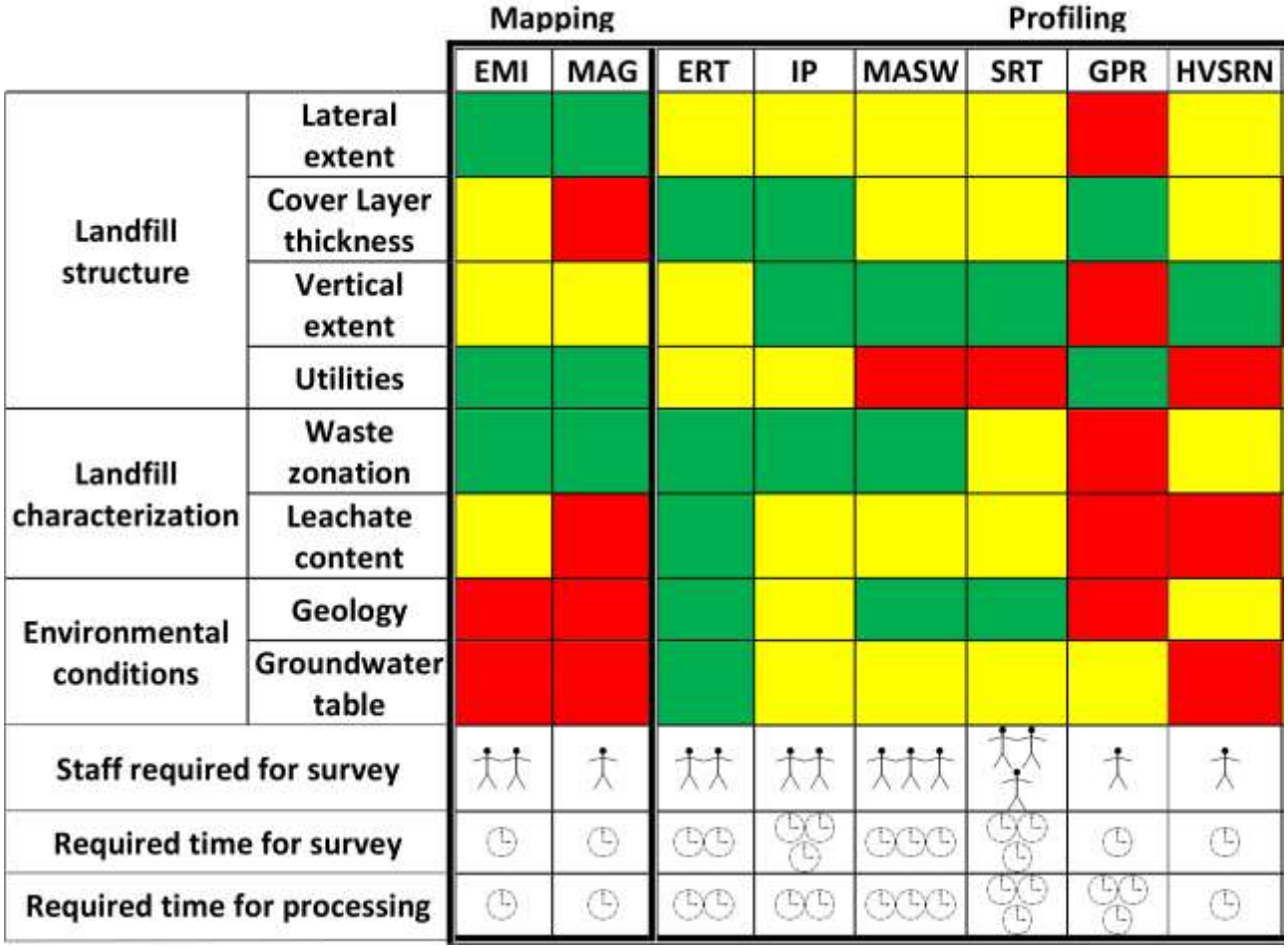
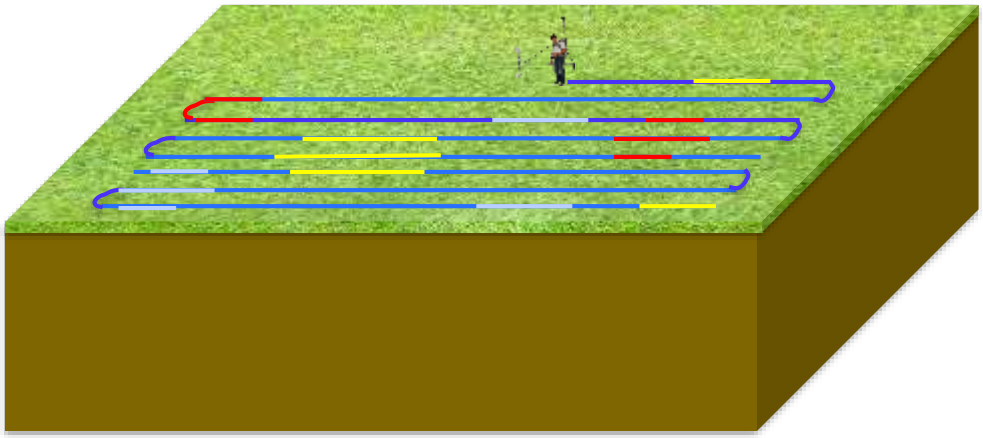
Principles, targeted properties and examples of geophysical methods applied in landfills

