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On the Major and Trace Elements Distribution in Two Different Egyptian Geologic Units: Nile Valley and Siwa Oasis

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Egypt, the 30^{th} country in the world with a surface of about 1,010,000 km^2 occupies the north-eastern part of the African Continent.

The majority of Egyp is desert, with a few oases scattered about.

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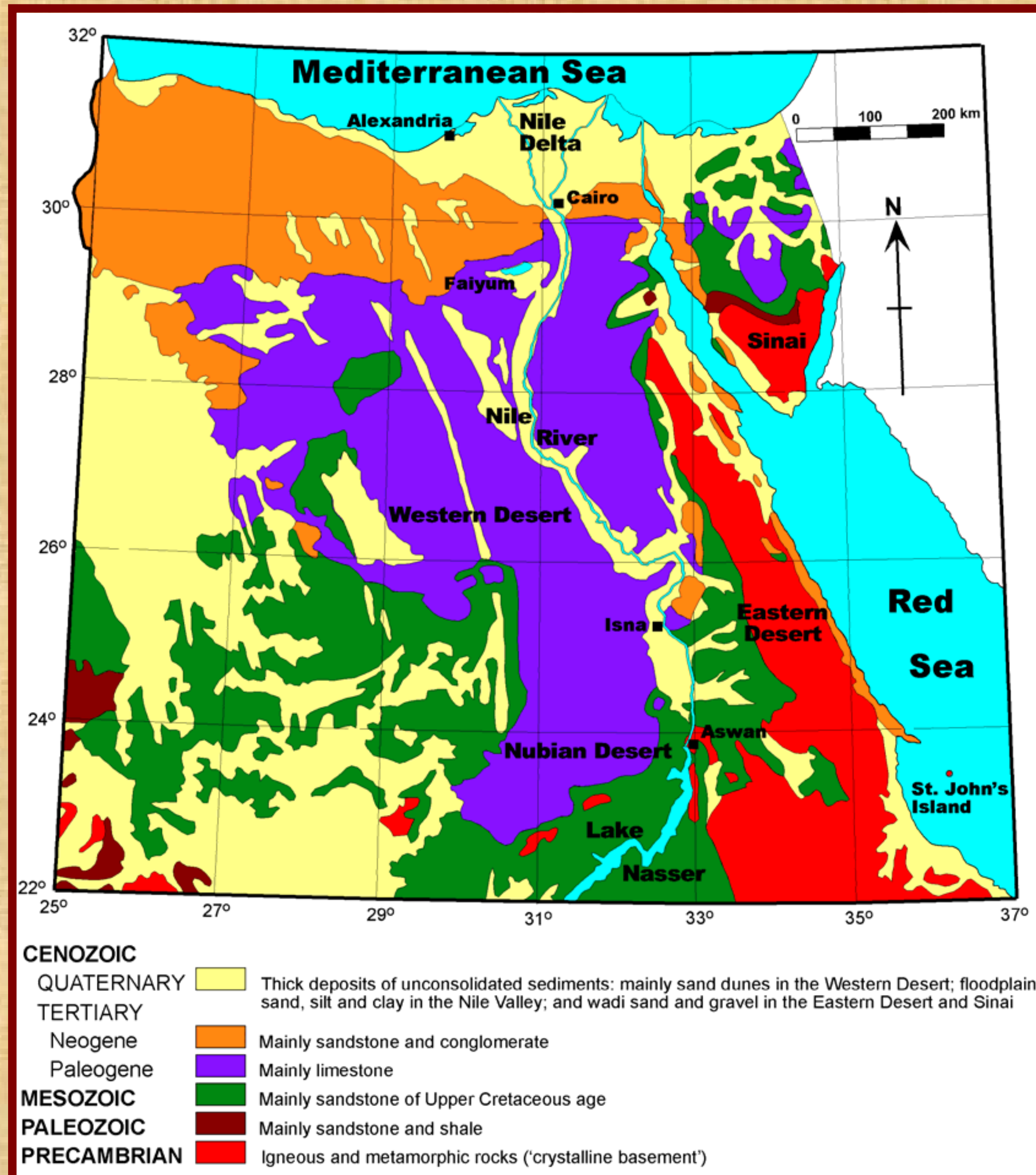
The Egypt geology comprises few major units overlying the Precambrian crystalline basement, mainly exposed in the Eastern Desert and southern part of the Sinai Peninsula.



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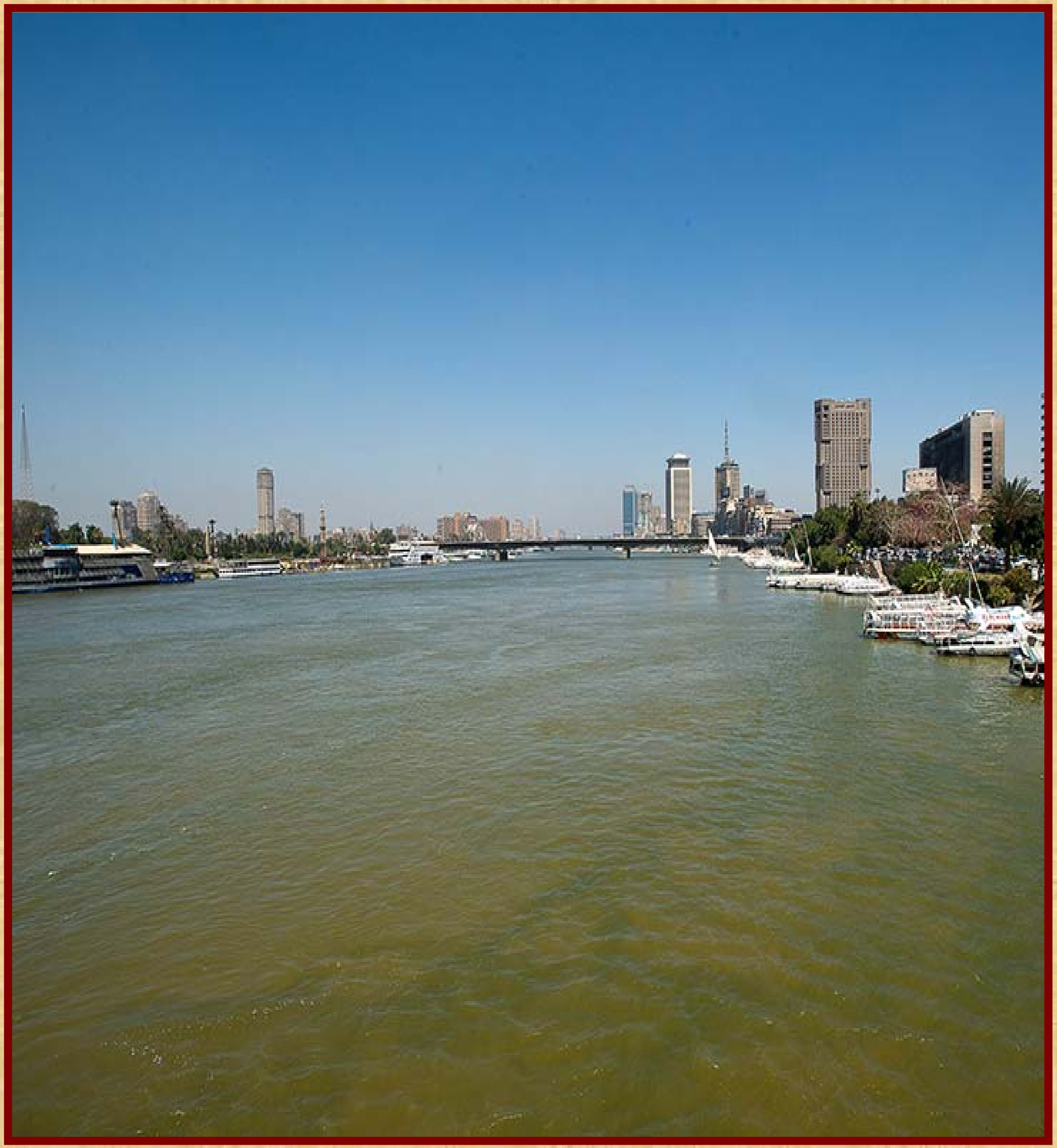
In spite of its aridity, Egypt has a population of more than ninety millions inhabitants mainly due to the Nile, the most important river of the Africa and sometime regarded as the longest river of the world.



