GEOPHYSICAL PROSPECTING OF MINERAL EXPLORATION

MAGNETIC METHOD

(S.O.S IN GEOLOGY AND WRM)

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M.SC 3RD SEMESTER

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.

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MAGNET

MAGNET IS A NATURAL SUBSTANCE THAT HAVE A PROPERTY OF ATTRACTION OR REPULSION OF ANOTHER NATURAL SUBSTANCE THAT RESEMBLE SIMILAR PROPERTIES.

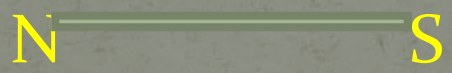
PARAMAGNETIC
DIAMAGNETIC
FERROMAGNETIC
ANTIFERROMAGNETIC

Magnetic prospecting is the oldest method of geophysical exploration, is used to explore for oil and mineral.

It gives information of the depth to basement rocks and thus locate and the extent of sedimentary basin.

PRINCIPLE

- The magnetic method of prospecting make use of potential field. It seek anomalies caused by changes in physical properties of subsurface rocks.
- MAGNETIC POLES: The lines along which the filings orient themselves are called lines of force. Each of these follows a curved path from a point near one end of the magnet designated as a pole to a corresponding pole near the other end. Poles always exist in pairs.



- MAGNETIC FORCE: Force (F) is the strength of two poles P1 and P2 separated by a distance r .

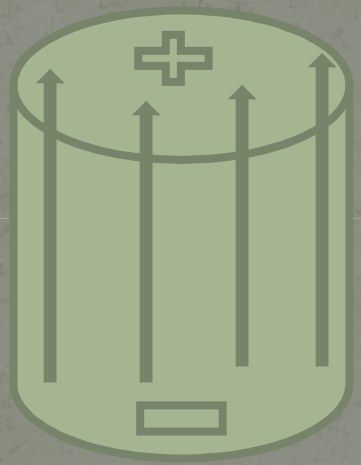
  $F = 1/\mu \cdot P_1P_2/r^2$

  μ= constant = permeability , unit for F is 1 dyne.
- MAGNETIC FIELD: The magnetic field strength at a point is defined as the force per unit of pole strength which would be exerted upon a small pole of strength P1 if placed at that point. Thus, the field strength H due to a pole of strength P2 is a distance r away is

  $H = F/P_1 = P_2/\mu r^2$

  MAGNETIC MOMENT: A dipole consists of two poles of equal strength P and of opposite sign separated by a short distance L. The product PL of the pole strength by the separation as M , is the magnetic moment of the dipole.

- INTENSITY OF MAGNETISATION: The intensity of magnetization I may be considered to be the induced pole strength per unit area along a surface normal to the inducing field. It is also equivalent to the magnetic moment per unit volume. Any magnetic material placed in an external field will have magnetic poles induced upon its surface.



- SUSCEPTIBILITY: In the case of homogeneous external field H which makes an angle θ with the normal to the surface of a material capable of being magnetized the induced pole strength per unit area is

$$I = kH\cos\theta \text{ or } I = kH$$

- K = proportionality constant = susceptibility
- Positive susceptibility = paramagnetic
- Very high susceptibility = ferromagnetic
- Negative susceptibility = diamagnetic
- MAGNETIC INDUCTION: The magnetic poles induced in a material by an external field H will produce a field of their own H', which is related to the intensity of magnetization I by the formula

$$H' = 4\pi I$$

The total magnetic flux inside the material, as measured in a narrow cavity having an axis perpendicular to the field , is called magnetic induction B.

