# MAGENTOTELLURIC METHOD FOR MINERAL EXPLORATION

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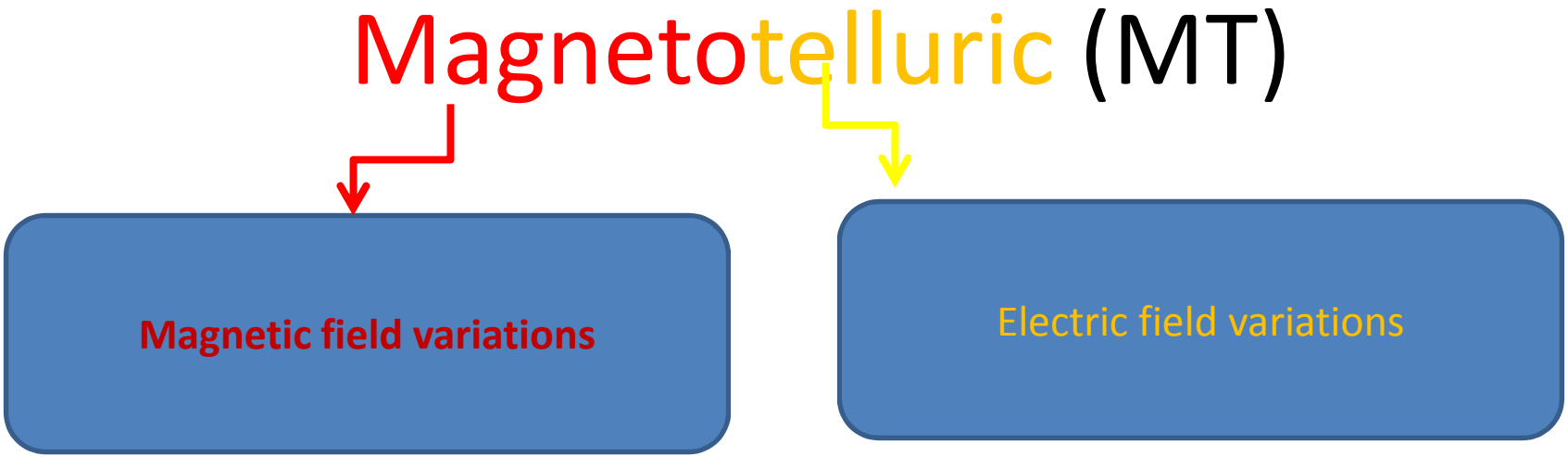
***Disclaimer:***

*This presentation is a part of the assignment for MSc III Semester Mineral Exploration theory paper. This is an attempt to enable the students to collect and review the literature, prepare powerpoint presentation and present the work, independently. The data and literature used here has been taken from various sources, and duly acknowledged. This can help as a guideline, and should not be treated as final.*

