J. Earth & Space Physics. Vol. 30, No. 2, 2004, P. 1- 6

# Detection of near-surface anomalies through 2-D normalized full gradient of gravity data

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(Received:30 May 2004, Accepted: 30 Nov.2004)

**Abstract**

The normalized full gradient (NFG) method defined by Berezkin (1967, 1973 and 1998) is already used for detecting reservoirs. We apply the method for delineating near-surface gravity anomalies. 2-D rectangular prisms with different coordinates are used as the synthetic models to be detected by the method. The NFG is also applied to real microgravity data to determine the place and depth of a subterranean water tunnel (ghanat).

**Keywords**: NFG, Synthetic models, Gravity data, Numerical results

## 1 INTRODUCTION

One of the best methods for locating reservoirs from gravity data is the normalized full gradient proposed by Berezkin (1967 ,1973 and 1998) designated as the NFG or GH. Xiao (1981) used the NFG for oil exploration in China ( Xiao and Zhang,1984). The method had been used by the Chinese in different oil fields with no effective results until 1990. In the early 1990s, new efforts to apply the method to the high-precision gravity data, were initiated. Zeng et al. (2002) published the results of implementing the method for 2-D cases sections of anticlines with homogenous density in the Shengli oil field.

## 2 THE NFG

The 2-D NFG of gravity anomalies is defined as (Berezkin, 1973),

$$G_H = \frac{G(x,z)}{G_{cp}(z)} = \frac{\sqrt{V_{xz}^2(x,z) + V_{zz}^2(x,z)}}{\frac{1}{M}\sum_0^M \sqrt{V_{xx}^2(x,z) + V_{zz}^2(x,z)}} \tag{1}$$

where $G_H$ is the NFG at point $(x,z)$, $V_{zz}(x,z)$ and $V_{xz}(x,z)$ are the first vertical and the first horizontal derivatives of gravity data. $G(x,z)$ is the full gradient of gravity data and $G_{cp}(z)$ is the average of the full gradient at level z and M is the number of data points. Berezkin (1973) expressed the gravity anomalies over the range $(-L,L)$ by finite Fourier sine series,

$$\Delta g(x,z) = \sum_1^N B_n \sin\frac{\pi n x}{L} e^{\frac{\pi n z}{L}} \tag{2}$$

where

$$B_n = \frac{2}{L}\int_0^L \Delta g(x,0)\sin\frac{\pi n x}{L}dx \tag{3}$$

L is the length of the gravity profile and N is the number of terms of the series. From eqn. (2) we have,

$$V_{xz}(x,z) = \frac{\pi}{L}\sum_1^N nB_n \cos\frac{\pi n x}{L} e^{\frac{\pi n z}{L}} \tag{4}$$

$$V_{zz}(x,z) = \frac{\pi}{L}\sum_1^N nB_n \sin\frac{\pi n x}{L} e^{\frac{\pi n z}{L}} \tag{5}$$

Defining a smoothing factor for eliminating high-frequency noise resulting from downward continuation we finally have,

$$\Delta g(x,z)=\sum_{1}^{N}B_n\sin\frac{\pi nx}{L}e^{\frac{\pi nz}{L}}\left(\frac{\sin\frac{\pi n}{N}}{\frac{\pi n}{N}}\right)^m \quad (6)$$

$$V_{xz}(x,z)=\frac{\pi}{L}\sum_{1}^{N}nB_n\cos\frac{\pi nx}{L}e^{\frac{\pi nz}{L}}\left(\frac{\sin\frac{\pi n}{N}}{\frac{\pi n}{N}}\right)^m \quad (7)$$

$$V_{zz}(x,z)=\frac{\pi}{L}\sum_{1}^{N}nB_n\sin\frac{\pi nx}{L}e^{\frac{\pi nz}{L}}\left(\frac{\sin\frac{\pi n}{N}}{\frac{\pi n}{N}}\right)^m \quad (8)$$

where m=2 for oil gravity exploration. Substituting equations (7) and (8) for equation (1), the NFG can be calculated. The method is especially useful for detecting characteristic points of gravitational bodies such as centroids and corners from singular points in the gravity field.

