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LEVELLING AIRBORNE AND GROUND GAMMA-RAY SPECTROMETRIC DATA TO ASSIST URANIUM EXPLORATION

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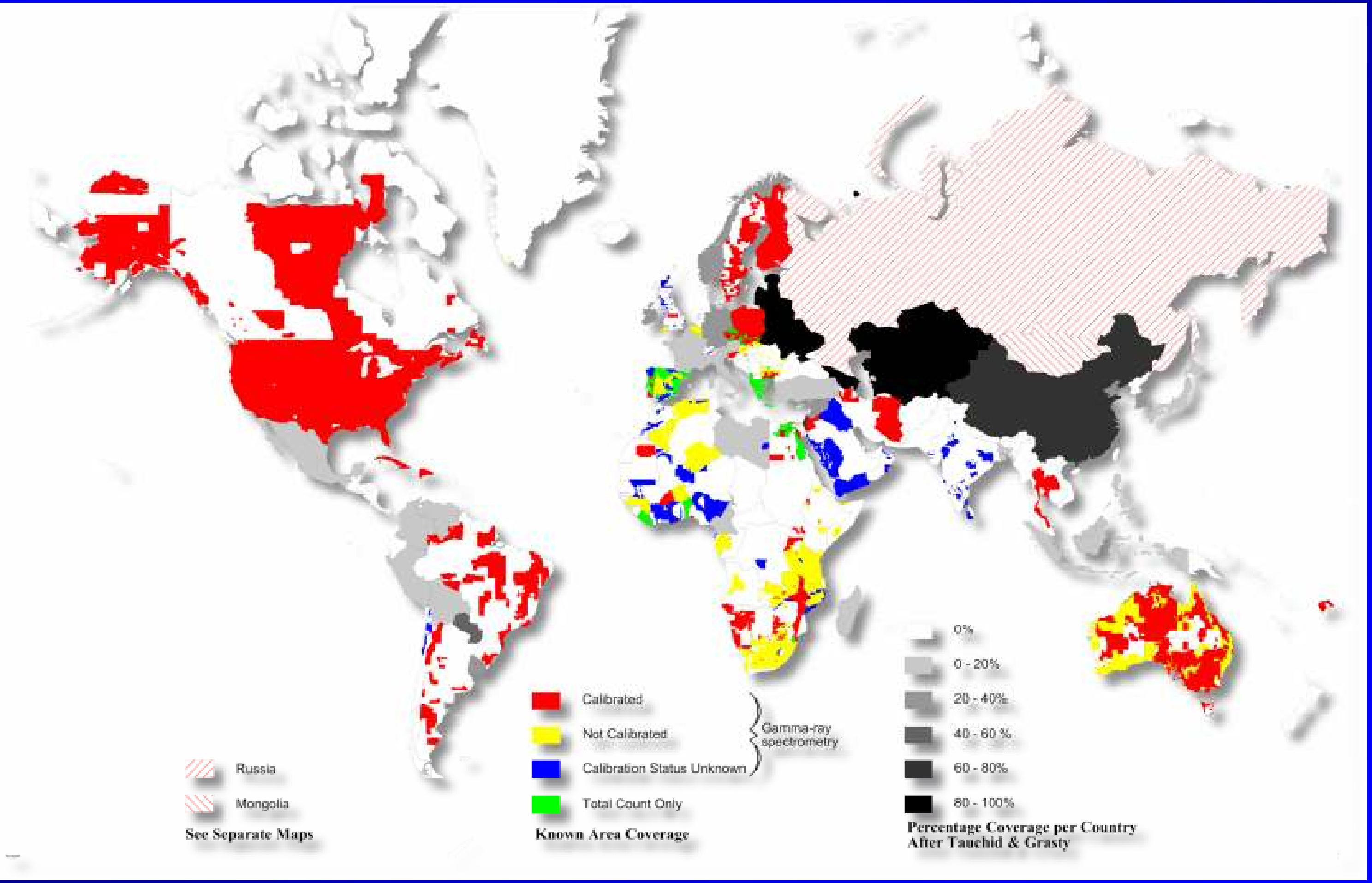
GLOBAL GAMMA-RAY SPECTROMETRY AND TOTAL COUNT COVERAGE

Compiled by Sally Barritt, 2005



Radioelement Mapping, IAEA (in press)

International Atomic Energy Agency

A GLOBAL RADIOELEMENT BASELINE

- **In the fifty years past, airborne and ground gamma-ray spectrometry and gamma total count surveys covered more than 50 % of the area of continents.**
- **Gamma-ray spectrometry was recognized as powerful technique for K, U and Th mapping.**
- **In order to standardize radiometric data, and make their full use, IAEA initiated a project of „A Global Radioelement Baseline“.**
- **Publication:**
  Radioelement Mapping,
  IAEA (in press).

A GLOBAL RADIOELEMENT BASELINE

- **A global radioelement baseline for gamma-ray spectrometric data requires that all gamma-ray data be acquired and processed in a globally consistent way.**

- **Instrument calibration:**
  Primary reference standards for laboratory gamma-ray spectrometry issued by the IAEA Seibersdorf Laboratory in 1987.

44.8 % K 400 ppm U 800 ppm Th

- **A global network of calibration facilities for field radiometric instruments.**