ULiege & BGS


Mapping
Profiling
EMI
MAG
ERT
IP
MASW
SRT
GPR
HVSRN
Landfill structure
Lateral extent
Cover Layer thickness
Vertical extent
Utilities
Landfill characterization
Waste zonation
Leachate content
Environmental conditions
Geology
Groundwater table
Staff required for survey
Required time for survey
Required time for processing

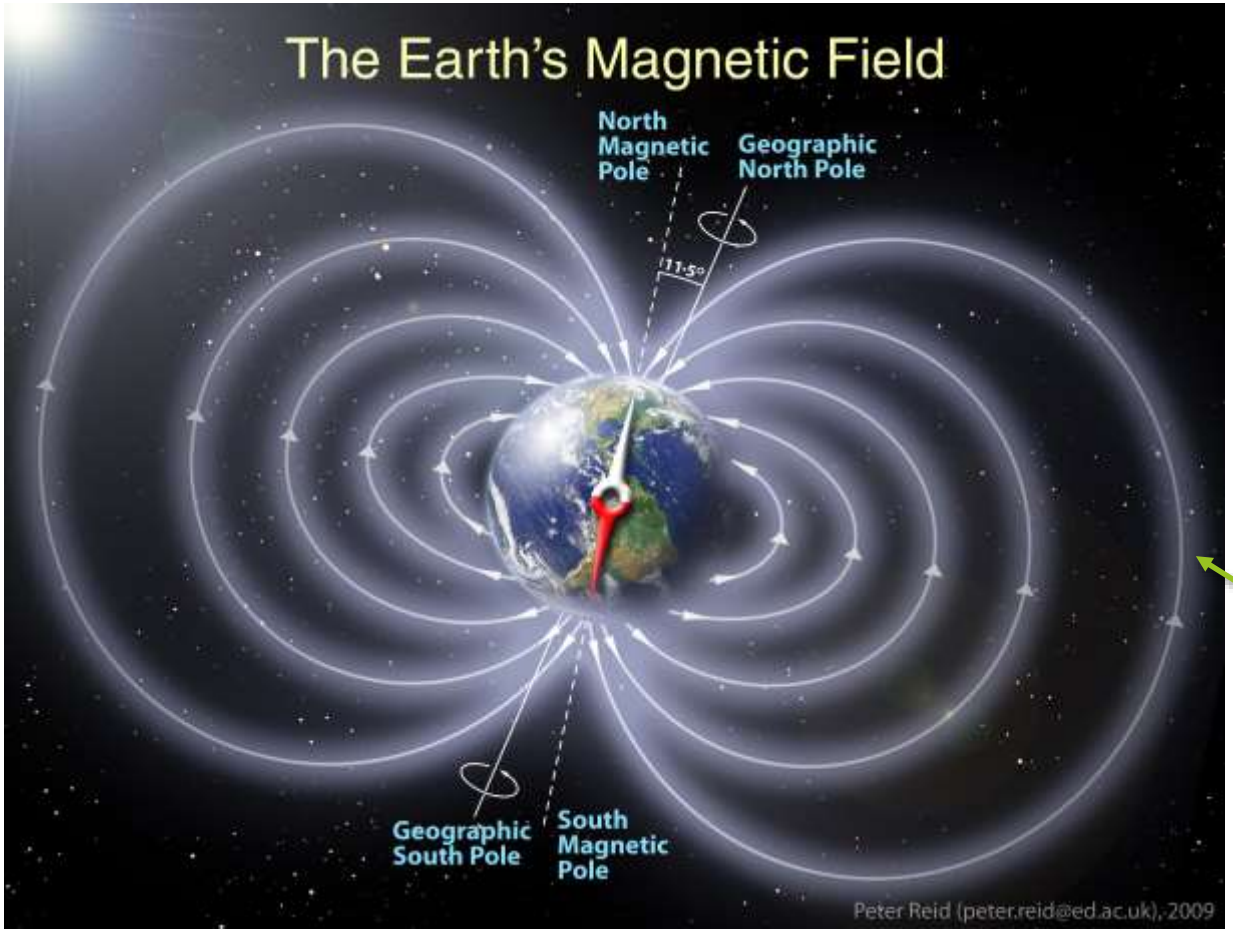
Mapping methods

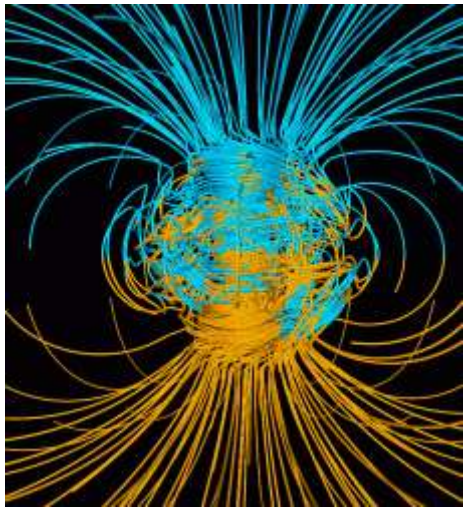
- They can provide a wide spatial coverage
- Relatively easy to deploy and acquire data



Introduction to Magnetometry

Basic principle





Glatzmaier-Roberts geodynamo model

Schematic representation of the invisible magnetic field lines

For example, in Liege (Belgium)

Magnetic Field

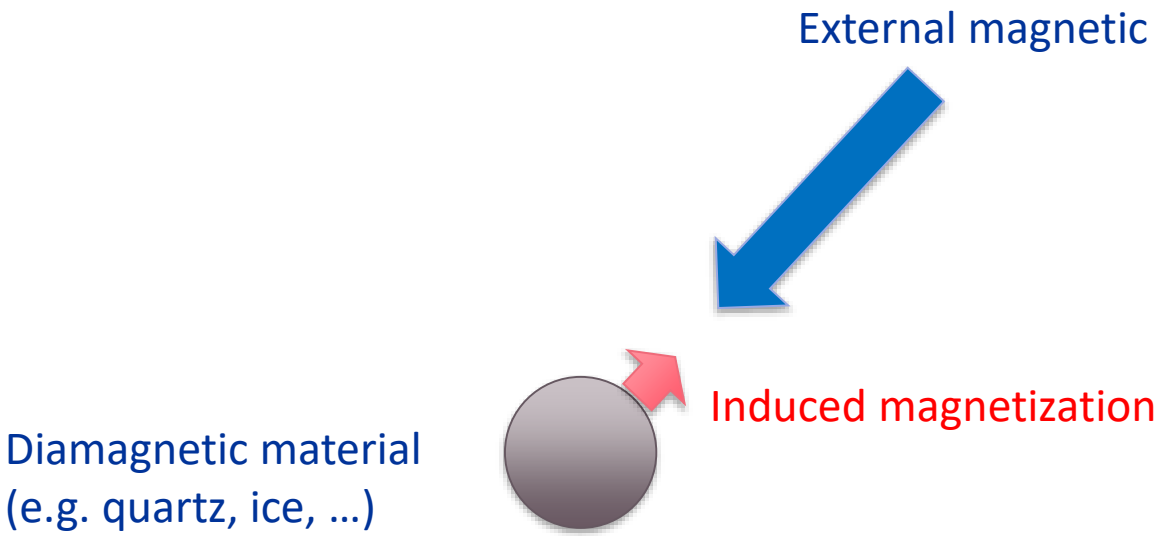
Model Used:	IGRF2020
Latitude:	50° 38' 43" N
Longitude:	5° 34' 21" E
Elevation:	0.0 km Mean Sea Level

Date	Declination (+ E | - W)	Inclination (+ D | - U)	Horizontal Intensity	North Comp (+ N | - S)	East Comp (+ E | - W)	Vertical Comp (+ D | - U)	Total Field
2020-02-25	1° 57' 1"	66° 2' 7"	19,850.6 nT	19,839.1 nT	675.6 nT	44,659.0 nT	48,872.0 nT
Change/year	0° 11' 10"/yr	0° 0' 44"/yr	10.2 nT/yr	8.0 nT/yr	64.8 nT/yr	48.5 nT/yr	48.5 nT/yr

*National Centers for Environmental Information –National Oceanic and Atmospheric Administration (NOAA)

The magnetometry method aims to find disturbances in the Earth's magnetic field

Magnetic disturbances?

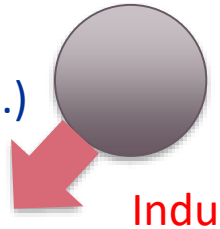


Weak, negative magnetic susceptibility of around -10^{-6} à -10^{-5} SI

Magnetic disturbances?