## 3 NUMERICAL RESULTS

Testing the efficiency of the NFG method, some 2-D rectangular prisms are considers under the surface. The contrast density of these prisms are equal to $1gr/cm^3$. The NFG with m=1 and N=10 is applied to detect the depth and x coordinates of the prisms and the results are shown in figures 1 to 6. These figures are quite self-explanatory and confirms the efficiency of the method. It is worth to knowing that the length of the profiles over these synthetic models is equal or greater than 10 times the depth of the top of the model. In another attempt, the method is used to delimit a subsurface water tunnel from real gravity data. Two profiles each 15m long with sample interval 2m are measured over the tunnel. The NFG determined the depth of the top of the tunnel very accurately (figures 7b and 8b). The central point of x coordinate of the tunnel is shifted about 1or 2 meters to the right from the peak of the anomaly (figures 7a and 8a) which is due to the shortness of the profile and can easily be treated by prolonging the length of the profile.

## 4 CONCLUSION

The NFG method is quite effective in delineating near-surface gravity anomalies. The method is full automatic. The only limitation is that the accuracy of the results depends greatly on the length of the profile. The best results especially in the case of the x coordinate of the anomaly are obtained when the length of the profile is equal or greater than 10 times the depth to the top of the anomaly.

## ACKNOWLEDGEMENTS

The author is thankful to the Institute of Geophysics, University of Tehran.

## REFERENCES

Berezkin, W. M., 1967, Application of the full vertical gravity gradient to determination to sources causing gravity anomalies (in Russian): Expl. Geopys., **18**, 69-76.

Berezkin, W. M., 1973, Application of gravity exploration to reconnaissance of oil and gas reservoir (in Russian), Neda Publishing House Russia.

Berezkin, W. M., 1998, Full gradient method in geophysical prospecting (in Russian), Neda Publishing House Russia.

Xiao, Y., 1981, Normalized full gradient method of gravity anomalies (in Chinese): Oil Geophy. Prosp., **16** No. 3, 47-57.

Xiao, Y., and Zhang, L., 1984, Application of normalized full gradient method of gravity anomalies to oil and gas exploration (in Chinese): Oil Geophys. Props., **19** No. 3, 247-254.

Zeng, H., Meng, X., Yao, CH., Li, X., Lou, H., Guang, Z., and Li, Z., 2002, Detection of reservoirs from normalized full gradient of gravity anomalies and its application to Shengli oil field east China: Geophy., **67**. No. 4, 1138-1147.