TOPICS

- Levelling airborne gamma-ray spectrometric data

THE RADIOMETRIC MAP OF AUSTRALIA

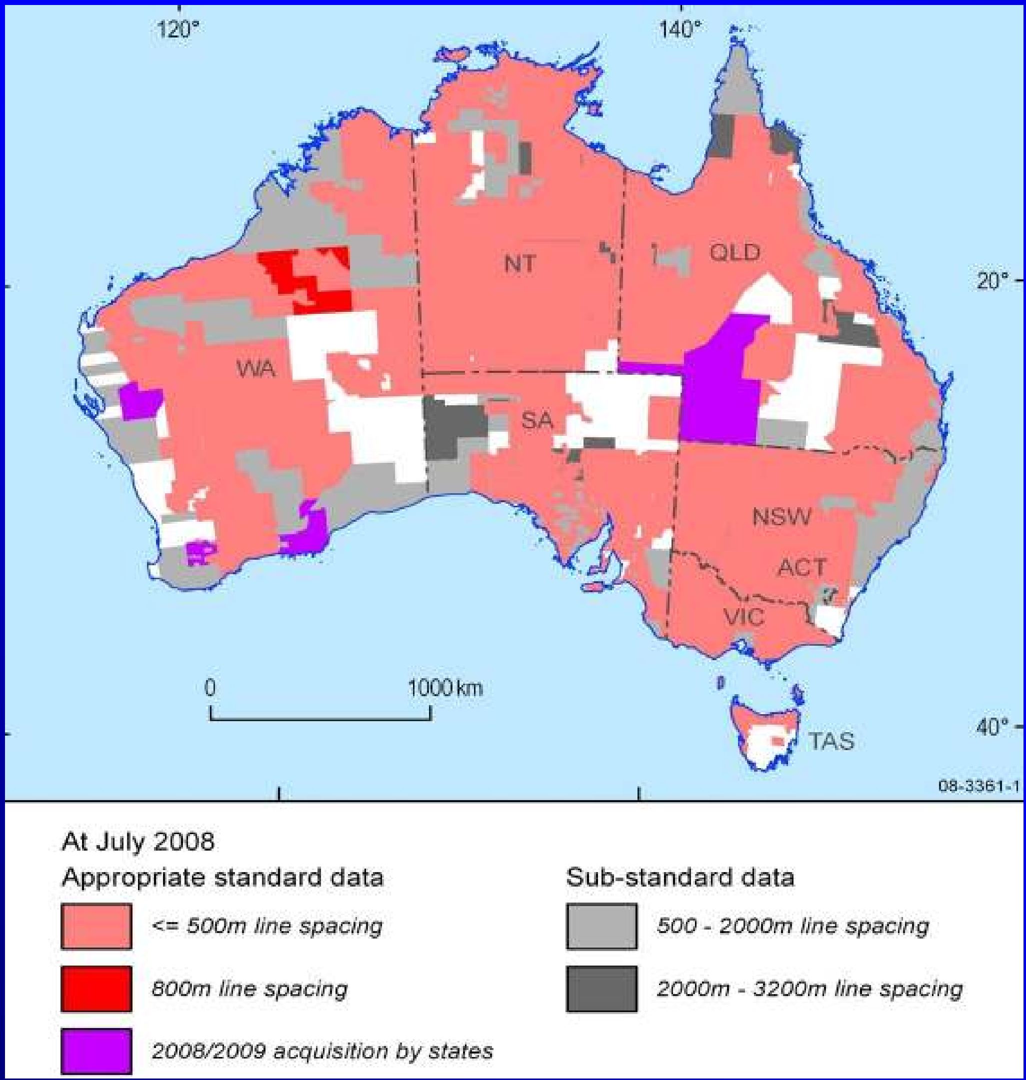
Data: Geoscience Australia

- Levelling ground gamma-ray spectrometric data

GEOMETRICAL CORRECTION FOR GROUND MEASUREMENT

Data: Charles University in Prague

AUSTRALIA – AIRBORNE GAMMA-RAY SPECTROMETRY SURVEY COVERAGE



In Australia, over 80 % of the continent is covered by airborne gamma-ray spectrometry flown over the past 40 years.

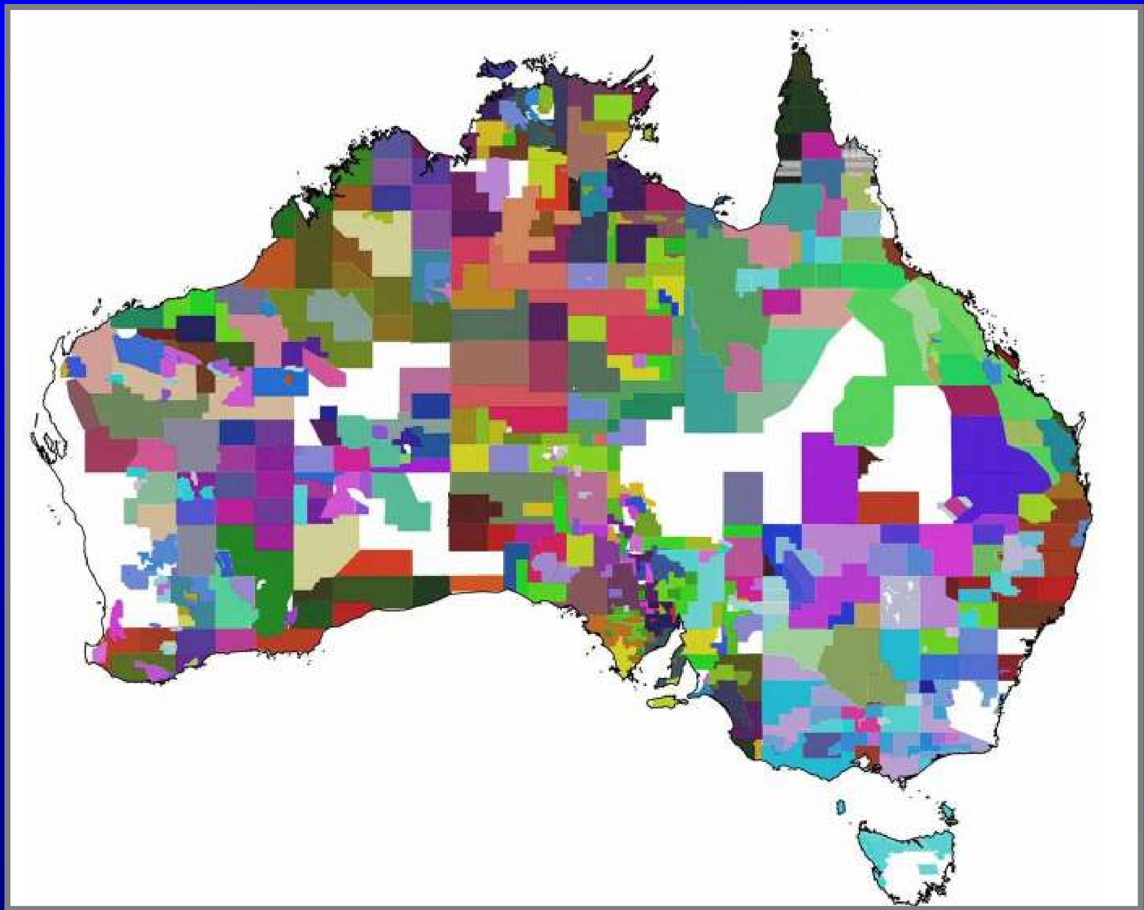
Standard data were reported in K, U, and Th concentration.

Sub-standard data were reported in counts per second.