External magnetic field

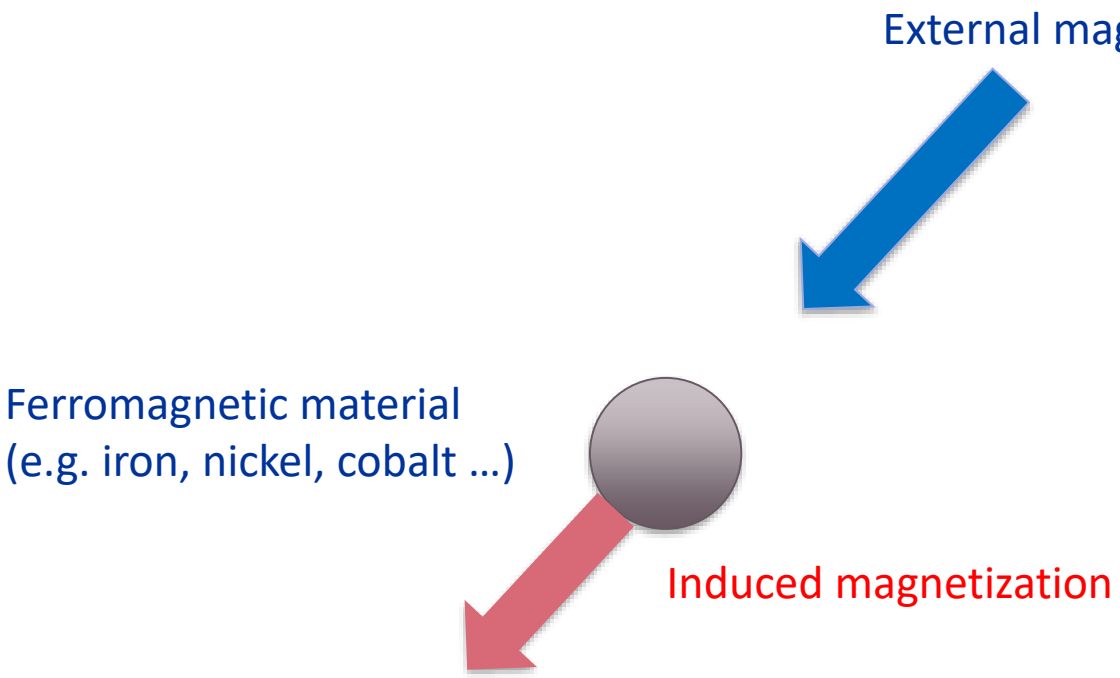
Material paramagnetic
(e.g. aluminium, sodium, lithium…)



Induced magnetization

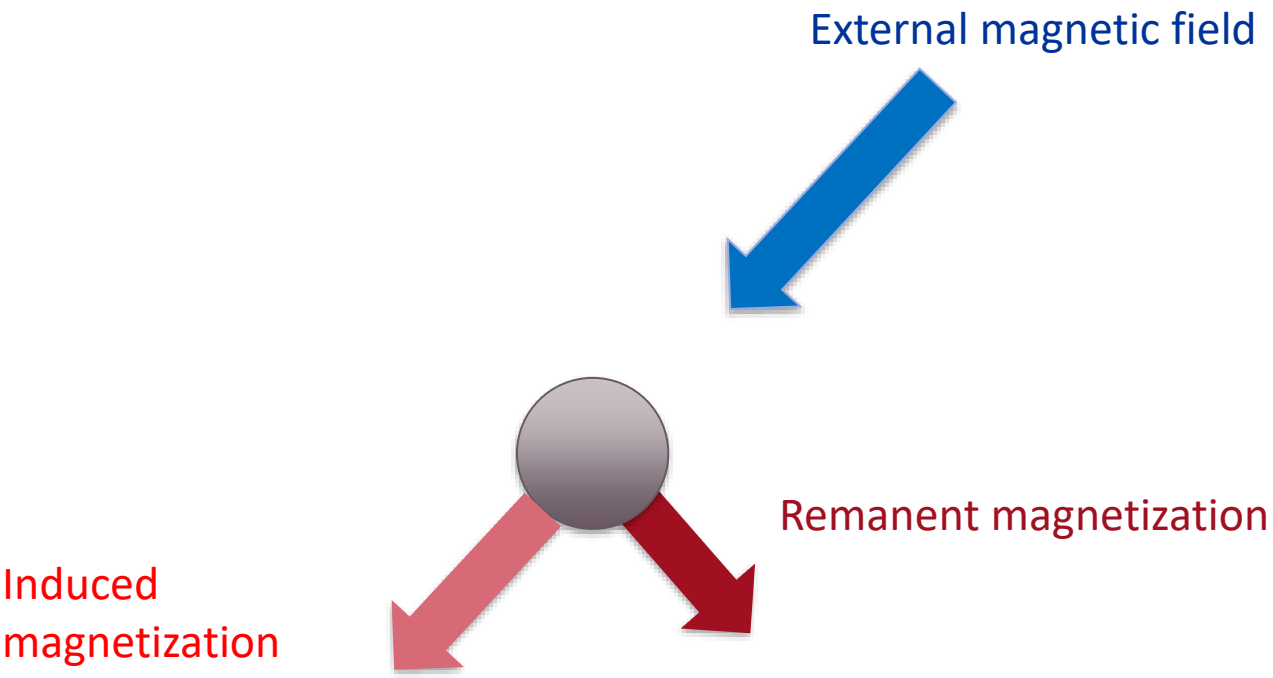
Weak, positive magnetic susceptibility of around 10^{-5} à 10^{-3} SI

Magnetic disturbances?

