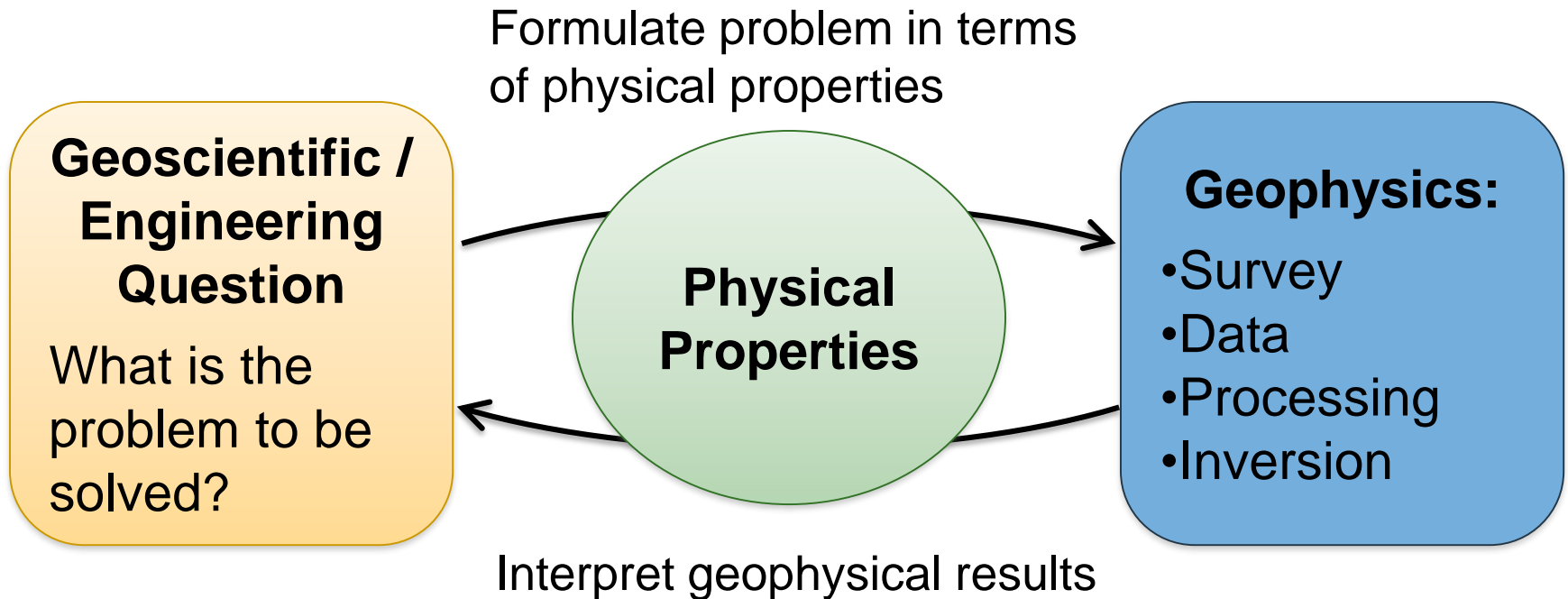


# What have we learned from the Case Histories

- Earth materials have a range of physical properties.
- Application of geophysics is carried out in a 7 Step process. Physical property of the target must be different from host material
- Knowledge of a single physical property does not uniquely identify a material. Interpretation was aided by using multiple surveys.
- Examples:
  - Gravel quarries: conductivity, elastic parameters
  - Karst investigations: density, conductivity
  - Mining: conductivity, chargeability

# MAGNETIC SURVEYING

# Principles for using Geophysics



# Some motivating examples for the use of magnetic susceptibility

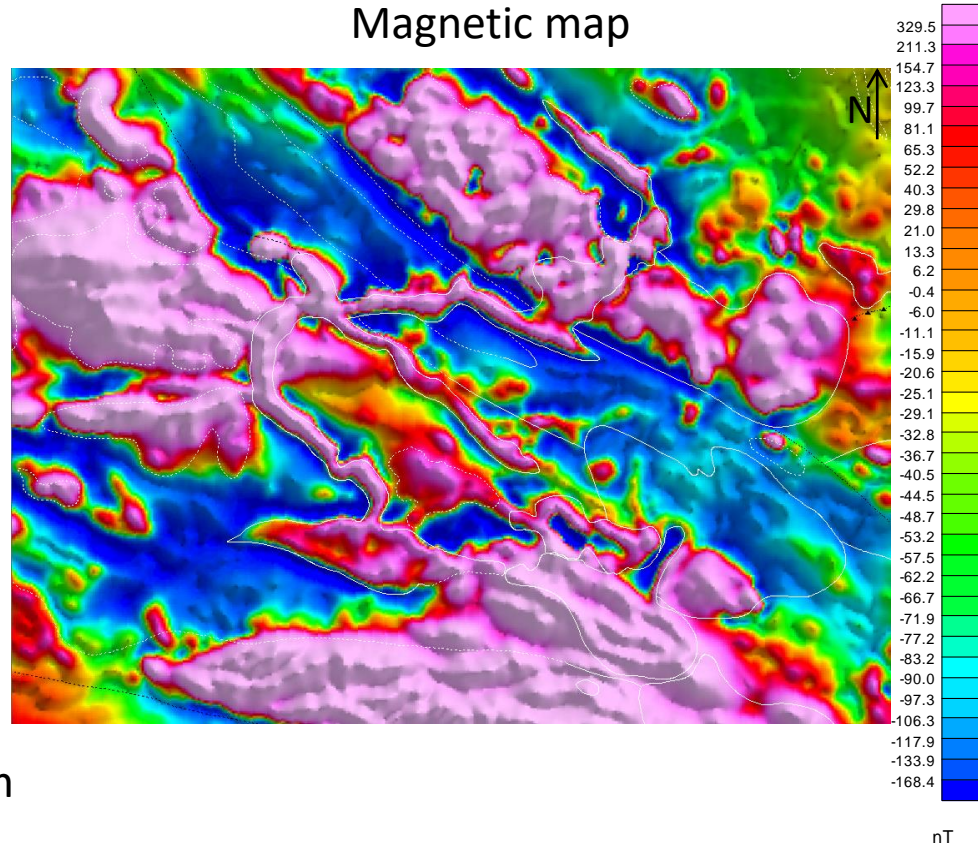
- Geologic mapping
- Ore deposits
- Geotechnical problems
- Unexploded ordnance
- Buried foundations
- Archeology