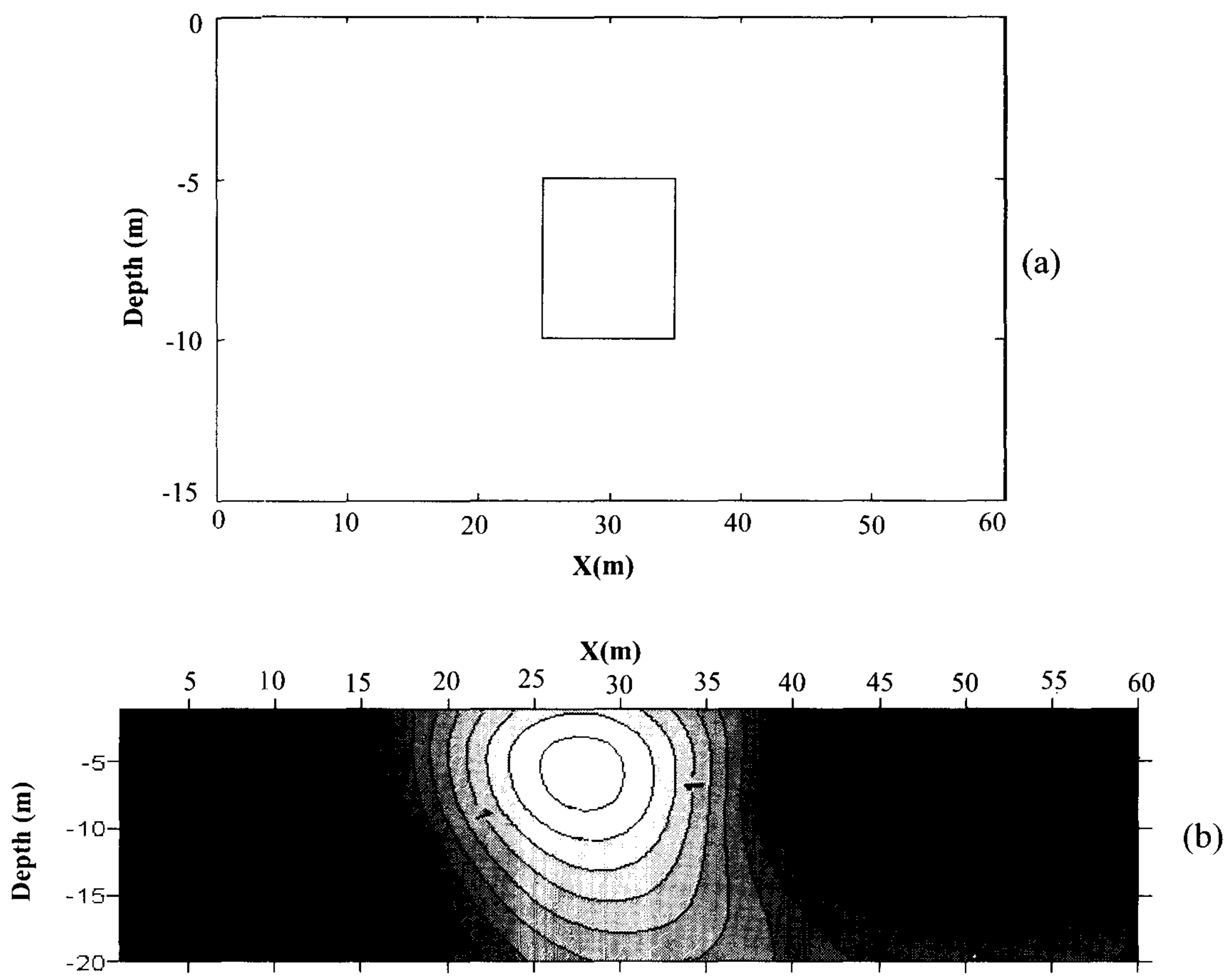


**Figure 1.** a) The 2-D prismatic block and b) the NGF.