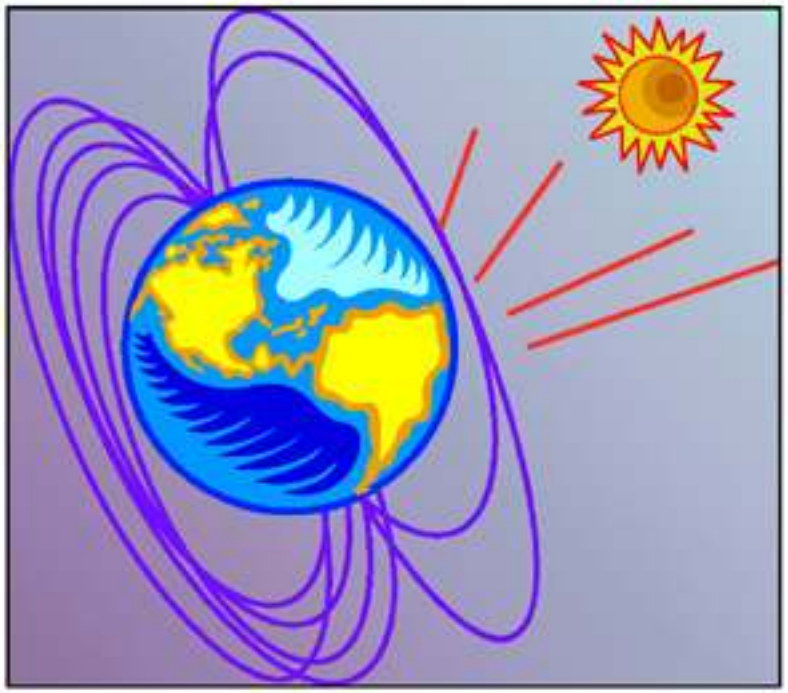
***October 2016***

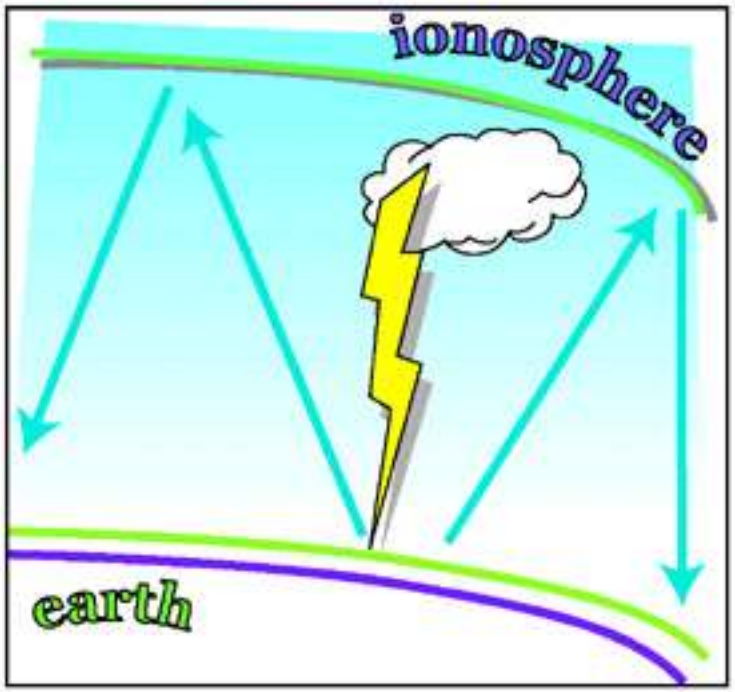
# Magnetotelluric (MT)




- **MT** is an Electromagnetic method which uses natural electromagnetic fields at the surface of the Earth to determine the distribution of electrical resistivity within the Earth (near-surface to core/mantle boundary) and **the deep structures**.
- MT is a geophysical method that measures magnetic and electric fields that are found in the earth.
- Basically, MT measures naturally occurring, time-varying magnetic and electric fields.

MT is one of the few techniques capable of sensing through the Earth’s crust to upper mantle.





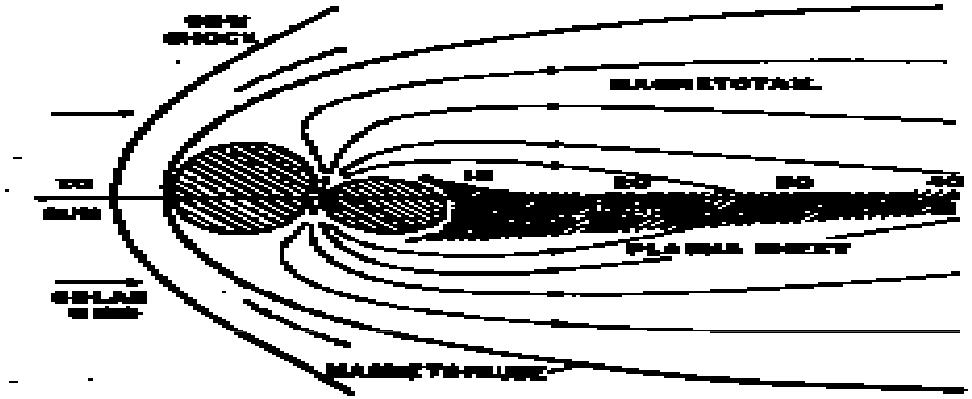

Interaction of solar particles with earth's magnetic field creates high-energy EM energy, which travel around the earth via thunderstorms.

•energy for the this technique is from natural source of external origin.

