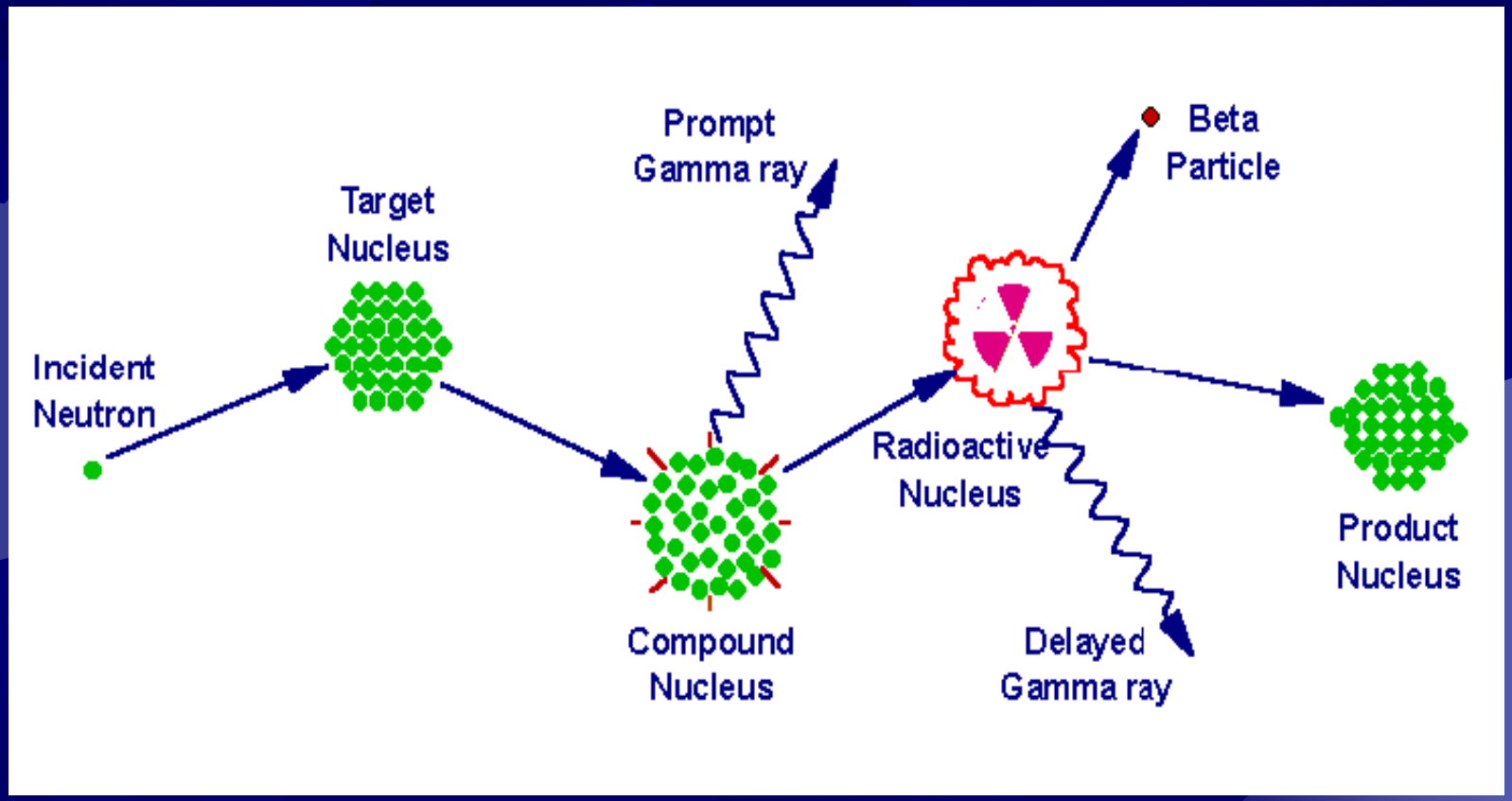
The n–gamma Reaction

The basic reaction for INAA



Example: $^{58}Fe + {}^{1}n \longrightarrow {}^{59}Fe + Beta^{-} + gamma\ rays$

Gamma ray energies = 142.4, 1099.2, 1291.6 KeV

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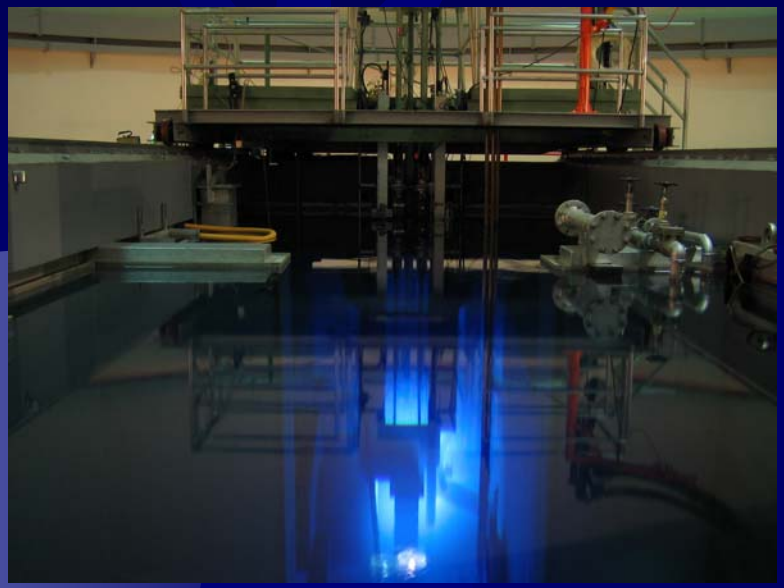
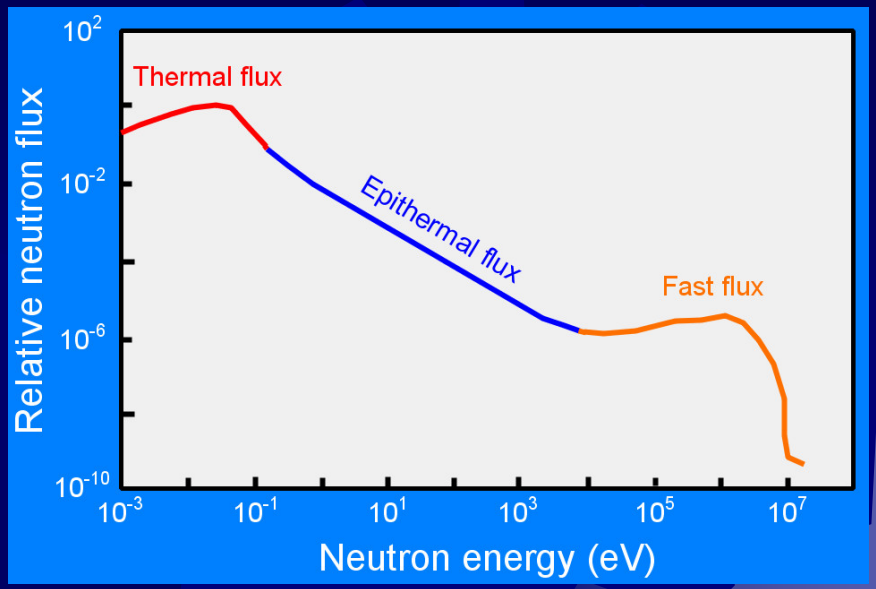
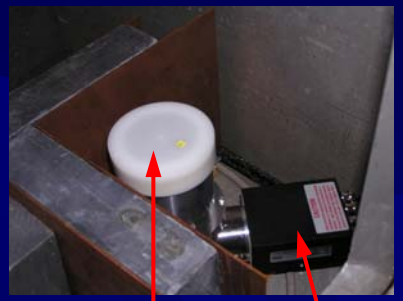