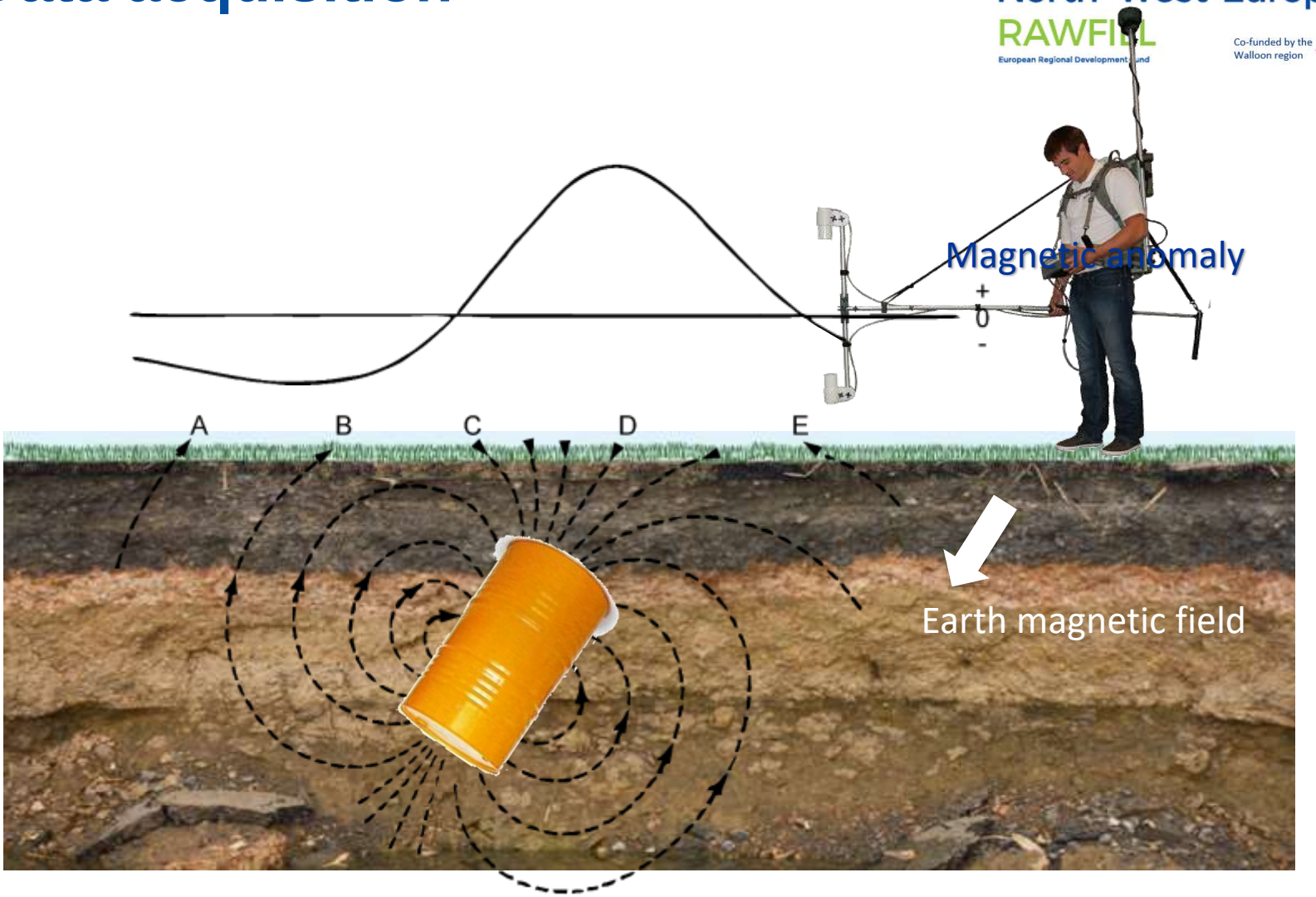


Large magnetic susceptibility of around 50 à 10^4 SI

Magnetic disturbances ?



