Preliminary Modeling of the Magnetic Effects of Steel Casings *for* *EDG, Lyons, France*

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Preliminary Modeling

INTRODUCTION:

To study the effects of the casing and to verify the accuracy of our specialized algorithms for modeling such structures, we initially carried out synthetic data studies over planes at various depths below the surface.

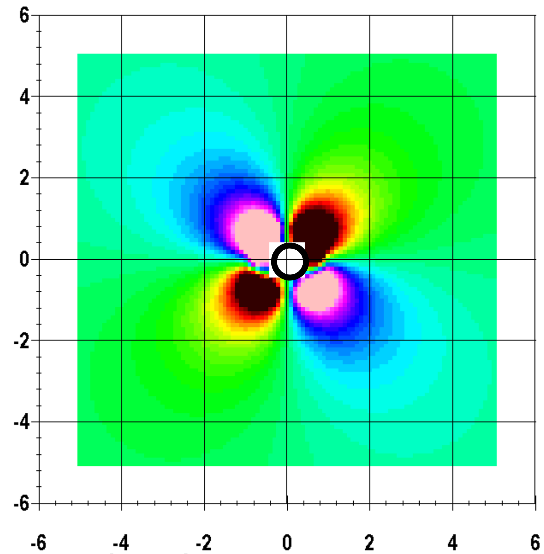
The steel casing was modeled as a 35 m long hollow cylinder with a diameter of 1.32 m and a susceptibility of 50 (SI). Prior to simulation of the response of this casing model within vertical boreholes, the response along two planes, one at the middle of the casing model (17.5 m depth) and one below the casing model (35.5 m depth) were simulated. For these studies, we modeled the response not only for the hollow cylinder but as well for a solid cylinder and a rectangular prism with the same volume as the solid cylinder. The purpose of these studies was to

1) verify that the response of the hollow cylinder was correct via comparison with the solid cylinder and prism
2) understand the symmetry of the response in the Bx, By and Bz (the 3 components of the magnetic field).

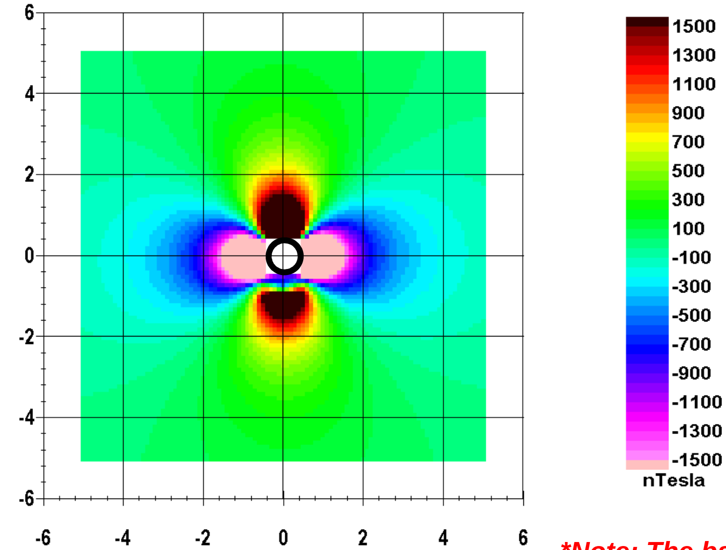
It is important to note that due to the high susceptibility of the casing, the polarization of the magnetic field inside the casing is not the same as the direction of the earth's field and thus lateral variations in response will not be the same as for a target with lower susceptibility.

The results for both planes (are presented on the following pages to illustrate:
1) The difference in the basic nature of the magnetic response for a target with a high susceptibility than for a target of low susceptibility
2) The symmetry of the different components of the magnetic field.
3) The response of a solid vs. hollow cylinder, the latter having a much lower amplitude.

Response at the Mid-Depth of the Casing

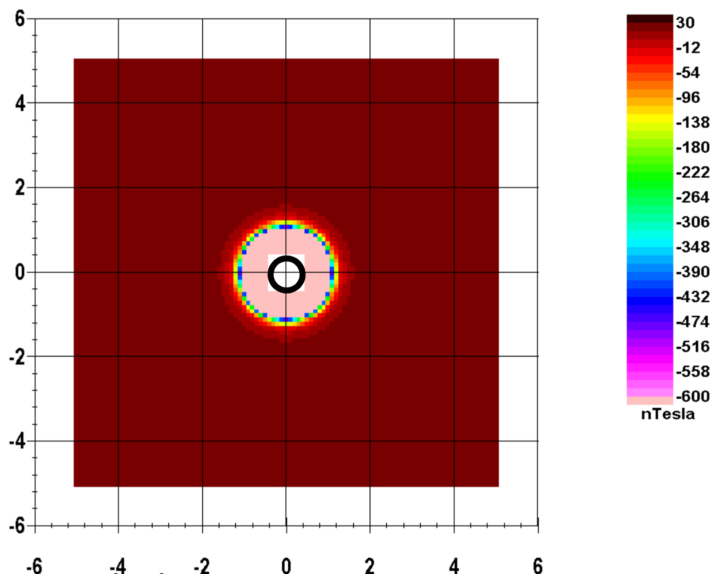


Bx (east)



By (north)

Note: The background response has been subtracted.



Bz (up)

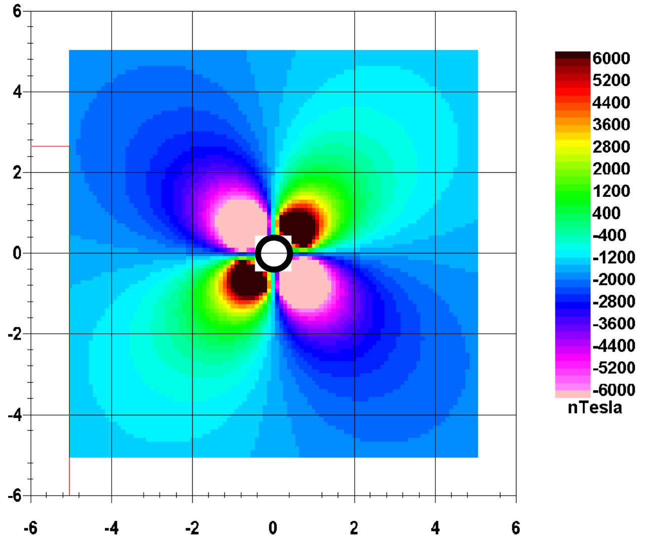
O Location of casing

5 m x 5 m plan view: Response on a plane through the object (z = -17.5m). Same scale for all components. The simulated measured response of 3 orthogonal components of the static field are shown.