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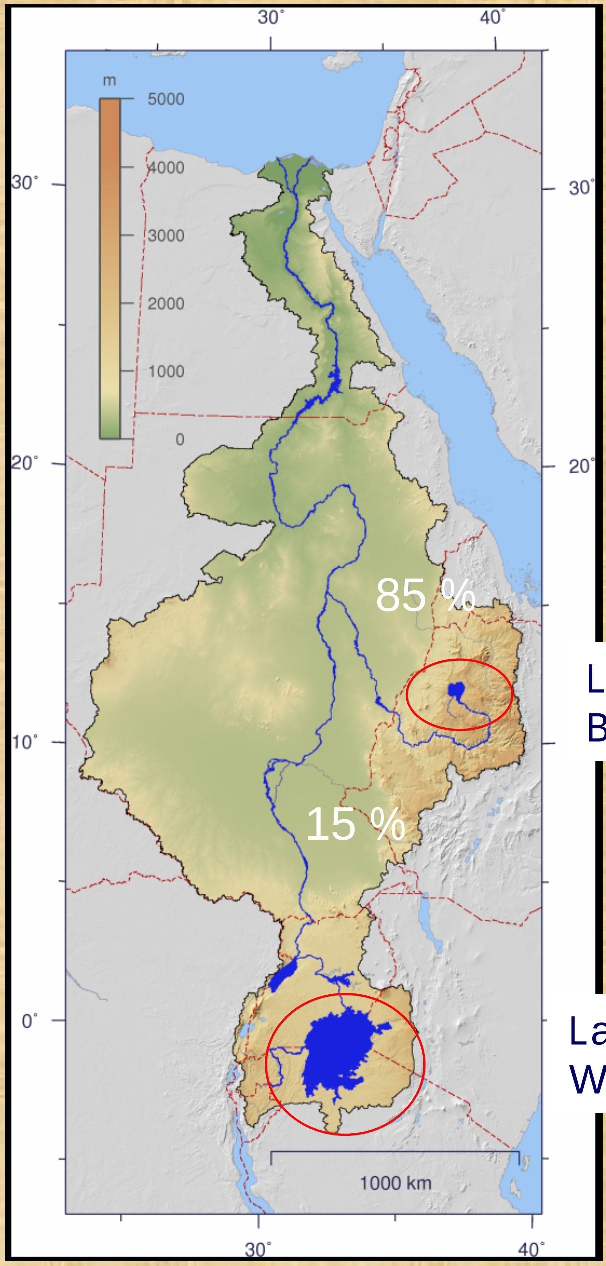
The major source of sediment of the Nile Basin is located in the Ethiopian Plateau where 85% of the Nile water comes from.

The Ethiopian Plateau consists of basalt and other igneous rocks, so it is expected the soil and sediments along Nile valley would reflect this peculiarity.



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On contrary, the Western Egyptian Desert host several oasis whose existence is mainly due to artesian aquifer able to maintain a local long lasting humid climate.

Siwa Oasis, with and area of about 100 km^2, although inhabited since antiquity, remain one of the most remote one. Contrary to Egypt valley, the Siwa Oasis is located in an area rich in Neogene outcrops consisting of sandstone and conglomerate.

The existing difference between the location as well as the geology of these formations together with the lack of any extensive studies, in particular regarding their geochemistry, made a comparative study of Nile valley and Siwa oasis soils and sediments an incentive one.

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Sediments present a significant importance as they carry a lot of information regarding the geochemistry of geological formations the river traverse.

At their turn, soil from the river floodplain could also bring information of the interaction between natural and anthropogenic factors, especially in those areas where human settlements have a long history.

For this reason we have chosen two completely different location such as Nile valley and Siwa oasis.

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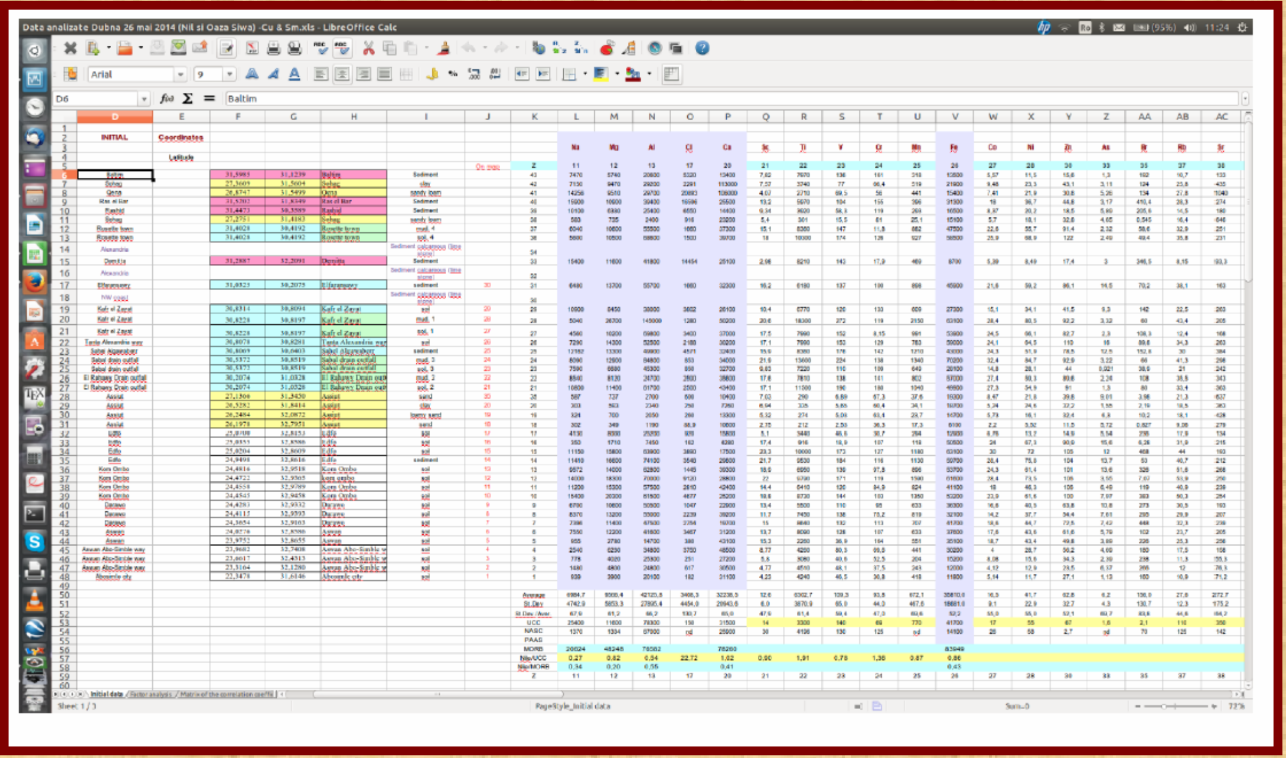
Such kind of studies need to collect and to process a huge amount of data.

This task could be sucessfuly accomplished only by using an appropriate mathematical instrument, *i.e.*

statistic analysis.



Although statistic analysis is a very powerful tool, it should be regarded as an auxiliary one in any attempt to interpret such data as the soil and sediment geochemistry as it helps in choosing the most appropriate model or pattern for the collected data of an investigated formation.

In geology, as in any other branches of science, statistic analysis of data could be very useful in checking the correctness of a model, but it never creates models itself.

Because, to imagine models and to check its correctness is the main task of a geologist.

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To these methods we could add some more intuitive procedures known as graphic analysis which in fact allows to visualize large set of experimental data and to infer the existing connections existing between them.

All of them were used to analyze the distribution of six major, rock forming elements (Na, Mg, Al, Ca, Ti and Fe) and 29 trace elements (Sc, V, Cr, Mn, Co, Ni, Zn, AS, Br, Rb, Sr, Zr, Sb, I, Cs, Ba, La, Ce, Nd, Eu, Td, Dy, Tm, Yb, Hf, Ta, Th and U) in samples of sediments and soils collected along the Egyptian sector of Nile (40 samples) and the Siwa oasis (10 samples).

Major elements geochemistry together with those of low mobility La, Sc, Cr, Co, Th, Zr, Hf or U are best suited for provenance and tectonic setting determination studies.

In addition, the relative distribution of the immobile elements that differ in concentration in felsic and basic rocks such as La and Th (enriched in felsic rocks) and Sc, Cr, and Co (enriched in basic rocks relative to felsic rocks) has been used to infer the relative contribution of felsic and basic sources in investigated sediments.

In this case, the graphic analysis gives the most intuitive results

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For a better understanding, all data were interpreted within some standard models such as Upper Continental Crust (UCC), Post Archaean average-Australian Shale (PAAS) , North American Shale Composite (NASC), Mid-Ocean Ridge Basalt (MORB) as well as the Average Soil Composition (ASC) as compiled by Vinogradov.

UCC, PAAS and NASC are average sedimentary rocks whose age, greater than 500 millions years, describe the average geochemistry of the upper crust.

MORB are the most recent volcanic rocks whose composition is close to those of the upper mantle.