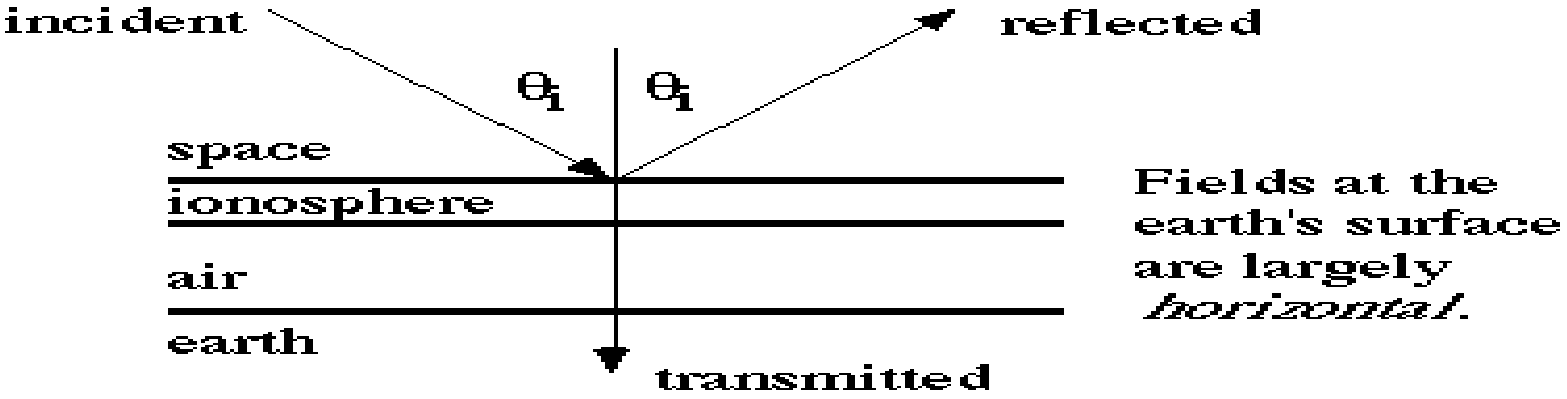
• this external energy, known as the primary electromagnetic field, reaches the earth's surface, part of it is reflected back and remaining part penetrates into the earth.

# Magnetotelluric Method

Interactions between the earth's magnetic field and the solar wind (charged particles streaming off the sun) create small variations in the earth's magnetic field (1/50,000,000):

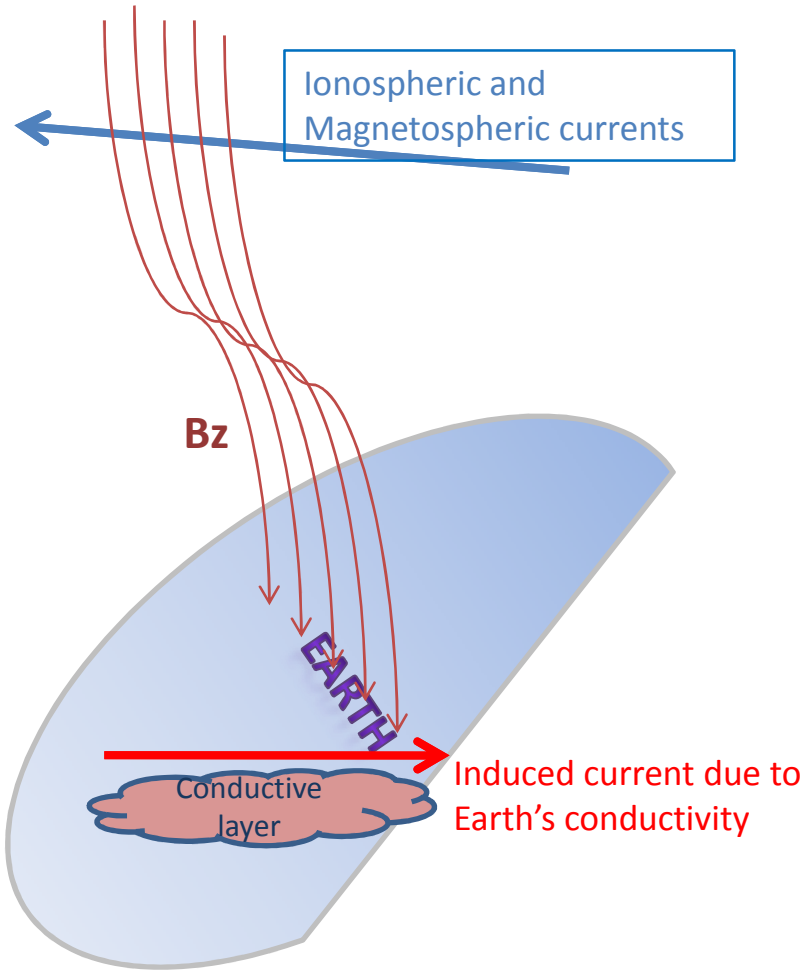


These variations (dH/dt) induce electric currents in the earth. Because of the large conductivity contrast between space and the iosn , m waves are bent to vertical incidence. These vertically incident waves impinge on the surface of the earth.



