224D3: Magnetic anomalies produced by simple geological structures

Remember that objects can acquire both **induced** and **remnant** magnetization.

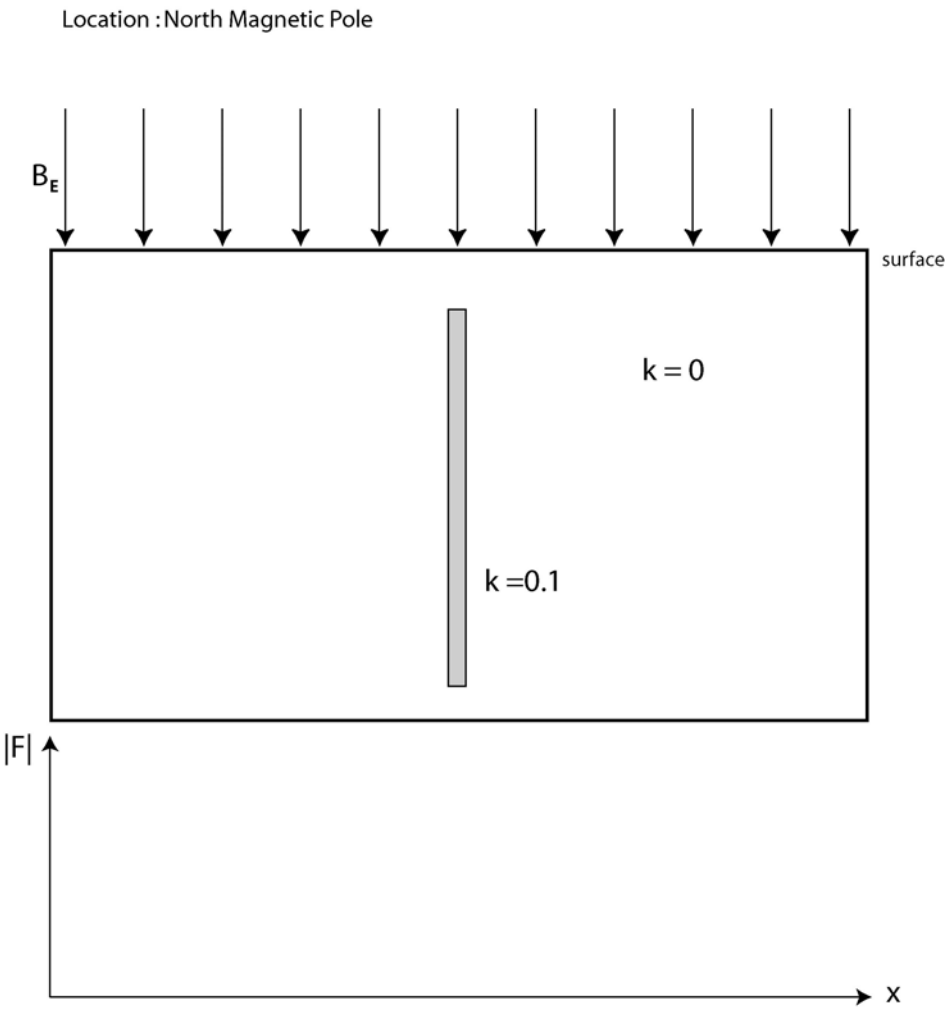
Induced magnetization will disappear when the applied magnetic field is removed.

Remnant magnetization is frozen into the material.

In the following examples, we will consider just induced magnetization. This will be in a direction **parallel** to the Earth's magnetic field. Remnant magnetization can be in any direction.

