Magnetic methods

Principle: Magnetic surveys record the spatial variation in the Earth's magnetic field. In marine archaeology, magnetic surveys are often used to detect and map the geology of wreck sites and determine the composition of magnetic materials found on the seafloor. Every kind of material has unique magnetic properties, and different materials below the ground can cause local disturbances in the Earth's magnetic field that are detectable with sensitive magnetometers. The chief limitation of magnetometer surveys is that subtle features of interest may be obscured by highly magnetic geologic or modern materials.

Basic features: Magnetic surveys at sea often involve the use of two (sometimes more) spatially separated sensors to measure the gradient of the magnetic field (the difference between the sensors). This so-called gradiometric method provides a better resolution and is able to detect smaller phenomena. Magnetometers may also use a variety of different sensor types. Proton magnetometers have largely been superseded by faster and more sensitive fluxgate and cesium instruments. Marine magnetometers can either be towed at the surface or near to the bottom, in both cases a sufficient distance away from the ship to avoid pollution from the ship's magnetic properties.

Resolution and precision: The resolution of the magnetic/gradiometric data will mainly depend on the type of magnetometer sensor, the number of sensors, and the tow depth. Surface towed magnetometers allow for a wider range of detection at the price of precision accuracy that is afforded by the near-bottom magnetometers.

Platforms: Magnetic or gradiometric surveys can be carried out from relatively small vessels. For shallow depths (0 – 2 m) the magnetometers can be mounted on a fixed structure. For greater depths (up to 30 m) they can be mounted on a depth-controlled towfish. For very large depths the sensors are normally installed on an ROV (Remote Operated Vehicle) or AUV (Automated Underwater Vehicle).

Advantages:

- Fast survey method
- Can be performed from small vessels in very shallow water

Disadvantages:

- Only ferronous materials detected
- Image resolution deteriorates quickly with target depth
- Large tow distance can make navigation difficult

Literature:

J. I. Boyce and E. G. Reinhardt. 2004. Marine Magnetic Survey of a Submerged Roman Harbour, Caesarea Maritima, Israel. *The International Journal of Nautical Archaeology*, 33(1), 122–136.

Camidge, K., Holt, P., Johns, C., Randall, L. & Schmidt, A. 2010. Developing Magnetometer Techniques to Identify Submerged Archaeological Sites Theoretical Study Report. Cornwall Council Historic Environments Projects, 121 pp.

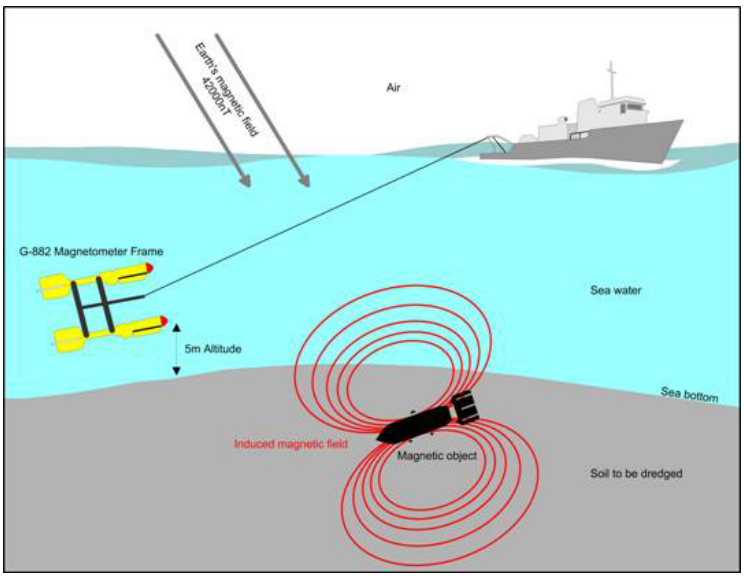

Fig. 1 - Schematic overview of a magtnetometer survey at sea (© aDeDe)