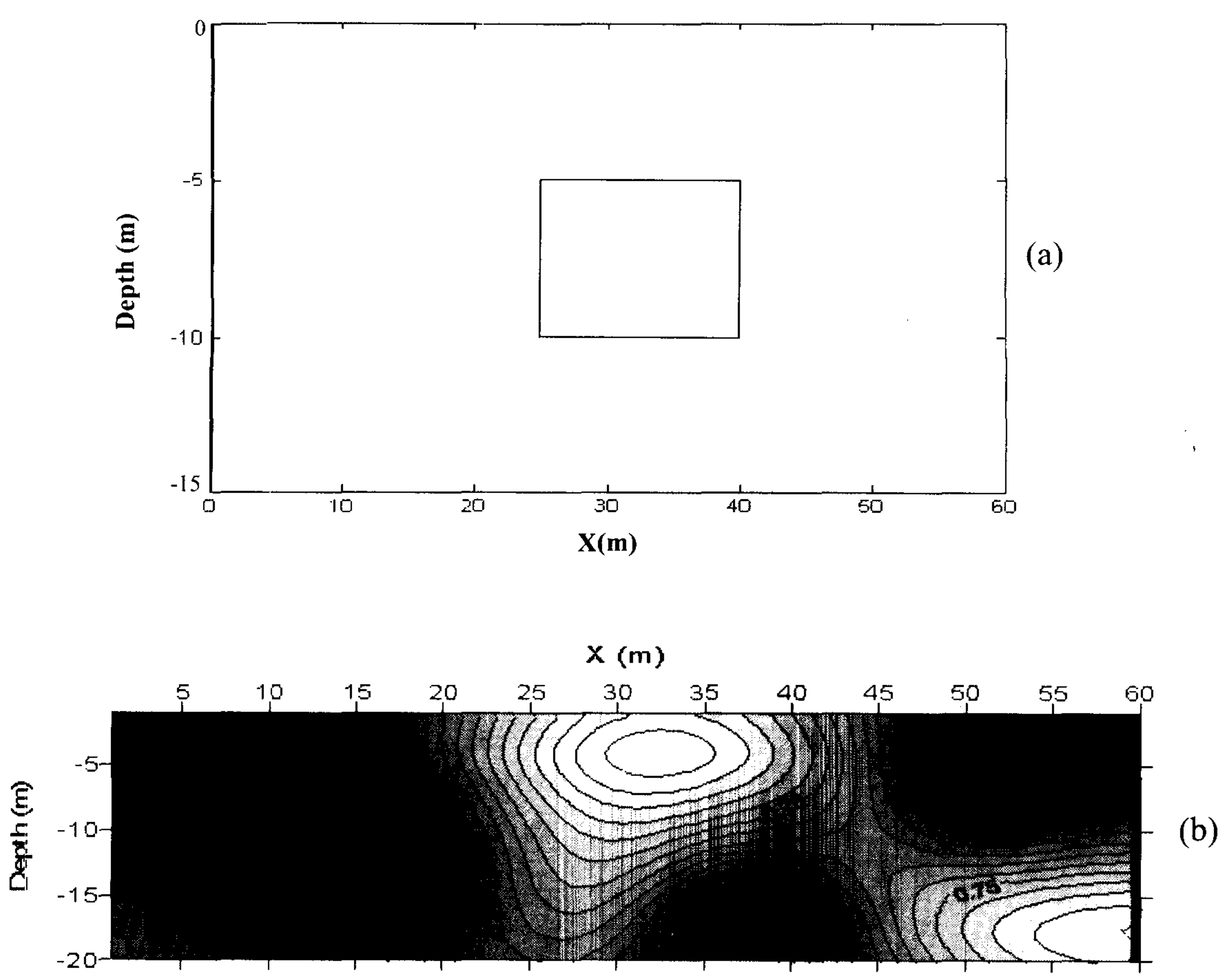


**Figure 2.** a) The 2-D prismatic block and b) the NGF.

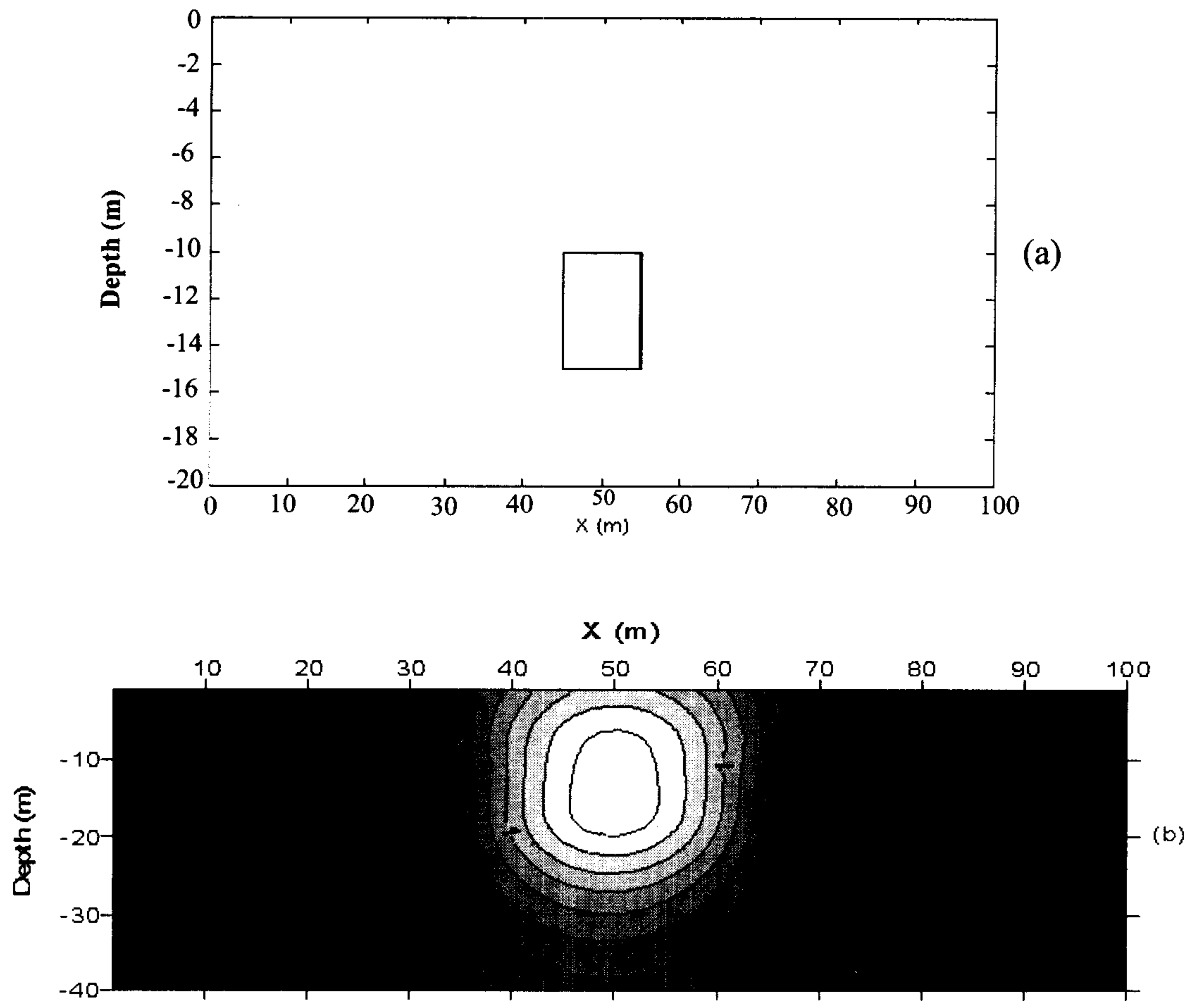