Data acquisition

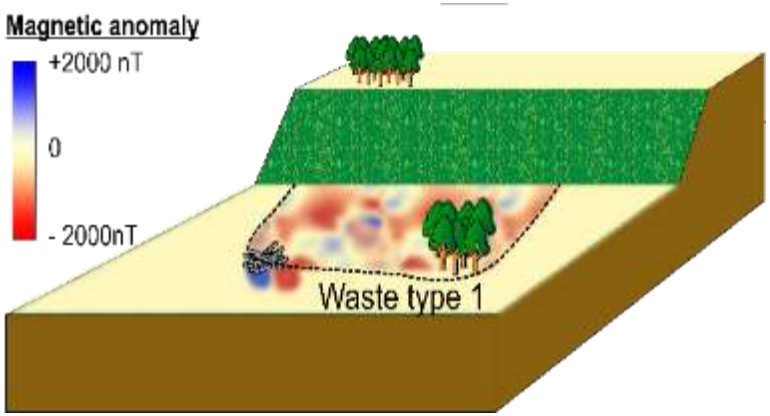



Trimble

Targeted property

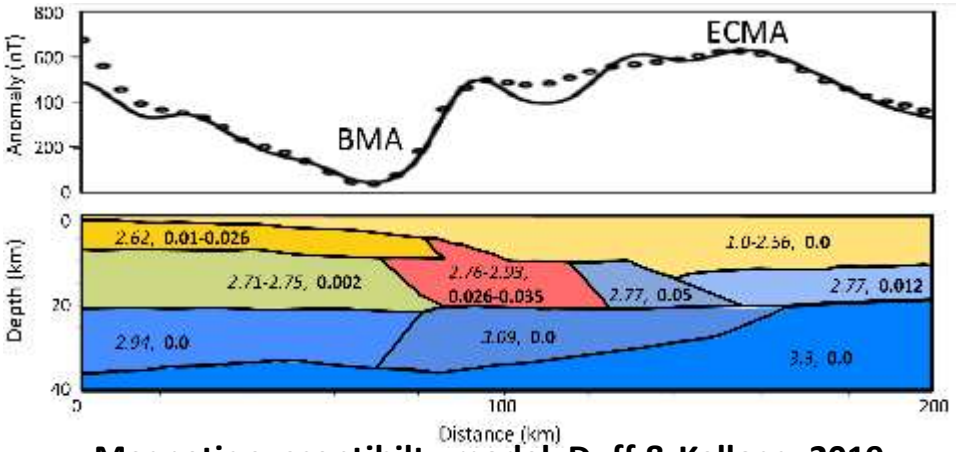
Qualitative

Display the magnetic field values, the magnetic gradient or total field magnetic anomaly



Quantitative

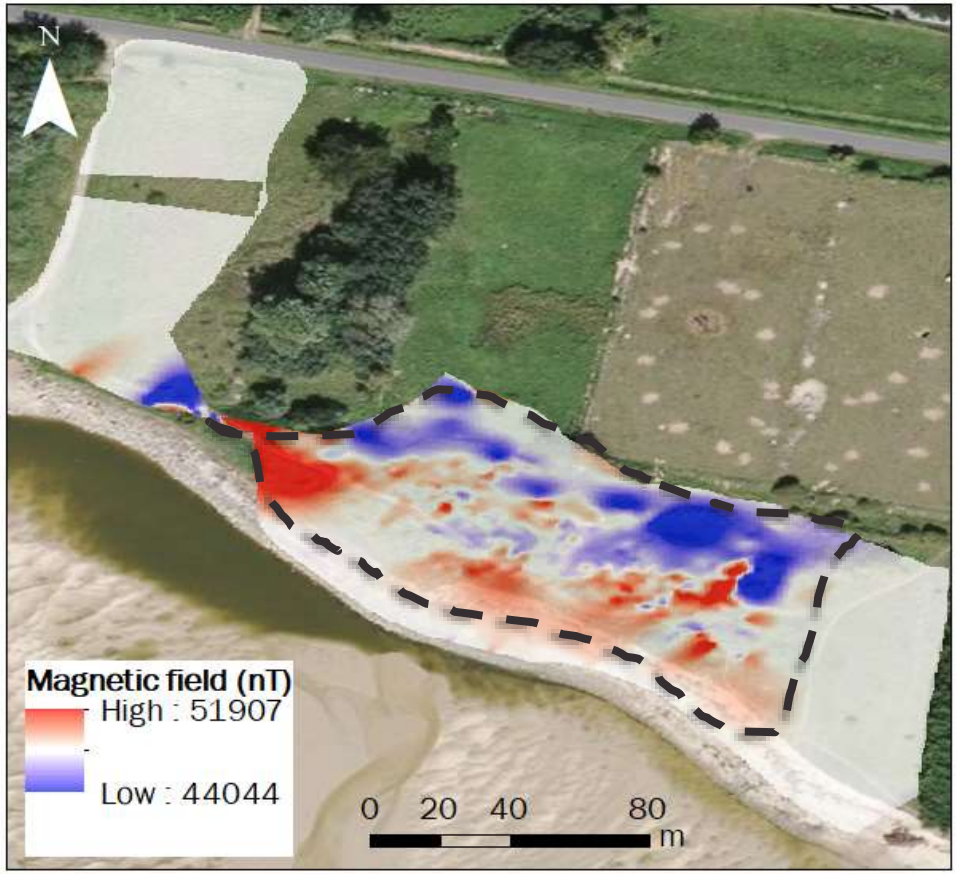
Model and/or invert the data to estimate magnetic susceptibility



Magnetic susceptibilty model. Duff & Kellogg, 2019.