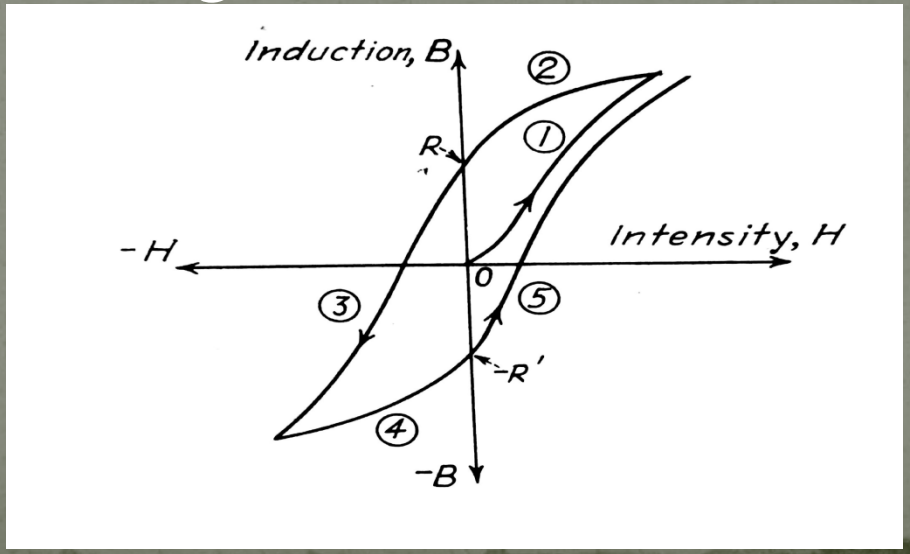
$$B = H+H' = H + 4\pi I = H+ 4\pi kH = (1+ 4\pi k)H = \mu H$$

- PERMEABILITY: It Is measure of the modification by induction of the force of attraction or repulsion between two magnetic poles.

$$\mu = B/H = 1+4\pi k$$

RESIDUAL MAGNETISM: The direct proportionality between B and H indicated to break down entirely in highly magnetic material. The behavior of a ferromagnetic substance undergoing cyclic magnetization and demagnetization.

Hysteresis loop



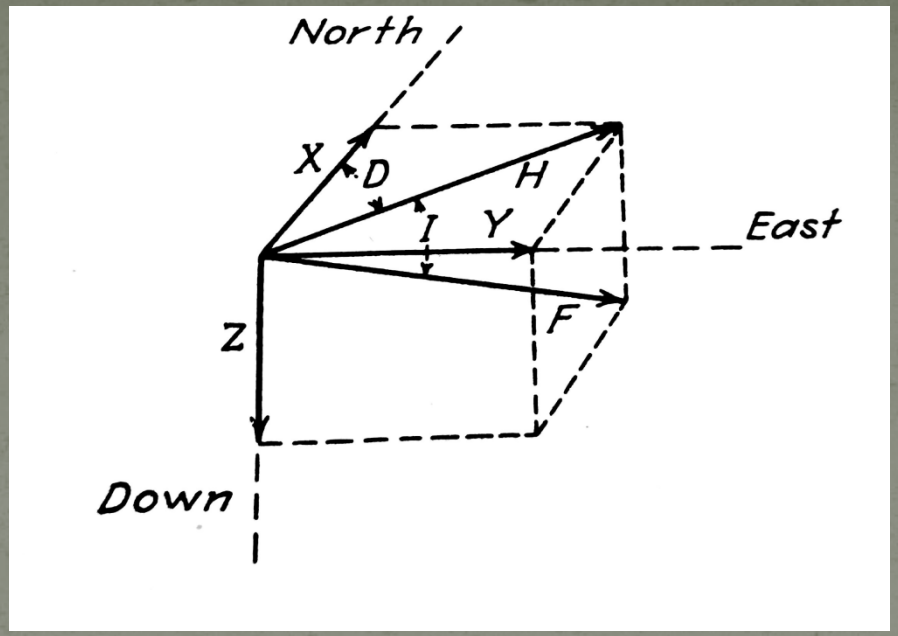
- MAGNETIZATION OF ROCKS : Magnetic rocks have almost always acquired their polarization from the earth's field .
- The polarization is of the induced type and its magnitude and direction are determined entirely by the magnitude and direction of the earth's field .
- When the earth's field changes , this kind of magnetization changes accordingly. Magnetic rocks display a remnant magnetization that is not related to the earth's present field but is governed instead by the field that existed when the rock was formed.
- Igneous rock= thermoremanent magnetization
- Sedimentary rock= depositional remanent magnetization

- UNITS OF MAGNETIC INTENSITY: Conventional unit of field intensity is the oersted.
- The GAMMA defined as 10^-5 Oe.
- The total magnetic field of the earth is normally about ½ Oe or 50,000 GAMMAS.
- GAMMA = nanotesla of the mksg system

MAGNETISM OF THE EARTH`

MAGNETIC ELEMENTS AND THEIR CHARACTERISTICS

At every point along the earth's surface a magnetic needle free to orient itself in any direction around a pivot at its center will assume a position in space determined by the direction of the earth's magnetic field F at that point.



