

MARINE GEOPHYSICAL STUDIES, METHODS AND INSTRUMENTS

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GENERAL

The geophysical method is basically an indirect method. It involves the study of those parts of the earth hidden from direct view by measuring their physical properties with appropriate instruments. It also includes interpretation of the measurements to obtain useful information on the structure and composition of the concealed zones.

The geophysical techniques most widely employed for marine geophysical investigations are the magnetic, gravity and seismic methods.

MAGNETIC METHOD

The magnetic method is the oldest geophysical technique. It is based on detection of spatial variation in the earth's magnetic field caused by changes in the underlying geology.

During marine geophysical surveys most commonly the absolute value of the earth's total field is measured, using proton precession magnetometer.

After applying required corrections (e.g. diurnal, regional) the magnetic data can be presented either in the form of profiles or as magnetic contour maps. The contour maps are prepared by joining the lines of equal strength of the anomaly field.

The essence of the interpretation of magnetic (or gravity) data is essentially to define a geologically acceptable model structure. It is to be shown by computation that the model structure is capable of producing a magnetic (or gravity) field closely comparable with the anomaly pattern observed.

Some important applications of marine magnetic surveys are:

- i. Mapping of geological structures.
- ii. Structural trend of the magnetic basement.
- iii. Defining existence and limit of sedimentary basins.
- iv. Depth to the basement and thereby estimate the thickness of sediments in a basin.
- v. Identification of the lineated seafloor spreading anomalies.
- vi. Paleomagnetism of seamounts.

GRAVITY METHOD

The gravity method involves the measurement, at the sea surface or seabed, small changes, in the Earth's gravitational field due to variations in the density and distribution of rock masses in the earth's upper layers.

A gravimeter is an instrument which measures gravity differences a large number of gravimeters have been designed, but fundamentally they fall into two categories,

- i. the stable type and
- ii. the unstable type

For measuring gravity aboard a surface ship mostly static type gravimeters are used.

Gravity measurements made from a moving ship include the effects of the ship's motion, which can introduce acceleration in both vertical and horizontal planes, much larger than the gravity difference to be measured. Some of these acceleration are corrected for, or minimised through instrument design for and Navigation control is the strongest problem in marine gravity surveys.

The gravity values measured from a moving ship need to be corrected for the east - west velocity of the ship. This effect, called "Eotvos effect", is originated by the Earth's rotation.

Gravity readings are obtained relative to the reading of the instrument at a base station and all readings therefore have to be reduced to this base value.

The geophysical investigations commonly two types of gravity anomalies are used; these are the Free air anomalies and Bouguer anomalies Free air anomaly values are obtained from measured gravity data after correcting for latitude and elevation effects. Bouguer anomaly values are obtained after applying an additional correction for the gravitational attraction of the rock layer between the datum and the plain of measured, or for the gravitational attraction of the layer of seawater.

Similar to magnetic method, after applying required correction, the gravity data can be presented either in the form of profiles or contour maps of various types of gravity anomalies.

Some important applications of marine gravity surveys:

- i. Study of the major structural features of the continental shelves and margins.
- ii. Study of the tectonics and dynamics of the crust and upper mantles.
- iii. As one of the diagnostic tool of identify ocean-continent boundary.

LIMITATIONS

The interpretation of gravity is subject to the indetermination principle; that is, to a given mass in depth corresponds one and only one, gravity anomaly at the surface; but an observed gravity anomaly can be caused theoretically by an infinite number of mass anomalies in depth. The same ambiguity holds good also for interpretation of magnetic data; any different

distributions of magnetic bodies can reduce the same anomalies. However the number of solutions can be restricted by taking into consideration the general geological information, drill-hole data, seismic reflection and refraction results etc.

SEISMIC METHOD

The seismic method is the most widely used marine geophysical technique because analysis of the field data can yield an unambiguous interpretation of the underlying geological structure.

This method of geophysical exploration utilizes the fact that sound waves travel with different velocities in different rocks. The principle is to initiate such waves at a point and determine at a number of other points the time of arrival of the energy that is reflected or refracted by discontinuities between different rock formations. This then enables one to deduce the position of the discontinuities and thus prepare the 'seismic' cross section of the underlying geological structure.

There are basically two approaches in seismic exploration techniques;

- a) Reflection method
- b) Refraction method

The basic components of marine seismic instrument system consists;

- a) Acoustic source: Sparker, Boomer, Airgun etc.
- b) Acoustic receiver : Hydrophone
- c) Recording system: Analogue, digital

In seismic reflection work the hydrophones are trailed behind the shooting ship. Sound waves generated by source are reflected at nearly normal incidence from the ocean bottom and deeper interfaces and are received by the hydrophones. The mutual separation between the source and receiver is kept small as compared with the depths to be sounded.

The basis of the refraction method is the extension of Snell's Law in optics to seismic waves. The sound waves get refracted at interfaces where there is a velocity contrast. At critical angle of incidence, the sound wave is refracted along the interface and travels at the speed of sound in the higher velocity layer. Part of its energy continually reemerges into the lower velocity medium at an angle equal to that of the incident ray.

The source to receiver distance are kept large compared with the interface to be mapped. The times required for the travel of the sound wave at various source-receiver distance give information on the velocities and depths of the subsurface formations along which they propagate.

To some extent reflection and refraction work are complementary. The former gives in detail the shallow layering while the latter gives more generalized picture of a wider area and to a greater depth at the same time giving the velocities of each layer.

Modern clays at sea, seismic reflection surveys are carried out with multi-channel hydrophone; and seismic refraction surveys with sonobuoys as receiver - transmitter. The received signals are recorded digitally in magnetic tapes. The quality of the data are greatly enhanced by sophisticated data processing procedures using computers.

SUGGESTED READING

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