**Figure 3.** a) The 2-D prismatic block and b) the NFG.

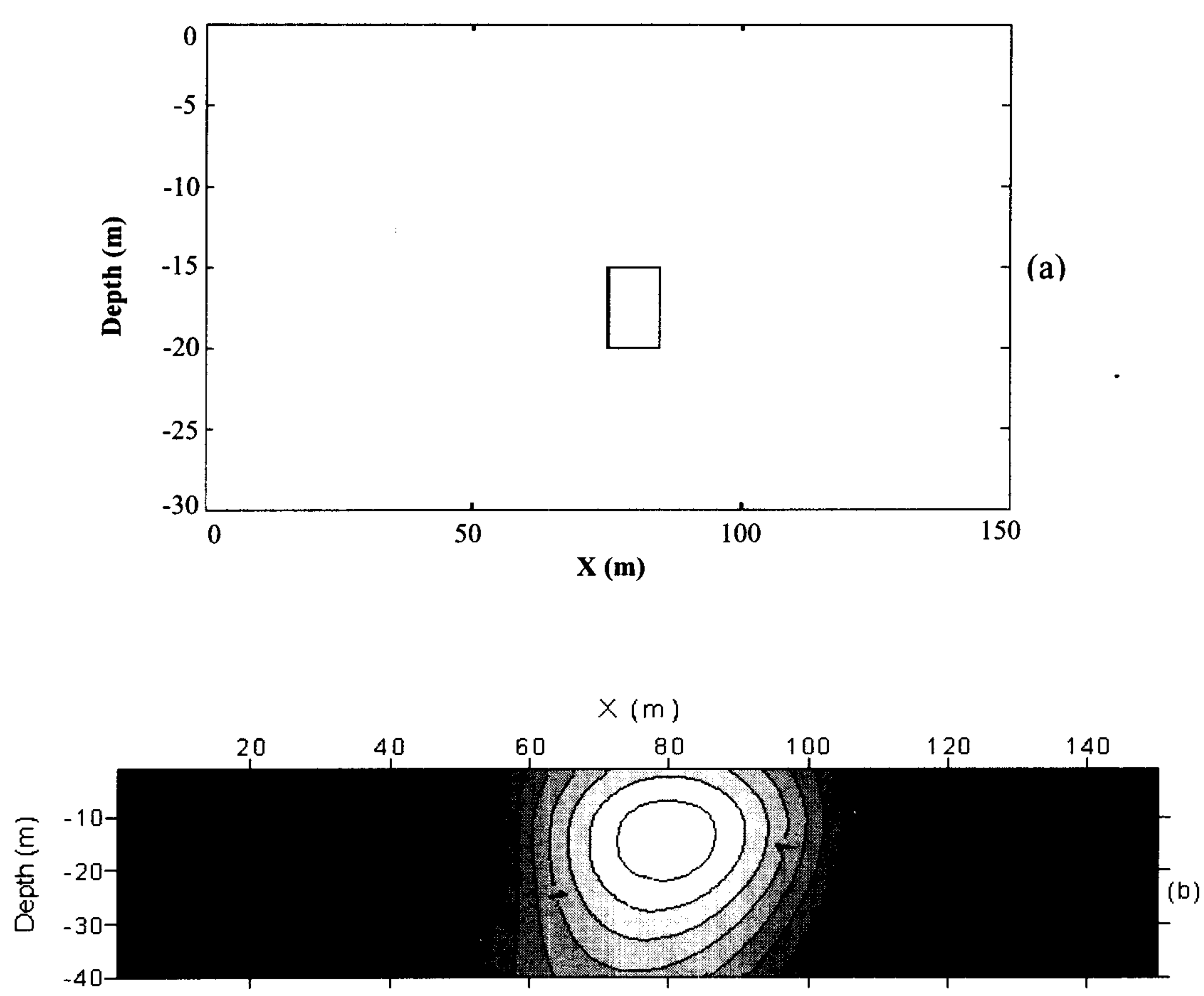