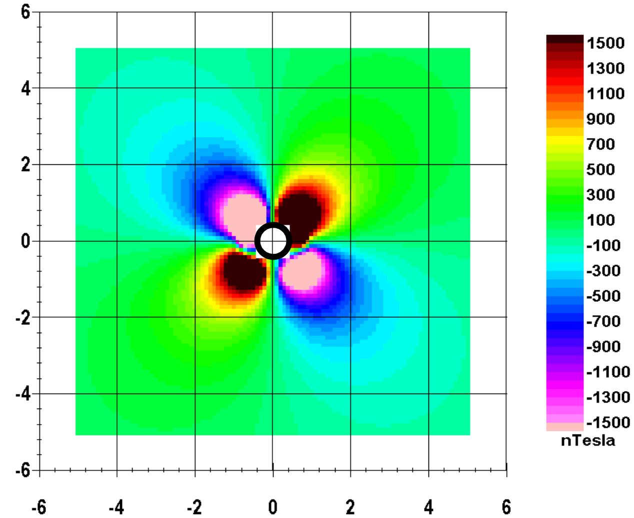
Due to the high susceptibility of the casing, the direction of the magnetic field is strongly altered in its vicinity, and thus the geometry of the response is different than it would be for a target with a much weaker susceptibility. While this may not be apparent in the response down the borehole, it is more clearly observed when observing the response below the target. ?????

Response at the Middle of the Target

Comparison of Effects of Polarization

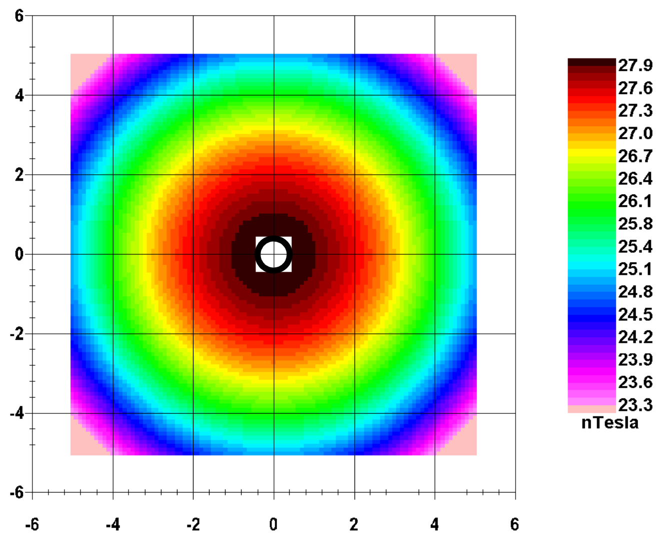


Bx, Hollow Cylinder,
Low Susceptibility

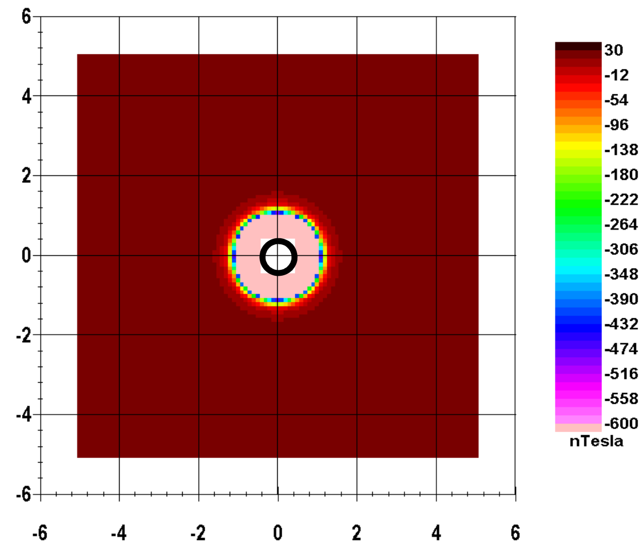


Bx, Hollow Cylinder
Strong Susceptibility

Bx (east) on a plane through the middle of the casing. Amplitude of the response is much higher for weak scattering algorithm.