# Need for Magnetism: Geologic mapping

Geology map



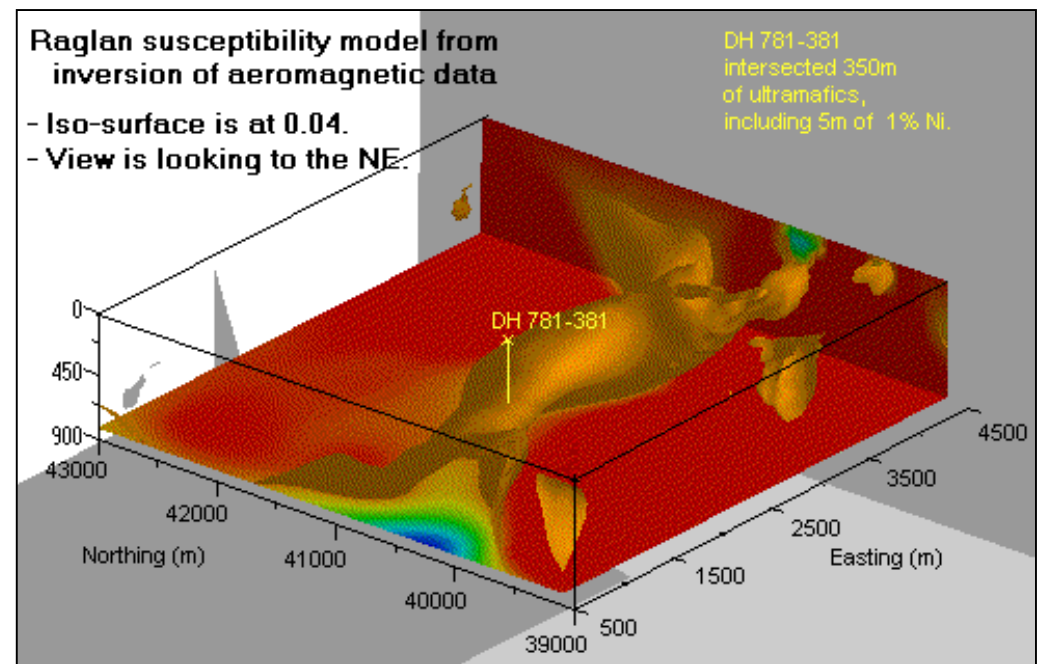
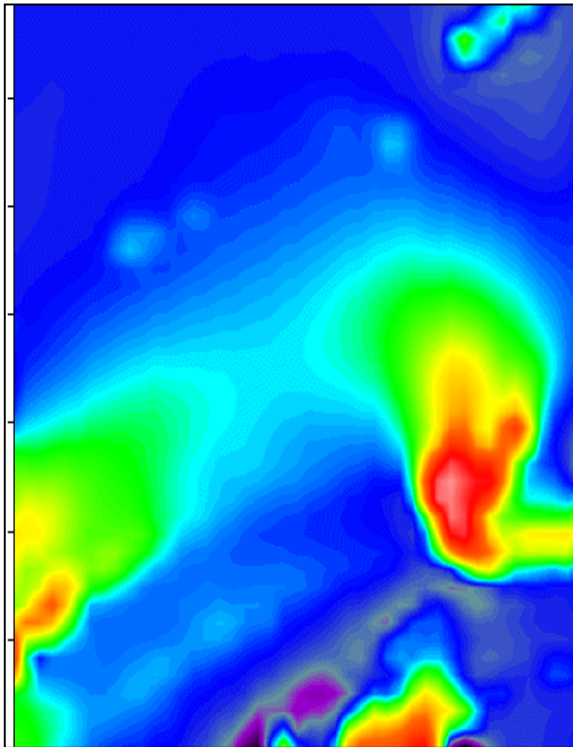
Magnetic map



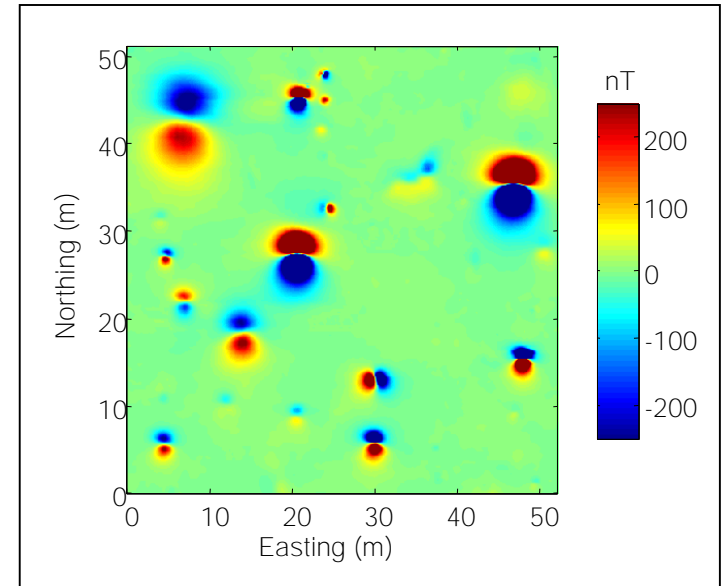
30 km

Geology contacts can be inferred from mag maps.

