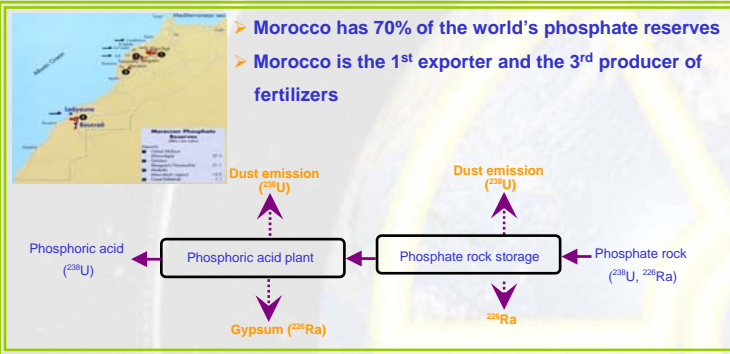


The development of the chemical industry devoted to the production of the phosphoric acid from the phosphate rock and the increasing use of phosphate fertilizers in agriculture contribute to the redistribution of the natural radioactivity in the environment, essentially ^{238}U and ^{232}Th and decay products. In this field, this work was focused on the analysis of ^{238}U and ^{232}Th decay series in Moroccan phosphate fertilizers and phosphates rocks. Uranium and thorium were determined by α -particle spectrometry after alkaline fusion and radiochemical separation. ^{226}Ra were determined by emanometry and γ -ray spectrometry.



Emanometry and γ -ray spectrometry for ^{226}Ra determination

Emanometry technique is based on the measurement of emanated ^{222}Rn by scintillation counting.

Measurement of ^{226}Ra by γ -ray spectrometry suffers from interference of its 186.2 keV line by the 185.7 keV line of ^{235}U . Therefore, ^{226}Ra activities was estimated from ^{214}Pb (242, 295, 352 keV) and ^{214}Bi (609, 1120 keV). The samples were also assumed to be in radioactive equilibrium.

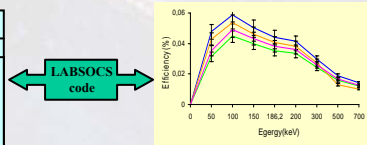
Measurements based on the standard source calibration (density = 1) are less accurate than those obtained by the emanometry technique. Higher experimental uncertainties may be attributed to **self-absorption effects** (the density and composition change from one sample to another).

	^{226}Ra activity (Bq.kg ⁻¹)	
	γ -ray spectrometry: Standard Source	Emanometry
Phosphate rock	1216 ± 500	1273 ± 87
Fertilizer 1	< DL	144 ± 9
Fertilizer 2	< DL	121 ± 8
Fertilizer 3	1635 ± 995	2182 ± 84



The detection efficiency is carried out by using LABSOCS code. The code takes into account the sample density and composition.

	LABSOCS Code	
	density	matrix
Phosphate rock	1.59	gypse
Fertilizer 1	0.92	gypse
Fertilizer 2	0.91	gypse
Fertilizer 3	1.43	gypse



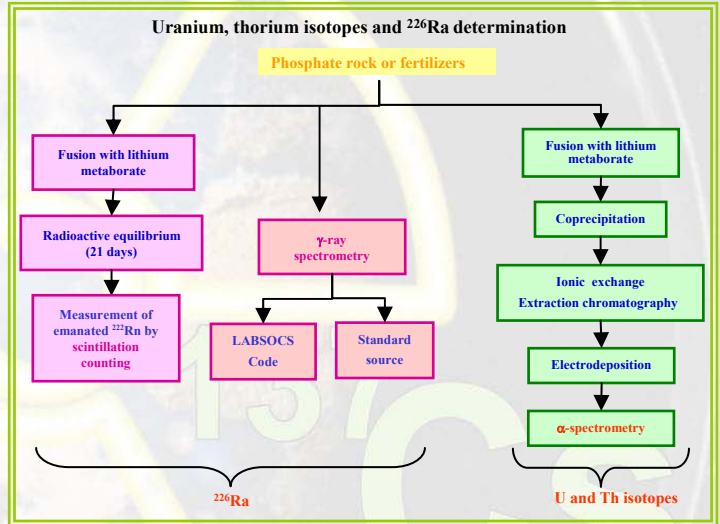
	^{226}Ra activity (Bq.kg ⁻¹)	
	γ -ray spectrometry: LABSOCS Code	Emanometry
Phosphate rock	1261 ± 102	1273 ± 87
Fertilizer 1	94 ± 10	144 ± 9
Fertilizer 2	84 ± 10	121 ± 8
Fertilizer 3	2150 ± 162	2182 ± 84

Results obtained by γ -ray spectrometry using the LABSOCS code and by emanometry are in agreement.

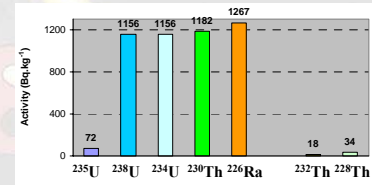
Conclusion and perspectives

- ✓ Youssoufia phosphate deposit exhibits enrichment in uranium and radium. Sequential extractions on the raw materials will give us an insight into the nature of the mineral and/or organic phases involved in the radionuclide retention.
- ✓ U, Th isotopes and ^{226}Ra contents in fertilizers drastically depends on the manufacturing process.
- ✓ The kinetic of release of uranium and its progenies during the process of phosphoric acid production is under investigation.

Experiments and techniques



U, Th isotopes and ^{226}Ra in Youssoufia phosphate



The very low $^{232}\text{Th}/^{238}\text{U}$ activity ratio confers to the sediment a **marine character**.

The $^{234}\text{U}/^{238}\text{U}$ and $^{230}\text{Th}/^{238}\text{U}$, $^{226}\text{RaU}/^{230}\text{Th}$ activity ratio are close to unity in the bulk phosphate, so that ^{238}U , ^{234}U , ^{230}Th and ^{226}Ra are considered to be in **radioactive equilibrium** within $\pm 2\sigma$ uncertainties. This may be an indication that uranium-bearing phases are enclosed in compounds which have protected them from the weathering processes or that **chemical weathering was minimal**.

U, Th isotopes and ^{226}Ra in Moroccan fertilizers