# Principle of Magnetotelluric Method

- Naturally occurring variations (time varying) in the Earth's magnetic fields induce electrical currents in conductive layers, which could be recorded at on the Earth's surface .
- Vertical wave attenuation characterized by a skin depth, which is proportional to the incidence wavelength.

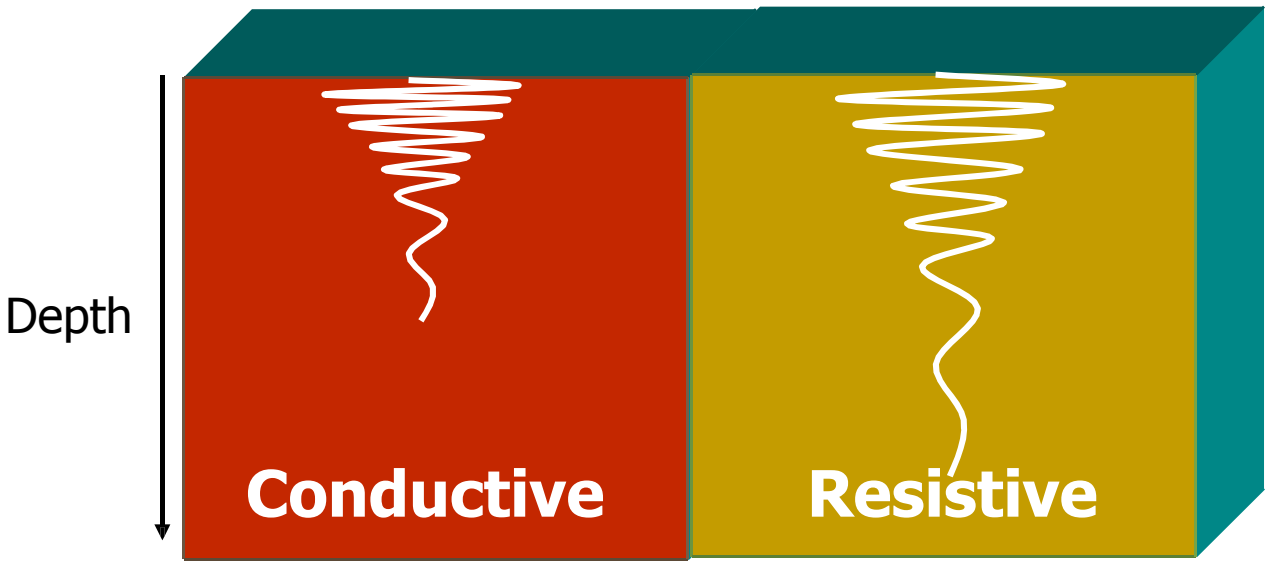


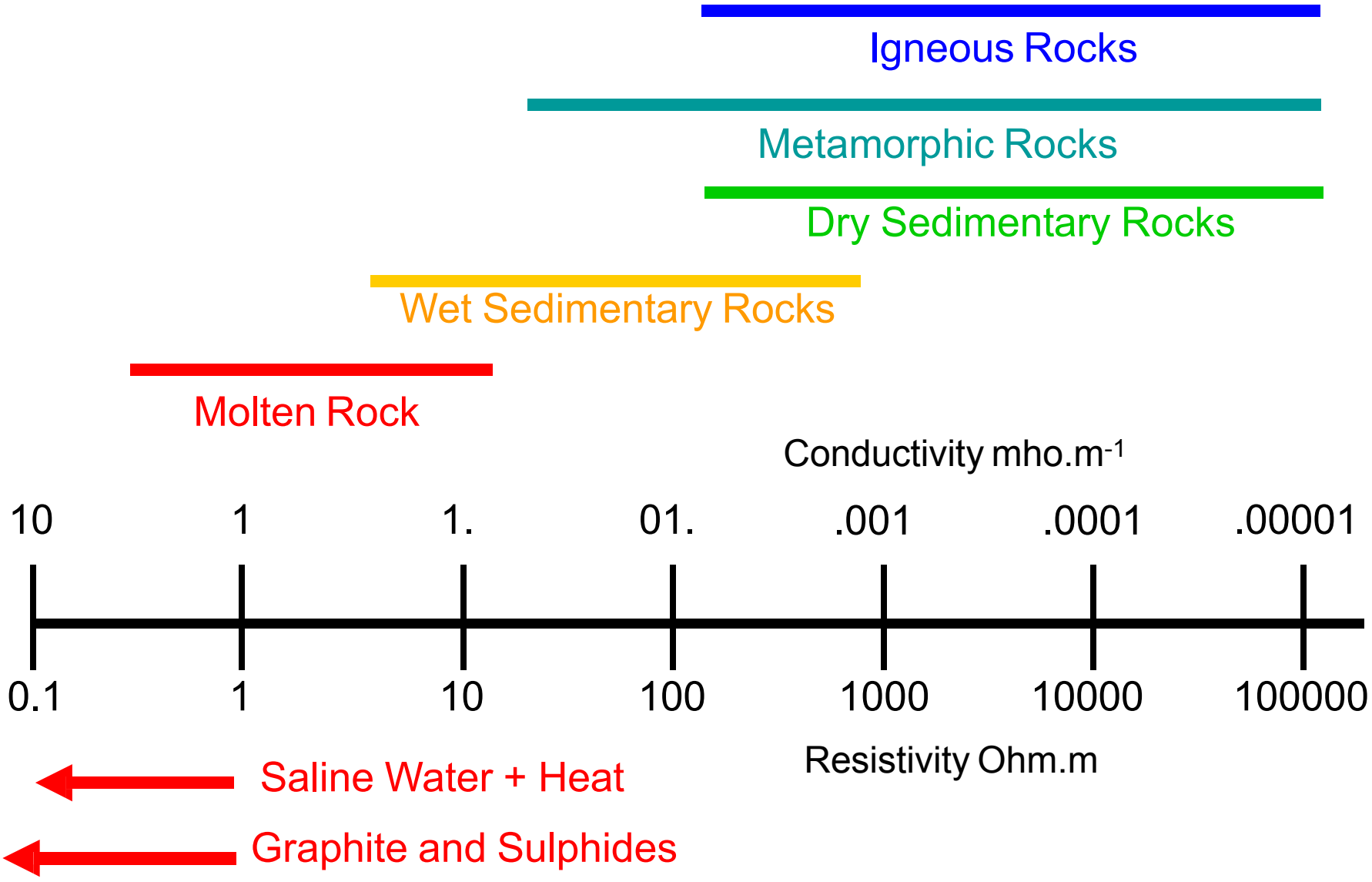
# Principle of Magnetotelluric Method

- MT obeys the **Maxwell-Faraday's equation** version of Faraday's law which describes how a time varying magnetic field creates ("induces") an electric field. This dynamically induced electric field has closed field lines just as the magnetic field.
- Hence the equation is $$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$
- The voltage induced in a closed circuit is proportional to the rate of change of the magnetic flux it encloses.

