


The Mole

passive gamma-ray soil sensor system



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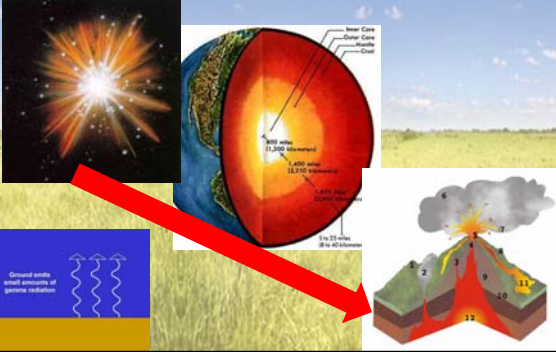
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2. Gamma-ray



Inner Core
Outer Core
Mantle
Crust

3,000 miles (4,800 kilometers)
1,000 miles (1,600 kilometers)
4,000 miles (6,400 kilometers)
12,700 miles (20,300 kilometers)

Ground emits small amounts of gamma radiation

2. Gamma-ray

Radioactivity

heavy, unstable element (e.g. Uranium)

spontaneous decay

- alpha particles (He nuclei)
- proton
- beta particle (electron)
- neutron
- gamma ray

α

β

γ

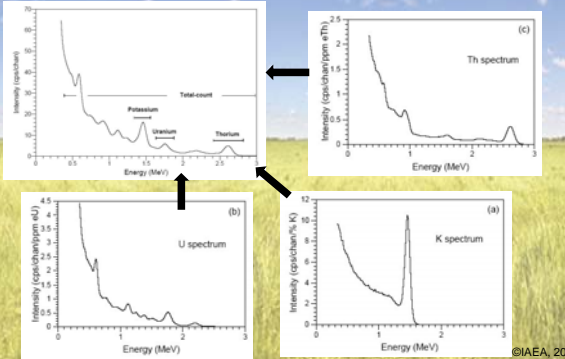
- Alfa: He, shielded by paper
- Beta: 1 electron, shielded by aluminum
- Gamma: EM radiation, shielded by 4 m lead

2. Gamma-ray

Half life times

²³⁸ U	4.46*10 ⁹ yr
²³² Th	1.39*10 ¹⁰ yr
⁴⁰ K	1.3*10 ⁹ yr
¹³⁷ Cs	30 yr

2. Gamma-ray: What is it?



Intensity (cps/channel) vs Energy (MeV)

Total count

Potassium

Uranium

Thorium

U spectrum

Th spectrum

K spectrum

Intensity (cps/channel) vs Energy (MeV)

Intensity (cps/channel) vs Energy (MeV)

Intensity (cps/channel) vs Energy (MeV)

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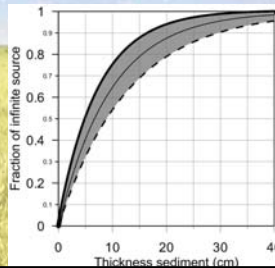
3. Gamma

Half thickness:

- Air 121m
- Water 14 cm
- Rock 6 cm
- Dry soil 10 cm

1 vol.% more soil moisture
= 1 % more attenuation

90 % of radiation from top
30 cm of soil



4. Measurement gamma ray

Sensing system The Mole consists of:

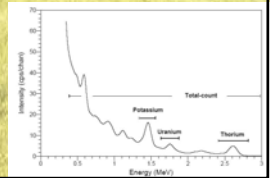
- Csl crystal
- Photomultiplier
- Multi-Channel Analyser (MCA)
- USB connection to laptop
- Laptop
- GPS
- Dedicated data log software



4. Measurement gamma ray

Spectrum analysis:

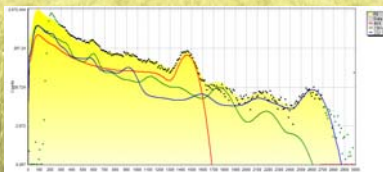
- Windows/ROI analysis
- Full Spectrum Analysis (FSA)
- Multivariate (PLSR, data mining, regression trees)
- Deterministic



4. Measurement gamma ray

Full Spectrum Analysis

- Standard spectra of 1 Bq/kg of a nuclide
- Sensor (crystal) specific
- Incorporates sensor calibration
- Chi-squared algorithm

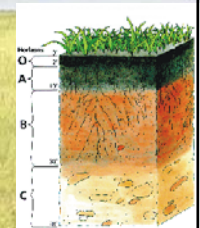


5. From gamma to soil properties

Which properties can be mapped?