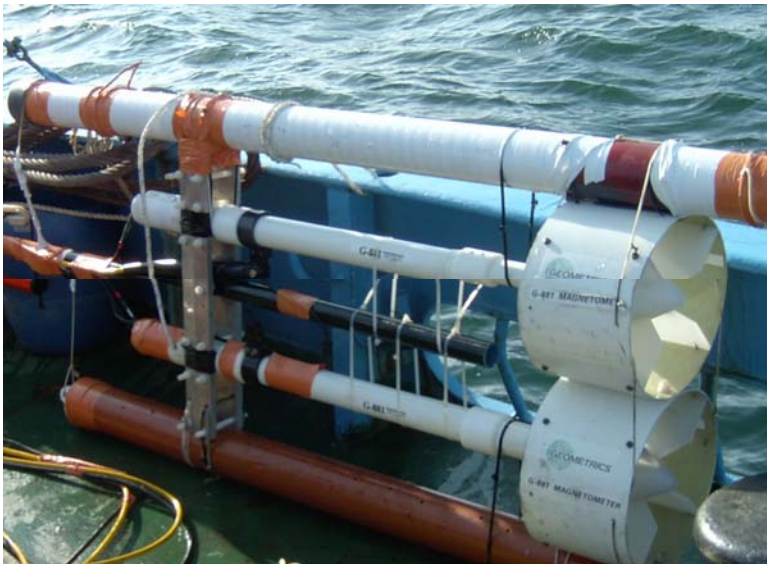

Fig. 2 Marine magnetometer array in vertical gradient acquisition mode (©G-Tec)

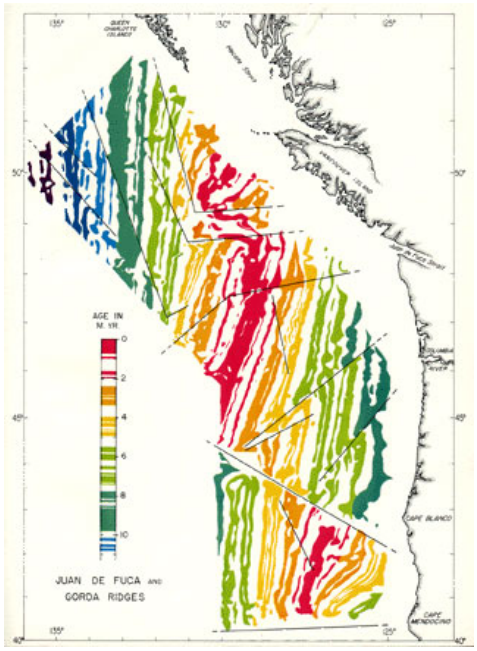

Fig. 3 Marine gradiometry data off Juan de Fuca (© USGS)

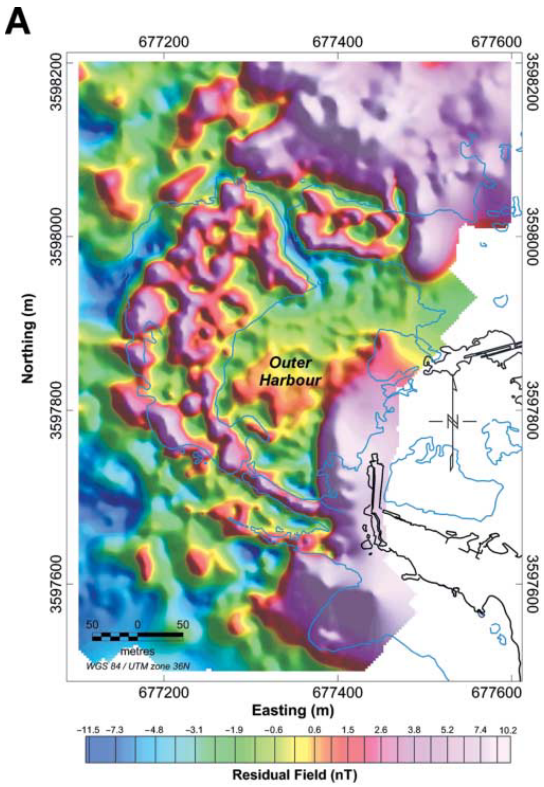

Fig. 4 Residual magnetic field map of the submerged Roman harbour Caesarea Maritima (Israel). Linear positive magnetic anomalies most likely indicate a framework of concrete foundation (© J. Boyce)