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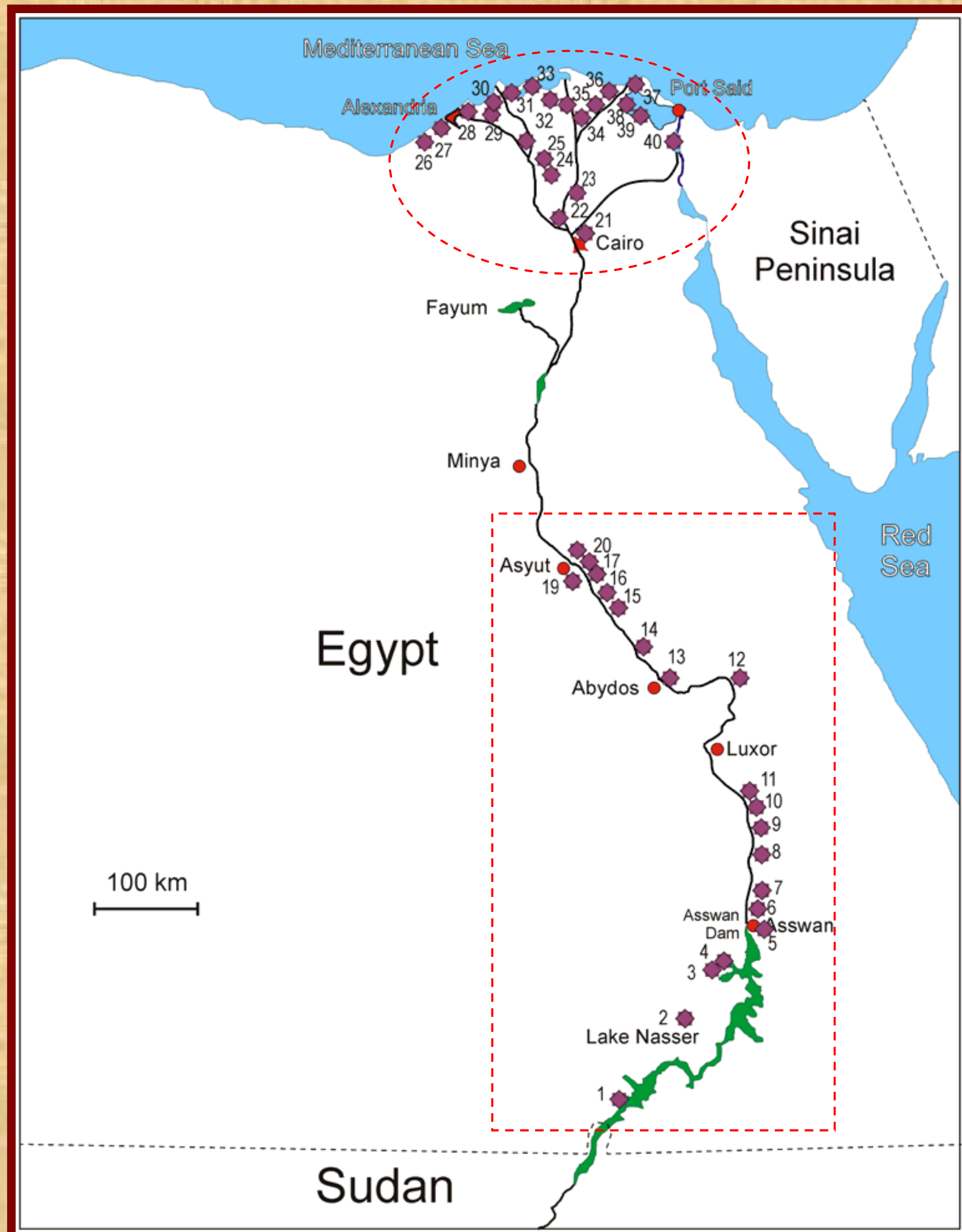

The lower Nile as well as the Nile Delta collecting points

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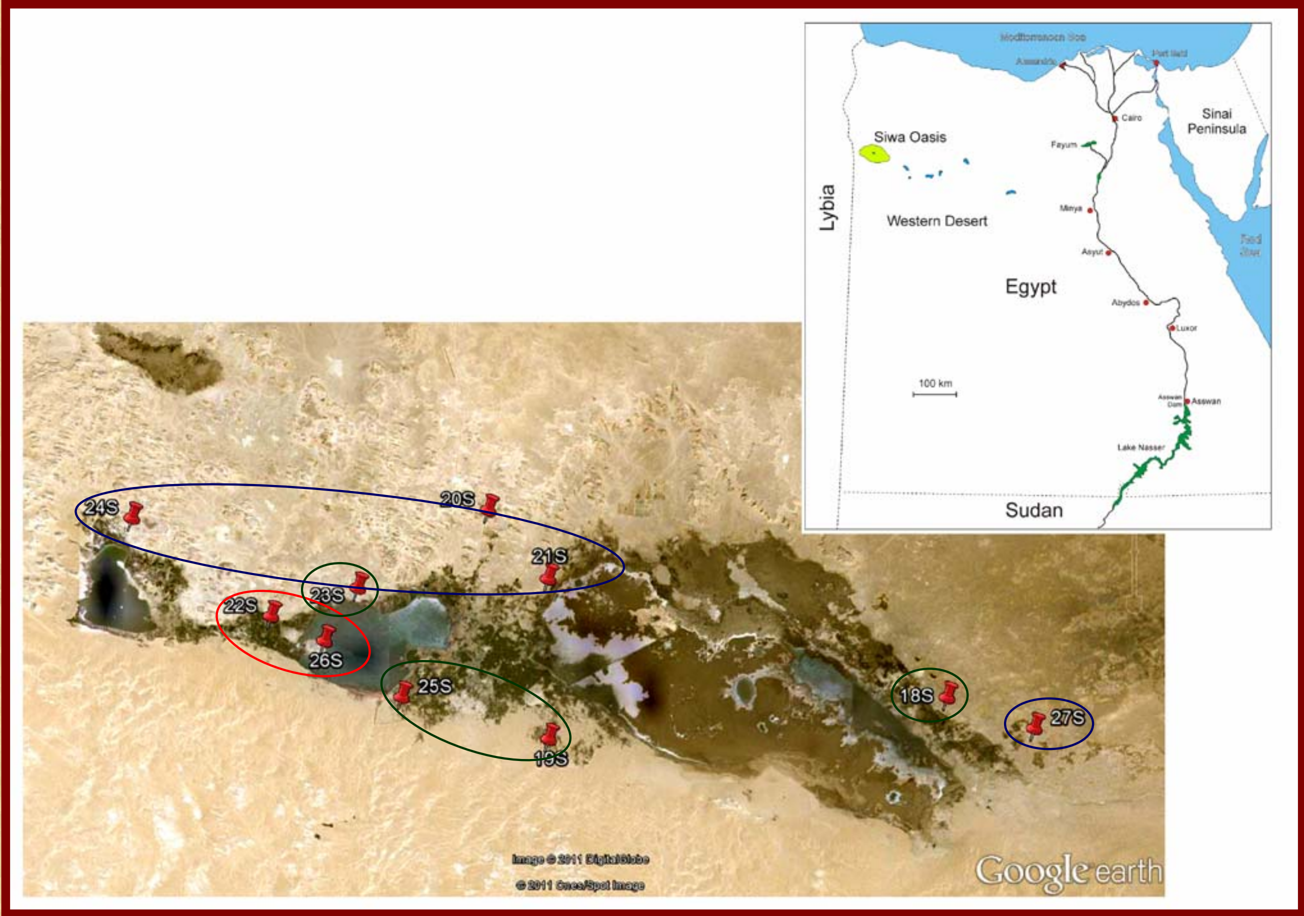