# Need for magnetics: Mineral exploration

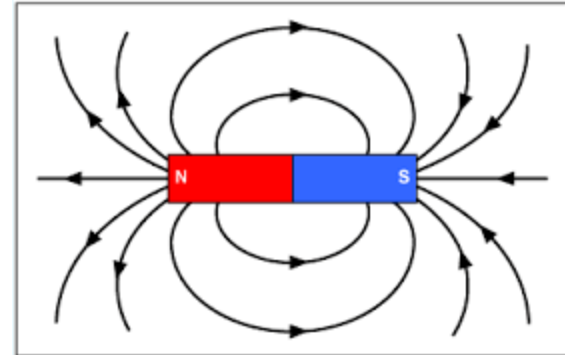
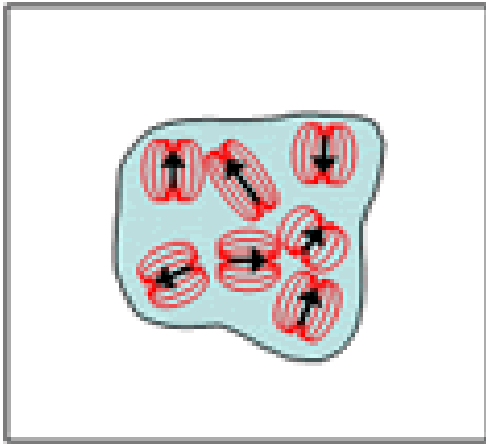


# Need for Magnetics: UXO



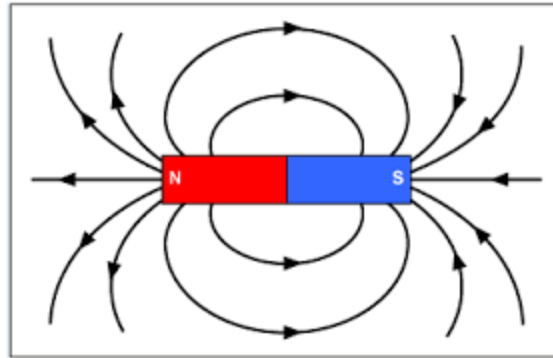
# Magnetic materials and Magnetization

- Earth materials are built up of minerals that behave as small magnets





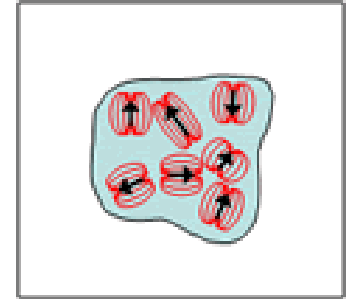
# Bar Magnet



- North pole and South pole (dipole)
- Dipole moment  $m$  is related to the strength of the magnet
- Field lines extend from the north pole to the south poles

# Magnetic materials and Magnetization

- Earth materials are built up of minerals that behave as small magnets



- Strength of each magnet is given by the magnetic moment

$$m_i \text{ A-m}^2$$

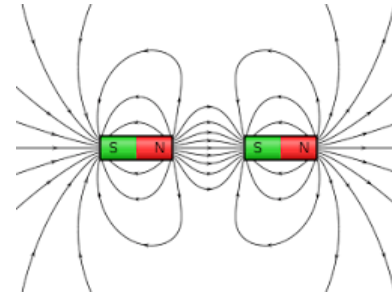
- Magnetization 
$$M = \frac{\sum m_i}{Volume}$$

Units: A/m dipole moment per unit volume

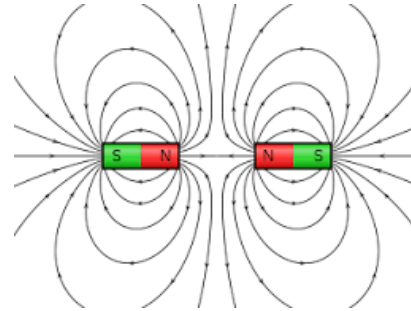
- When the particles are randomly distributed M can be zero