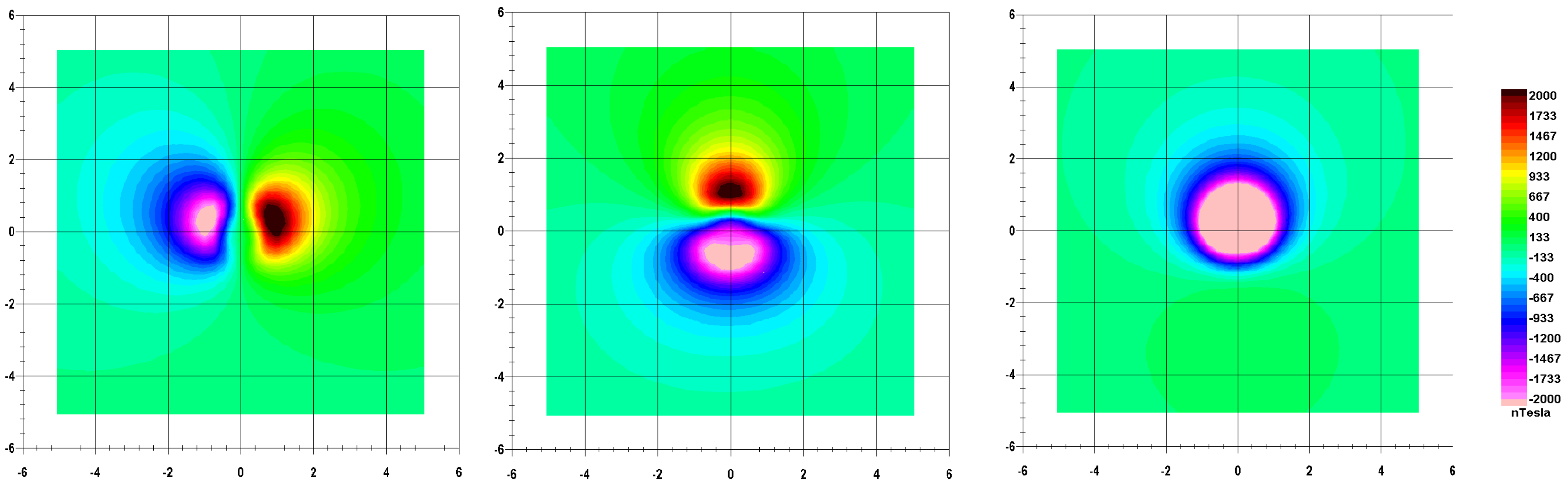
Bz, Hollow Cylinder,
Low Susceptibility



Bz, Hollow Cylinder
Strong Susceptibility

For Bz (up) there is little variation in the response for weak scattering (23-28 nT vs. -600-30nT).

Response Below the Target

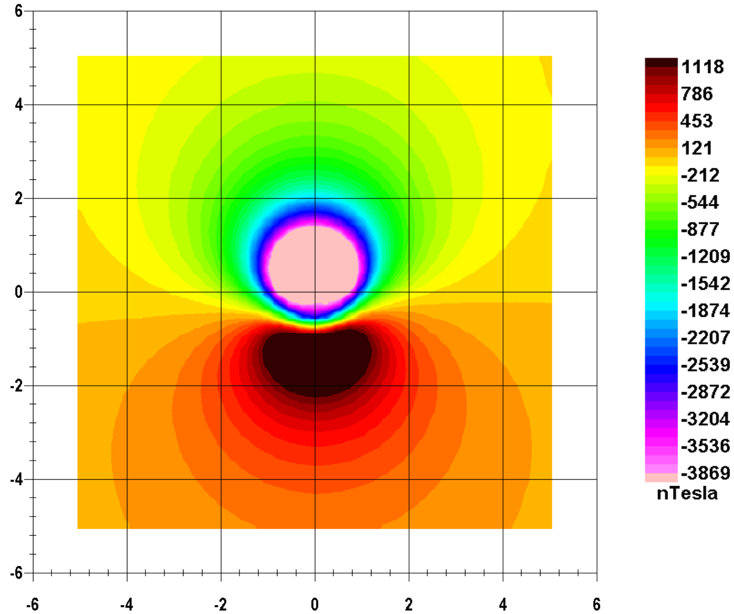


Bx (east) By (north) Bz (up)

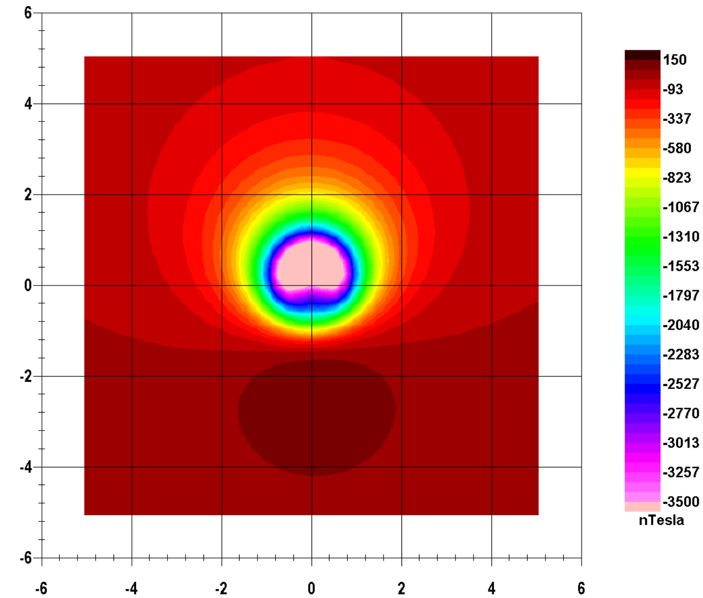
Note: The background response has been subtracted.

5 m x 5 m plan view: Response on a plane 0.5 m below the object. Same scale for all components for a casing with high susceptibility. These figures show clearly the nature of the near-field, strong scattering effects of the casing. Bz is essentially a monopole rather than a dipolar response while Bx,By are distorted dipoles rather than quadrapoles as they would be in the weak scattering case.

Response Below the Target



Bz, Hollow Cylinder,
WEAK SCATTERING



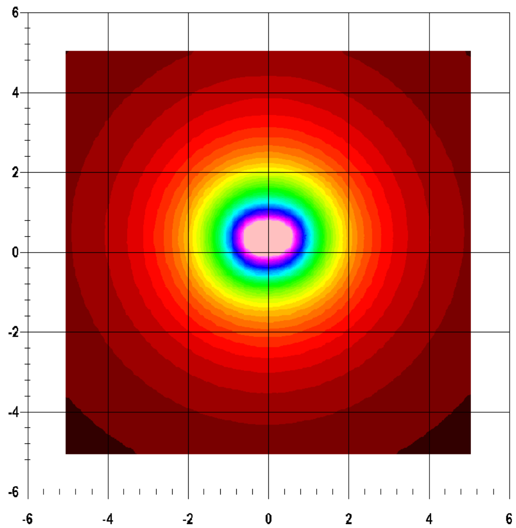
Note: The background response has been subtracted.

