Radiometric Map of Portugal

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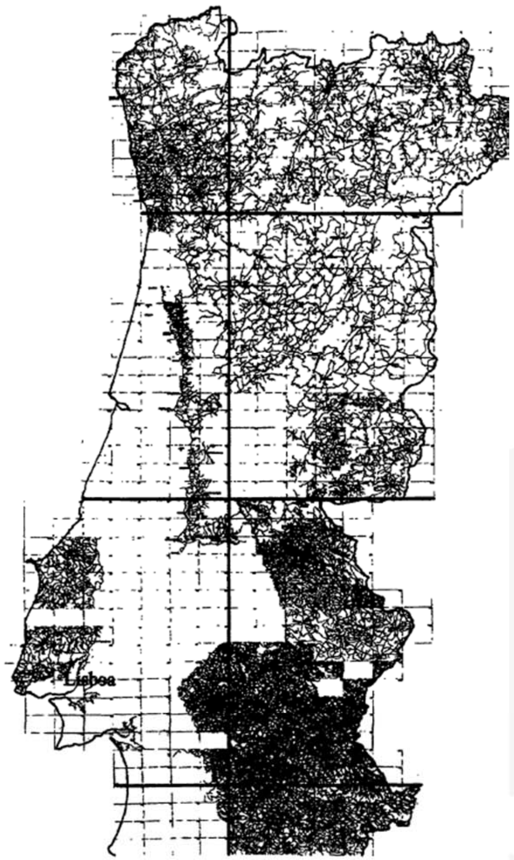
Mineral Resources and Geophysics Research Unit

Radiometric survey and data managment and calibration in Portugal: An historical perspective



- Radiometric measurements were started in 1955 due to the interest in uranium exploration.
- Measurements were undertaken with total count scintillation counters carried by prospectors on foot and Geiger-Müller counters.
- A significant part of the country was covered with vehicle-borne scintillation counters in order to identify areas that were later investigated with hand-carried SPP2 counters or other scintillation counter models.

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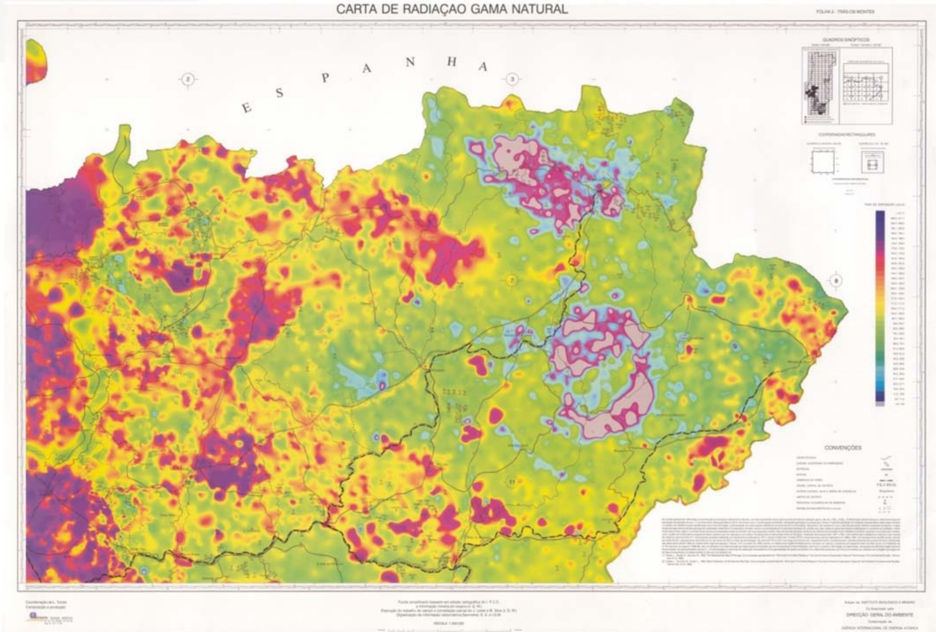
Collection and compilation of radiometric data (1)

- From the 1980's onwards radiometric measurements were used for mineral exploration. Initially for **U, Sn, W, Au** and **phosphates** and later for **base metals** in the Iberian Pyrite Belt, Northern Alentejo and Beiras regions.

•Towards the end of the 80's with indications given by IAEA (M. Tauchid) and Dr. Torres the compilation and calibration of all data was started. The 1:200000 scale maps were initiated soon after.
These were made using linear interpolation by minimum curvature, 250 m cells, 10 m radius and minumum number of points = 10.



Collection and compilation of radiometric data (2)

•These 1/200 000 sheets were made and financed by the Directorate General of the Environment (today *APA* - Portuguese Environment Agency) and did not cover the whole country.

• In the end of the 90's the process of filling in the areas where no measurements existed was initiated. This was started in the north of the contry with SPP2 scintillation counters.