# Small magnets in presence of large ones

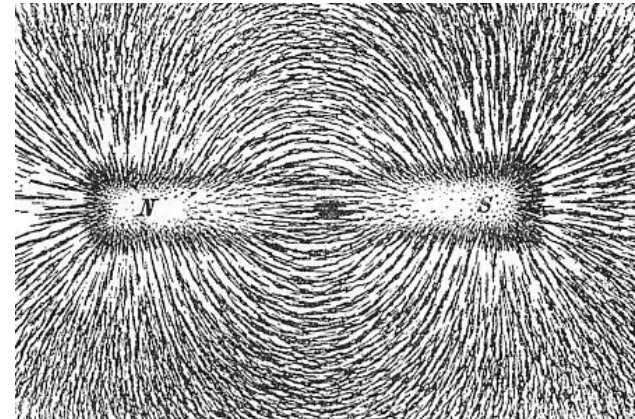
- Opposite poles attract



- Like poles repel

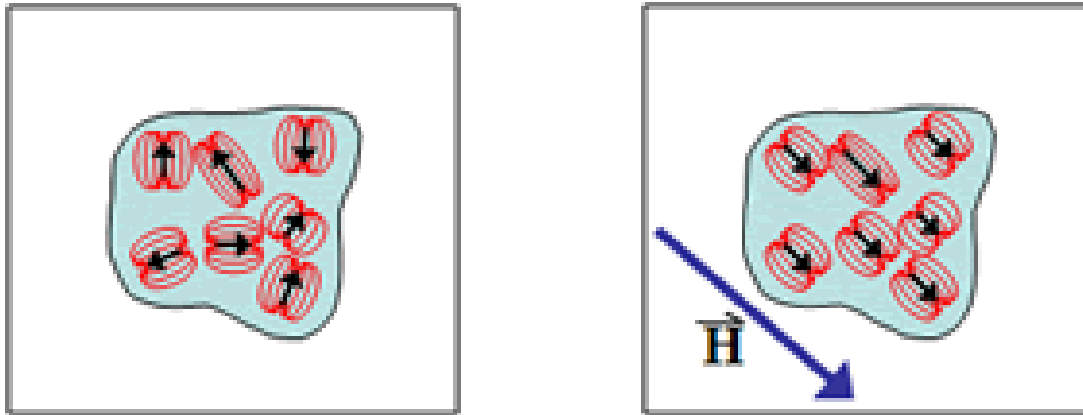


- Small magnets align with fields of a larger magnet



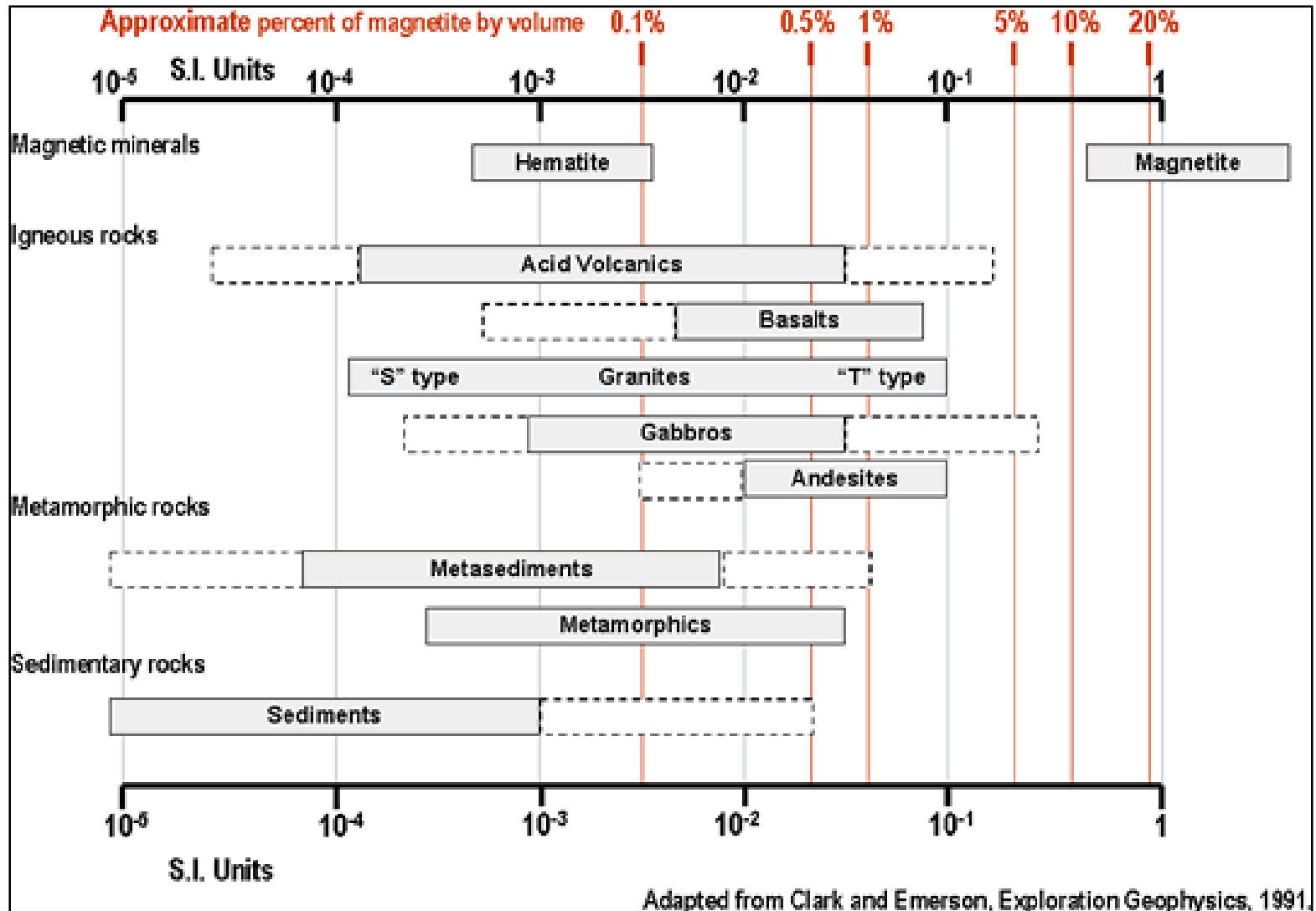
# Magnetic Susceptibility: $\kappa$

- Ability for a rock to become “magnetized” when an external magnetic field is applied.
- Units: dimensionless



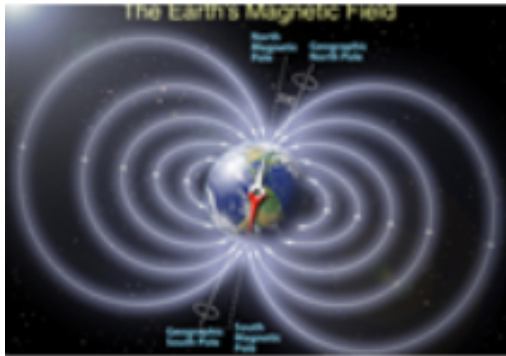
- Magnetization:  $M = \frac{\sum m_i}{Volume}$   
Units: Dipole moment per unit volume