Bz, Hollow Cylinder
Strong Scattering

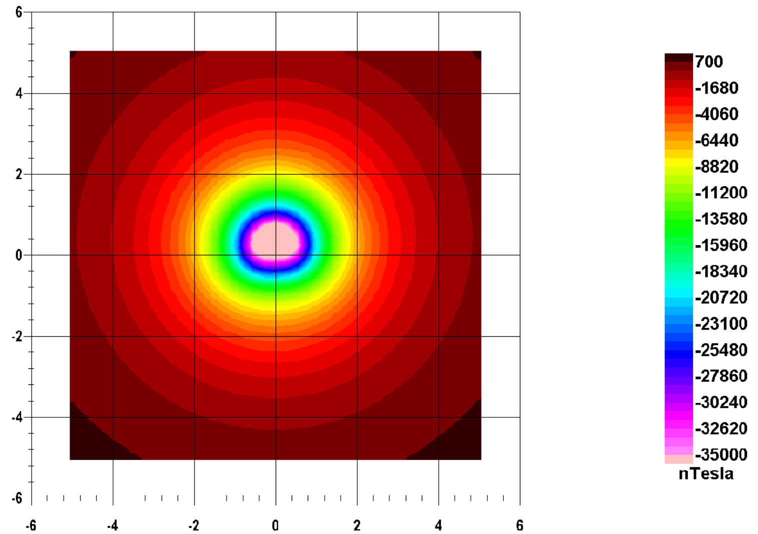
The figure on the left shows the response below the model for weak scattering or polarization parallel to the earth’s field

However, given the high susceptibility of the model, weak scattering is not a reasonable assumption here, and an algorithm that does not assume polarization parallel to the earth’s field is essential for properly modeling the problem. In this algorithm, the polarization angle and strength are calculated. The significant difference in the two figures, both in the symmetry and amplitude, illustrates the problem with any weak scattering assumption as normally utilized in geophysical modeling.

Response Below the Target

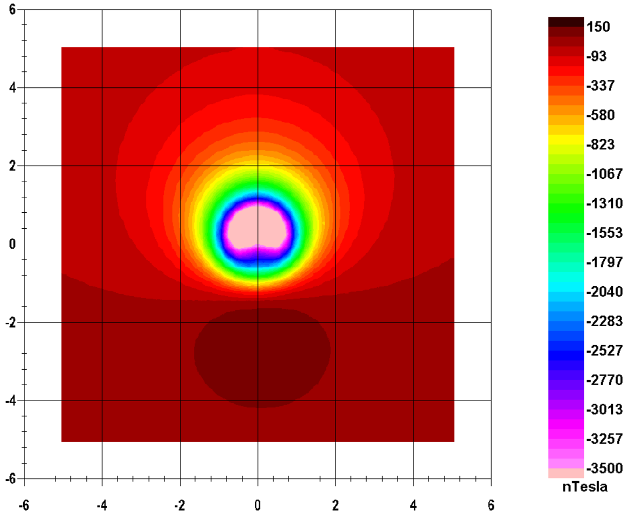


Bz, for a Prism



Bz, for a Solid Cylinder

Note: The background response has been subtracted.



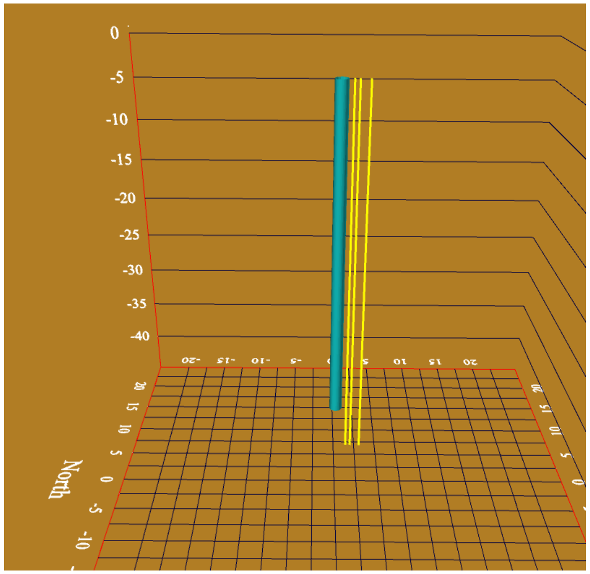
Bz, Hollow Cylinder

Plan view: Response on a plane 0.5 m below the object.

Response of a solid cylinder, a cylindrical shell, and a rectangular prism all with the same susceptibility of 50 SI.

These figures are shown as part of our studies to verify the accuracy of the modeling of the hollow, high susceptibility casing.

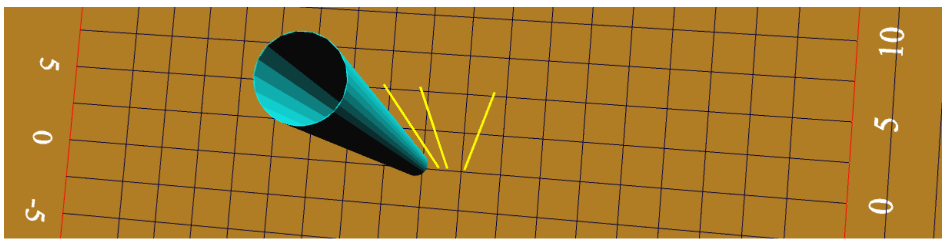
Synthetic Borehole Study of The Vertical Cylinder Model



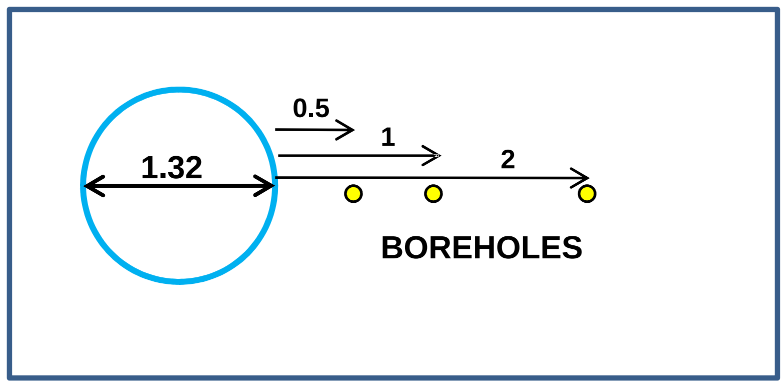
The model of the casing, shown to the left, has a susceptibility of 50 (SI units), and is 1.32 m in diameter and 35 m long. The top is located just below the surface (0.01m).

The magnetic response was simulated for three vertical boreholes at distances of 0.5 m, 1 m, and 2 m from the east edge of the target, between depths of 0 and 40 m. It is understood that the magnetic field will be measured between 10 and 30 m mPD, which is about 14-34 m below the surface.