• More recently (2010) this task was revived through an internal project (**RADIOM** – Carta Radiométrica Nacional) @ 1:500000 scale mapping with the following actions:

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Actions (1):

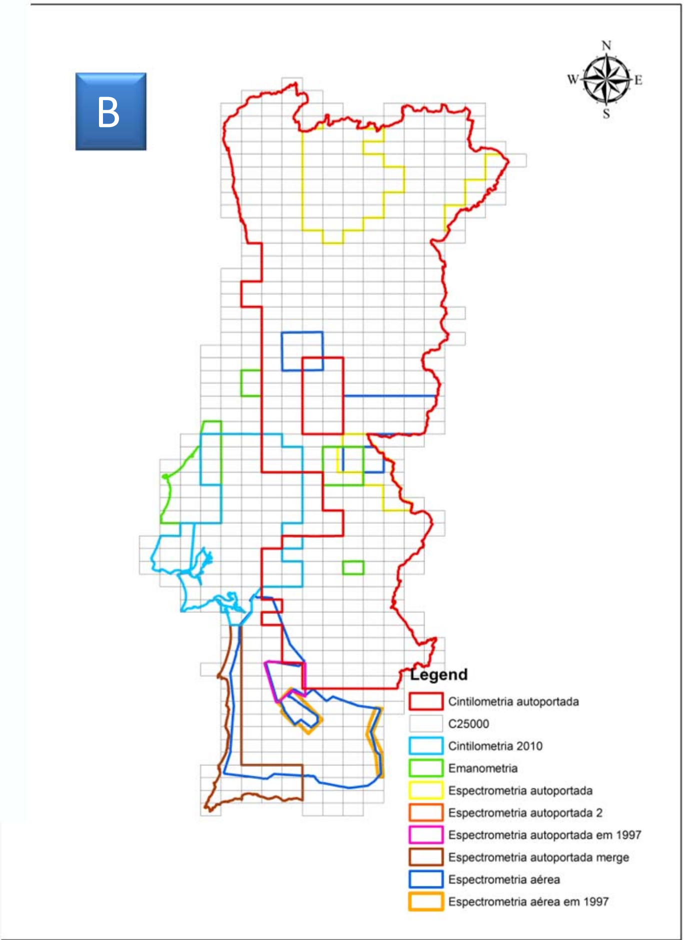
1) Recovery of all previously compiled information.

2) Collection of “missing” data in the sectors of the Lower Sado Tertiary and Tagus Basins.

3) Colection of “missing” data in bands in the South Portuguese Zone that were not covered by aerial surveys.

Actions (2):

A. The last surveys were carried out with SPP2 Scintillation counters



B. Different methods through the years.

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Equipment (1)

Total count scintillation counters

Vehicle-borne equipment manufactured in the Atomic Energy Research Establishment in Harwell, UK. Detector size equal to that of the SPP2
Approximately 55000 km of measurements were carried out between 1957 and 1962.

Terrestrial Scintillation counters

In the total count radiometric hand-carried surveys a SAPHYMO SRAT, type SPP-2, were used.
The detector is a 1 x 1.5 inch (15.2 cm3) NaI(TI) (sodium iodide activated with thallium) scintillation crystal.

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Equipment (2)

Aerial and terrestrial spectrometers

256 channel Gamma ray spectrometers with ANI(T1) scintillation crystal, GPS navigation system, covering the energy spectrum from 0 to 3 Mev, with slection of spectral windows: "total count" (0.41 to 2.81 Mev), K (1.37 to 1.57 Mev), U (1.66 to 1.86 Mev), Th (2.41 to 2.81 Mev) and cosmic radiation (>3 Mev).

In the newer land surveys carried out a Gamma ray Exploranium GR-820, with GPX-256 de 4.0L, and GPX-21 de 0.35L detectors were used in foot-borne measurements. Additionally we have a 16L sensor for airborne surveys

EXPLORANIUM
RADIATION DETECTION SYSTEMS

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Calibration of equipment (1)

These equipments were frequently calibrated **using calibation blocks** in an airfield located in the Algarve away from external sources of influence.
These blocks, often made of cement with standard dimensions **contain radiation sources with known quantities of U, Th and K** with the associated errors that simulate naturally occuring substances.

The evaluation of the instrumental sensibility is normally made using the weighted least squares technique (e.g. Løvborg et al., 1981).

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Calibration of equipment (2)

Using a calibrated a GR-256 Exploranium spectrometer a dozen sites previously surveyed by the car-borne and foot-borne scintillation counters, covering a large range of values and encompassing diverse geological units, **were revisited and remeasured.**

Exposure rates were calculated from the concentrations of equivalent uranium, thorium and potassium supplied by the GR-256. Exposure rates calculated from those concentrations were **linearly correlated** with the values in counts per second of the scintillation counters. **The linear relationships established for the different sensors are used to calculate the exposure rates from the original data.**

Separate surveys were carried out in the Góis-Segura and IPB areas. Each of these surveys used the calibration blocks in the Algarve airfield.