# MT Based on these 3 concepts:

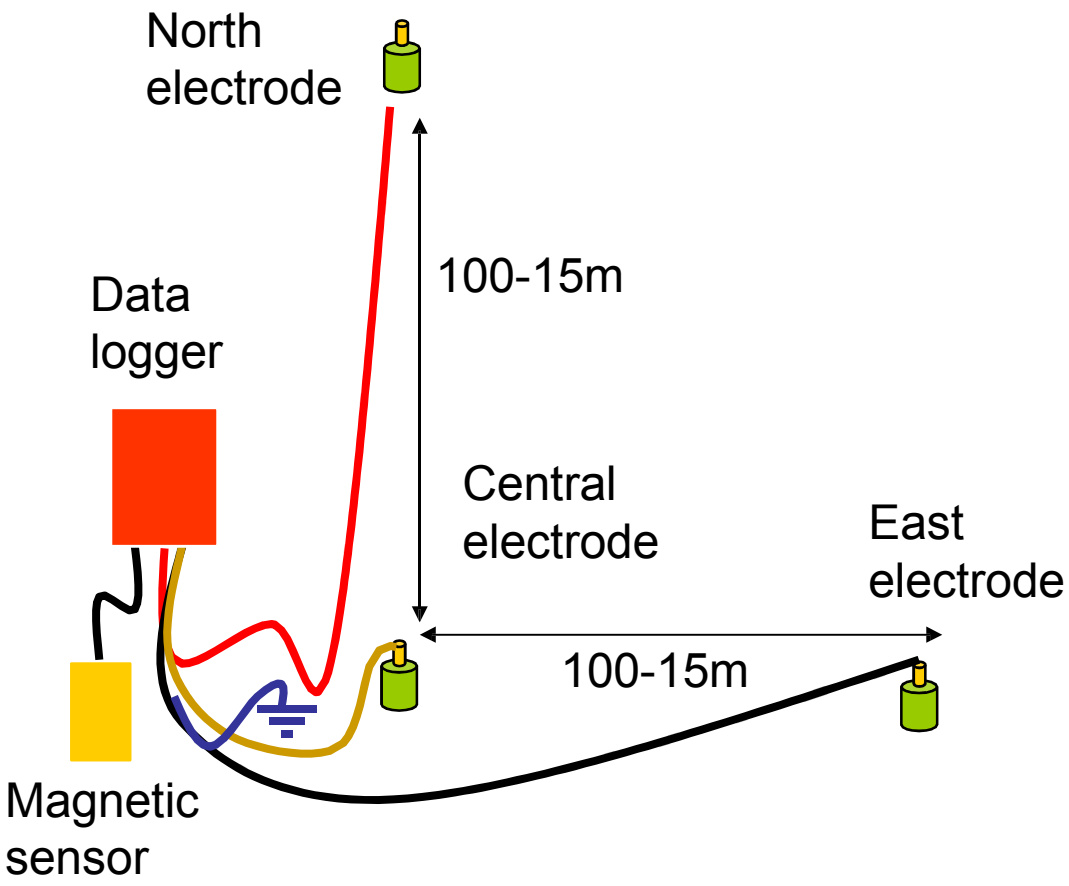
1. Low frequencies penetrate deeper than high frequencies
2. High frequencies image the near-surface
3. Signals penetrate further in resistive material




Igneous Rocks
Metamorphic Rocks
Dry Sedimentary Rocks
Wet Sedimentary Rocks
Molten Rock
Conductivity mho.m-1
10
1
1.
01.
.001
.0001
.00001
0.1
1
10
100
1000
10000
100000
Resistivity Ohm.m
Saline Water + Heat
Graphite and Sulphides

# EQUIPMENTS

*Equipment layout*




A typical MT station layout. The stations can be anywhere from a quarter-mile to tens of miles apart, depending on the type of survey.

# EQUIPMENTS

•MT equipment requires an area of soil or sand of approx 100 x 100 m in which the sensitive instruments can be buried.
•First, electrodes are buried in the ground about 100 m apart in a north-south/east-west cross (right).
•Then each is connected to a computer at the centre of the cross.
•Now sensors known as coils which measure the Earth's magnetic field are also buried in the ground:
❑one in a north-south direction and
❑the other aligned east-west.
•These are also connected to a computer which records the continuously changing magnetic and electrical fields for several days.
•The magnetotelluric equipment is so sensitive even a gust of wind could affect the readings, so it needs to be buried.

**ELECTRODES**

**AuScope Earth Data Logger system**

*Fluxgate sensors*

# INTERPRETATION

- MT method assumes that the earth structure is two-dimensional; i.e., that there is a dip and strike. Therefore, MT stations are acquired along profiles (2-D) or on a grid (3-D) from which profiles can be extracted.
- Almost all MT interpretation is done in 2-D, usually dip lines.
- The MT interpreter takes the processed data and interprets it to a **representation** of **true resistivity versus depth**. This can be done using
  - **forward**
  - **inverse modeling.**
- With forward modeling, the interpreter creates a cross-section, computes the MT response and compares it with the acquired data;
- for inverse modeling, the interpreter allows the computer to create a cross-section from the acquired data.
- Both types of modeling result in cross-sections or maps of the subsurface where the resistivity of the subsurface is interpreted to represent certain geologic formations or units.
- There are two commercial MT workstations running on PCs. They allow the interpreter to process, review, edit, interpret, plot, and map data. They also allow for the integration of other types of geophysical and geological data (e.g., structure, well logs, surface dips).