Prior to examining the response in the boreholes, the responses at two planes, one through the middle of the target and one below it, will be examined.



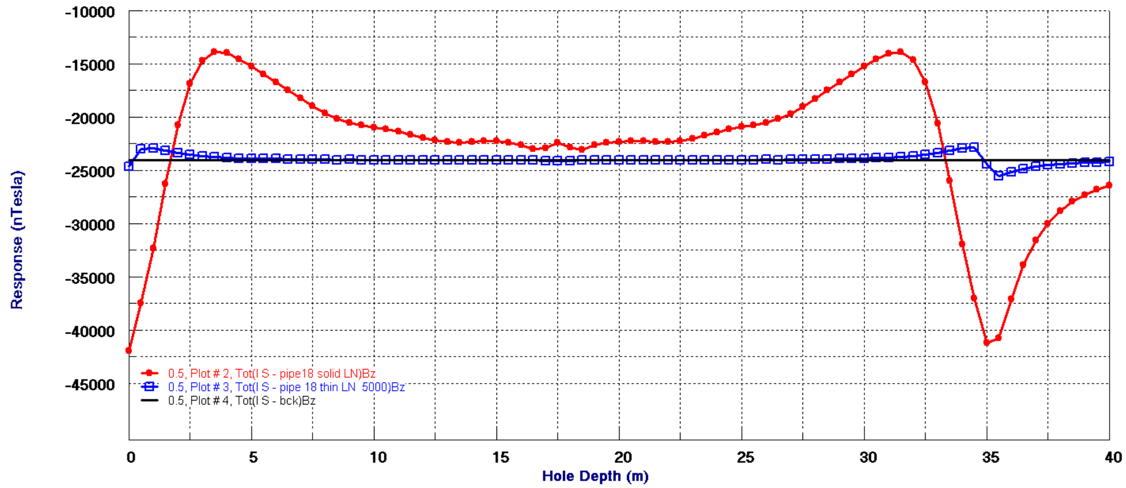
Background Magnetic Field for Hong Kong:
Inclination: 32.50
Declination: -2.43
Intensity: 44900 nT



PLAN VIEW

Borehole: Solid Cylinder vs. Hollow Cylinder

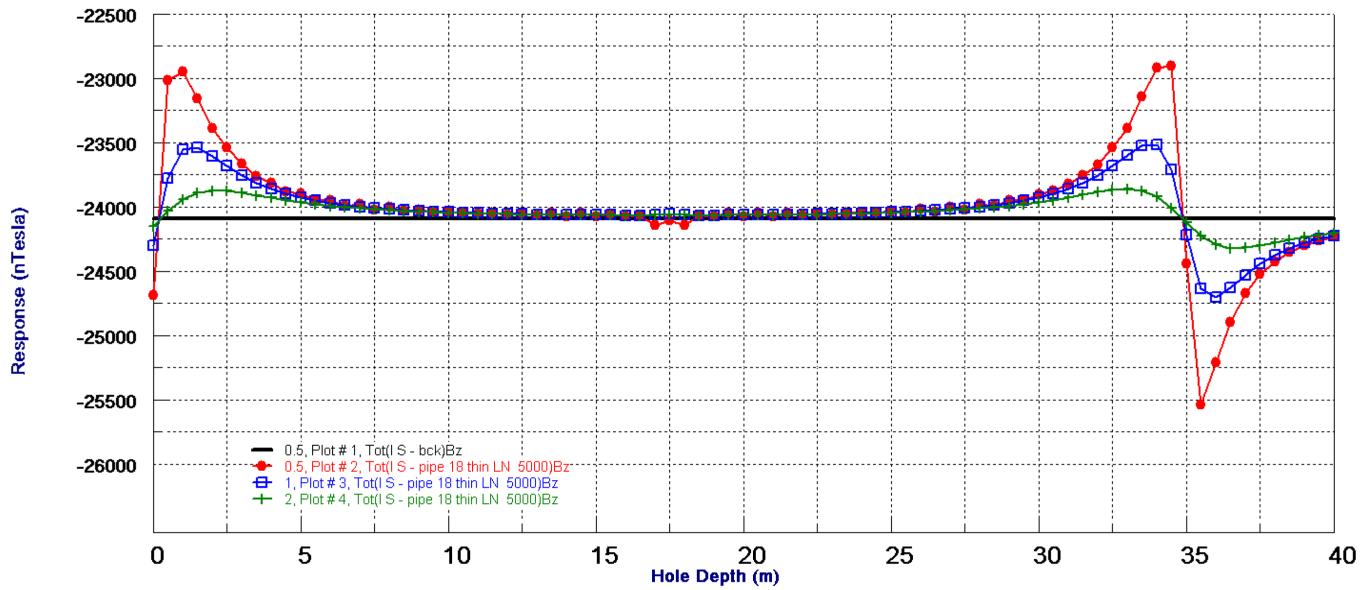
Axial Component: Up the BH



Solid cylinder (red) vs hollow cylinder (blue) along a borehole 0.5 m away from the edge of the casing.

Borehole: Effect of Distance

BH: Axial Component (up)