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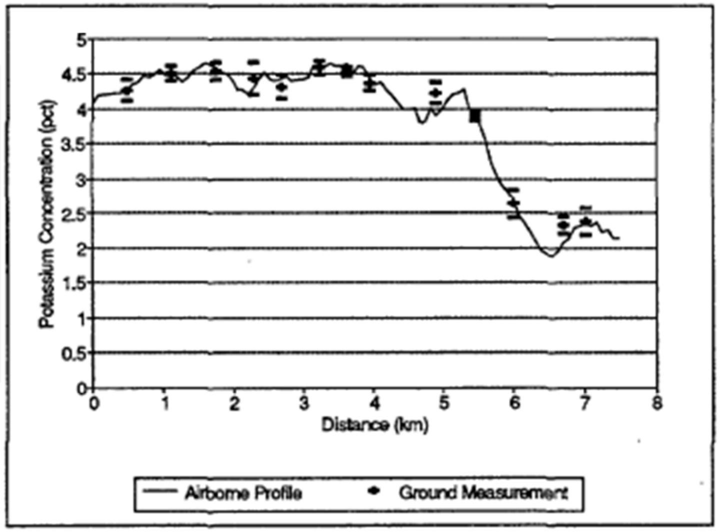
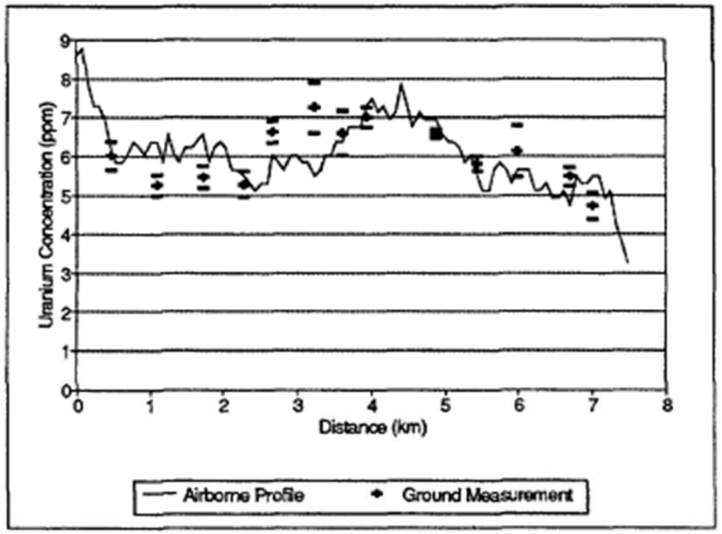
Calibration of equipment (3)



Terrestrial concentrations of K with the K obtained by aerial radiometry measurements.
K calibrated with the RTZ flight in the IPB.

Terrestrial concentrations of U with the U obtained by aerial radiometry measurements.
U calibrated with the RTZ flight in the IPB.



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Calibration of equipment (4)

The total count vehicle-borne system also requires calibration. This was done using the SFM GAD-6 portable spectrometer after calibration on the concrete calibration pads (given to the SFM in Portugal by the IAEA). However, because of possible effects of road material on the measurements, some modifications to the SPP2 calibration procedure were necessary.

SFM requested help in this calibration. This could be done in conjunction with the calibration of the airborne surveys carried out which are also presented in counts per second.

SFM: Serviço de Fomento Mineiro (precursor to the IGM, INETI and now LNEG

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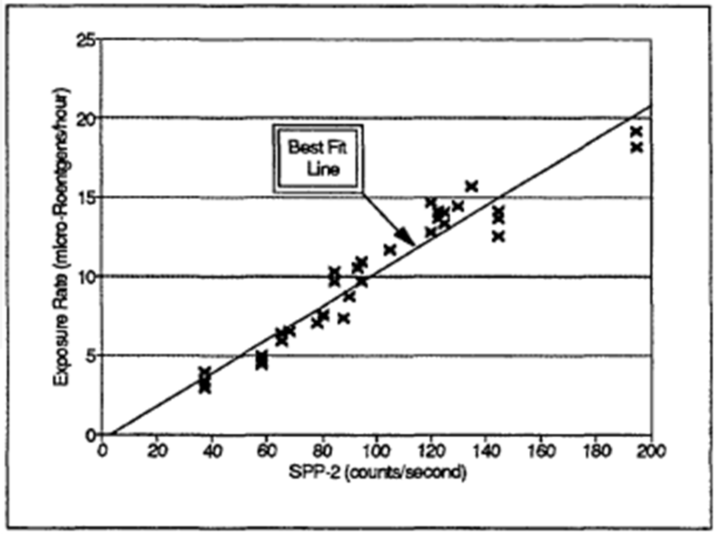
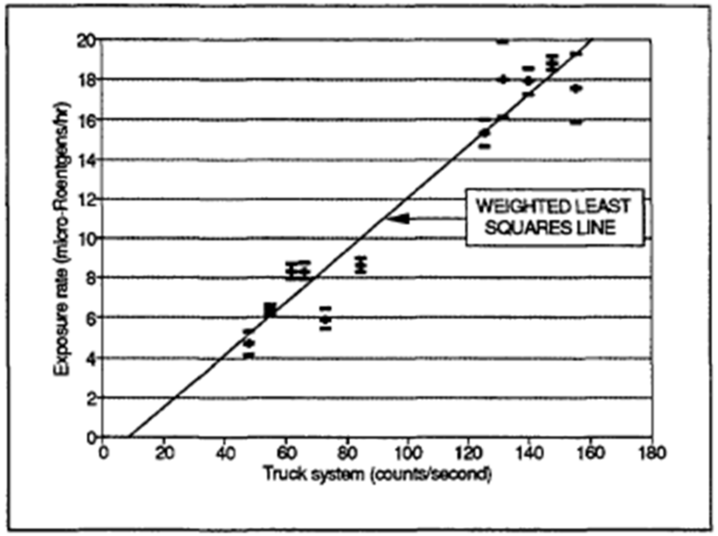
Calibration of equipment (6)

Calibration with spectrometer GR-256



Relationship between SPP2 total counts and rate of exposure calculated from the terrestrial concentrations of K, U and Th.



Relationship between vehicle-borne counts and rate of exposure calculated from the terrestrial concentrations of K, U and Th.

Data quality control (1)

Knowing the data available, the data was then **verified** eliminating wrong or incorrect data:

1) All **data points outside the borders of Portugal were removed**;
2) All **vehicle-borne data along major highways and roads with very heavy traffic patterns were removed**;
3) Negative radiation exposure rates were detected. These points were numerous (31556) and located in the western part of the RTZ flight path. **All these points were zeroed.**

These negative points are not real – they result from the “b” slope value of the calibration curve equation.