The Siwa oasis collecting points

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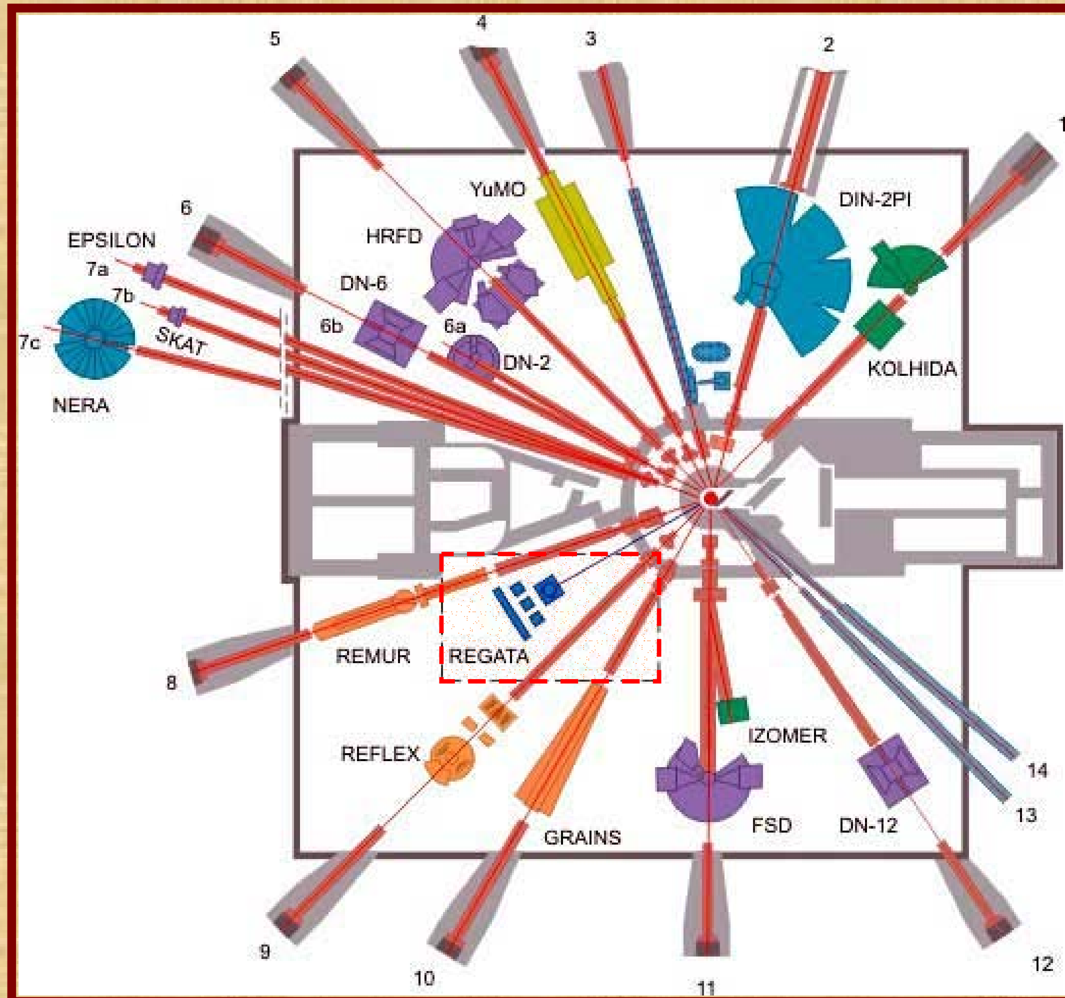
The content of all elements were determined by Epithermal Neutron Activation Analysis (ENAA) at the Neutron Physics Frank Laboratory of the Joint Institute for Nuclear Research



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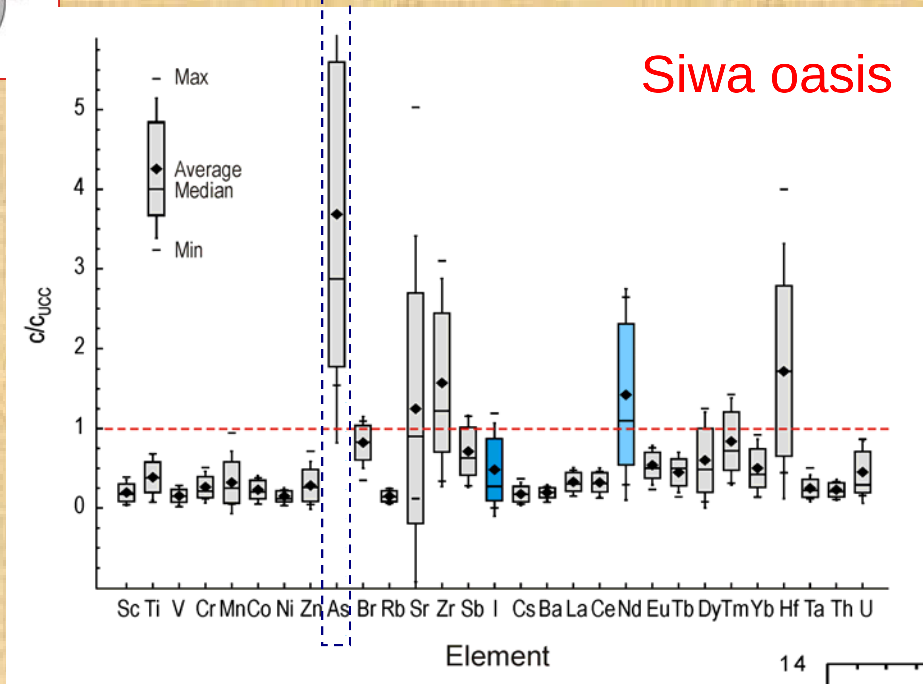
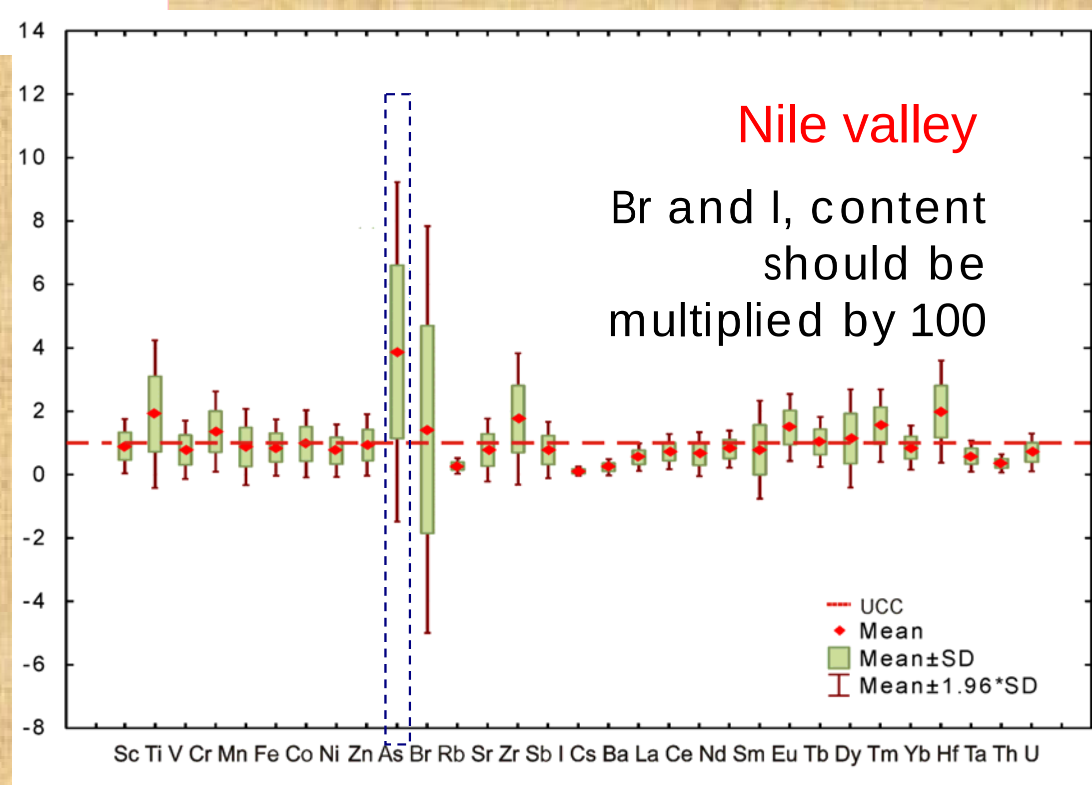


Trace elements box diagrams



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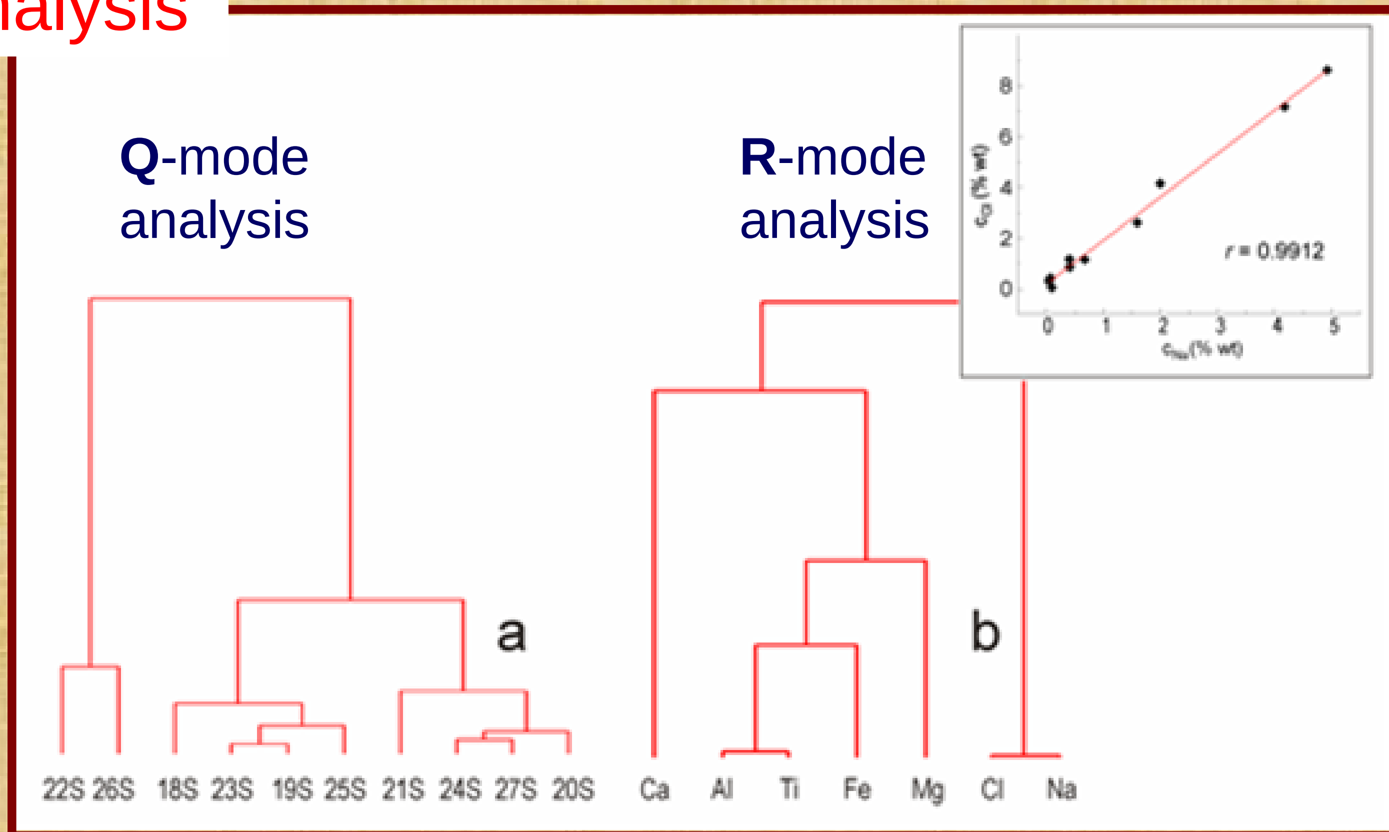
Correlation analysis