**Figure 4.** a) The 2-D prismatic block and b) the NFG.

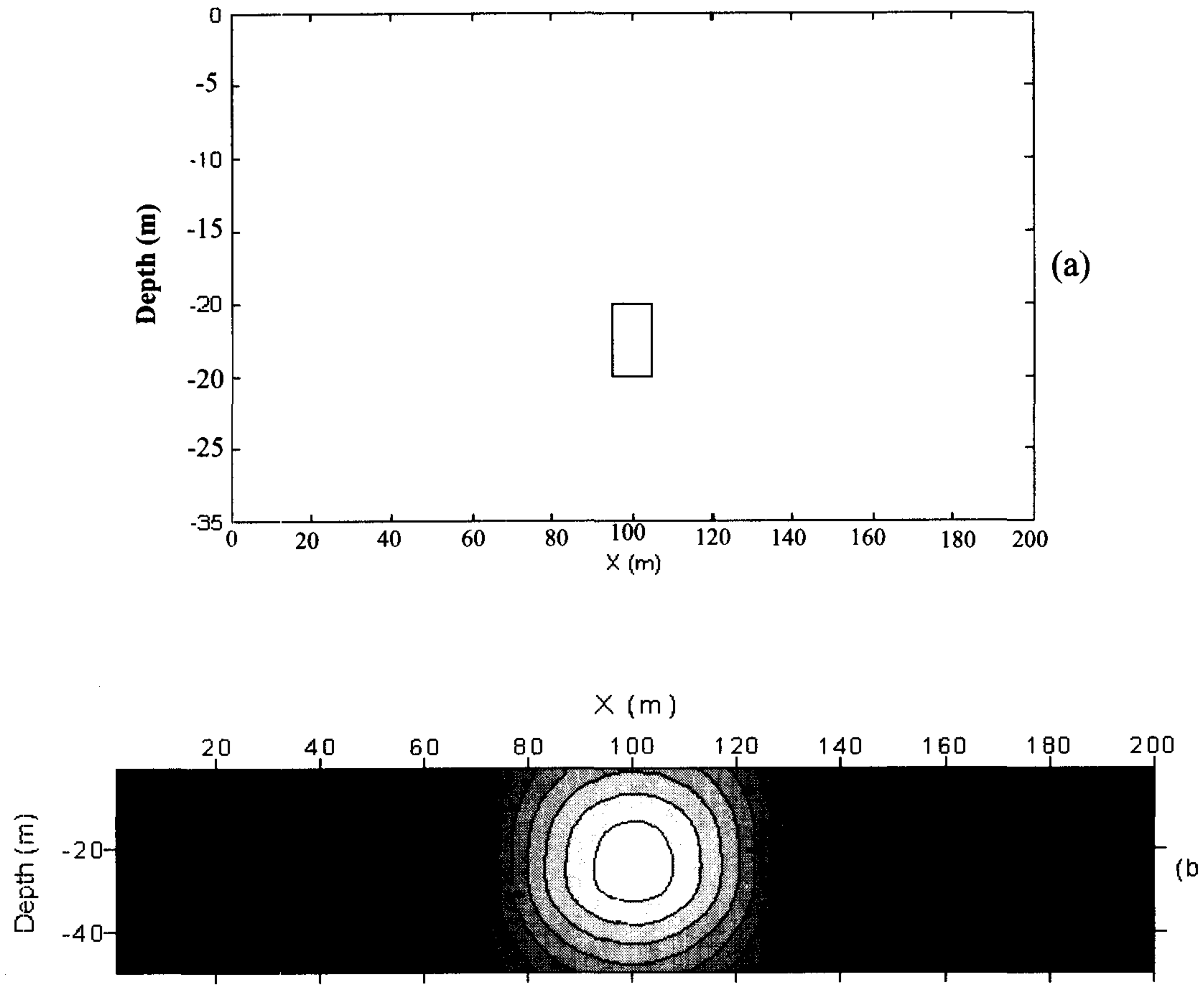


Figure 5. a) The 2-d prismatic