Mapping - quality control (1)

Pontos saraiva sem Aut-E, com negativos

	TE µR/h	µR/h a miliR/h	mR/h a µGy/h	µGy/h a nGy/h
Min	-3.9	-0.0039	-0.034047	-34.047
Máx	1533.5	1.5335	13.3875	13387.455
Méd	8.0600	0.0081	0.0704	70.3642
Desv P	6.1369	0.0061	0.0536	53.5752
n	835123			

Pontos saraiva sem Aut-E, sem negativos e sem alguns repetidos

	TE µR/h	µR/h a miliR/h	mR/h a µGy/h	µGy/h a nGy/h
Min	0	0	0	0
Máx	1533.50	1.5335	13.3875	13387.455
Méd	8.1137	0.0081	0.0708	70.8323
Desv P	6.0584	0.0061	0.0529	52.8901
n	834973			

Statistical exercise to check whether negative values that were zeroed influenced the map outcome and the overall statistics.

No! *Because although many (31556) these are insignificant compared to the total number of points (841440)*

4) **Repeated values for the same location were found**. Some had the same radiation values, others not. **In some cases the point was repeated 20 times in the same location;**

Mapping - quality control (2)

The exposure rate was obtained from the transformation of the *cps* measured in the recently acquired SPP2 readings by the formula suggested by Torres (1992):

ER=0,128*cps-2,47. **Not** SI units

Nowadays it is measured using the rate of kerma in the air which represents the kinetic energy of the loaded particles liberated by ionising radiation in a sample of matter. Gray is the unit used.

Conversions were calculated by:

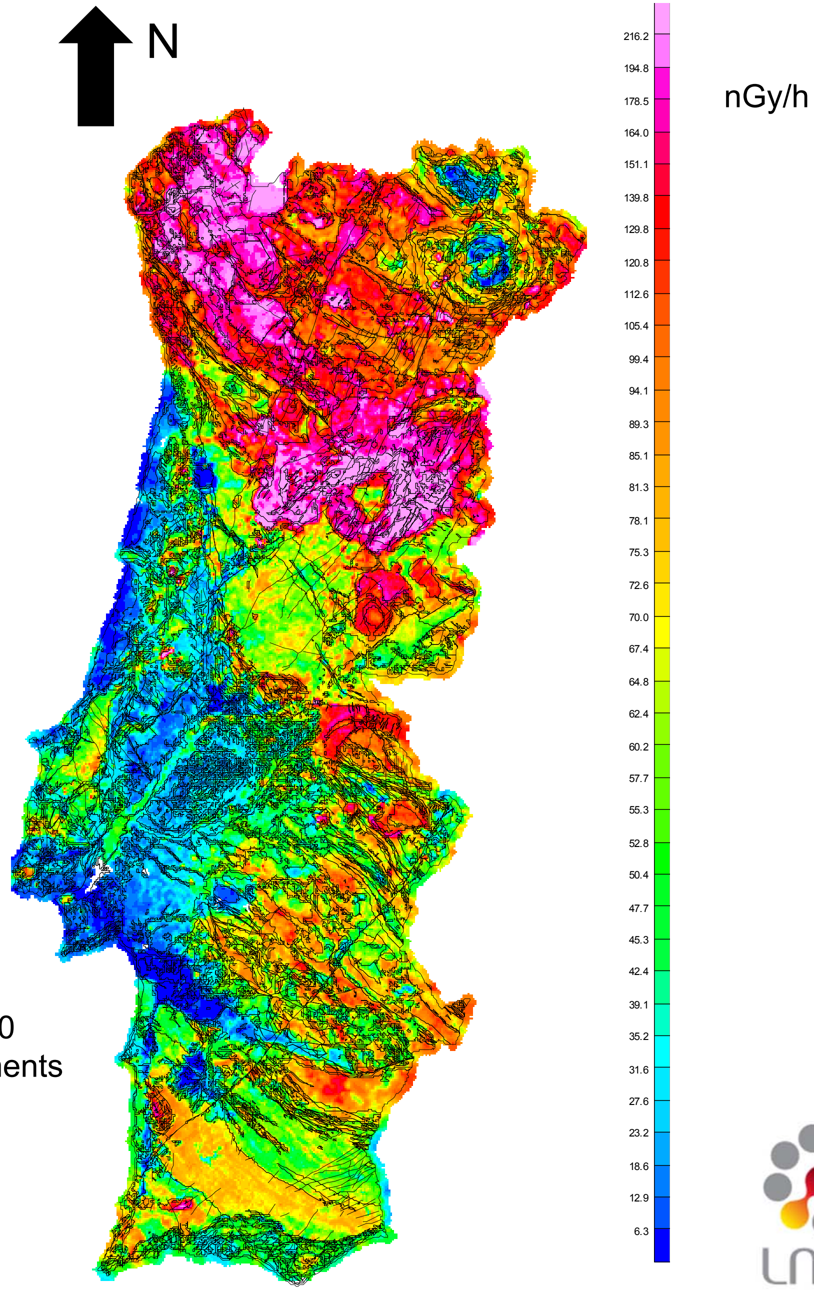
μR/h → mR/h (**Z1*10^(-3)**)

mR/h → μGy/h (**mR/h*8.73**)

μGy/h → nGy/h (**μGy/h*1000**)