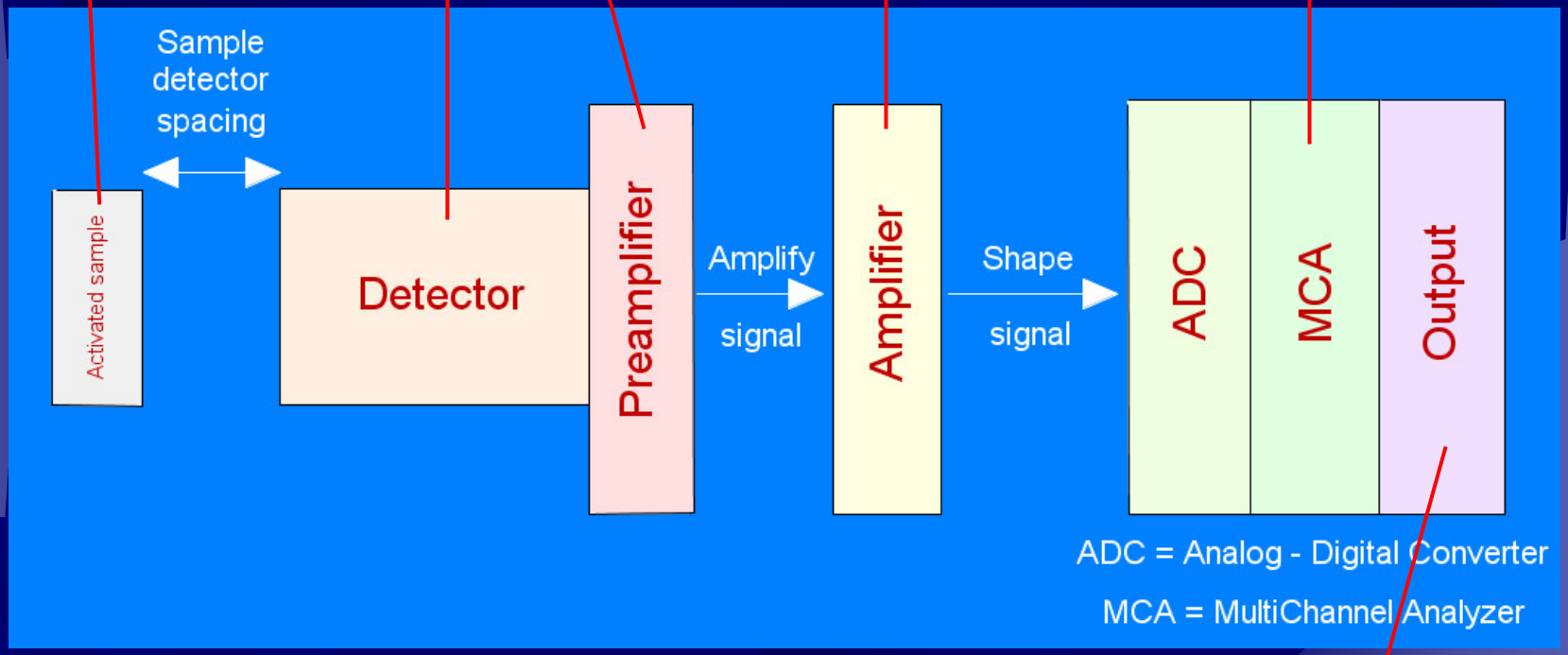
UML 1 Mw Research Reactor

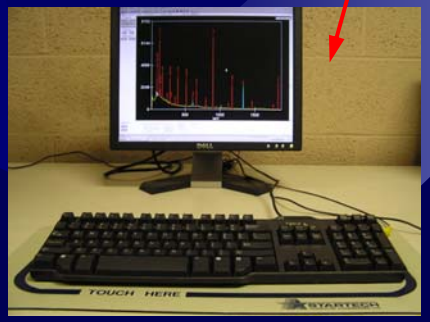
The Neutron Source

Different neutron energies are used for different types of experiments.