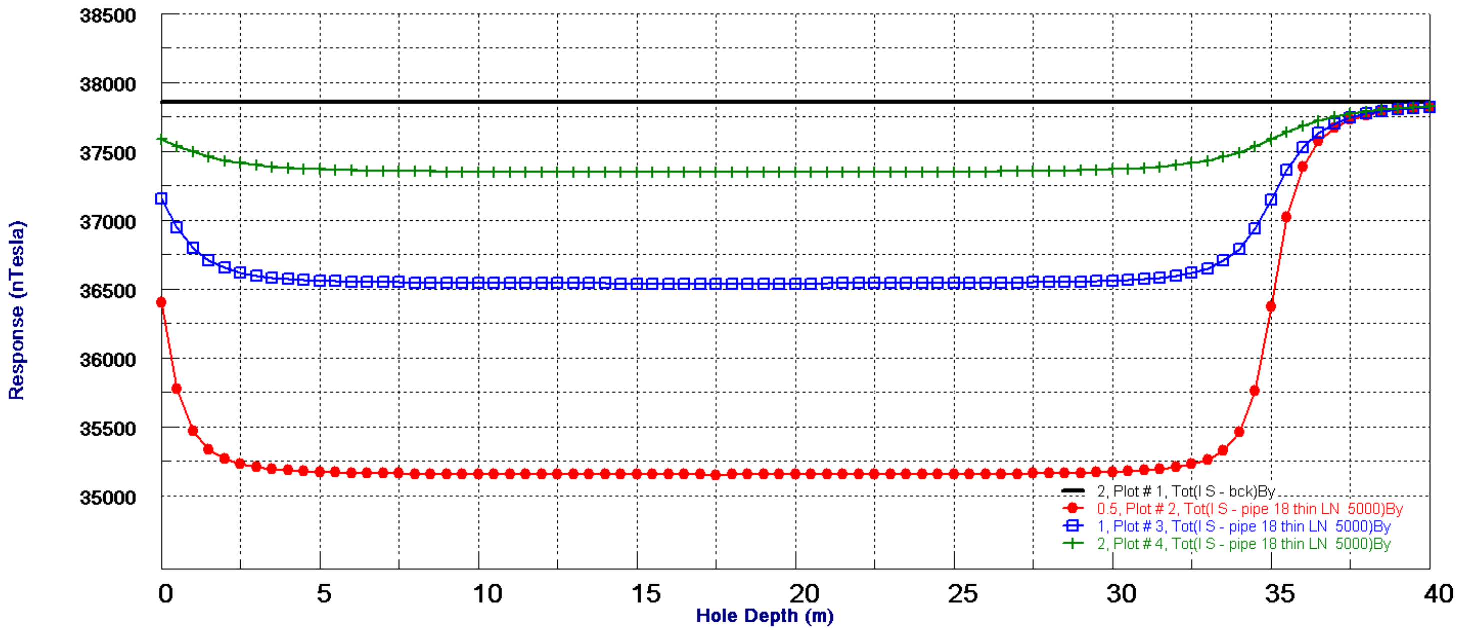
Comparison of the response of the hollow cylinder in three boreholes at different distances from the target.

Red: 0.5 m Blue: 1 m Green: 2 m

Borehole: Effect of Distance

BH: Longtitudinal Component (Y)

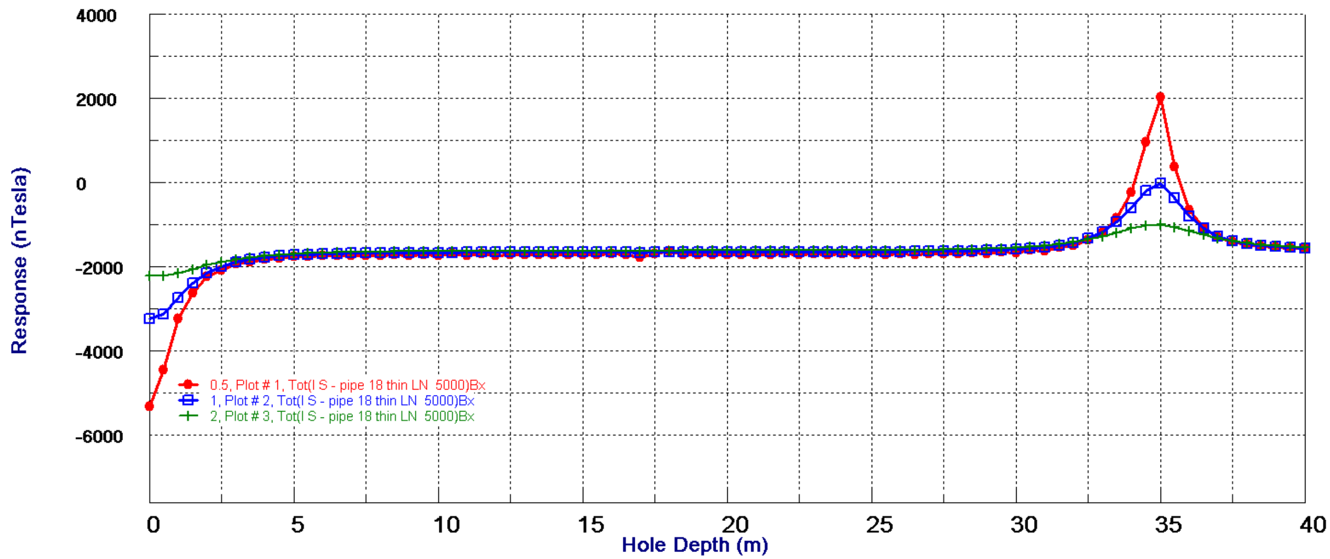
Response of hollow target in BH.



Comparison of the response of the hollow cylinder in three boreholes at different distances from the target.

Red: 0.5 m Blue: 1 m Green: 2 m

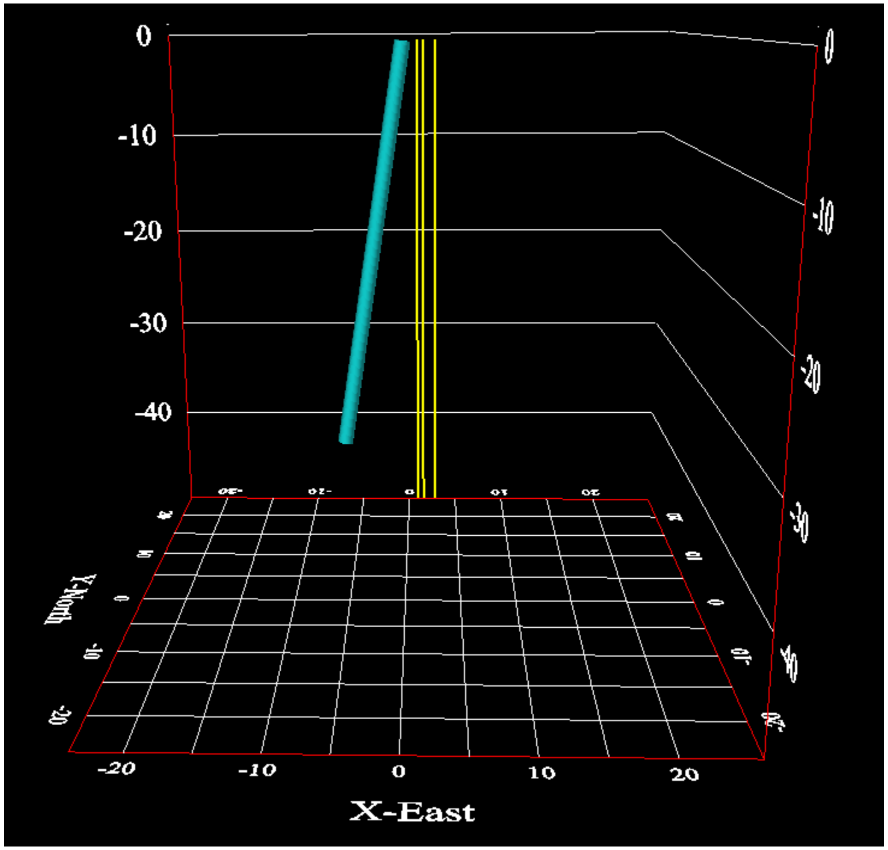
BH: Azimuthal Component (X)