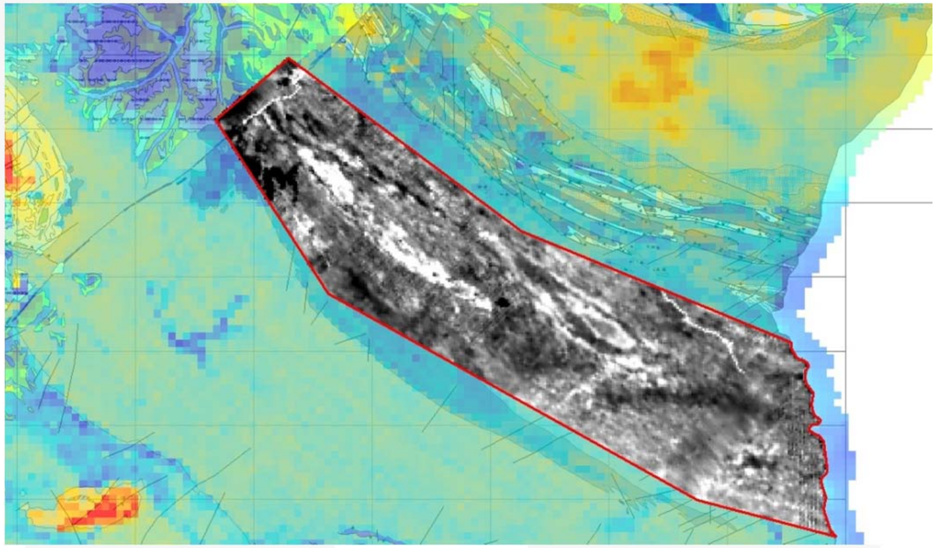
N

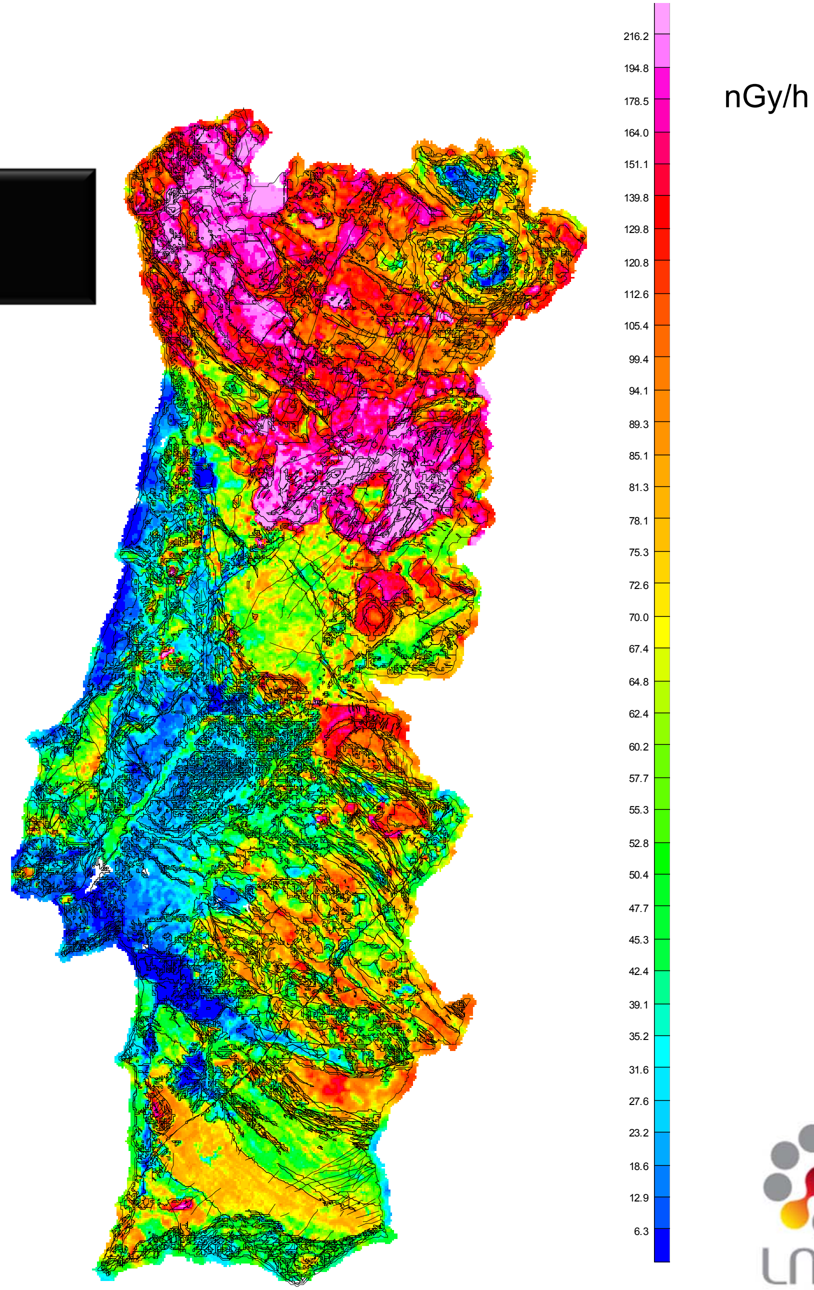
841 440
measurements



A new global vision of structures in more detail