Data acquisition flow sheet

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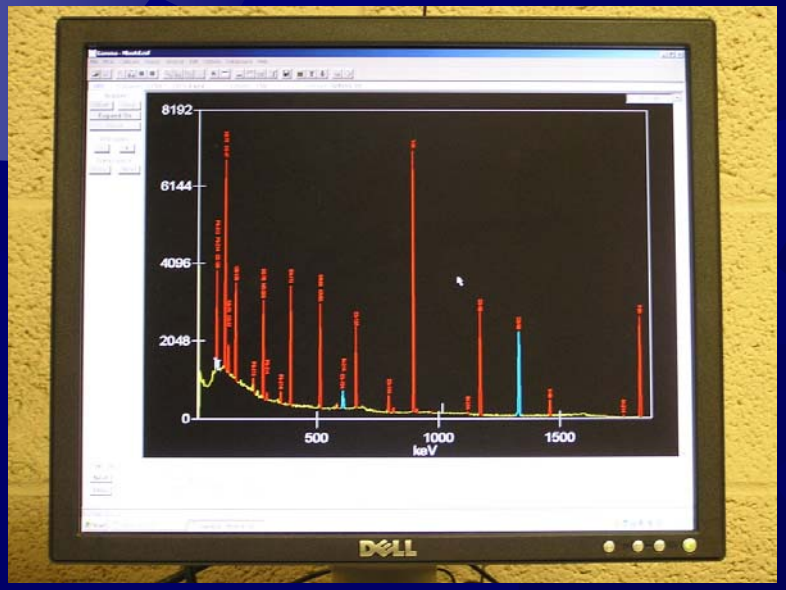
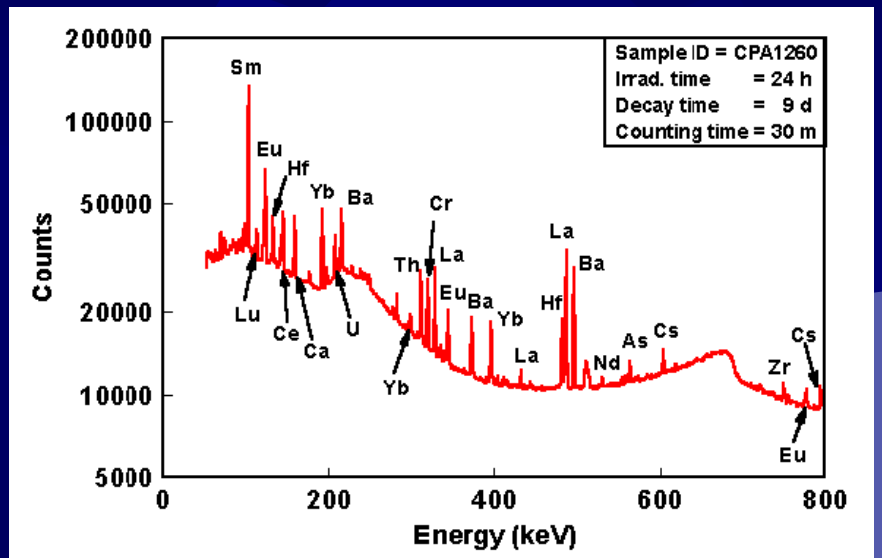
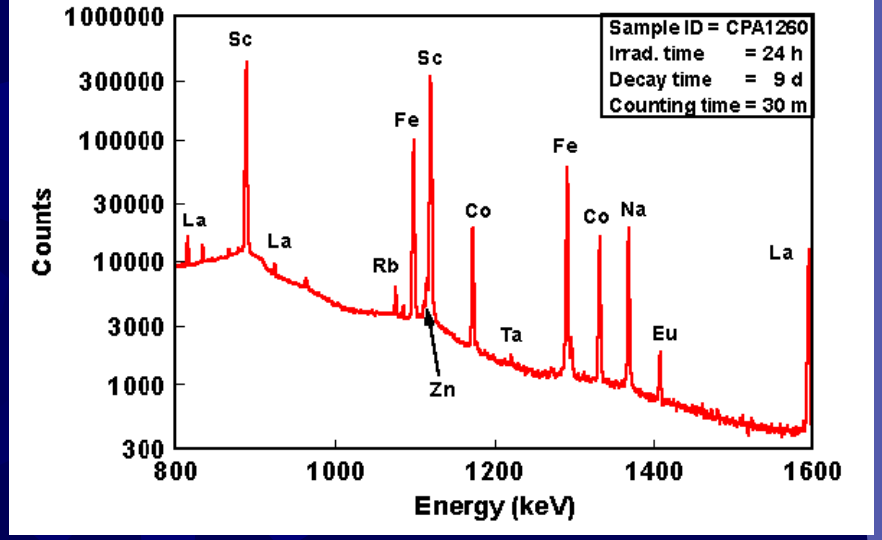
UML INAA Lab