NaCl Rich samples

Organic rich samples

Carbonates rich samples

Carbonates

Clay

NaCl

The Siwa oasis major elements

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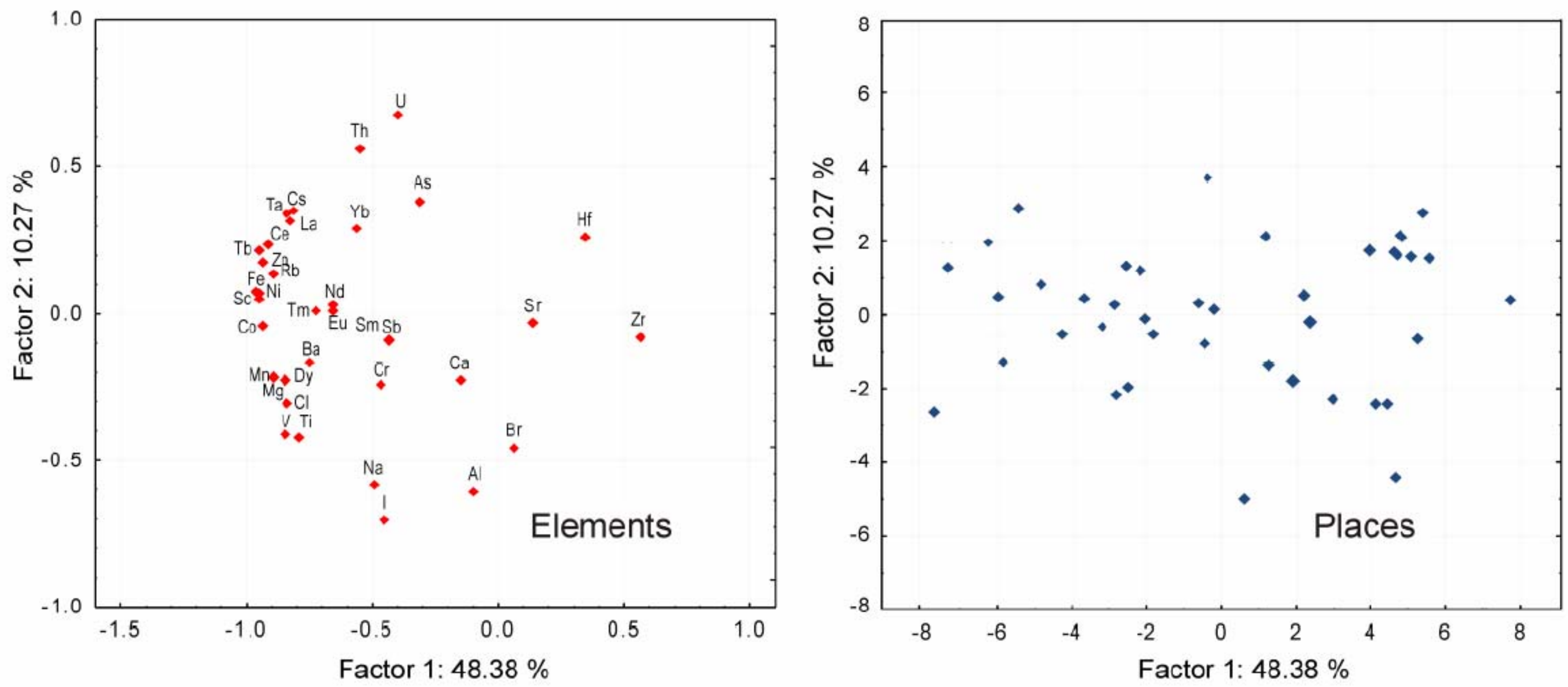
Principal component analysis

R-mode analysis

Q-mode analysis



The Nile sediments and soils

Principal component analysis: Factor loadings

Upper Core Volcanic Marine

Element	Factor 1	Factor 2	Factor 3
Na	0.220	0.115	**0.822**
Mg	**0.608**	0.287	**0.654**
Al	**0.690**	0.151	0.560
Cl	-0.201	-0.101	**0.694**
Sc	**0.916**	0.255	0.155
Ti	**0.613**	0.152	**0.636**
V	**0.679**	0.127	**0.634**
Mn	**0.754**	0.216	0.502
Fe	**0.949**	0.219	0.132
Co	**0.925**	0.137	0.203
Ni	**0.965**	0.164	0.113
Zn	**0.918**	0.284	0.077
Rb	**0.787**	0.385	0.213
I	0.197	-0.002	**0.865**
Cs	**0.713**	0.498	0.040
Ba	**0.729**	0.033	0.281
La	**0.697**	0.550	0.0627
Ce	**0.832**	0.452	0.0794
Nd	**0.615**	0.192	0.1805
Tb	**0.863**	0.448	0.0989
Dy	**0.704**	0.190	0.5135
Tm	**0.825**	-0.073	0.0399
Yb	0.333	**0.713**	0.1135
Ta	**0.715**	0.586	0.0293
Th	0.297	**0.876**	-0.0420
U	0.199	**0.855**	-0.2006

The Nile sediments and soils

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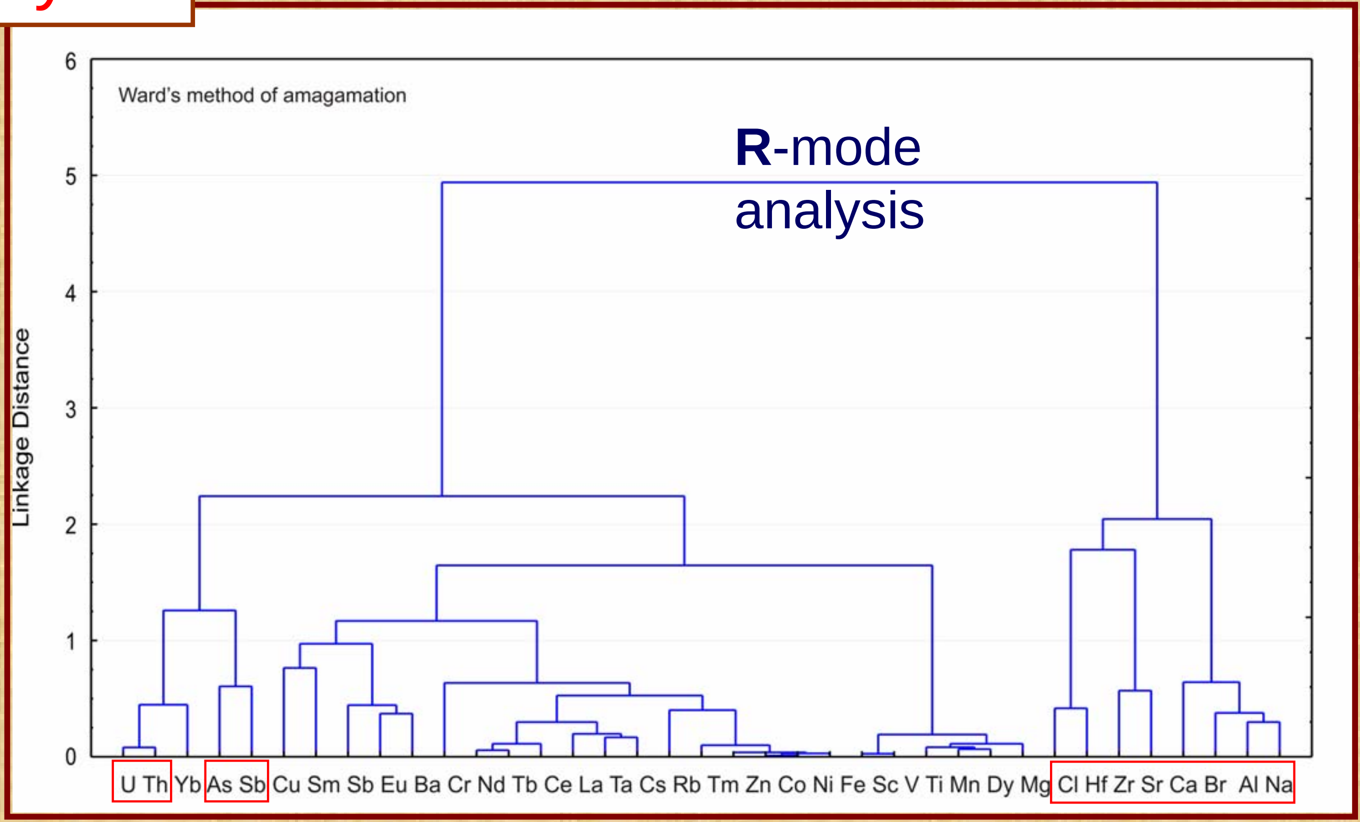
Correlation analysis