e.g. Promine-GoCAD





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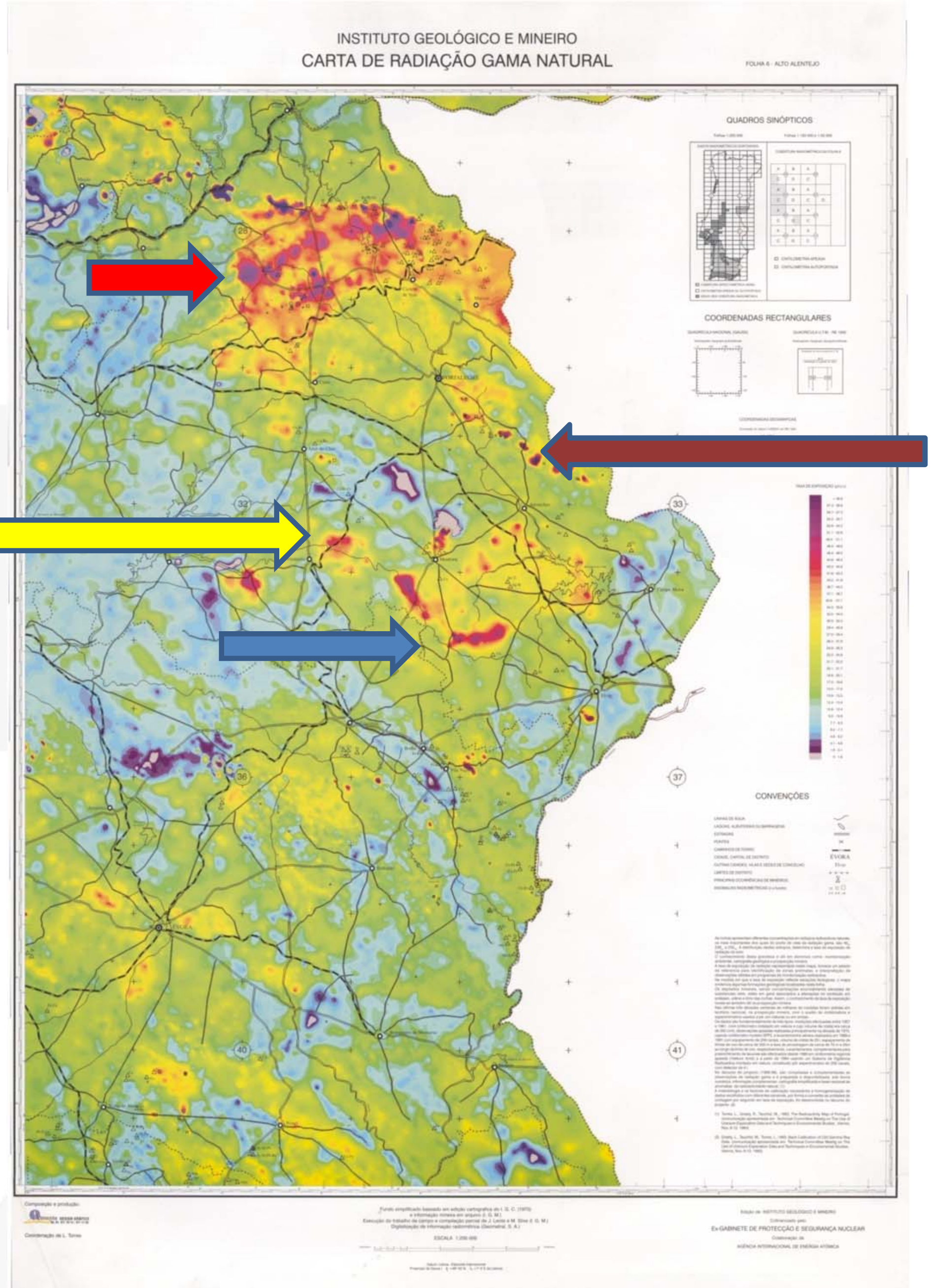
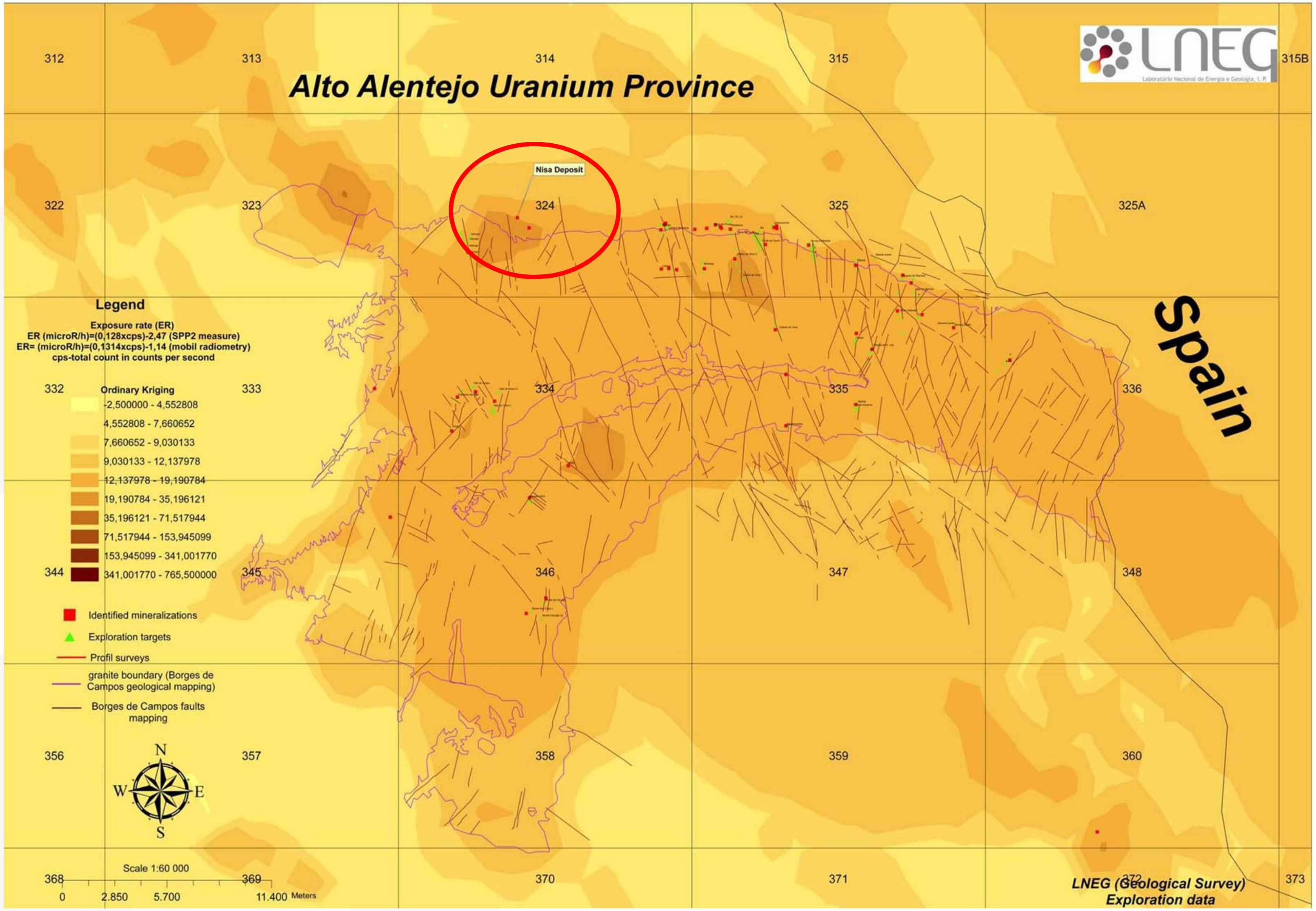