F = FIELD , H = HORIZONTAL COMPONENT
Z= VERTICAL COMPONENT , I = INCLINATION ANGLE
D = DECLINATION ANGLE
the curve around the earth connecting all points is called the magnetic equator.

VARIATION IN TIME IN THE EARTHS MAGNETIC FIELD

- SECULAR VARIATION – Slow changes in the earth's field which take place progressively over decades or centuries are known as secular variation .
- DIURNAL VARIATION - Magnetic prospecting are the smaller but more rapid oscillation in the earth's field which have a periodicity of about a day and an amplitude averaging 25 GAMMAS. It show two types:
- Quit day : smooth , regular and low amplitude
- Disturbed day : less regular and is associated with magnetic storms.
- MAGNETIC STORMS – In short - term variations in the earth's field there are transient disturbances which by analogy with their meteorological counterparts are called magnetic storms.
- They tend to come at about 27 days of intervals. Their frequency correlates with the extent of sunspot activity.

MAGNETIC SUSCEPTIBILITY OF ROCKS

- Pulverized samples of rocks can be placed near a field magnetometer and the deflection of the magnetometer needle caused by the sample can be used to calculate the susceptibility.
- Two coils primary and secondary coils are wound around the space where the sample is placed. When a known current is sent through the primary coil the voltage induced in the secondary is measured and related to the susceptibility by appropriate calculation.
- When an external magnetic field is used for measuring susceptibility, it is customary to specify the strength of this field in tabulating the results.
- Igneous and metamorphic : high susceptibility than sedimentary rock.

TECHNIQUES AND INSTRUMENTS

- THERE ARE SEVERAL INSTRUMENTS THAT USED FOR MAGNETIC INTERPRETATION :
- FLUX – GATE MAGNETOMETER: Instrument use for ferromagnetic element of high permeability. If the earth's field is superimposed upon a cyclic field induced by a sufficiently large alternating current in a coil around the magnet the resultant field will saturate the core.
- NUCLEAR RESONANCE (PROTON) MAGNETOMETERS: It works on the laws of quantum mechanics . Two spheres are randomly oriented in its axis, one parallel and one antiparallel, when the external field is applied. The nuclei in the latter group will have a higher energy level than those in the former . For this reason a larger number of the nuclei will point in the antiparallel direction and there will be a resultant magnetic force in that direction.

- Survey on land
- Spacing of station is much closer, 25 ft. of separation , metallic materials should be far apart as 30-35 yd.
- Survey with airborne magnetometer
- Number of techniques used for this purpose: radio devices ,aerial photography, doppler system..... doppler system based on the doppler frequency effect that is observed in radio signals sent out from a moving plane and returned from the ground.
- Survey at sea
- A sensor is placed far enough away from the ship to prevent interference from magnetic materials. This objective is to tow the magnetometer, installed in a waterproof casing, behind the ship,usually500-1000 ft. behind the fantail. The recording equipment in the instrument room is connected to the sensing element by a cable attached to the tow line.

DATA INTERPRETATION

- QUALITATIVE INTERPRETATION
- The presence or absence of a fault or an intrusive body may be of much more importance than its shape or its depth of burial .
- QUANTITATIVE INTERPRETATION
- Interpretation of a vertical-field data is generally more manageable than in the case of total field data, but the applicability of such an interpretation can be quit limited in areas where the actual field deviate substantially from the vertical.
- APPLICATION:
- In mineral exploration, petroleum exploration, anomalies and fault tracing.

THANK YOU