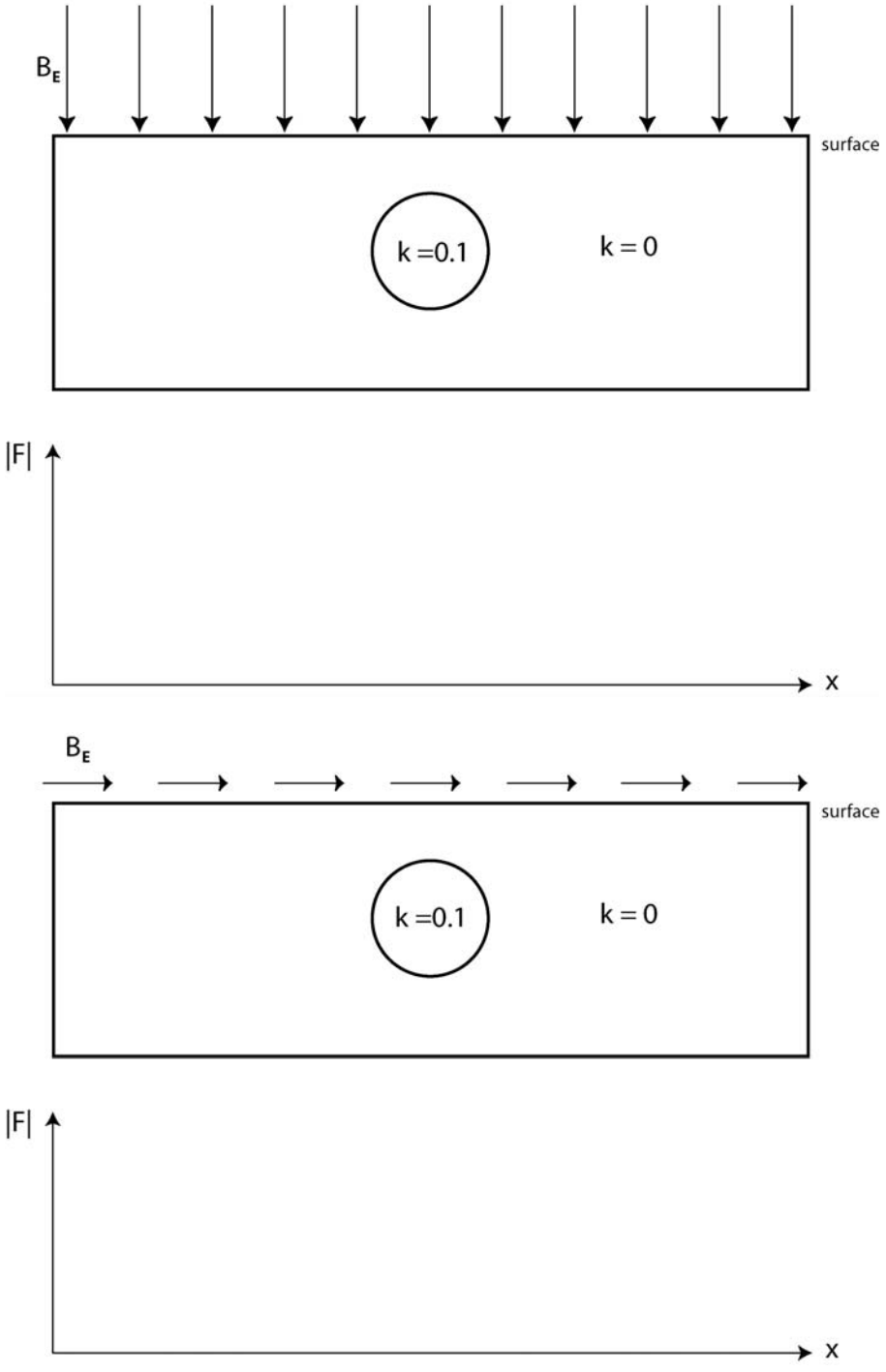
3.1 Dike (Monopole)

- in the presence of the Earth's magnetic field, the dike develops an **induced magnetic moment**
- if the structure extends to depth, then the lower monopole can be ignored since for a monopole, $B_r = \mu m/r^2$
- compute **total field** at surface by adding B_r and B_E as **vectors**