Geoscience Australia

AUSTRALIA – AIRBORNE GAMMA-RAY SPECTROMETRY SURVEY COVERAGE

1970 – 2008



540 airborne gamma-ray spectrometric surveys.

Differences in survey parameters:

- **flying height**
- **profile separation**
- **detector volume**
- **energy window width**
- **standards and calibration**
- **data processing**

Results are not directly comparable.

Geoscience Australia

Australia-Wide Airborne Geophysical Survey 2007 (AWAGS)

Location of the AWAGS survey flight lines flown in 2007

The AWAGS serves as a radioelement baseline for all current and future airborne gamma-ray spectrometric surveys in Australia.

Survey parameters:

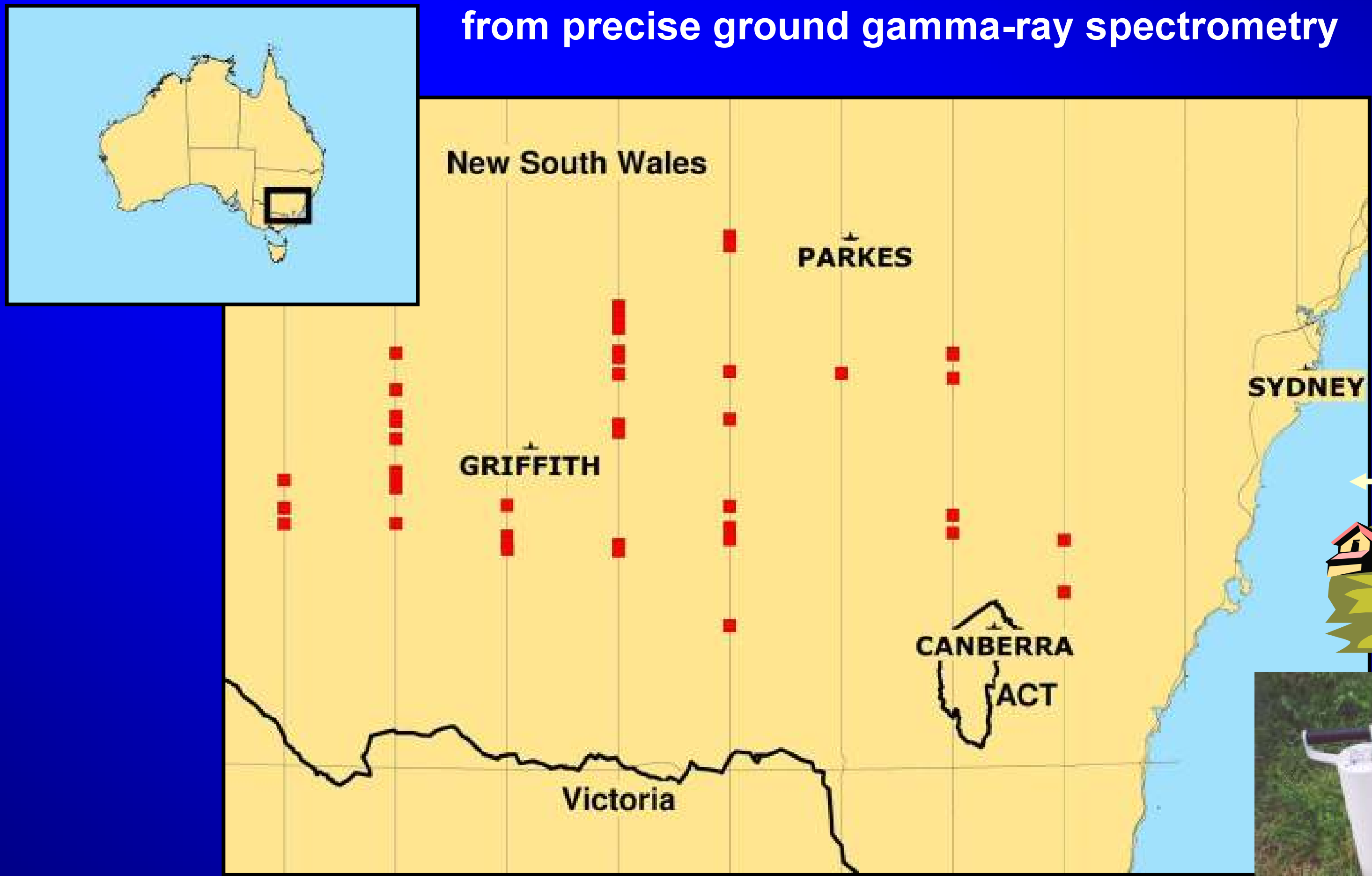
- nominal survey height 80 m
- N – S flight lines spaced 75 km
- E – W tie lines spaced 400 km
- 33 litre NaI(Tl) detector

Data were acquired and processed to IAEA standards

Geoscience Australia

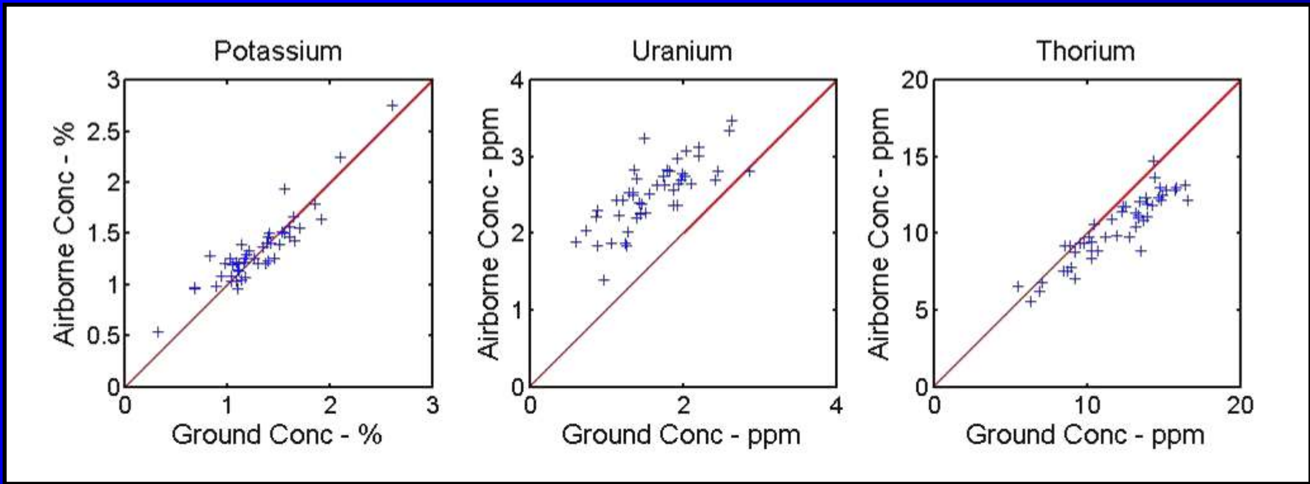
AWAGS BACK-CALIBRATION

Correction factors for airborne data derived from precise ground gamma-ray spectrometry