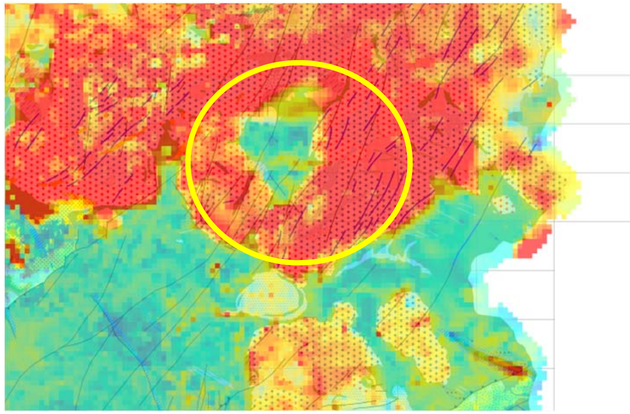
Classical monazite – rich in LREE (Ce++, La)

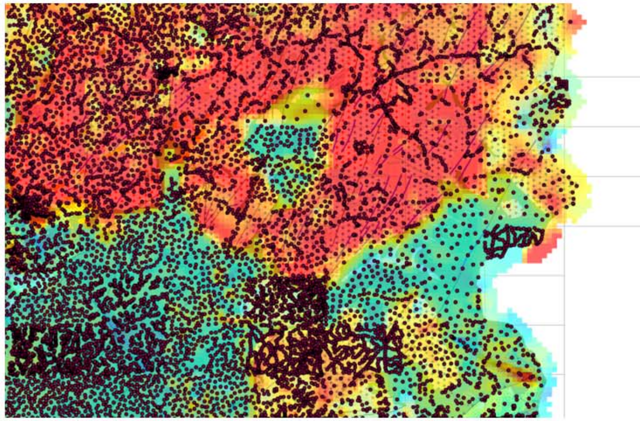
Nodular monazite – rich in intermediate REE (Eu++, Sc, Y)