# Magnetic Susceptibility of Rocks



# Magnetic Survey

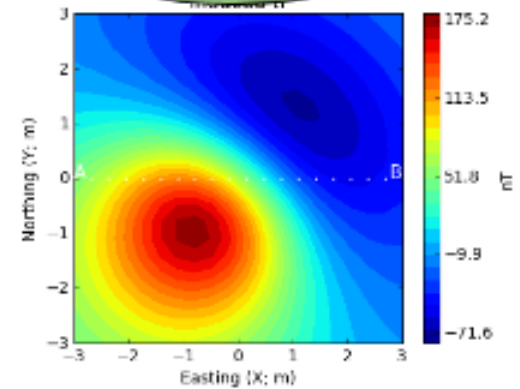
Source



Input energy

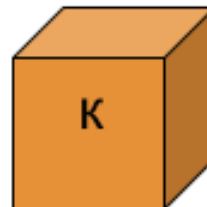
Measured response

Data



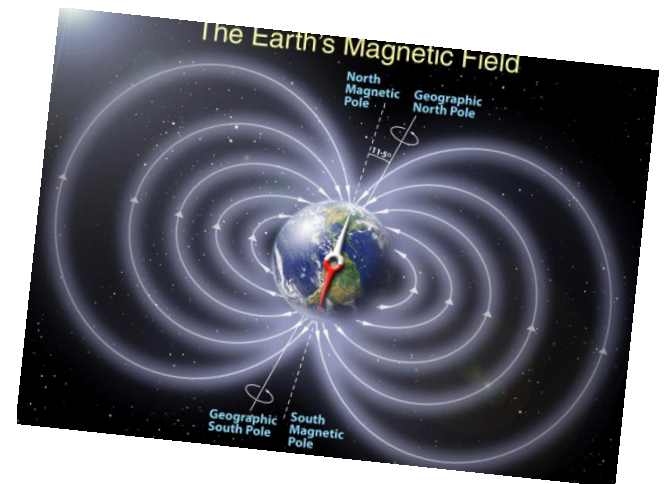
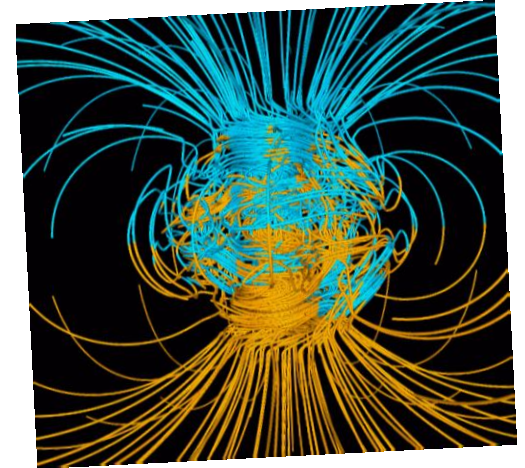
Subsurface

Physical Property:



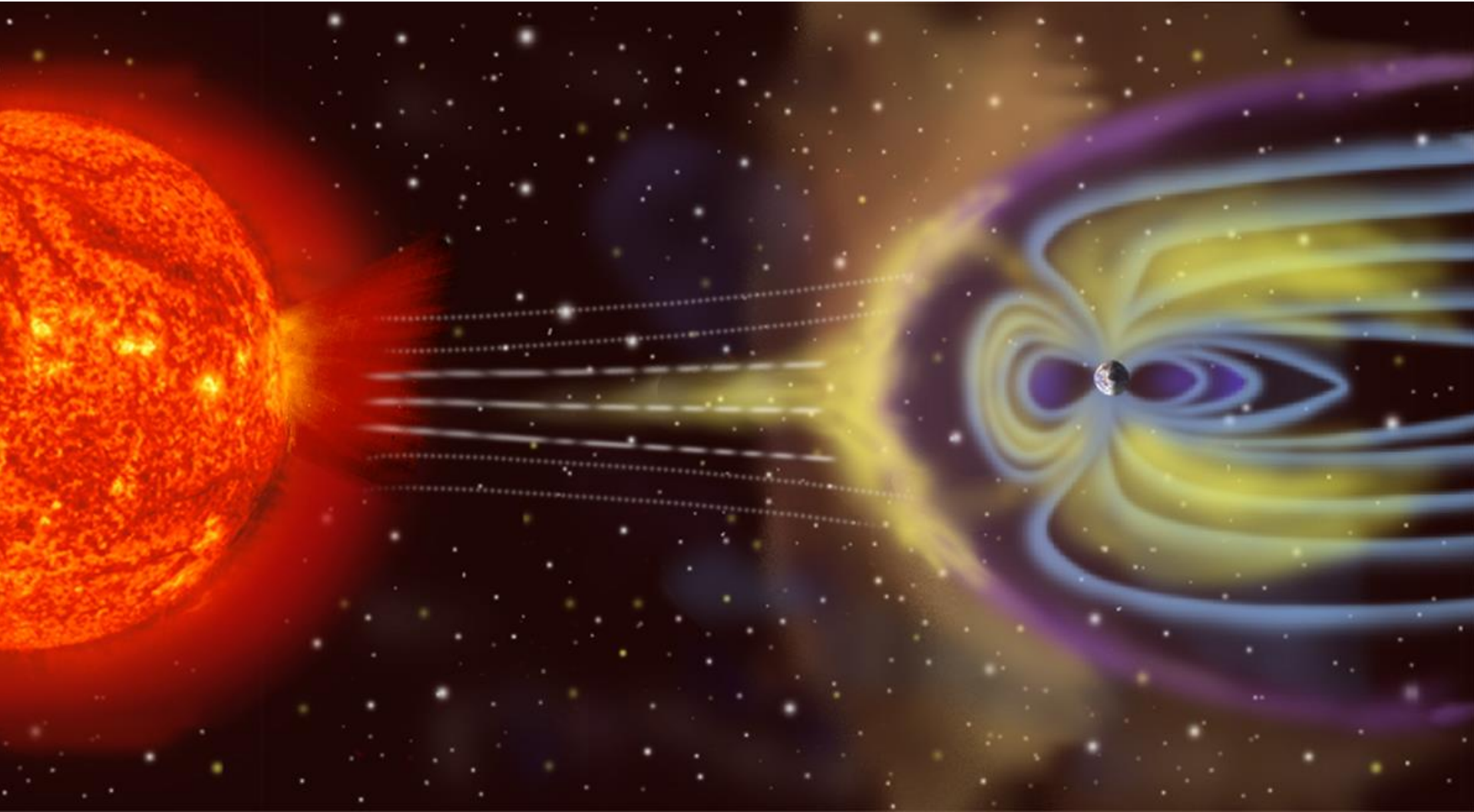
# Earth's Magnetic field

- Geomagnetic dynamo.
- Complicated inside the earth near the core.
- Outside the earth it looks like a magnetic field due to a dipole.