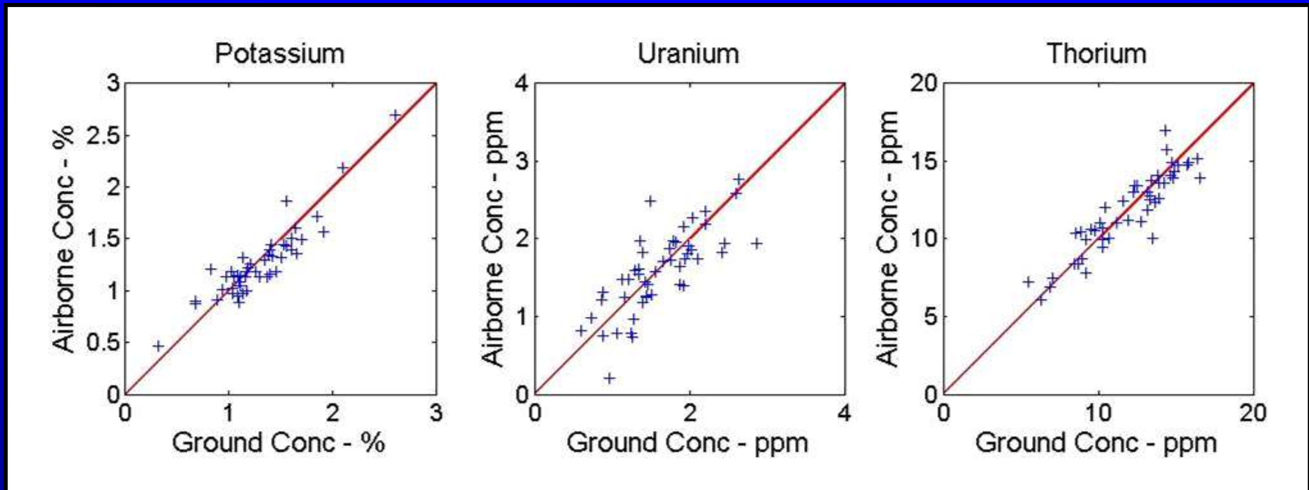


Location of 47 AWAGS back-calibration field sites

AWAGS BACK-CALIBRATION



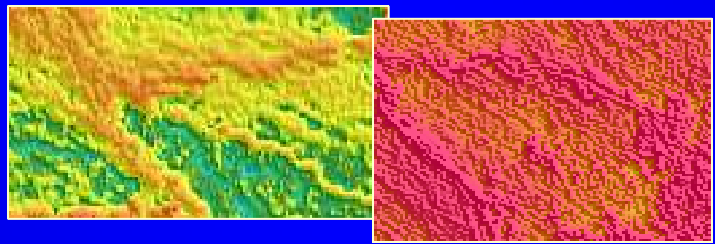
Before back-calibration



After back-calibration

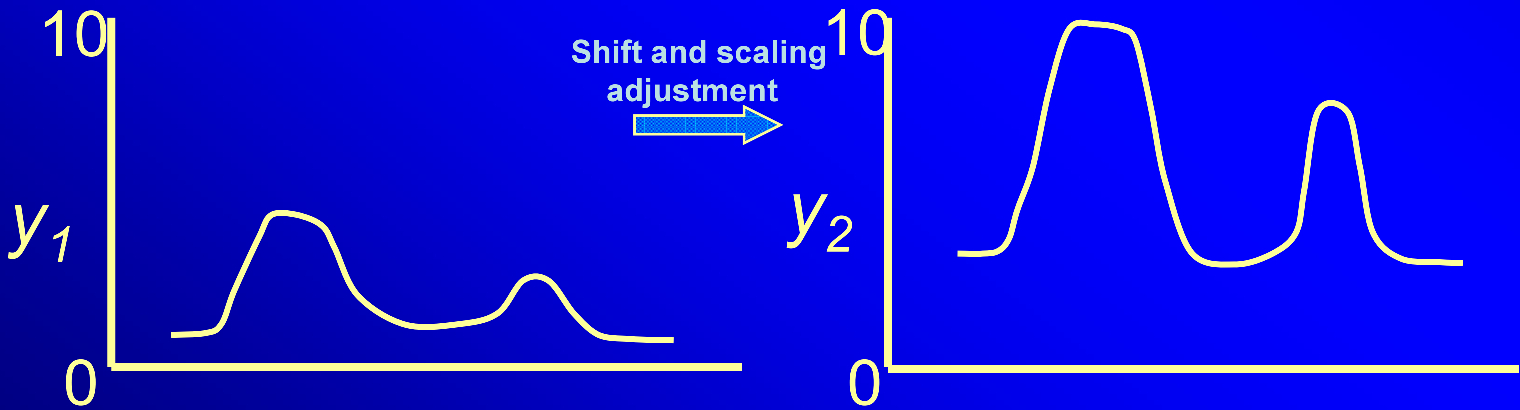
Correlation between airborne and ground K, U and Th radioelement estimates before and after back-calibration of the AWAGS data.