The Nile sediments and soils

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In interpreting the origin as well as of the evolution of a chosen geologic unit, besides the major elements, an important role play the so called “incompatible elements”, *i.e.* elements that due to cationic radius have difficulty in entering cation sites of the minerals and are concentrated in the melt phase of magma (liquid phase) and hence enriched in continental crust.

For instance Sc, Zr, REE, Hf, Th, U are preferentially used in provenance studies.

Zr plays a special role as the mineral zircon is very resilient to weathering and could also be used to trace the origin.

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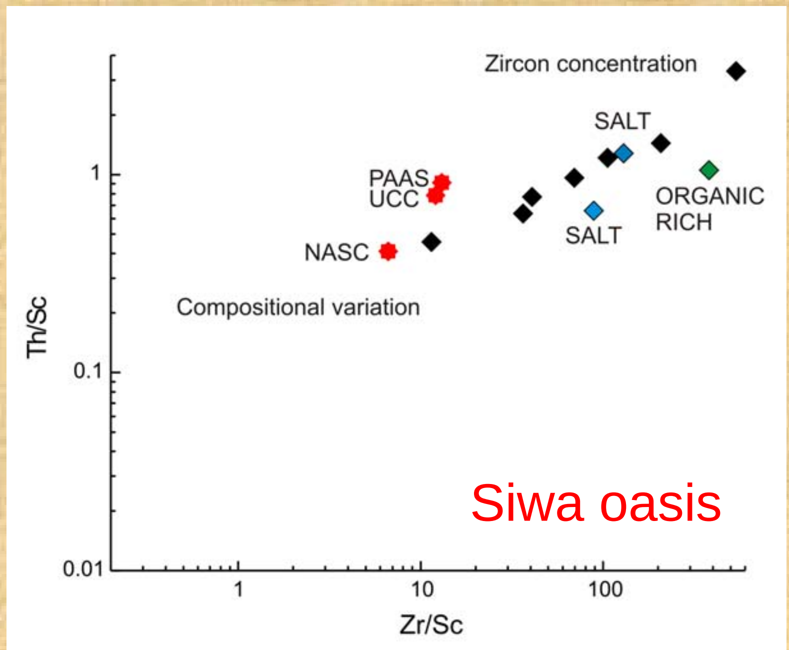

Zr enrichment attests the sediments degree of recycling

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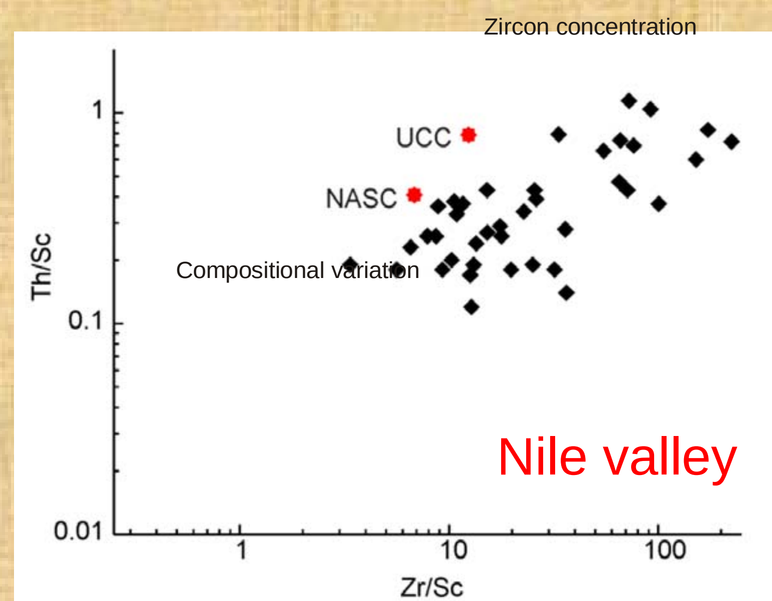
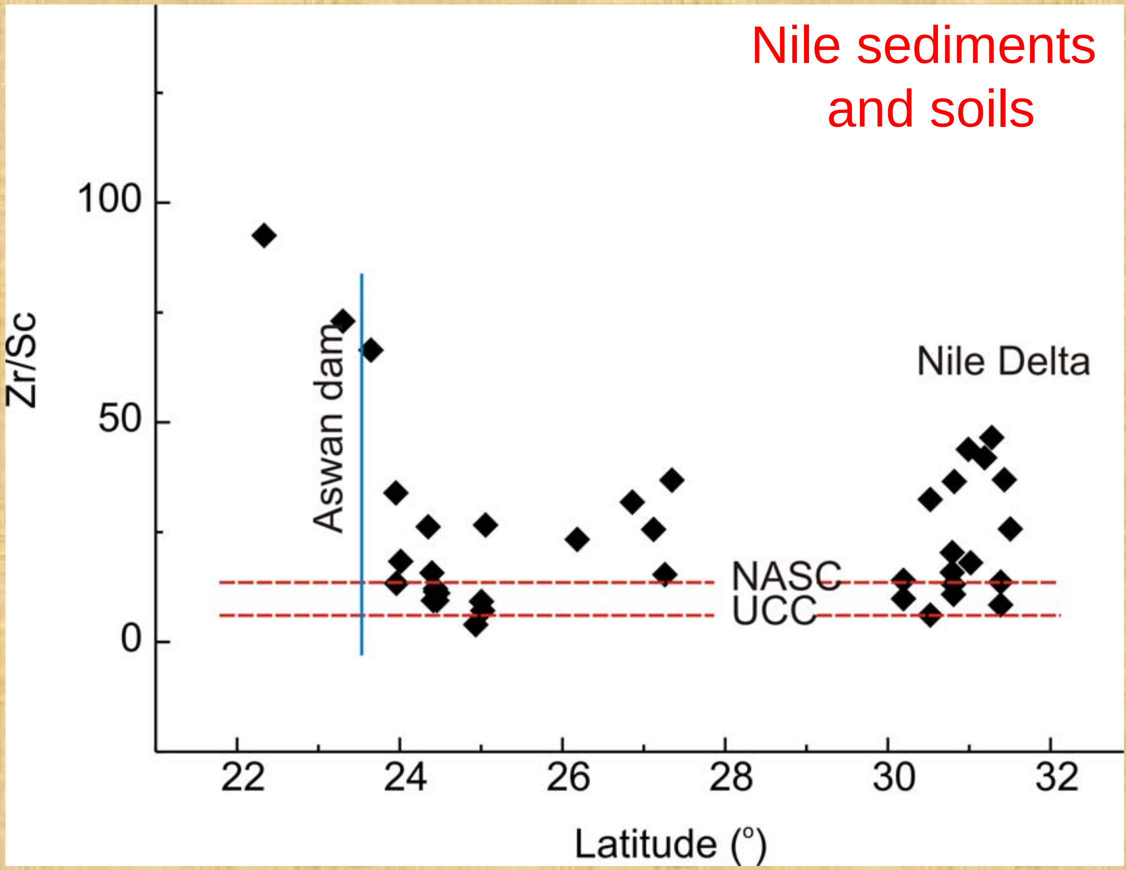
Th/Sc vs. Zr/Sc diagram





Zr/Sc as weathering proxy

Latitude dependence of the Zr/Sc ratio illustrating the relative steadiness of the weathering process downstream Aswan High Dam.