Response of hollow target in the borehole. Comparison of responses in boreholes at different distances from the target. There is very little difference in the responses except at the top and bottom of the boreholes.

Red: 0.5 m Blue: 1 m Green: 2 m

Dipping Model

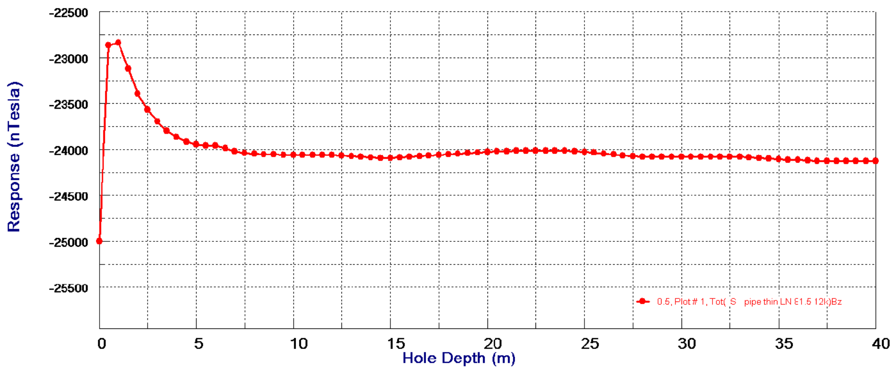


The dipping casing has the same dimensions, but is now dipping at 81.5 degrees to the west.

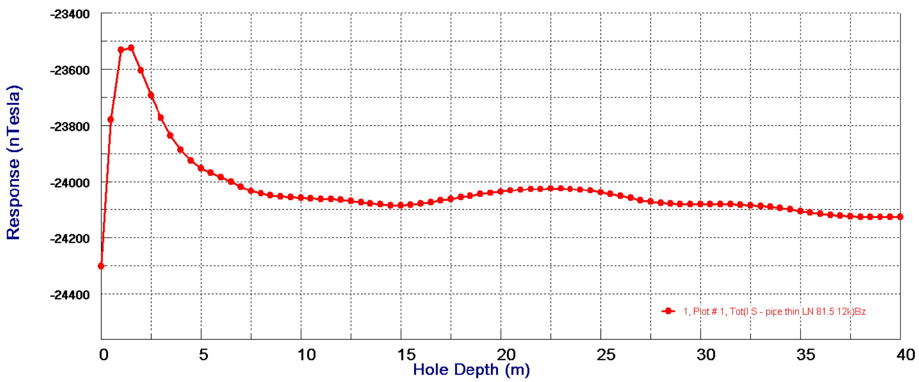
The response was simulated for three vertical boreholes at distances of 0.5 m, 1 m, and 2 m from the east edge of the top of the target.

In this case, the axial component is magnetic component tangential to the axes of the cylinder, the azimuthal component is the component perpendicular to the borehole whose horizontal projection is along the azimuth of the borehole. The horizontal component is horizontal and perpendicular to the axial and azimuthal components.

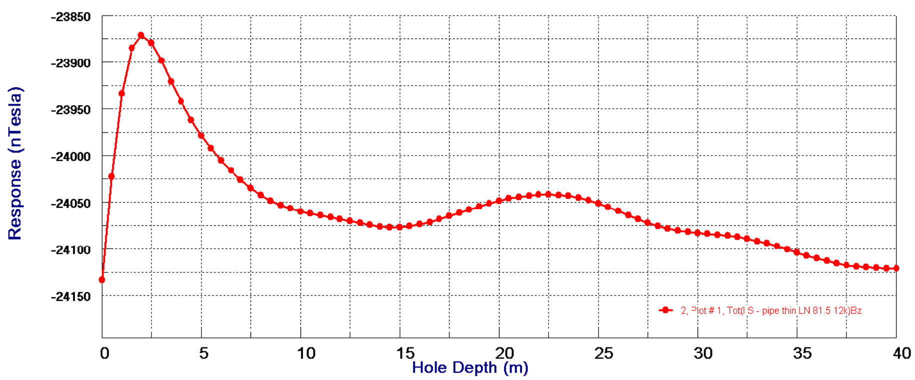
BH: Axial (dipping target) – Effect of Distance