LEVELLING THE AUSTRALIAN NATIONAL RADIOMETRIC DATABASE



y_1 y_2

$$y_2 = G_{y_1}^{y_2} y_1 + S_{y_1}^{y_2}$$



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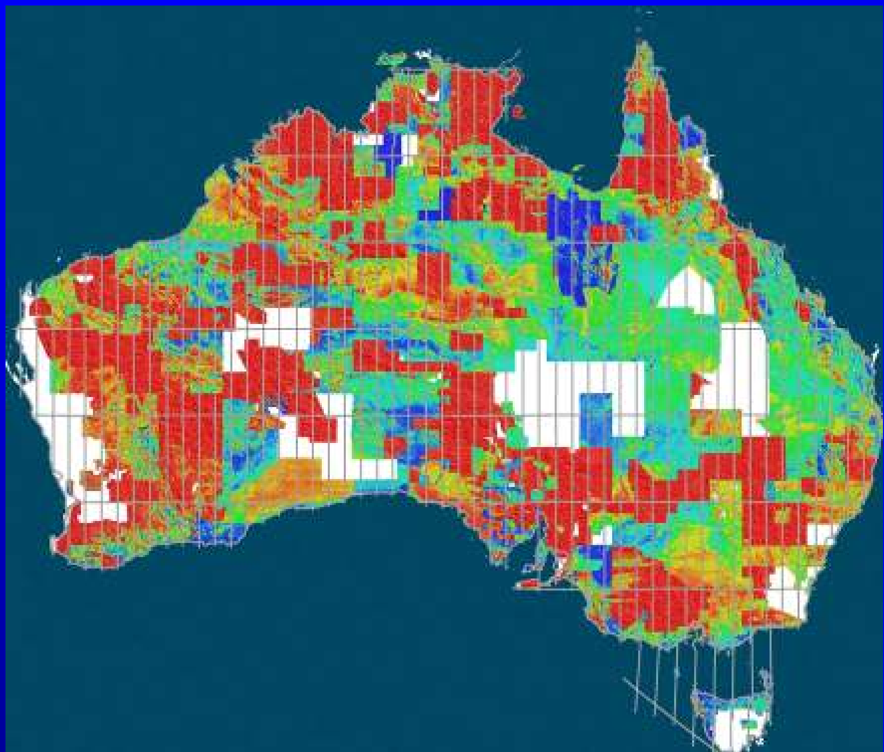
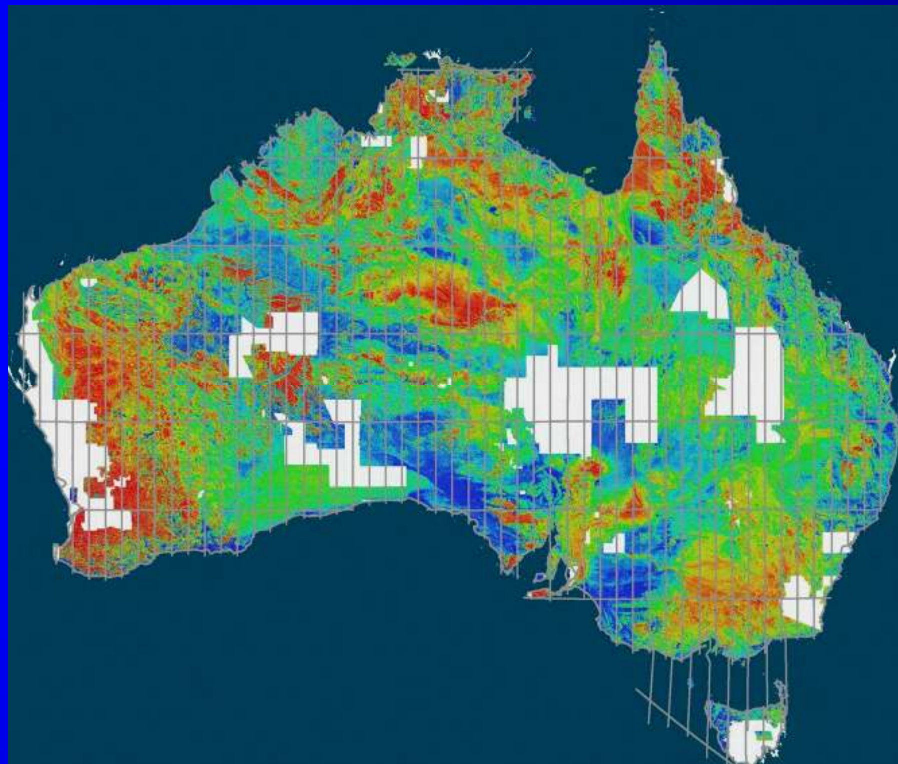
LEVELLING THE AUSTRALIAN NATIONAL RADIOMETRIC DATABASE



Concentration of thorium before grid levelling

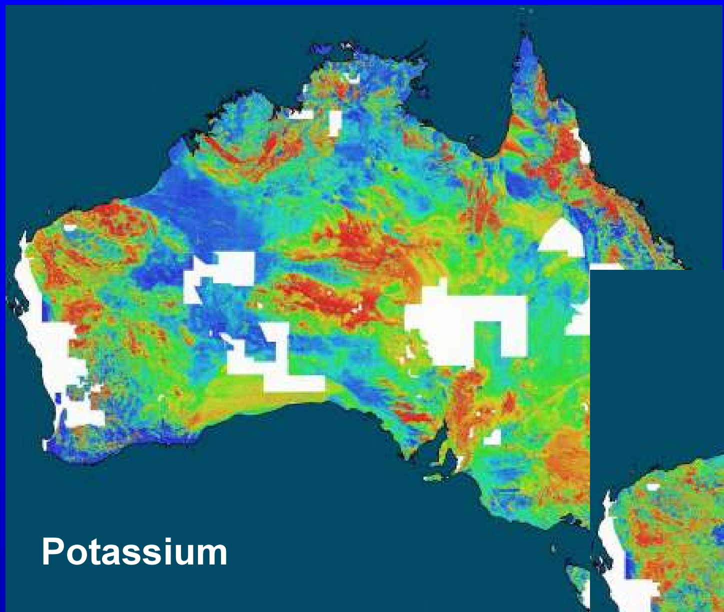


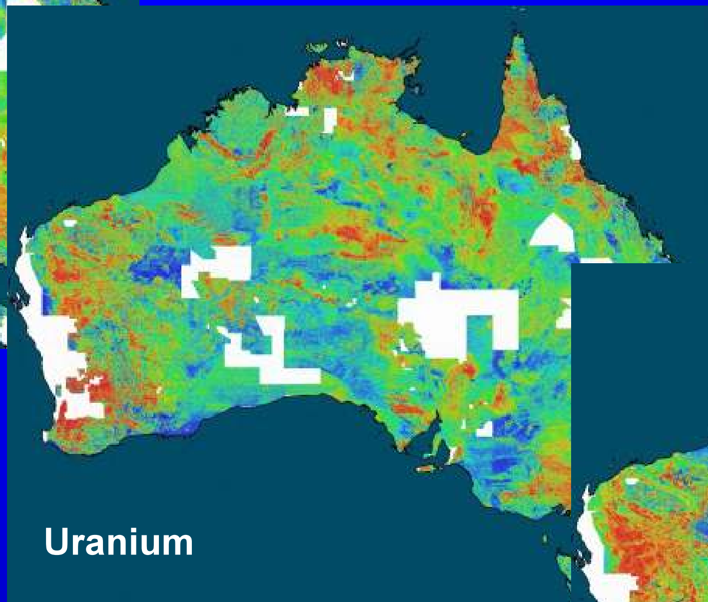
Concentration of thorium after grid levelling