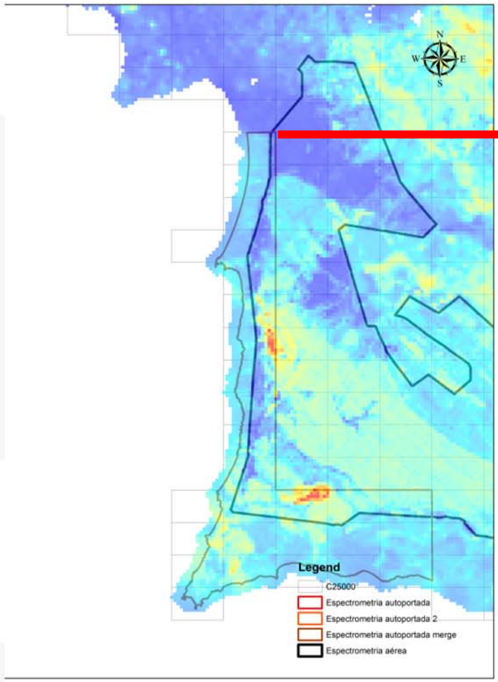


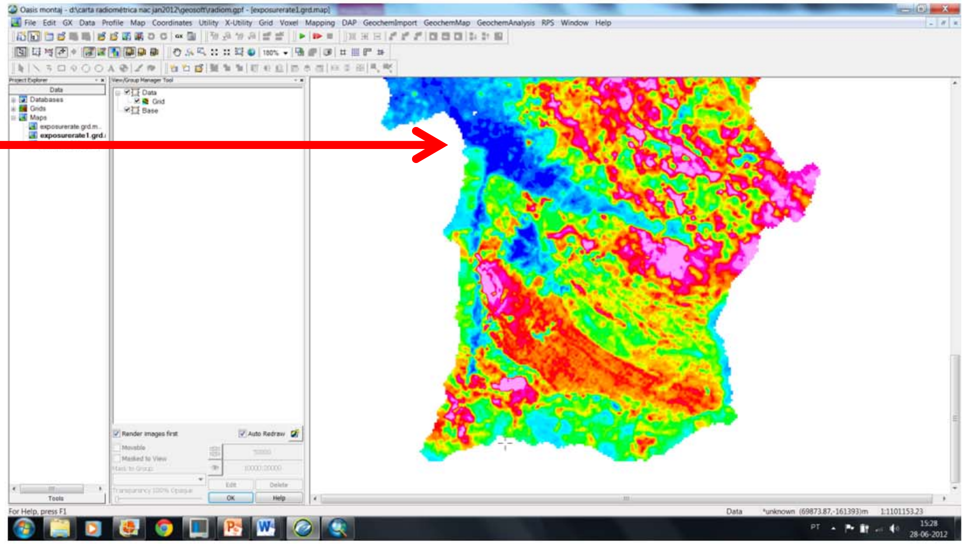
Alto Alentejo Uranium Province
Nisa Deposit
Spain
Legend
Exposure rate (ER)
ER (microR/h)=(0,128xcps)-2,47 (SPP2 measure)
ER= (microR/h)=(0,1314xcps)-1,14 (mobil radiometry)
cps-total count in counts per second
Ordinary Kriging
-2,500000 - 4,552808
4,552808 - 7,660652
7,660652 - 9,030133
9,030133 - 12,137978
12,137978 - 19,190784
19,190784 - 35,196121
35,196121 - 71,517944
71,517944 - 153,945099
153,945099 - 341,001770
341,001770 - 765,500000
Identified mineralizations
Exploration targets
Profil surveys
granite boundary (Borges de Campos geological mapping)
Borges de Campos faults mapping
Scale 1:60 000
0 2.850 5.700 11.400 Meters
LNEG (Geological Survey)
Exploration data

Manteigas grabben

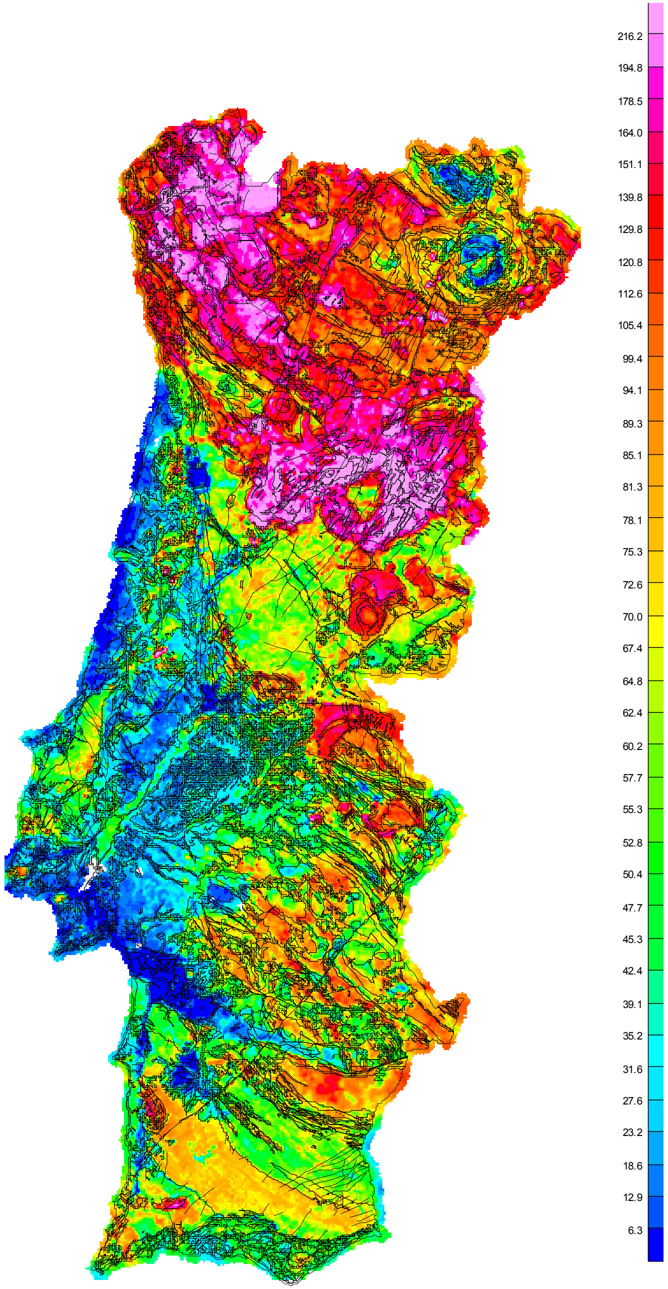








Is this real? (to be verified)
Needs surface attenuation?
??????



Thank you

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