Gamma ray spectrum for a multi element sample





Detection limits (DL) for elements that can be determined by INAA	
DL (nanograms)	Elements
0.01-0.1	Au, Eu, Ho, Ir, Sm, Lu
0.1-1	Ag, As, Co, Cs, Hf, La, Sb, Sc, Se, Ta, Tb, Th, Tm, U, W, Yb
1-10	Ba, Br, Ce, Cr, Gd, Mo, Na, Nd, Ni, Rb, Sr, Zn, Zr
10-100	K
100-1000	Fe

Advantages of INAA

- Can analyze a large number of elements simultaneously
- Very low detection limits for many elements
- Small sample sizes (1 – 200 mg)
- No chemical preparation
- Nondestructive. The material is available for other analytical techniques
- Relatively low entry cost (~$60,000) compared to other high sensitivity analytical methods

Forensics – Source of the Maple Syrup

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Collecting sap the modern way. Plastic barrels and polyethylene tubing.

Transferring sap to the sugar house

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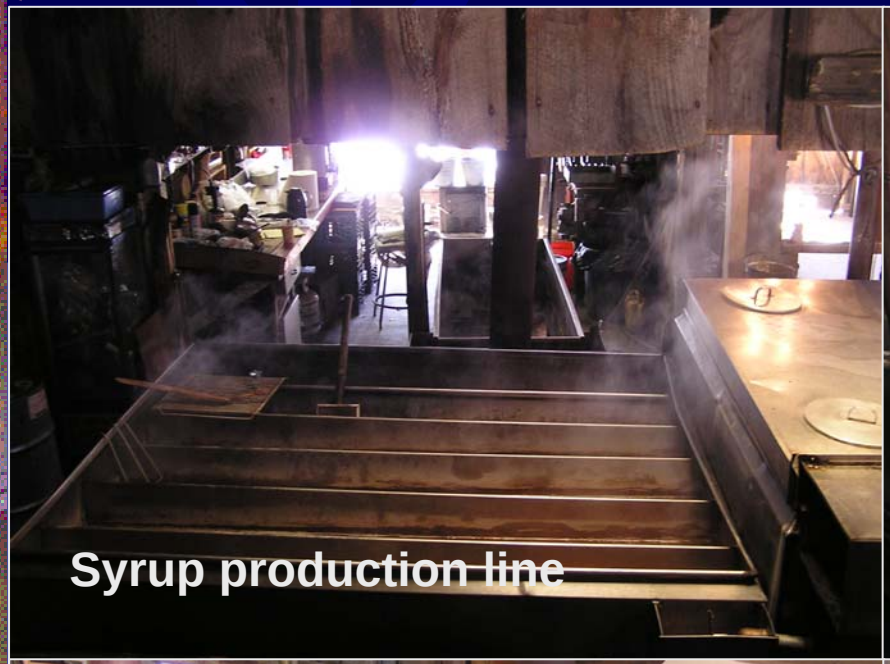
Sap holding vats