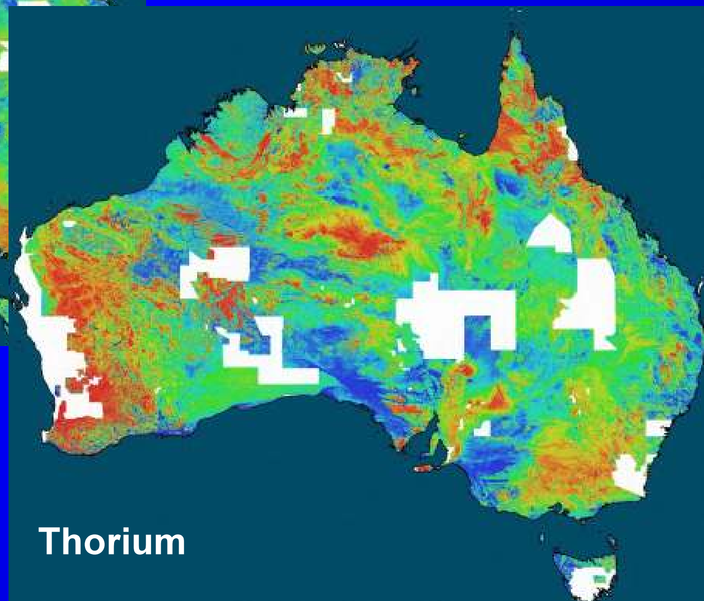
Geoscience Australia

THE RADIOMETRIC MAP OF AUSTRALIA

* Heat flow studies and geothermal energy
* Background map for radioactive contamination



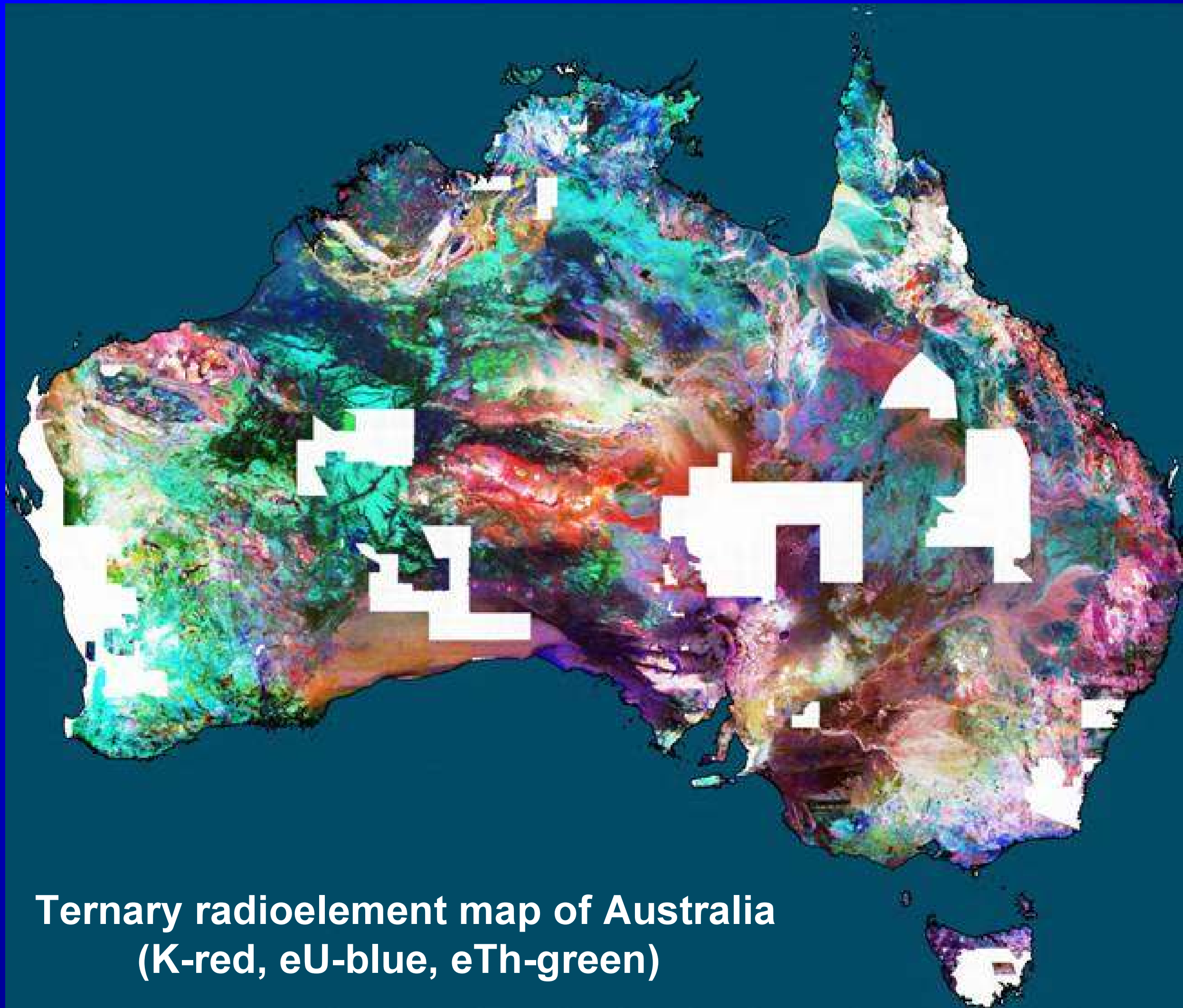




Benefits:

* A consistent map
* Uranium and thorium potential
* Integration with other geophysical data sets
* Derivation of a terrestrial gamma dose rate map
* Comparison of geochemical patterns in survey areas