0.5 m from edge of object

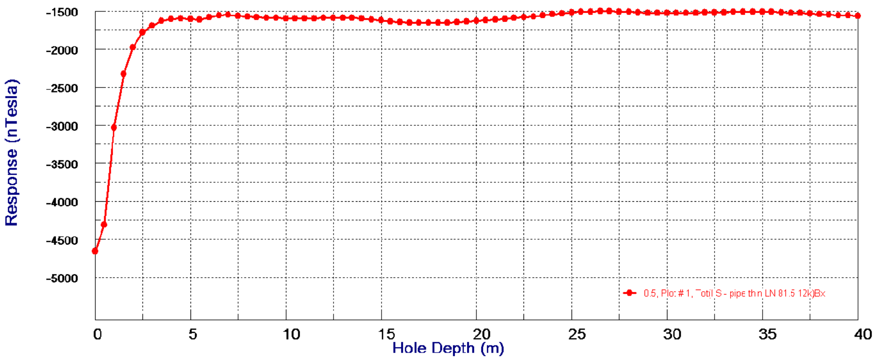


1 m from edge of object

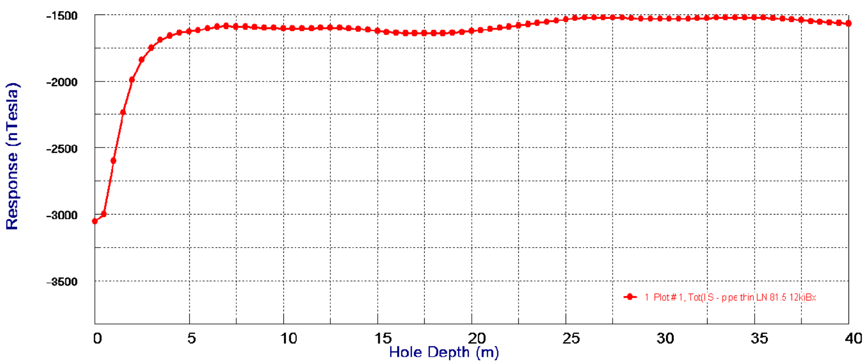


2 m from edge of object

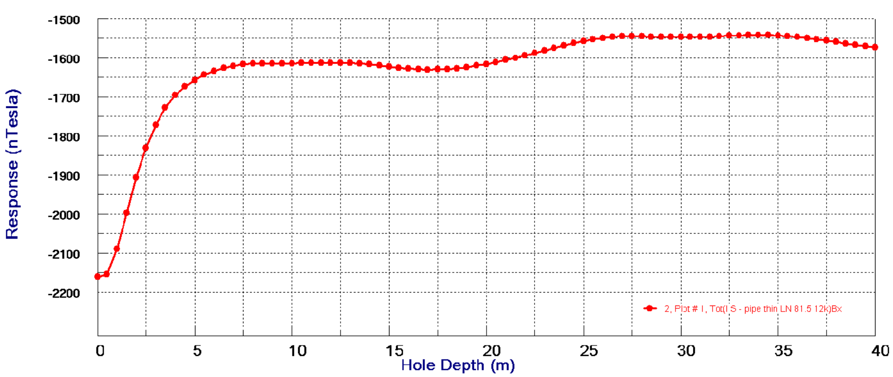
BH: Azimuthal (dipping target) – Effect of Distance



0.5 m from edge of object



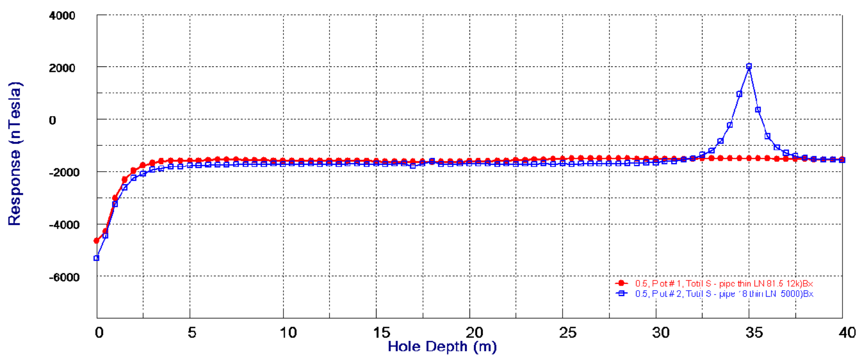
1 m from edge of object



2 m from edge of object

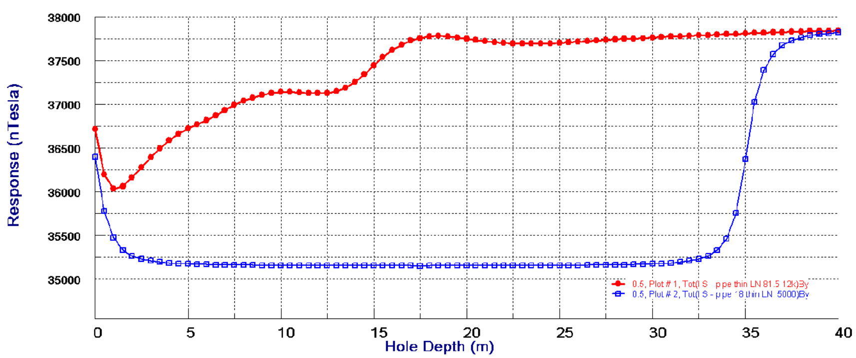
BH: Vertical vs. Dipping Casing

Vertical casing
Dipping casing

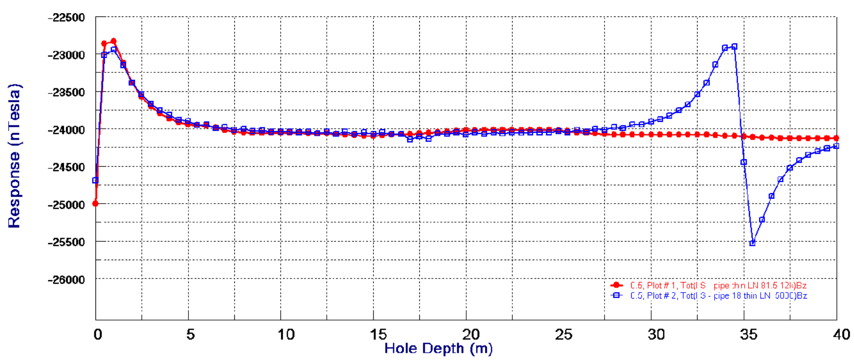


Bx (horizontal)

The plots show the variation in the 3 orthogonal responses along the borehole between the vertical and dipping hollow casing.



By (azimuthal)



Bz (axial)

Summary

-There is a fairly significant difference in the amplitude and sharpness of the response at distances of 0.5, 1, and 2 m from the casing.

-The dip of the casing has a considerable effect on the shape of the response down the hole.

-Due to the high susceptibility of the casing, a weak scattering algorithm is not appropriate for this problem as the casing affects the direction of polarization.