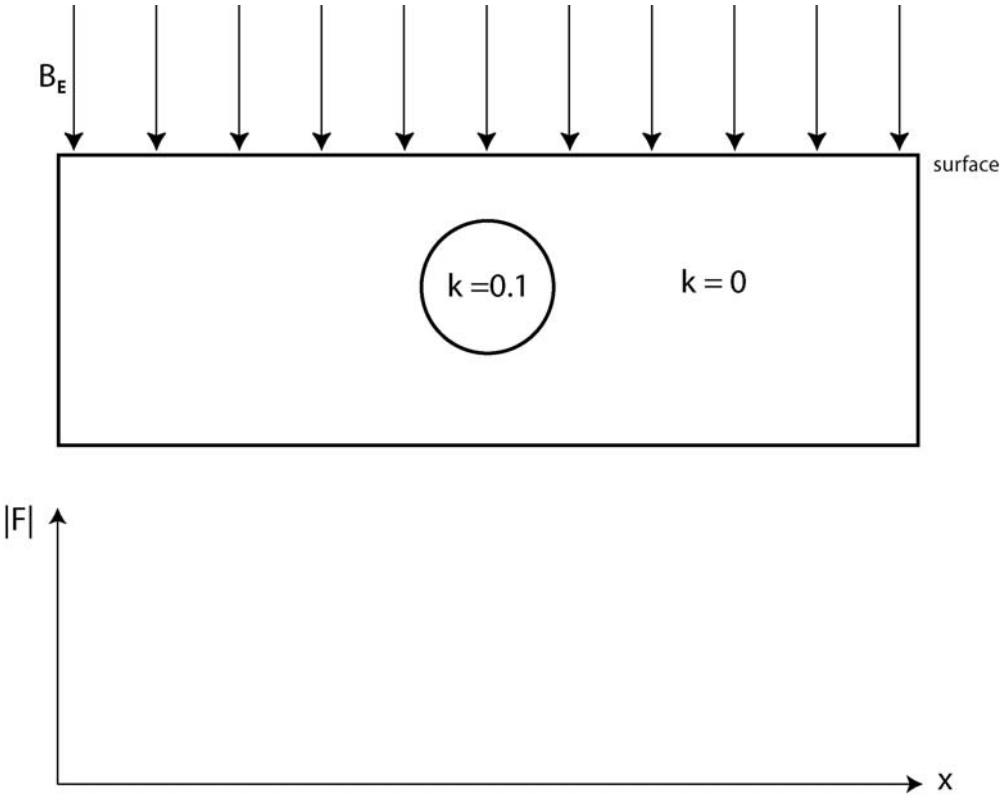
3.2 Cylinder

- The cylinder has an **induced magnetization** with negative monopoles on upper surface and positive monopoles on the lower surface. One can show that net effect is a dipole at centre of cylinder
- for a dipole, the magnetic field falls away as $1/r^3$
- note that the magnetic field anomaly is different at the magnetic north pole and equator