- Soil texture, clay, loam, grain size
- Nutrients, soil organic matter, pH, Fe, K
- Basis for soil models / pedotransfer functions

Depends on the size and scale of
calibration dataset



5. From gamma to soil properties

Sampling/calibration

- Nutrients – Field/ local scale
- Texture – Regional scale
- Parent material – Global scale possibly

Different calibration approaches:

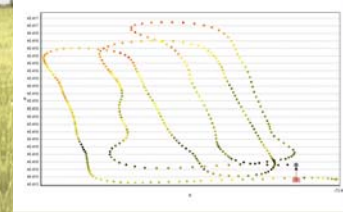
- Separate spectrum analysis (ROI, FSA)
- Incorporated spectrum to soil data conversion (multivariate, deterministic)

Field day

Site 40 by 60 meter

5 rows

Very wet conditions



Field day

Spectrum analysis

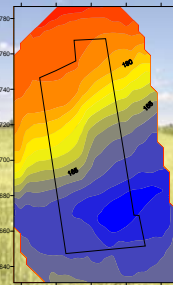
Moving average

11 seconds



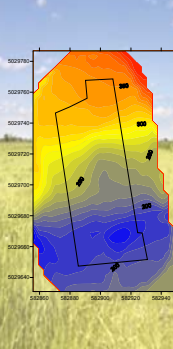
Field day

Total counts



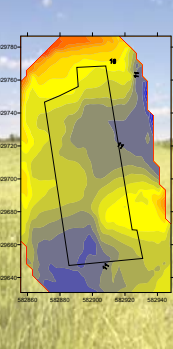
Field day

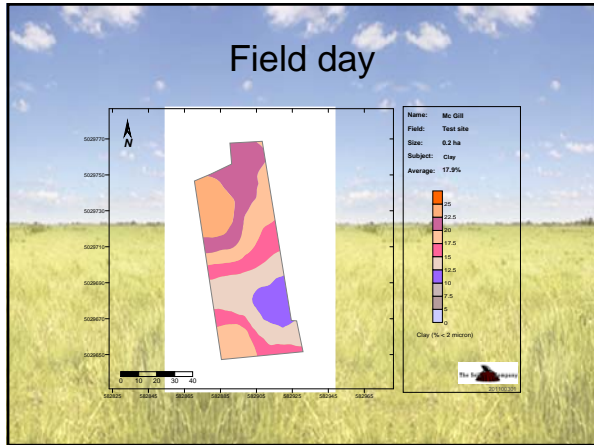
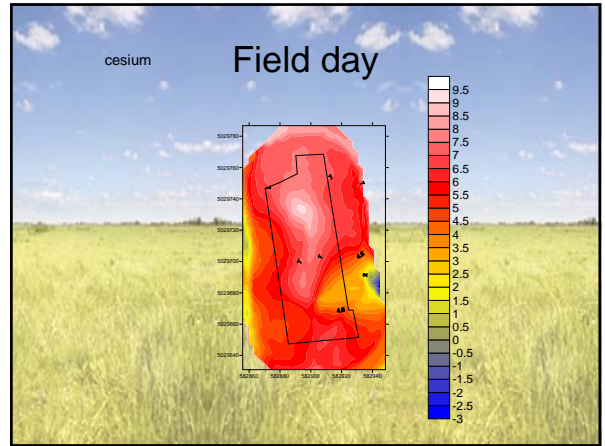
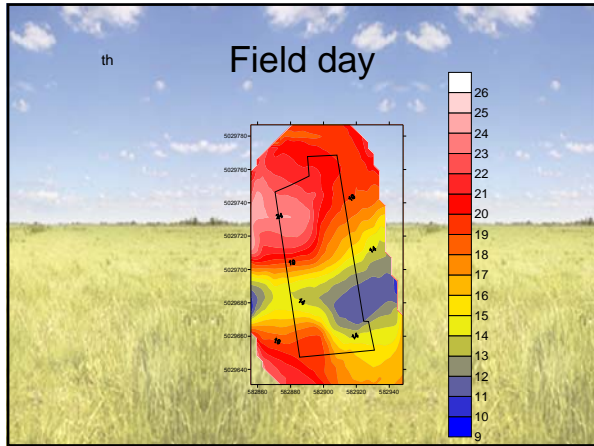
K40



Field day

uranium





Thank you for your attention.

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