block and b) the NFG.

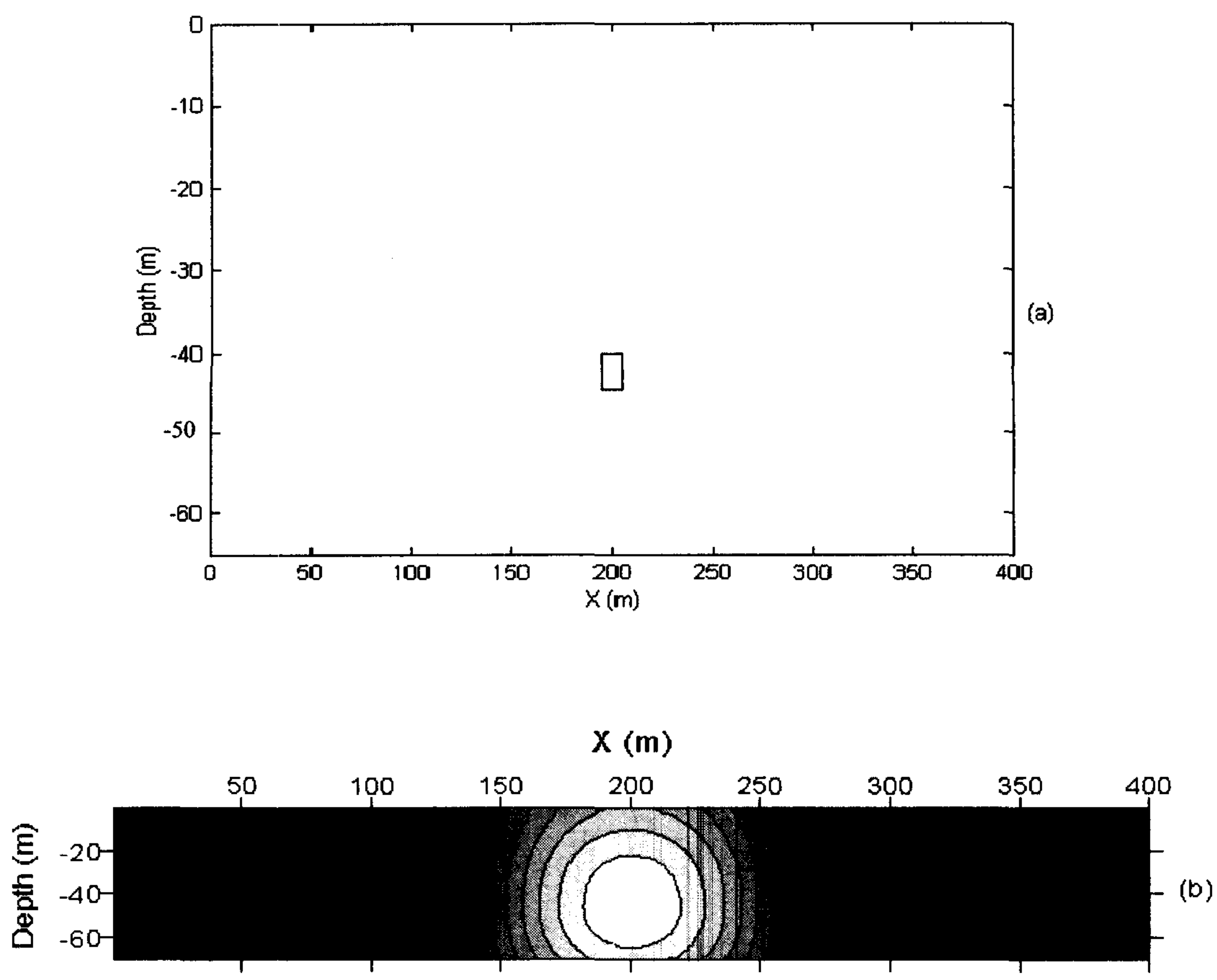


Figure 6. a) The 2-d prismatic block and b) the NFG.