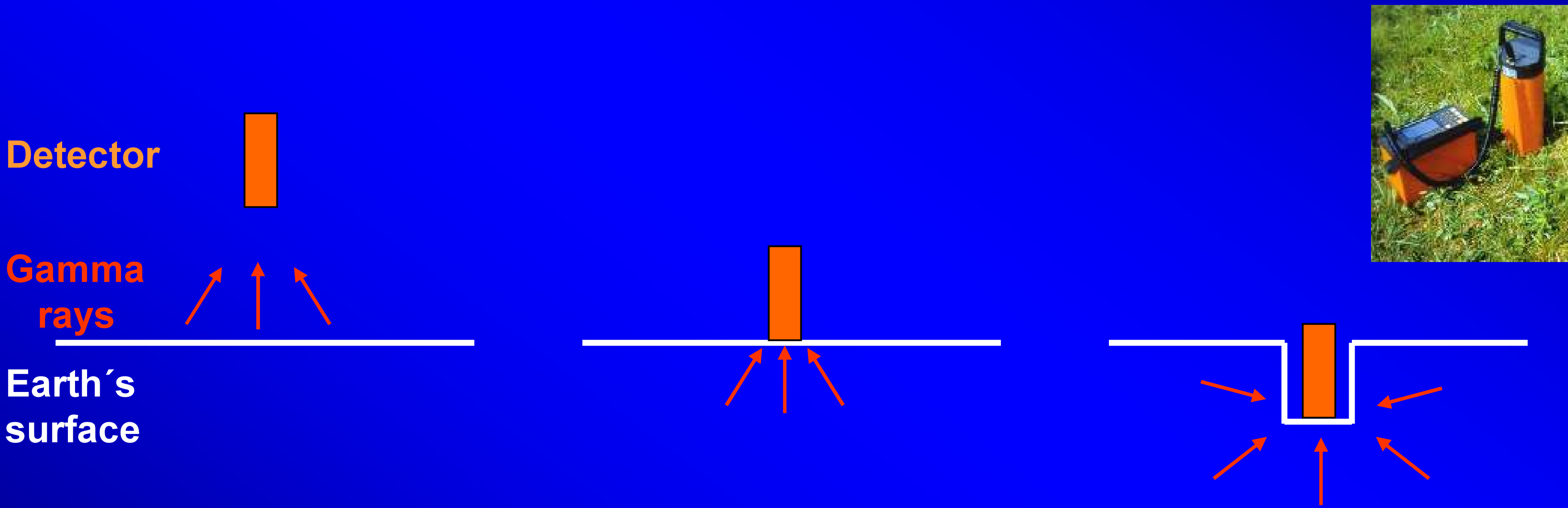
THE RADIOMETRIC MAP OF AUSTRALIA



The Radiometric Map of Australia link: www.ga.gov.au/minerals/research/national/radiometric

LEVELLING GROUND GAMMA-RAY SPECTROMETRIC DATA

Source – detector geometry is specified by the solid angle ω subtended by the source at the detector

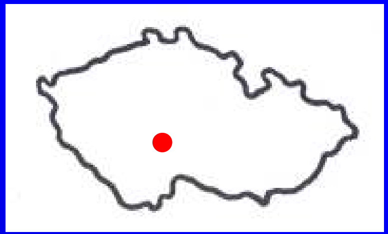


ω = 2π (sr)	***ω = 2π (sr)***	***ω > 2π (sr)***
+ attenuation of gamma rays in air	**calibration geometry**	

FIELD EXPERIMENTS

The descrease in gamma radiation with height above the earth surface

Czech Republic



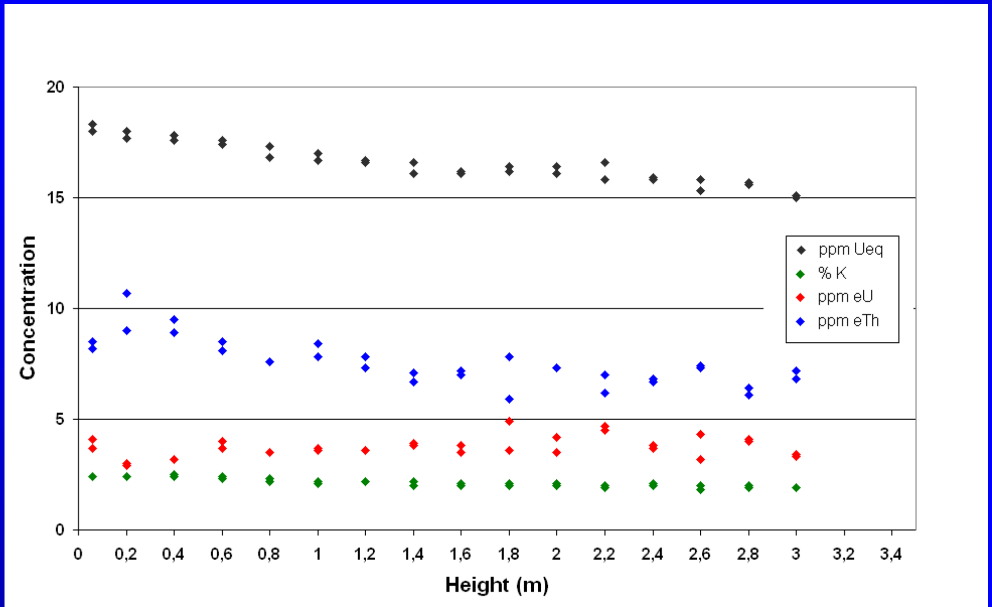
● Test site – crystalline rocks

Range of measurements 0 – 3 m in increments 0.2 m

Charles University in Prague

FIELD EXPERIMENTS

The descrease in gamma radiation with height above the earth surface



$I_h = I_0 E_2(\mu h)$

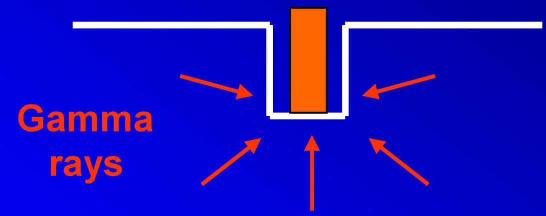
μ – linear attenuation coefficient of gamma rays in air (m^{-1})

Decrease in gamma radiation at low altitudes is relatively high and should be considered for ground data levelling

Parameter	TC	K	U	Th	Above
Energy (keV)		1461	1765	2615	ground
Decrease gamma (%)	7.2	10.4	6.4	5.4	0 – 1 m
μ (m^{-1}) ground	0.0168	0.0222	0.0129	0.0156	0 – 3 m
μ (m^{-1}) airborne	0.0067	0.0082	0.0084	0.0066	Flying height