# Magnetics – Earth's field





# Magnetic fields and definitions

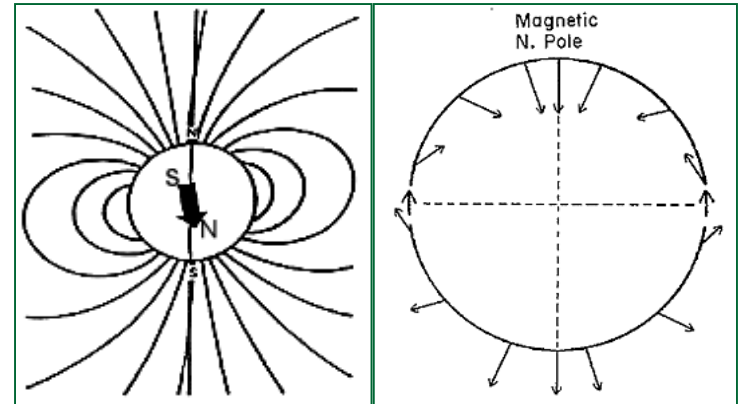
$\vec{B}$ : Magnetic Flux Density ( $Wb/m^2 = \text{Tesla}$ )

$\vec{H}$ : Magnetic Field ( $A/m$ )

$$\vec{B} = \mu \vec{H}$$

$\mu$  = magnetic permeability

$$\mu = \mu_0(1 + \kappa)$$



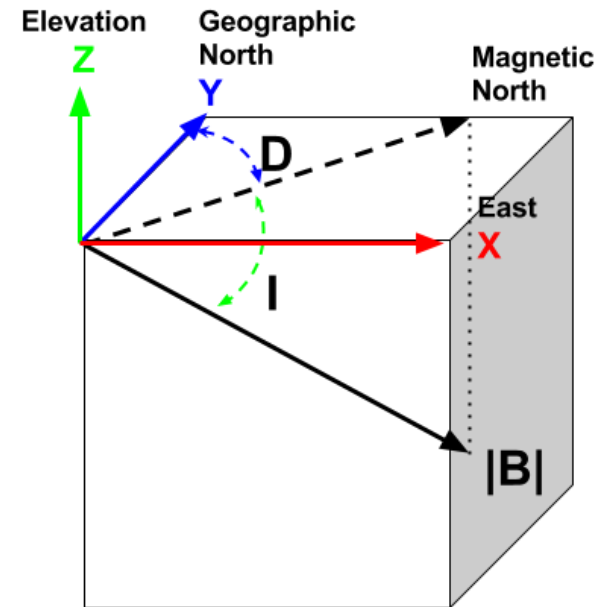
Magnetic permeability of free space:

$$\mu_0 = 4\pi \times 10^{-7}$$

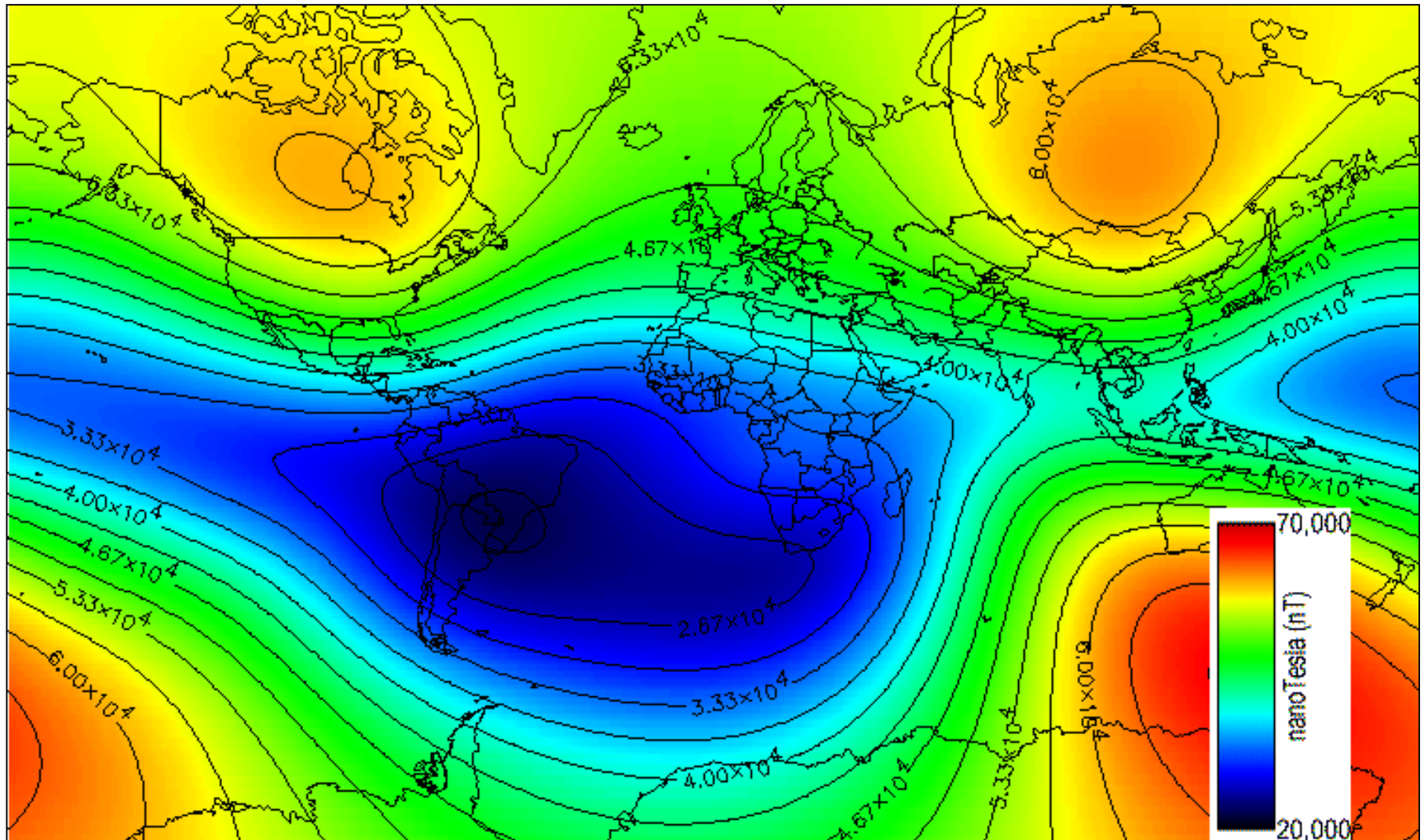
# Magnetics – Earth's field



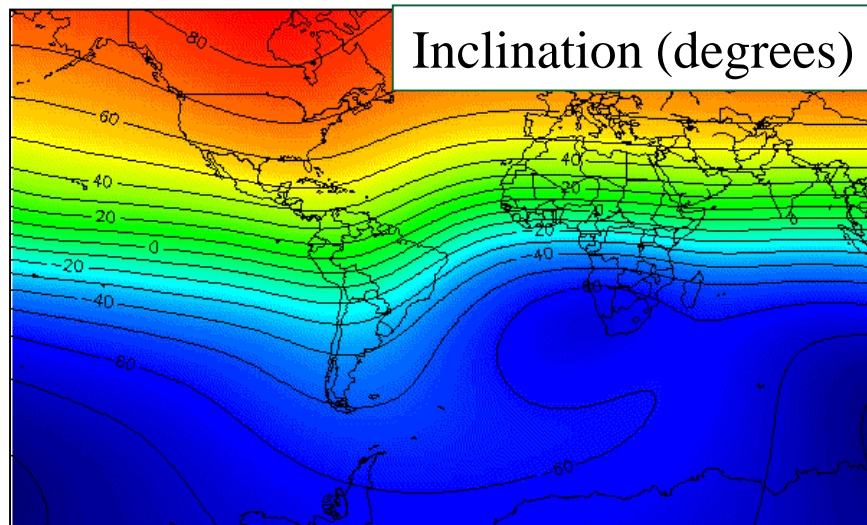
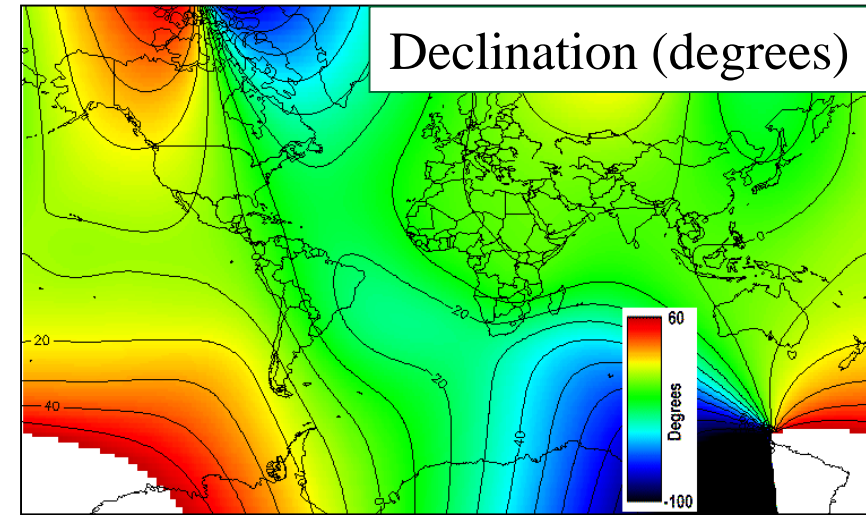
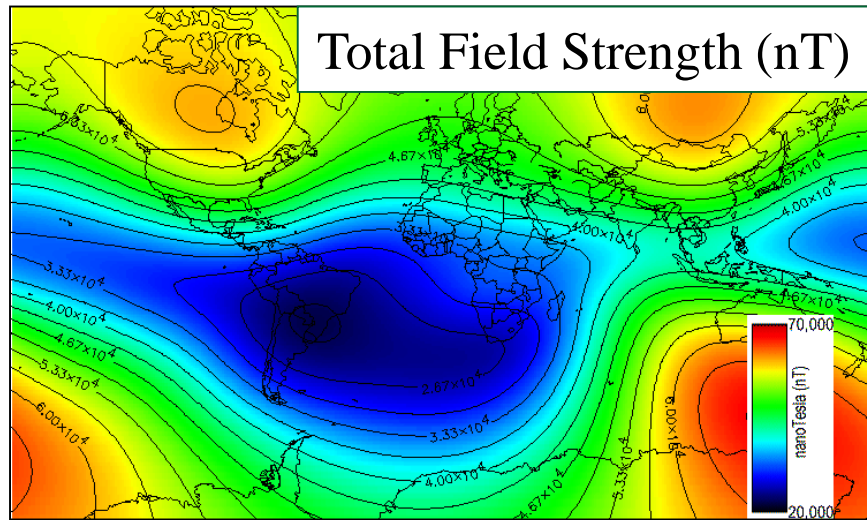
- [Link to GPG](#)
- How is the field described anywhere?
  - X, Y, Z
  - Inclination, Declination, Magnitude
- Compass? Inclination?
- Declination?
- Earth's field strength vs. anomalies.



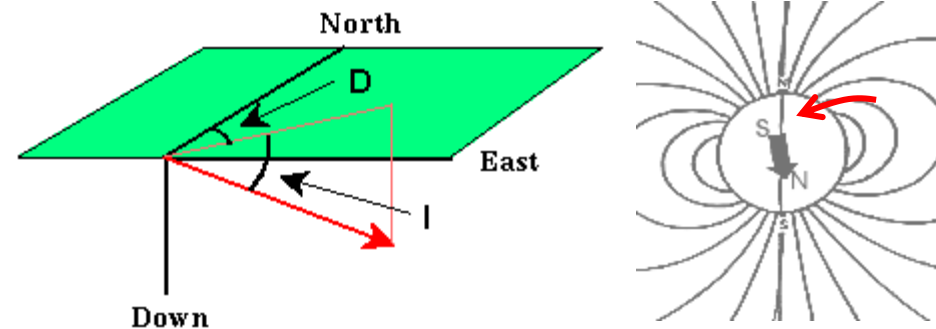
# Earth's Magnetic Field



# Earth's magnetic field: Strength |B| Inclination I Declination D

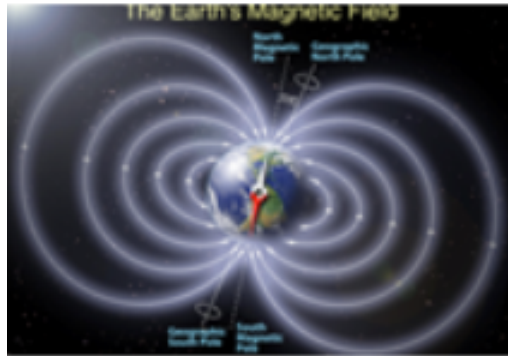


$$\begin{aligned} B_{\max} &= 70,000 \text{ nT} & H_{\max} &= 55.7 \text{ A/m} \\ B_{\min} &= 20,000 \text{ nT} & H_{\min} &= 15.9 \text{ A/m} \end{aligned}$$