Boiling down the sap


Syrup production line

Main boiler

Secondary boiler


Finish boiler

Concentrations (ppm) and ratios of trace metals in Maple Syrup

	Quebec	Newton	Winsor	Parker	Gale
Sc	0.030	0.010	0.009	0.004	0.006
Cr	1.67	0.67	0.71	0.83	0.87
Co	0.119	0.094	0.064	0.073	0.057
Zn	19.4	9.3	13.1	50.6	76.3
Rb	9.0	7.5	3.1	10.2	15.7
Sr	17.5	28.6	13.7	10.7	8.3
As	0.016	0.029	0.014	0.022	0.010
Sb	0.009	0.018	0.010	0.034	0.010
Se	8.72	ppb			
Zn/Cr	11.6	13.9	18.5	61	88
Rb/Cs	419	642	363	433	175
Ba/Sr	0.37	0.59	0.18	0.76	1.29
As/Sb	1.91	1.59	1.50	0.64	2.24

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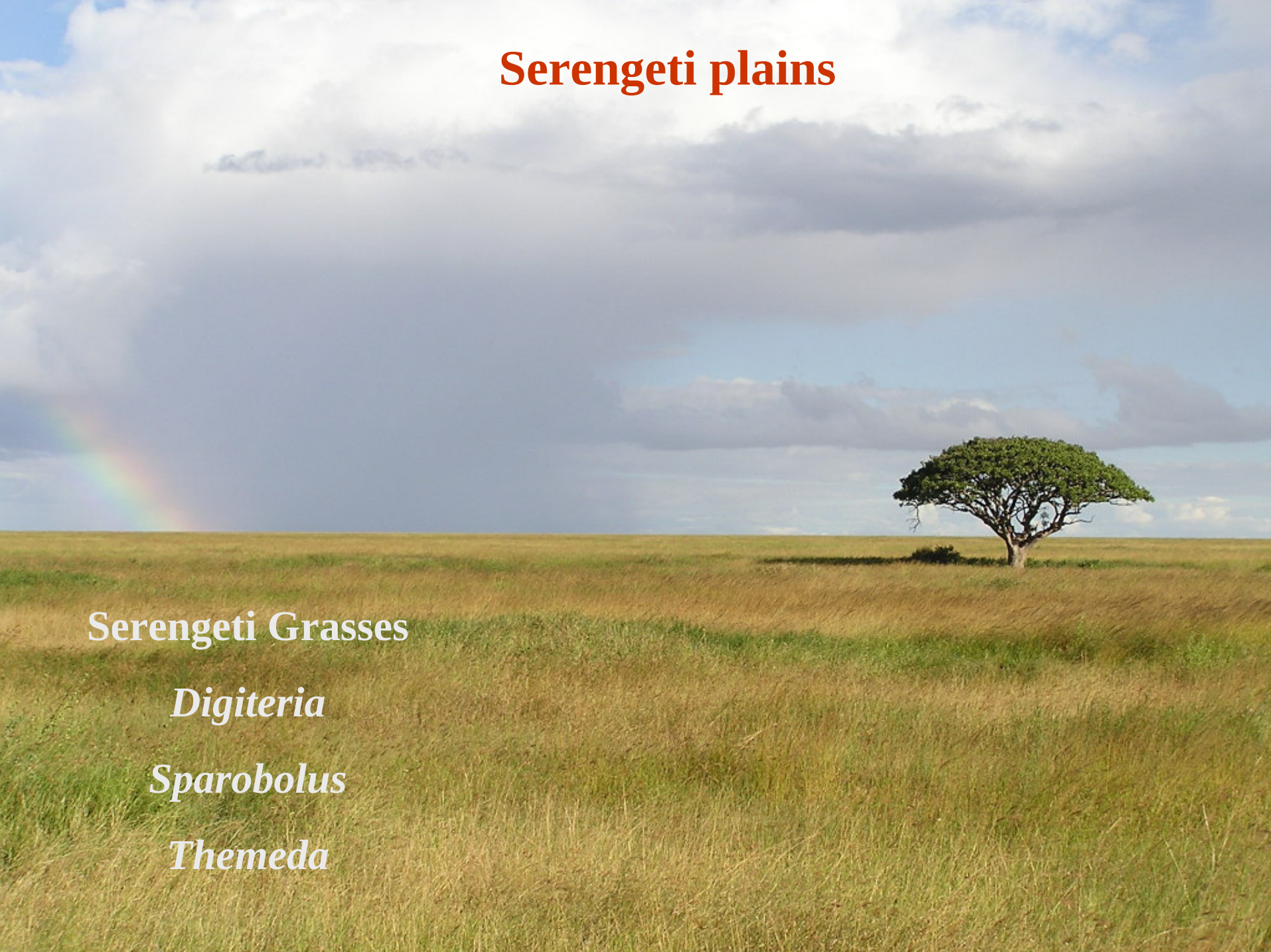
Location map for Tanzania National Parks