Magnetic susceptibility of MSW → 0.06-0.12 SI (Vollprecht et al., 2019; Appiah et al., 2018)

Lingreville landfill



Waste lateral extension

Pros and cons

Interreg North-West Europe RAWFILL
European Regional Development Fund
Co-funded by the Walloon region

Advantages

- Relatively easy to deploy in the field
- Rapid spatial coverage
- Can detect magnetic objects (e.g. drums)
- Can detect landfill boundaries

Limitations

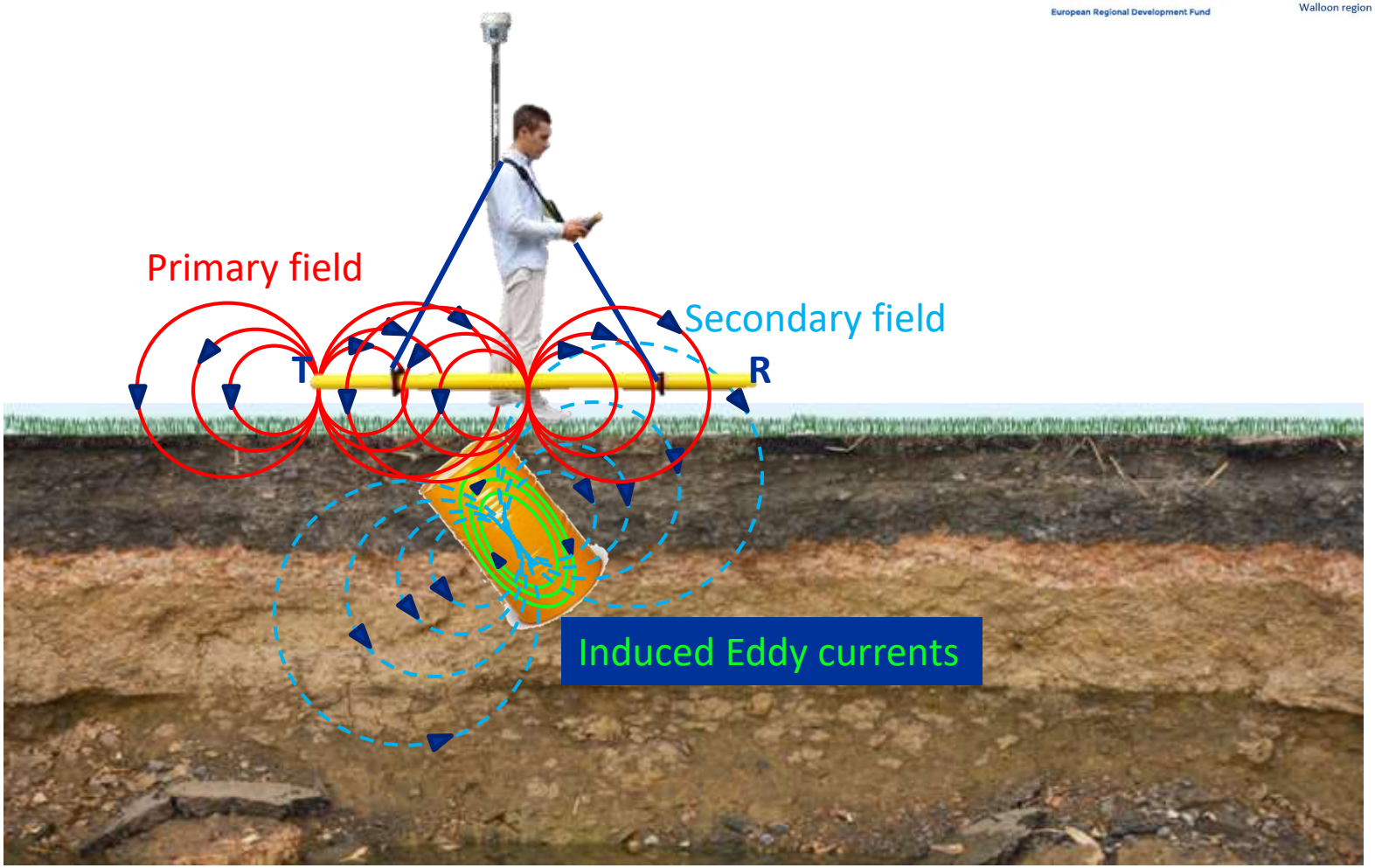
- Infrastructure of the site (e.g. fences, excavators, utilities) can interfere with the measurements
- Quantitative interpretation not trivial