# Magnetic Survey

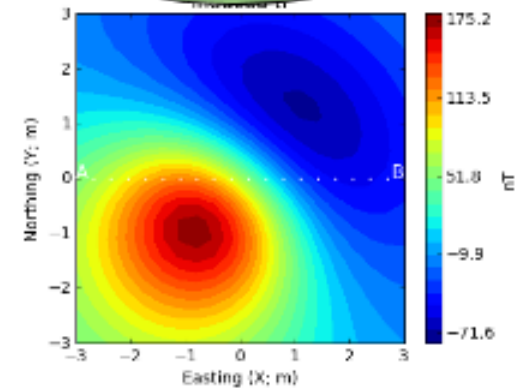
Source



Input energy

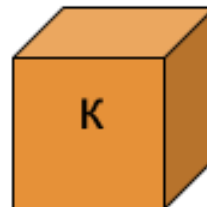
Measured response

Data



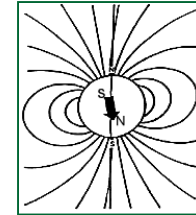
Subsurface

Physical Property:



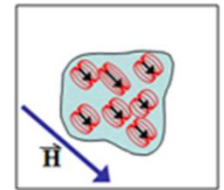
# Basics of Magnetism Surveying

- Earth's magnetic field is the source:

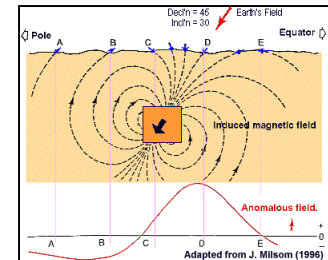


- Materials in the earth become magnetized

$$\vec{M} = \kappa \vec{H} \quad (\text{dipole moment per unit volume})$$



- Magnetized rocks create anomalous (compact object looks like a magnetic dipole)



- The anomalous field is a vector. To view we project it onto specific directions (x, y, z)

# Magnetic Applet



# Simulating the field due to prisms

## Define a 3D prism

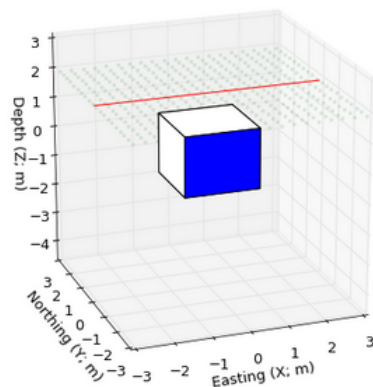
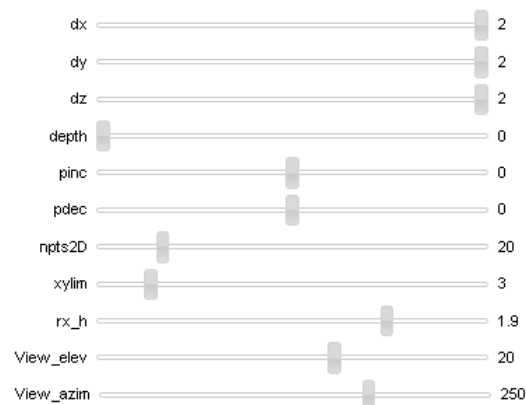
Our model is a rectangular prism. Parameters to define this prism are given below:

- dx: length in Easting (x) direction (meter)
- dy: length in Northing (y) direction (meter)
- dz: length in Depth (z) direction (meter) below the receiver
- depth: top boundary of the prism (meter)
- pinc: inclination of the prism (reference is a unit northing vector; degree)
- pdec: declination of the prism (reference is a unit northing vector; degree)

You can also change the height of the survey grid above the ground

- rx\_h: height of the grid (meter)

Green dots show a plane where we measure data.



## Magnetic applet

Based on the prism that you made above, below Magnetic applet computes magnetic field at receiver locations, and provide both 2D map (left) and profile line (right).

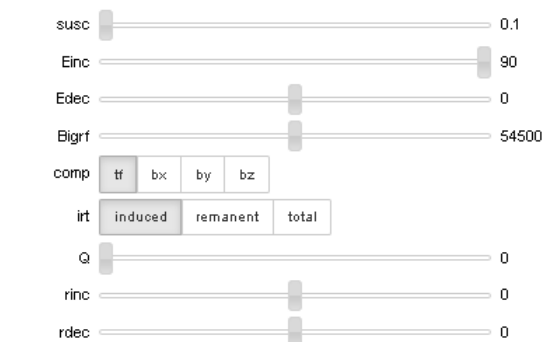
For the prism, you can alter:

- sus: susceptibility of the prism

Parameters for the earth field are:

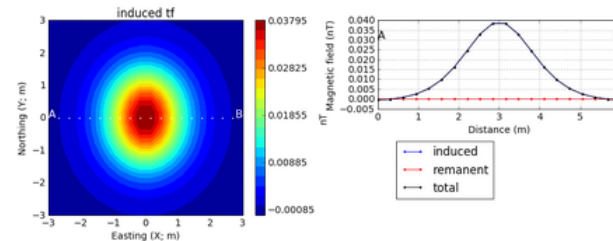
- Einc: inclination of the earth field (degree)
- Edec: declination of the earth field (degree)
- Bigrf: intensity of the earth field (nT)

For data, you can view:



Computing G

Computing G



True

■ [Interactive and live ...  
click here](#)