Serengeti plains



Serengeti Grasses

Digiteria

Sparobolus

Themeda

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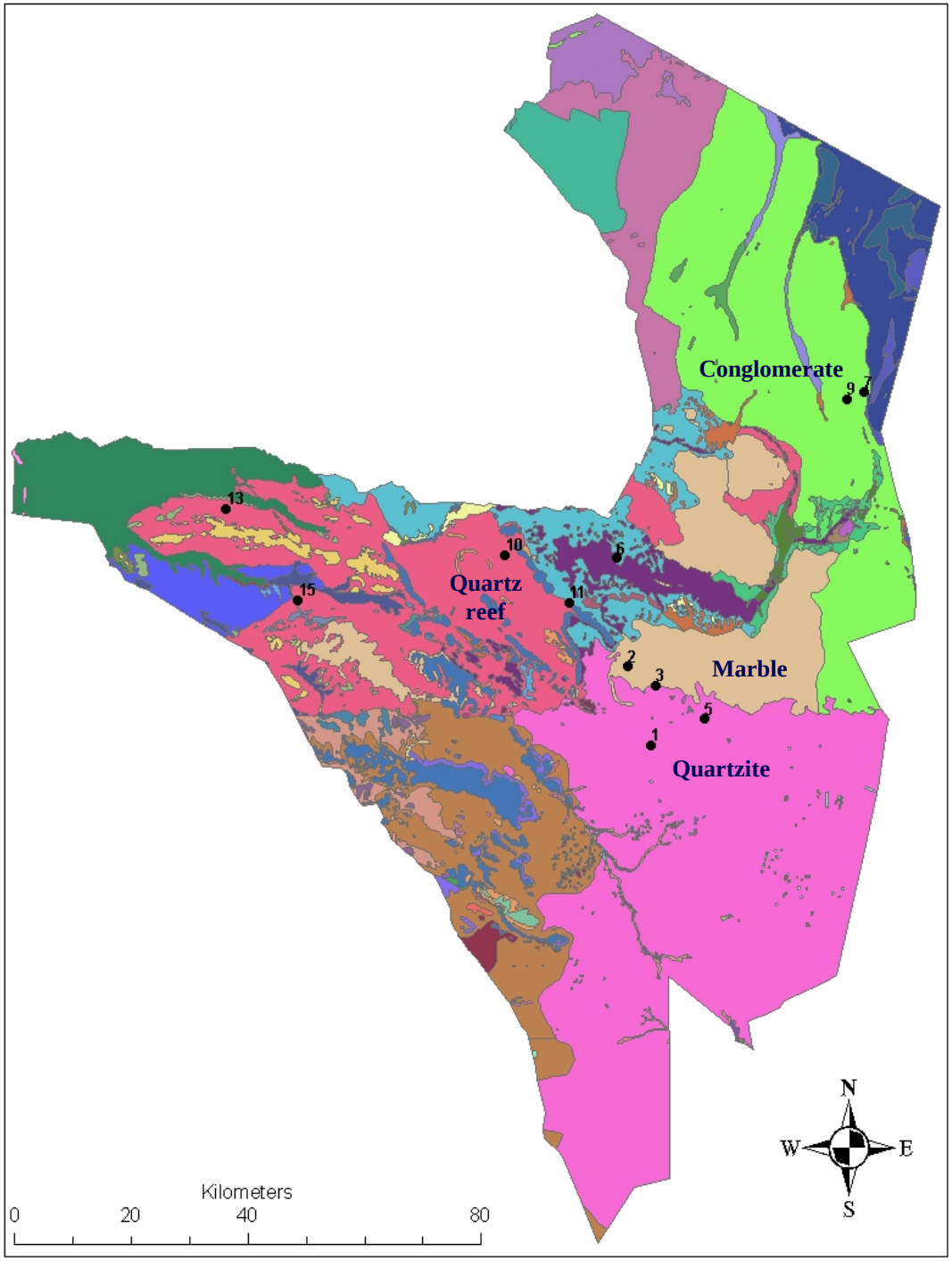