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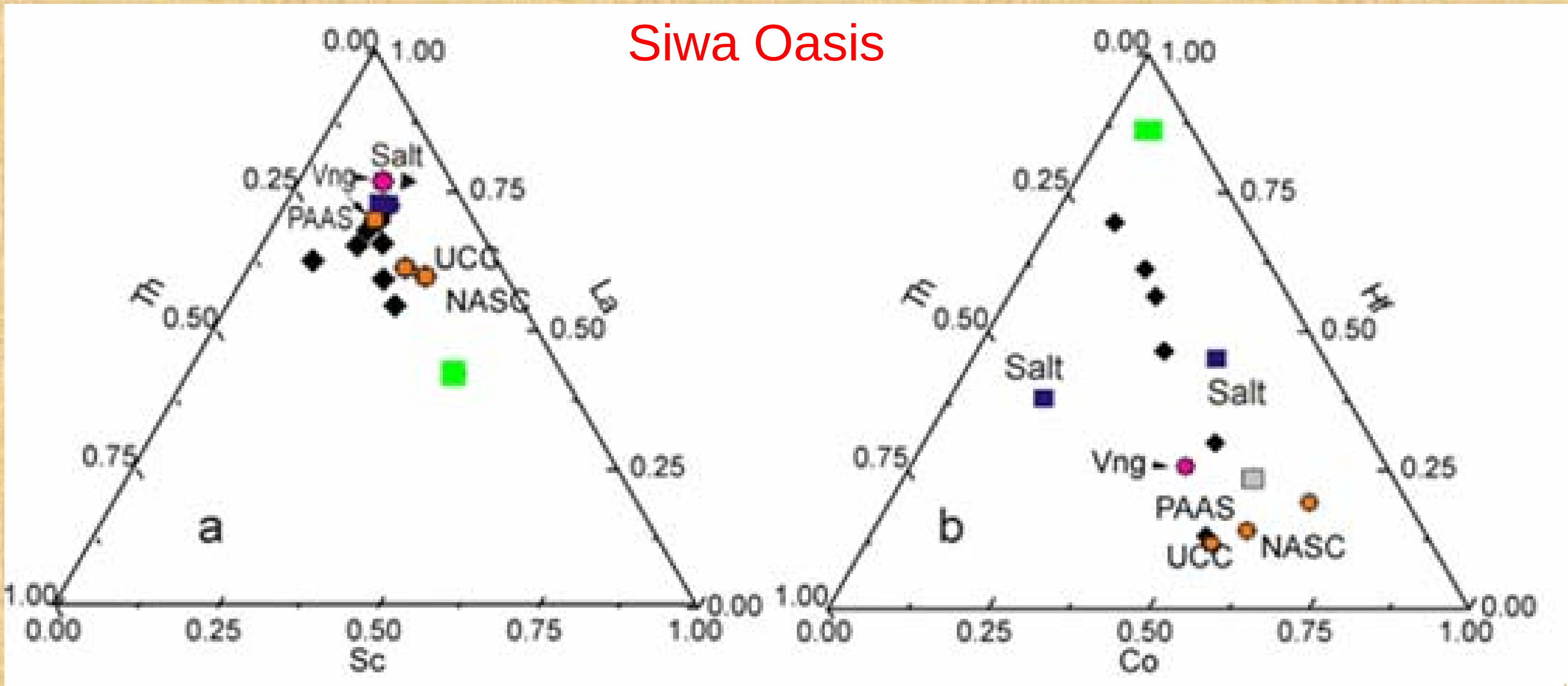
Ternary diagrams of incompatible elements



Sc-La-Th
and
Co-Th-Hf

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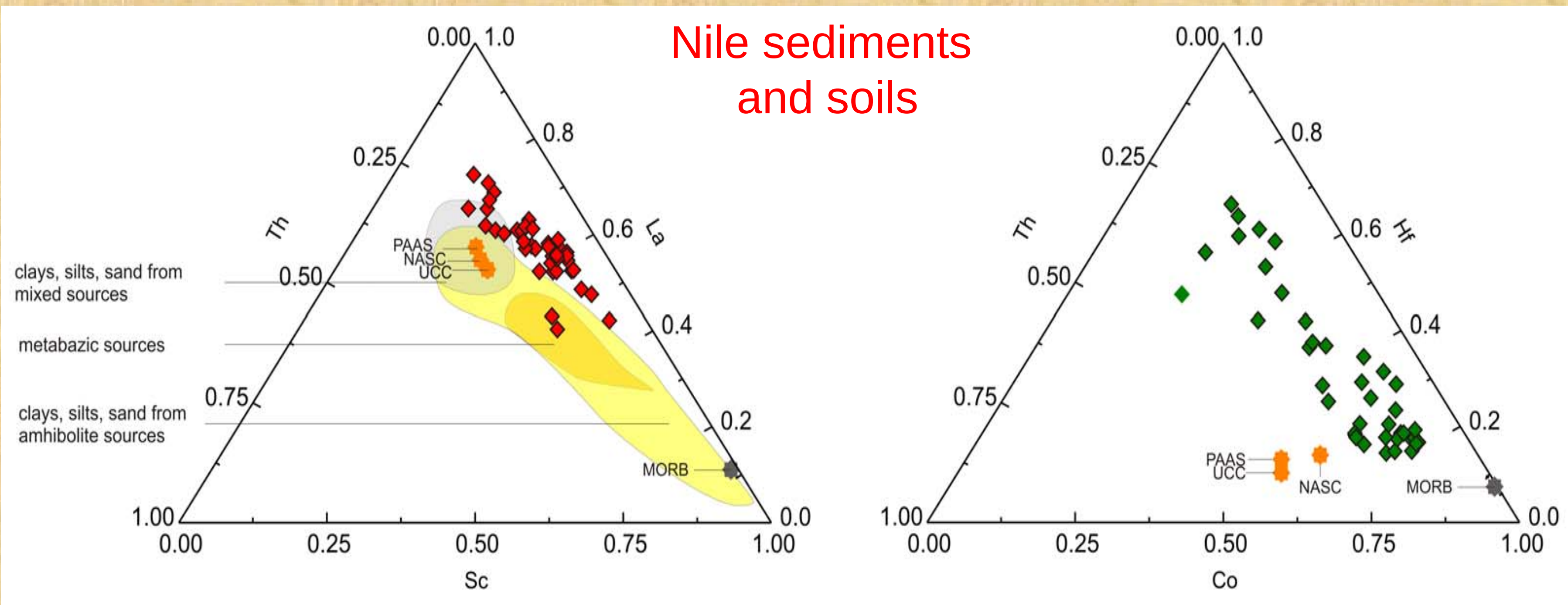
Ternary diagrams of incompatible elements