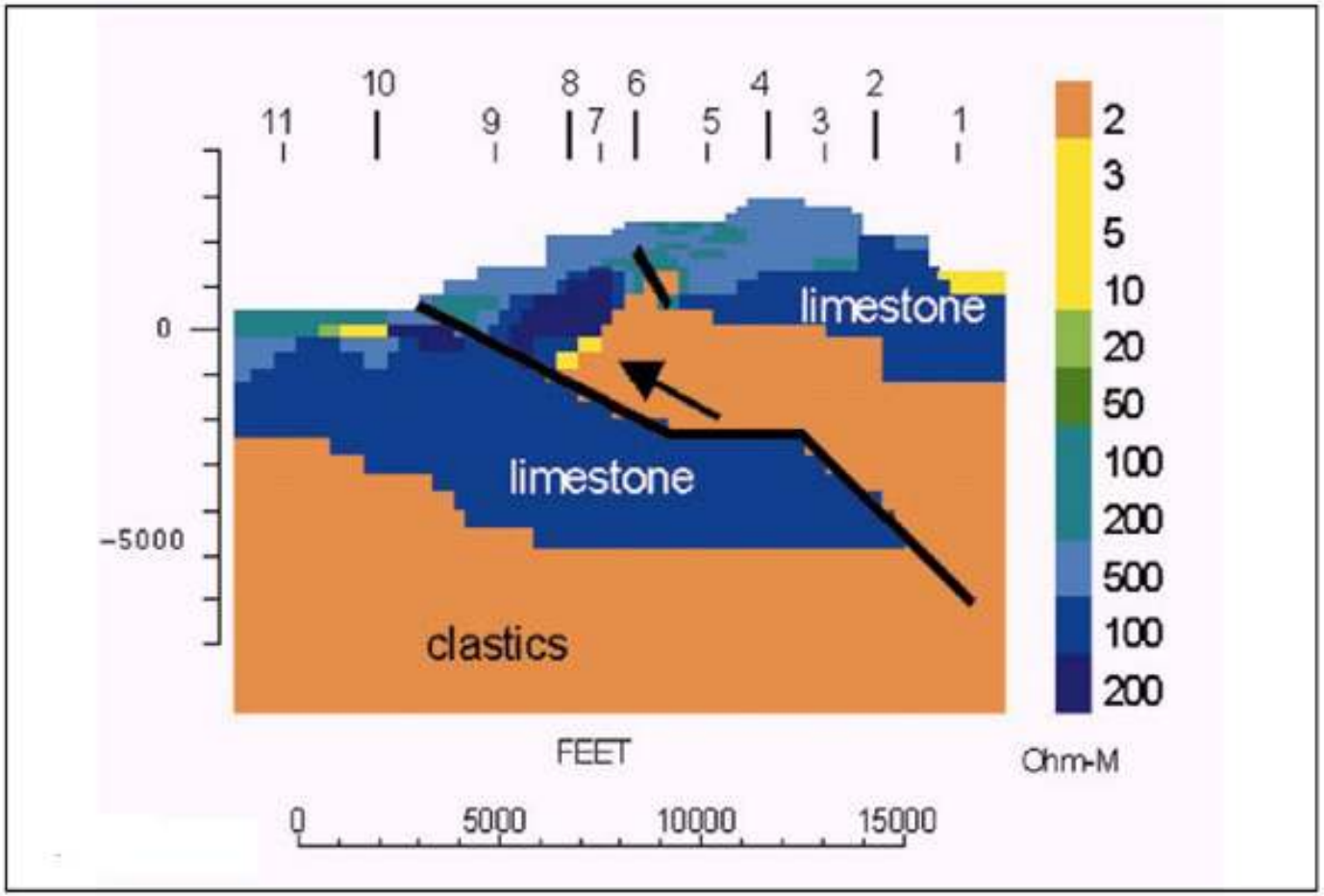



**Figure showing True Resistivity Vs. Depth**

# Applications

- **This method is preferred due to**,

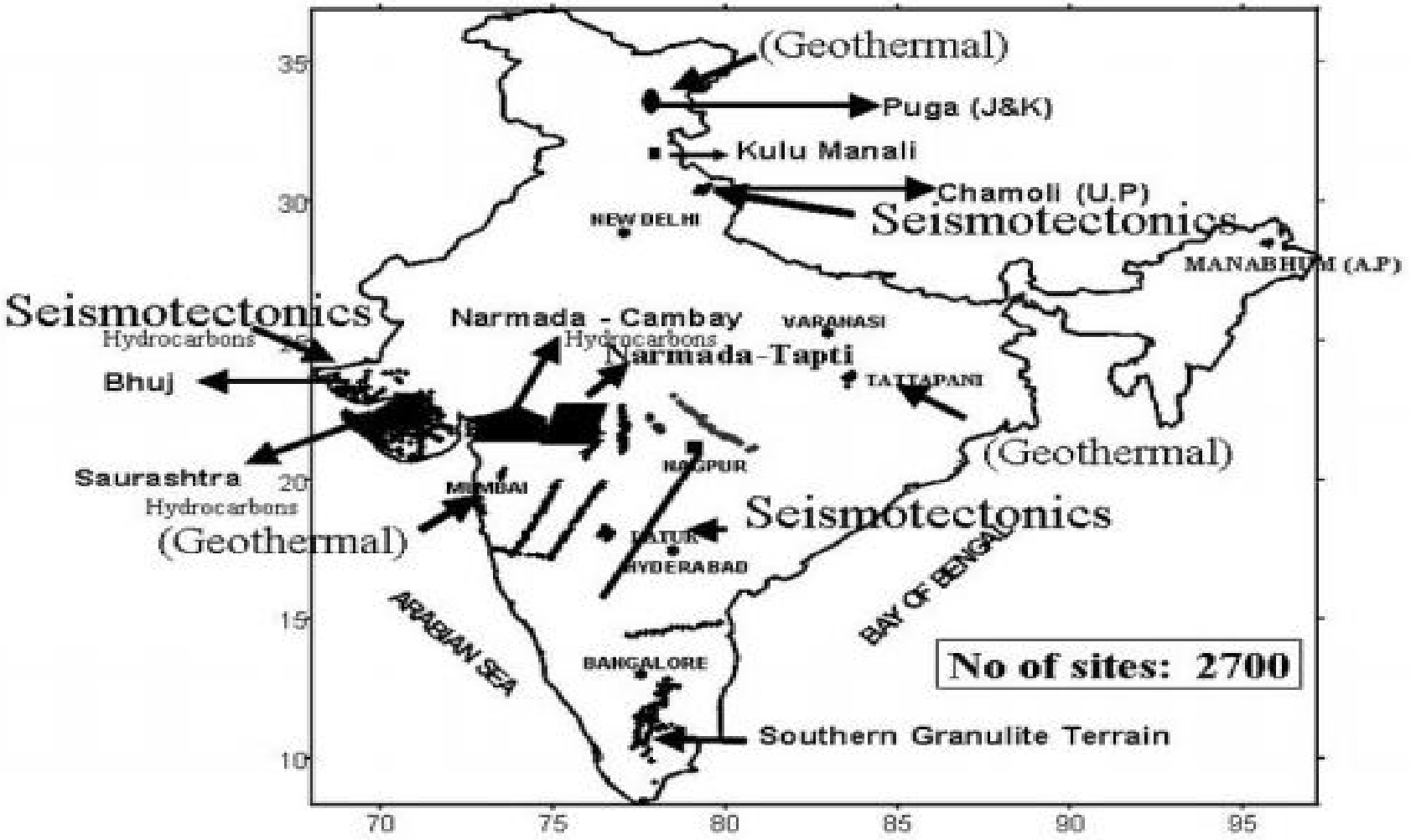
  1- Great depth of penetration over seismic

  2- Provide information on non/poor seismic and good/poor conductors.

  3-Excellent at mapping sedimentary basins

- **Recently** the importance of MT and Audio MT methods are increased due to their use for the petroleum exploration.

# Application in India




**Location of all MT stations occupied in different geological terrains distributed all over India**

Source: Harinarayana, T. (2008): Application of Magentotelluric Studies in India

# Application in India

| Serial Number | MT Usage For | Place |
|---|---|---|
| 01 | Oil Exploration | Saurashtra |
| 02 | Earthquake Studies | •Latur and Koyna, Maharastra<br>•Bhuj in Kutch, Gujrat<br>•Chamoli, Uttarakhand |
| 03 | Geothermal Studies | •Puga Nala<br>•Nala Bed |
| 04 | Deep Crustal Studies | •Seoni-Rajnandgaon(C.G)<br>•Edulabad(Telengana) to Khandwa(M.P)<br>•Decan trap region in Western India<br>•Kavali-Anantapur(Andhra Pradesh) |
| 05 | Marine Studies (MMT) | Gulf of Kutch |
| 06 | Ice Covered Region | Antartica (International Example) |

Source: Harinarayana, T. (2008): Application of Magentotelluric Studies in India

# Thank You