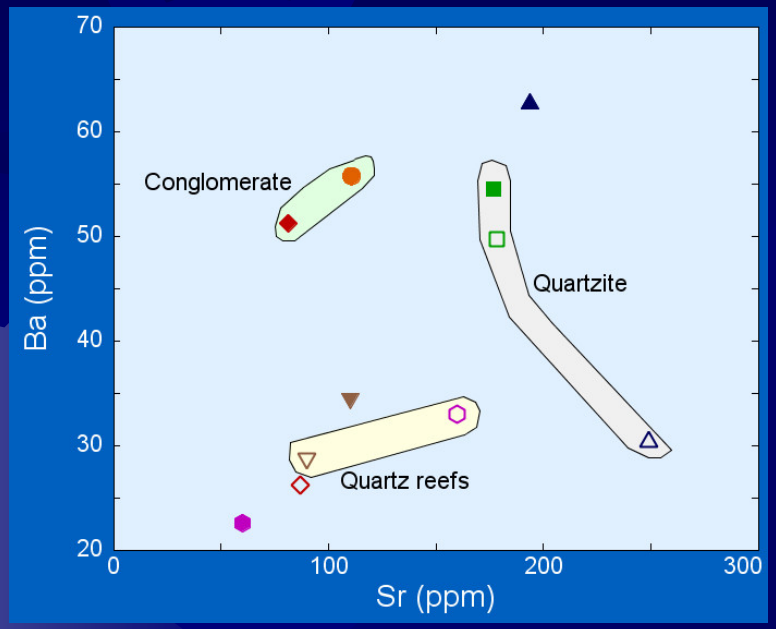
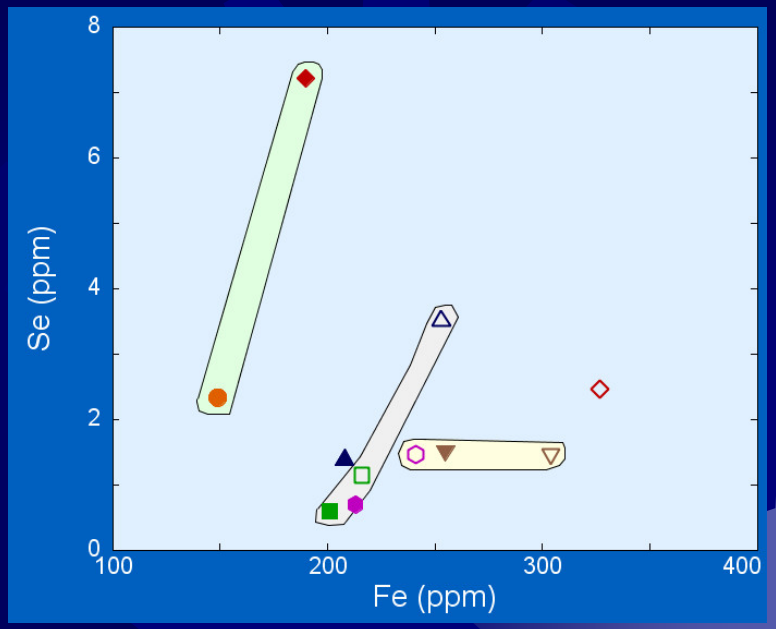
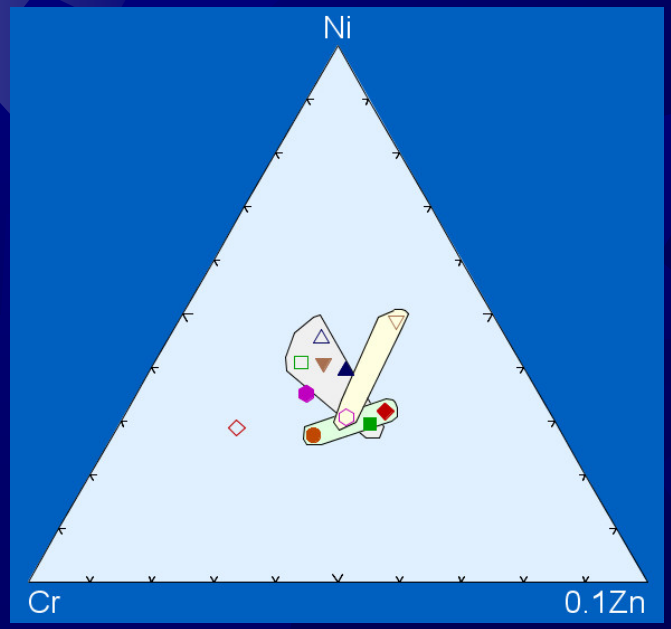
Sample Locations and Geology