Introduction to Electromagnetic induction (EMI)

Frequency-domain

ULiege & BGS

Principles and acquisition



Coil configuration

Horizontal coplanar HCP

Vertical coplanar VCP

Perpendicular coplanar VCP

Depth of investigation (DOI)

Skin depth

$$\delta = \sqrt{\frac{2}{\mu_0 \omega \sigma}}$$

Depth of penetration dependent on:

- Frequency of transmitted electromagnetic wave
- conductivity of the subsurface

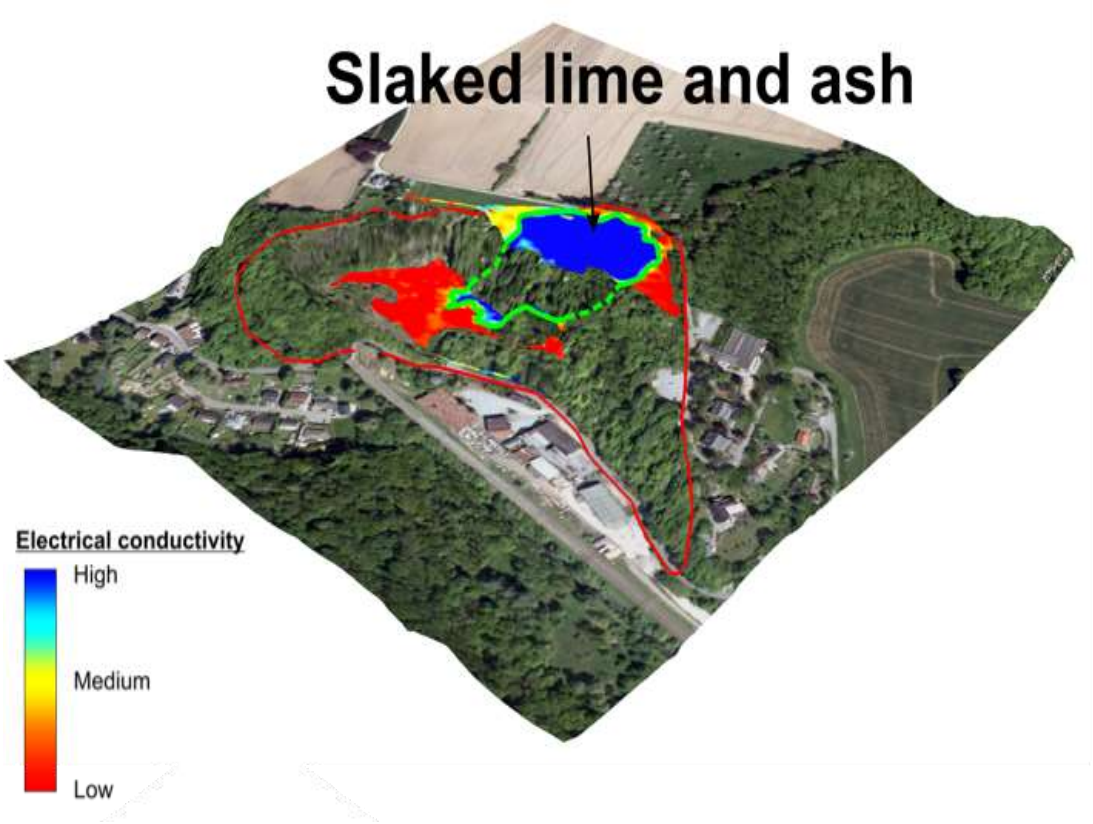
For a separation **s** between **Tx** and **Rx**, the induction number

$$\beta = \sqrt{\frac{s}{\delta}} \ll 1$$

As a rule of thumb:

- DOI ~ 1.5**s** HCP
- DOI ~ 0.75**s** VCP
- DOI ~ 0.5**s** PRP

Onoz landfill



Pros and cons

Advantages

- Rapid spatial coverage
- Can detect areas of increased leachate content and/or metallic scrap content
- Can detect landfill boundaries, geometry and structure (layering) of a landfill
- Multiple receiver coils can be used simultaneously

Limitations

- Infrastructure of the site (e.g. fences, excavators, utilities) can interfere with the measurements
- High electrical conductivity limits depth of investigation which may be problematic in landfills as organic waste, metal scraps or leachate have large values of electrical conductivity

Interreg

EUROPEAN UNION

North-West Europe

RAWFILL

European Regional Development Fund

Co-funded by the Walloon region

Thank you!

Raw materials recovered from landfills

Interreg North-West Europe RAWFILL
European Regional Development Fund
Co-funded by the Walloon region

The Interreg North-West Europe Project is coordinated by SPAQuE and unites 8 partners from 4 EU regions.

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