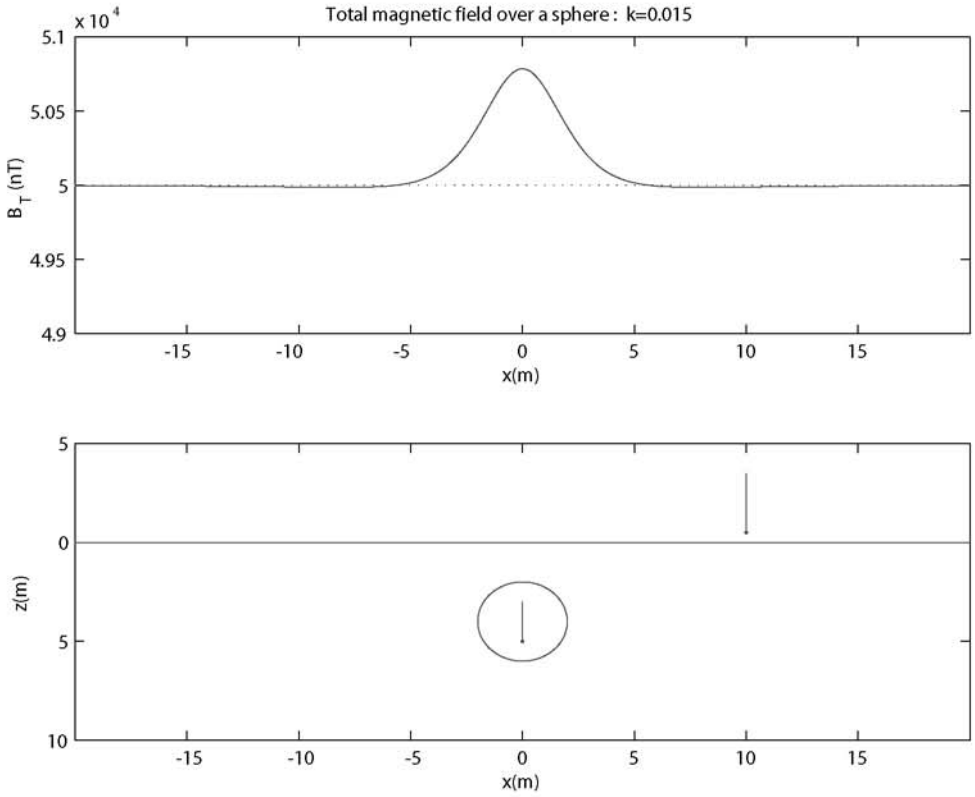


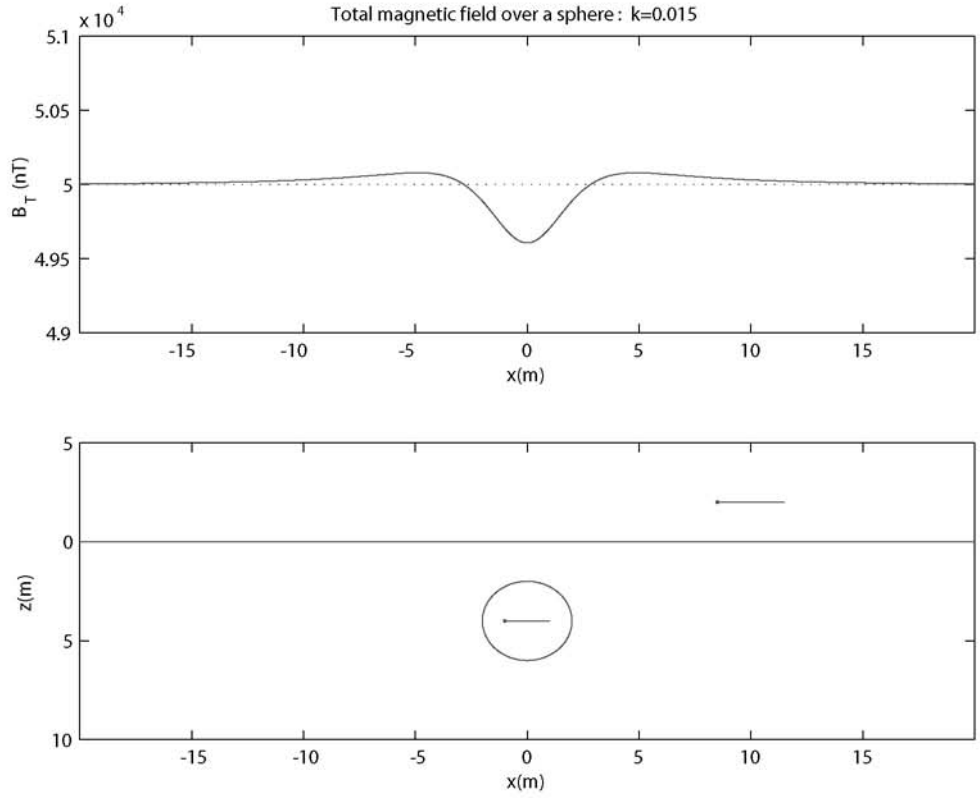
3.3 Sphere

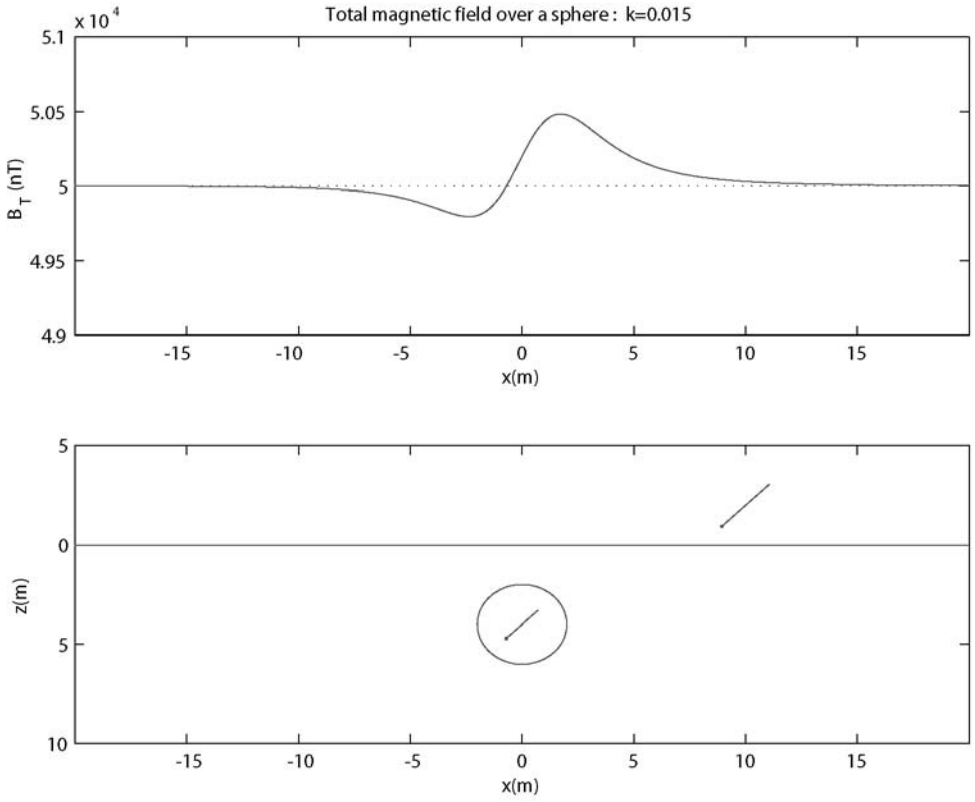
- As for cylinder, the sphere develops an induced magnetic moment, which is equivalent to a dipole at the centre.



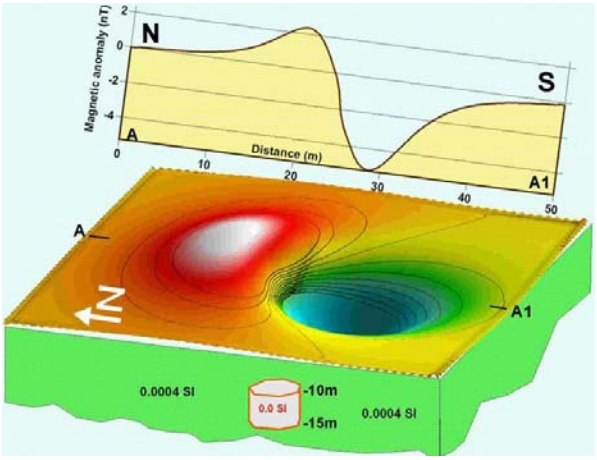
- what happens in between? MATLAB demonstration

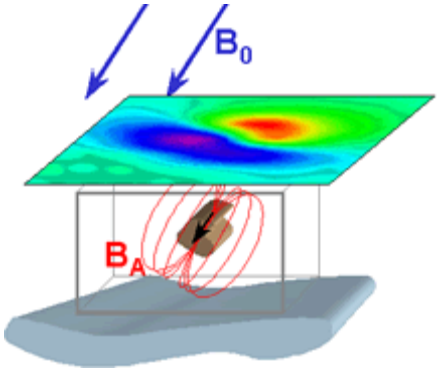

Total magnetic field over a sphere : k=0.015
x 10^4
5.1
5.05
5
4.95
4.9
B_T (nT)
-15
-10
-5
0
5
10
15
x(m)
5
0
5
10
z(m)
-15
-10
-5
0
5
10
15
x(m)


Total magnetic field over a sphere : k=0.015
x 10^4
5.1
5.05
5
4.95
4.9
B_T (nT)
-15
-10
-5
0
5
10
15
x(m)
5
0
5
10
z(m)
-15
-10
-5
0
5
10
15
x(m)