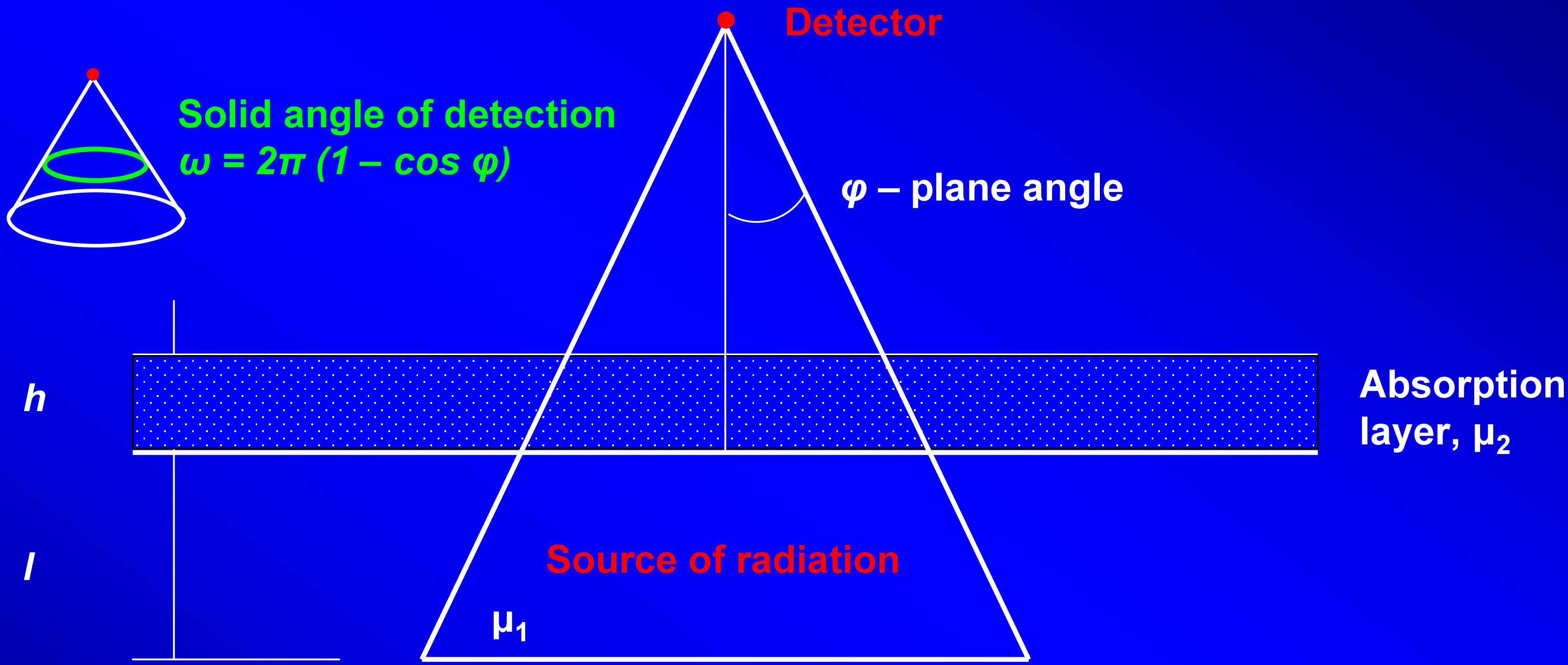
FIELD EXPERIMENTS

The increase in gamma radiation in a shallow hole and estimate of correction factors



Range of depth 0 – 0.4 m.
Field assays of K, U, Th and soil samples were taken in increments of depth 0.04 m.
K, U and Th in soil samples were also analyzed in laboratory.

GAMMA RADIATION OF A TRUNCATED CONE



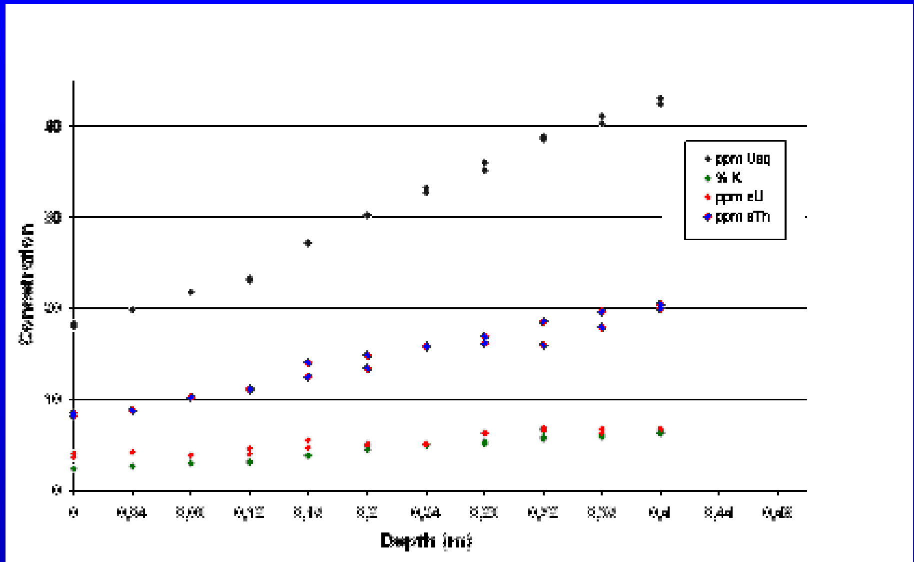
$$I = \frac{2\pi k c \rho}{\mu_1}\{E_2(\mu_2 h) - \cos\varphi\; E_2(\mu_2 h \sec\varphi) - E_2(\mu_2 h + \mu_1 l) + \cos\varphi\; E_2[(\mu_2 h + \mu_1 l)\sec\varphi]\}$$

E_2 – integral exponential function of the second kind

Charles University in Prague

FIELD EXPERIMENTS

The increase in gamma radiation in a shallow hole and estimate of correction factors



Correction factors for the conversion of apparent K, U, and Th concentrations determined in shallow hole to concentrations measured at the surface

Estimates of multiplication correction constants for radiometric measurement in shallow holes

Depth (m)	TC	K	U	Th	Based on	ω (sr)
0.0	1.00	1.00	1.00	1.00		2π · 1.00
0.2	0.60	0.53	0.76	0.59	Experiment	
	0.59	0.59	0.59	0.59	Geometrical model	2π · 1.68
0.4	0.42	0.39	0.59	0.41	Experiment	
	0.52	0.52	0.52	0.52	Geometrical model	2π · 1.91

Thank you for your attention !

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