Sc-La-Th

and

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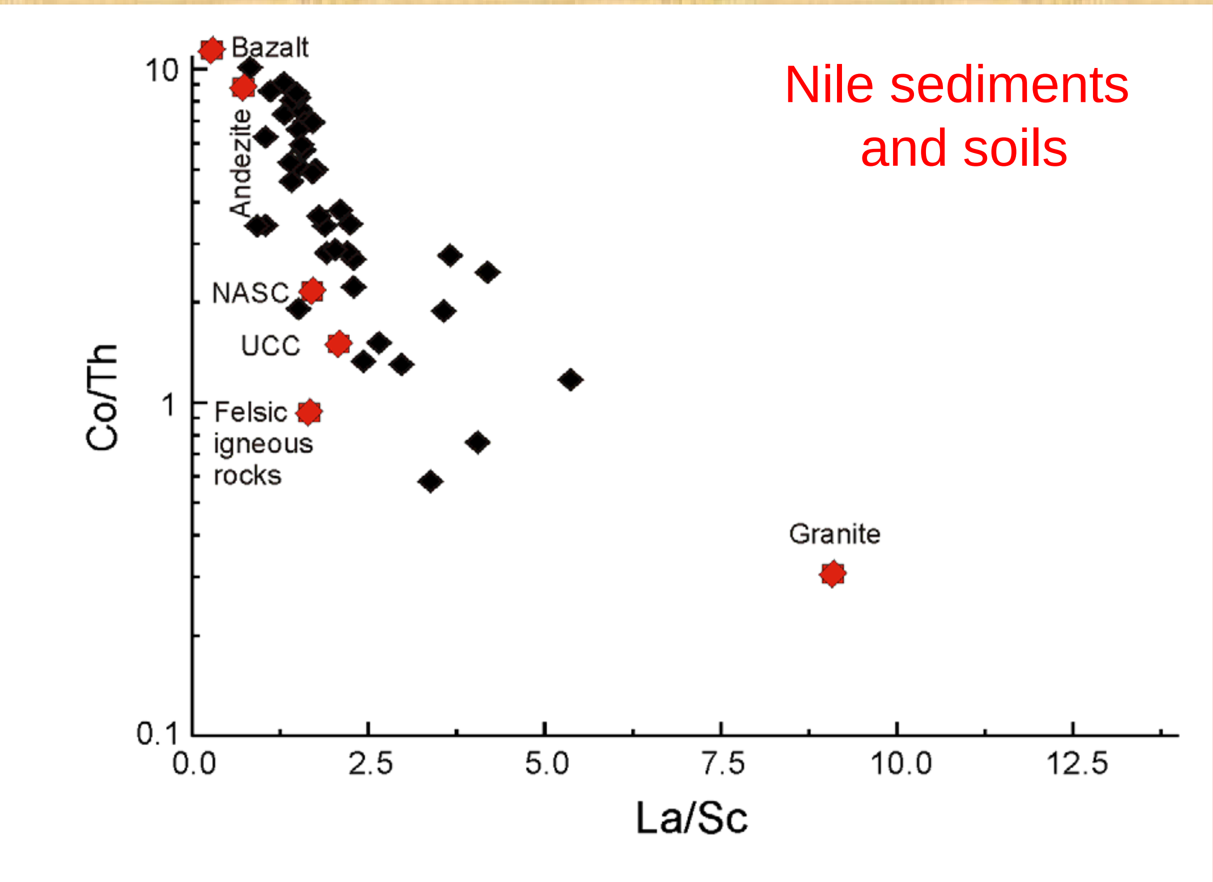
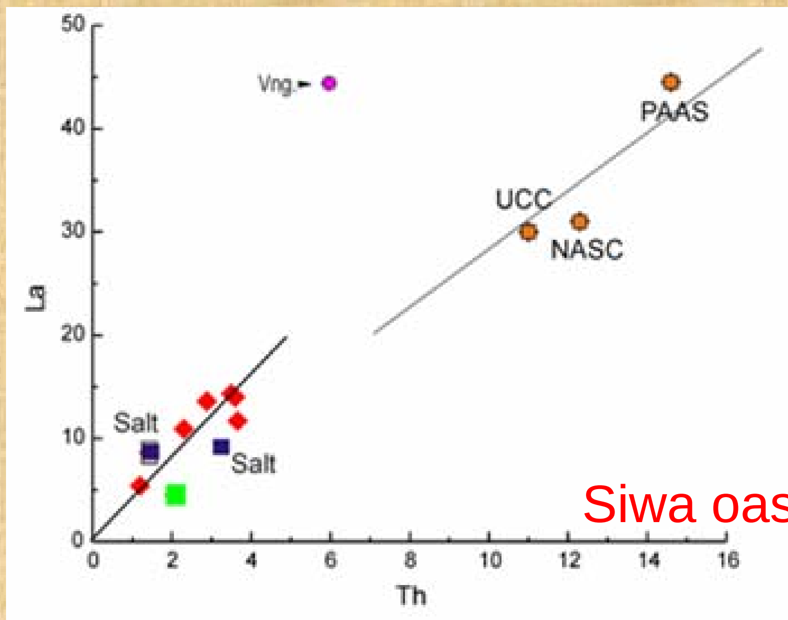


Incompatible elements Sc, Co, La and Th

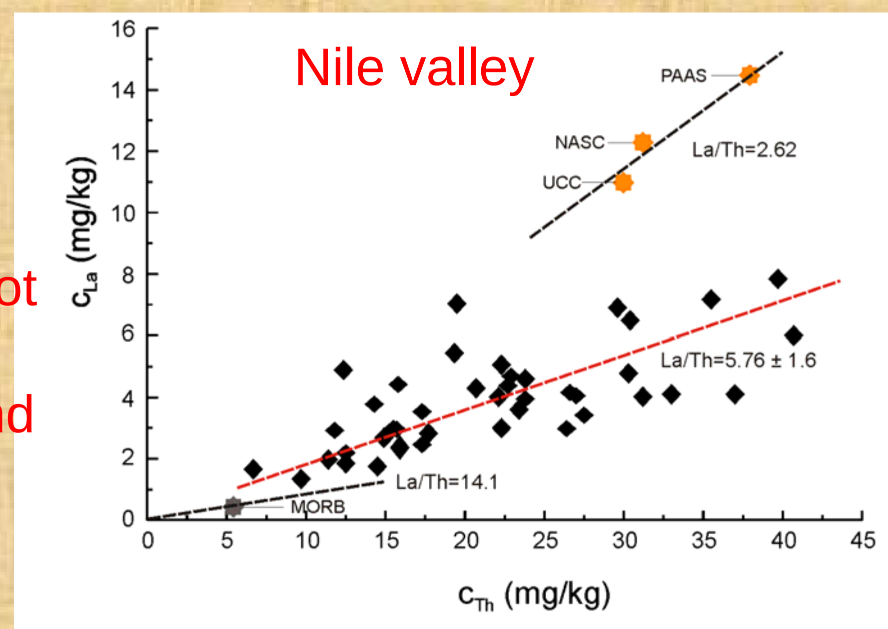
Plot of Co/Th versus La/Sc illustrating the dispersion of the Nile data suggesting a mixture between basaltic, andesitic and felsic igneous rocks with a possible contribution of the continental material

La vs. Th



Siwa oasis

La/Th average value of 4.1± 1.4 for Siwa soils and sediments seem to be closer to average UCC, NASC and PASS than to average soil



La/Th average value of 5.8 ± 1.6 plot evidences the differences between Nile sediments and UCC, NASC and PAAS on one hand and igneous MORB on the other.

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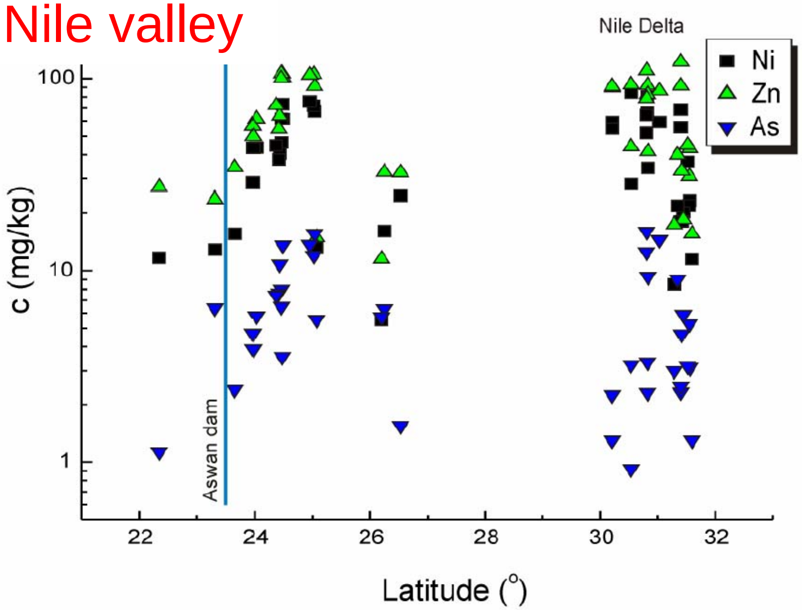
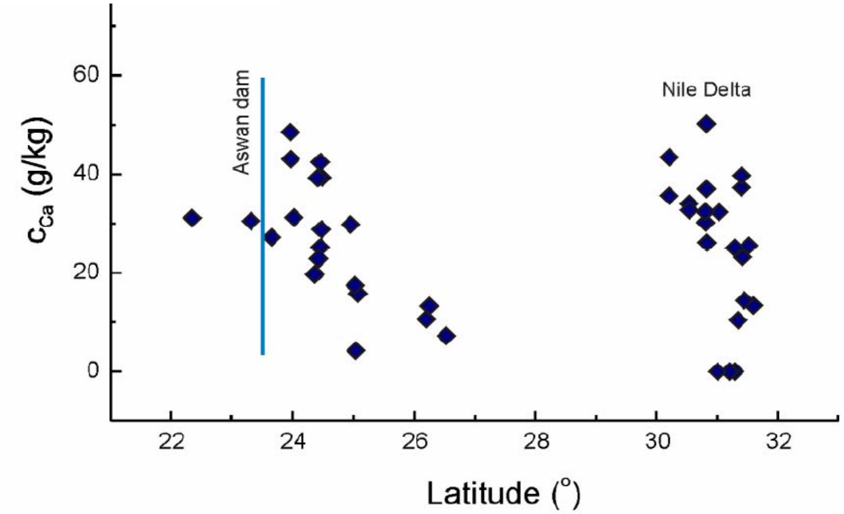
Elements vs. latitude

Nile valley



Latitude dependence of the Ni, Zn and As content.

Nile valley



Distribution of calcium in Nile sediments and soils with latitude.

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Concluding remarks:

In the case of Nile River, our study show that, in spite the majority of investigated elements present contents close to the Upper Continental Crust, their relative distribution points to the presence of fragments of igneous rocks mostly originating from the Ethiopian Plateau.

On contrary, in the case of Siwa oasis, the content of incompatible and low soluble elements such as Sc, Zr, La, Hf of Th showed for the majority of soil and sediments samples common traits to continental rocks at a lesser extent to the Nile sediments.

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Concluding remarks:

But, the relatively reduced number of studies devoted to both Nile valley and Siwa Oasis sediments and soils, we consider them excellent places for further detailed investigations regarding their geochemistry.

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Thank you for attention!!