In map view





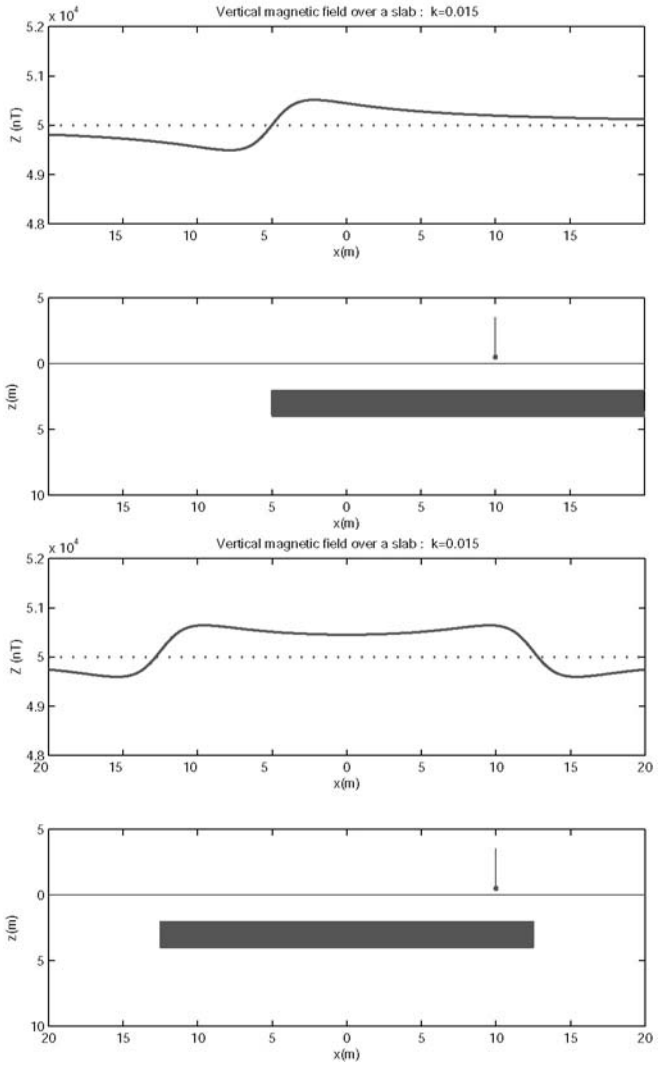
From *http://www.gif.ubc.ca*

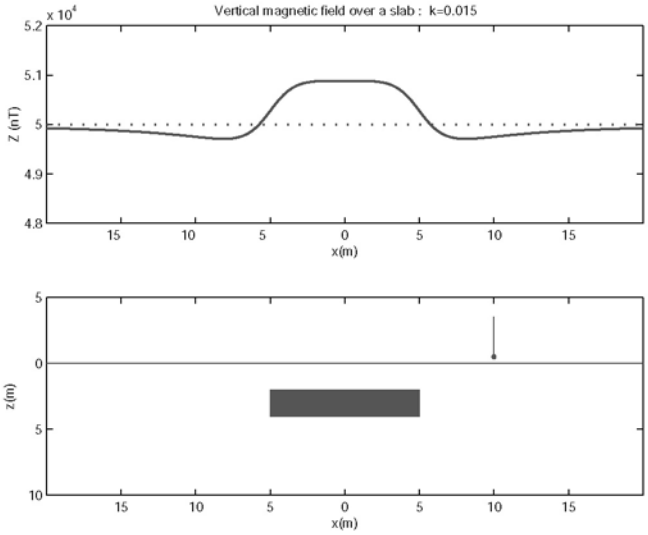
3.4 Thin sheet or slab

- an infinite sheet develops negative poles (South poles) on the upper surface and positive poles (North) poles on the lower surface. If the sheet is thin (vertical direction), then these cancel to give no net magnetic field at the surface.

- when finite in horizontal distance, the poles near the edge do not cancel and a positive-negative anomaly is observed.

- thus the magnetic anomaly is sensitive to the edges of structures





3.5 Basement topography

- superimpose an infinite layer and a finite layer (D3.4)

MJU March 2006