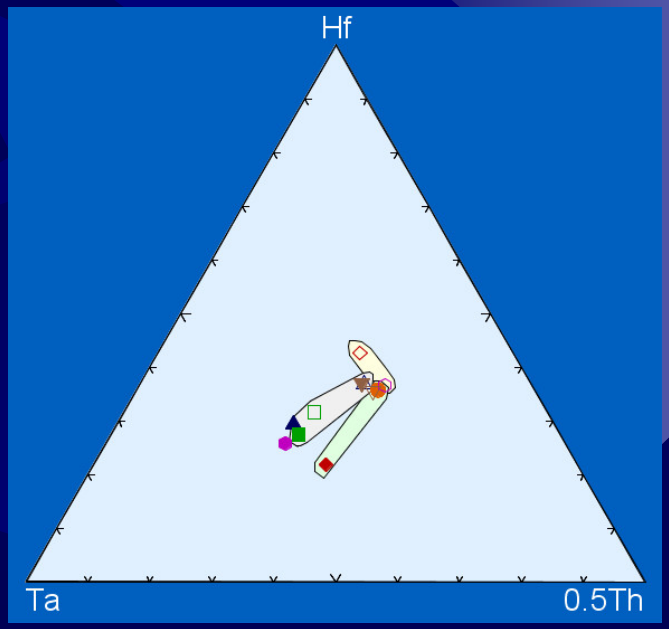


Trace element distributions for grasses from geographic areas with different bedrock geology.

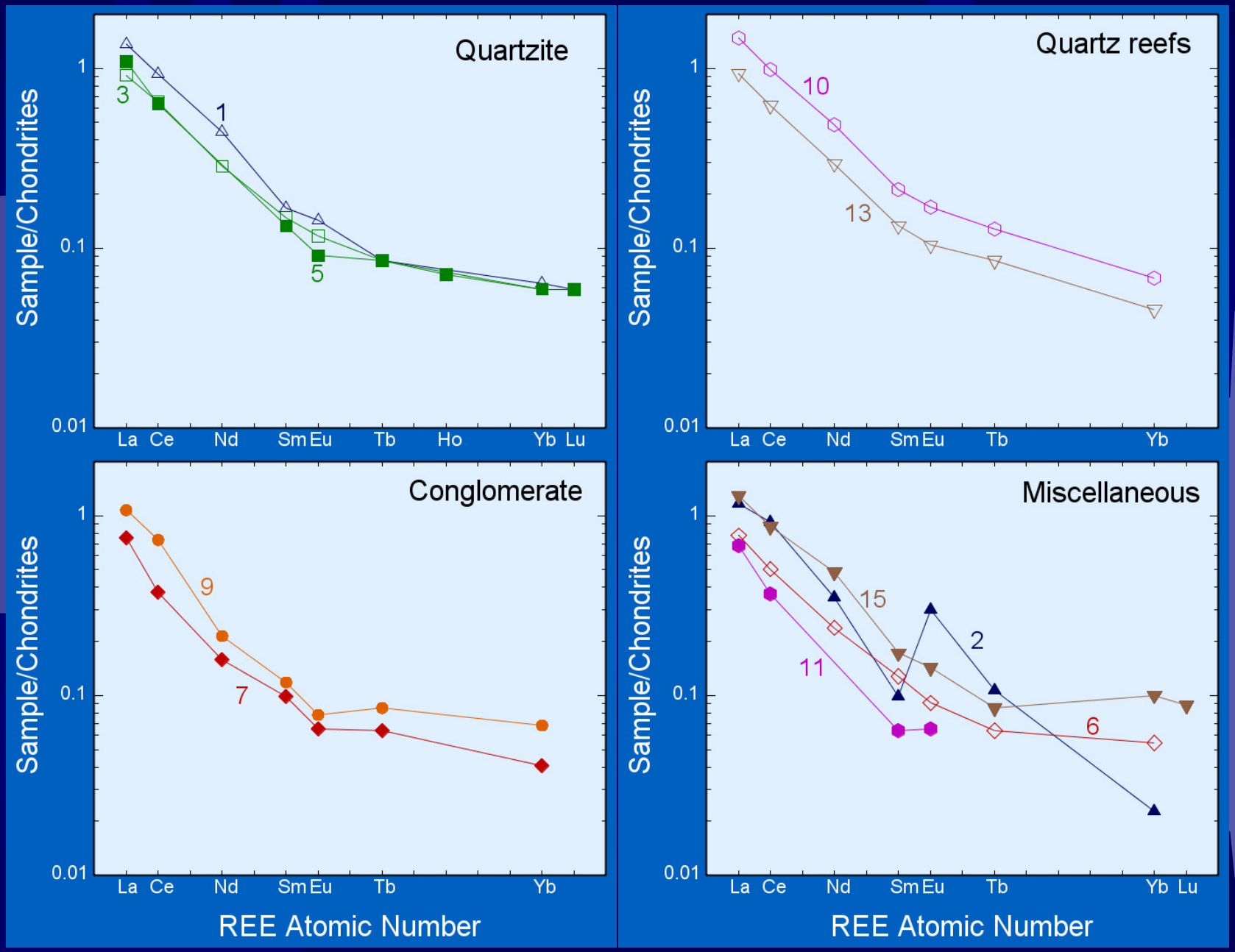








Grass Rare Earth Element (REE) patterns



That’s All Folks!