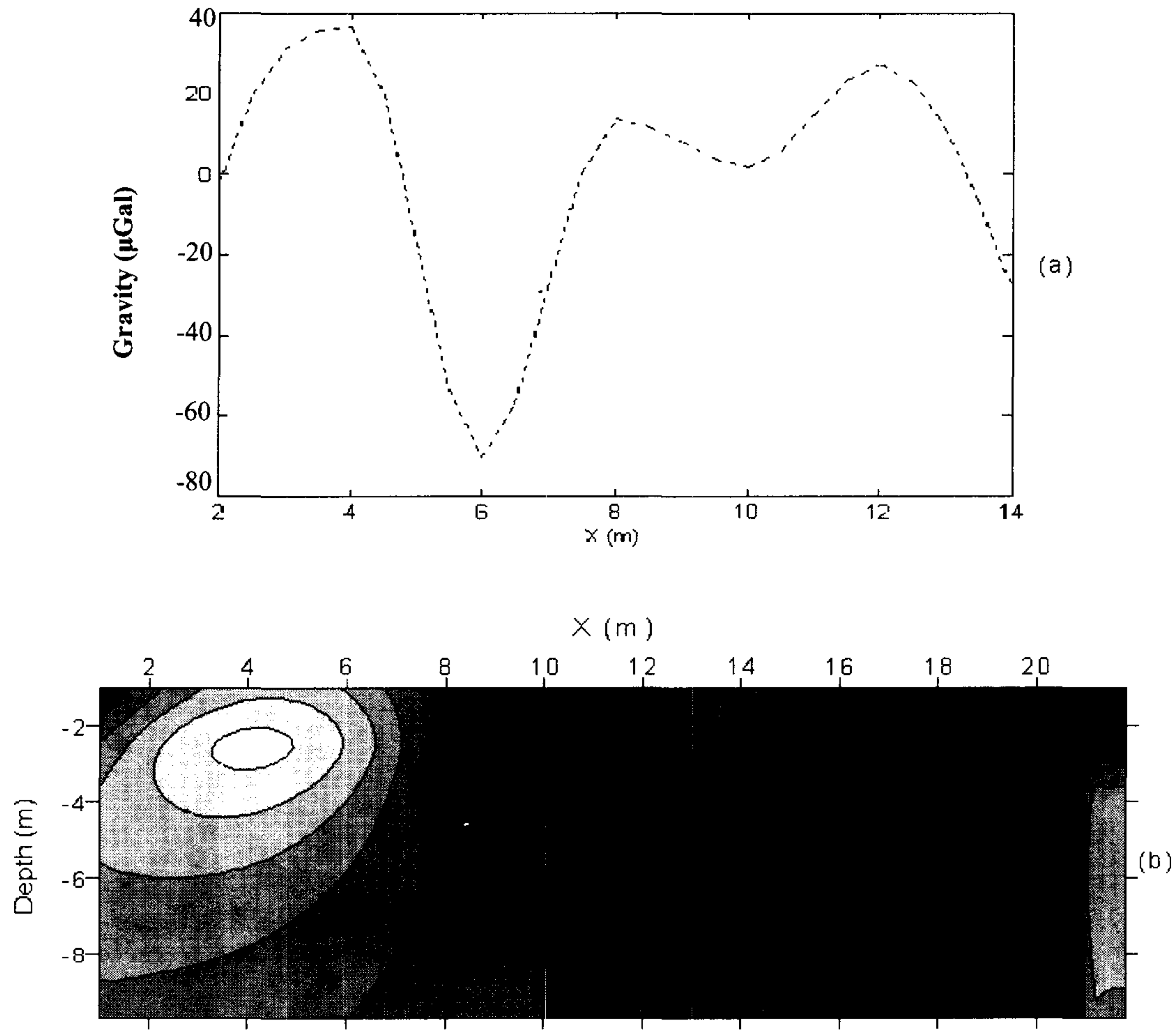


**Figure 7.** a) The gravity effect of the tunnel and b) the NFG.

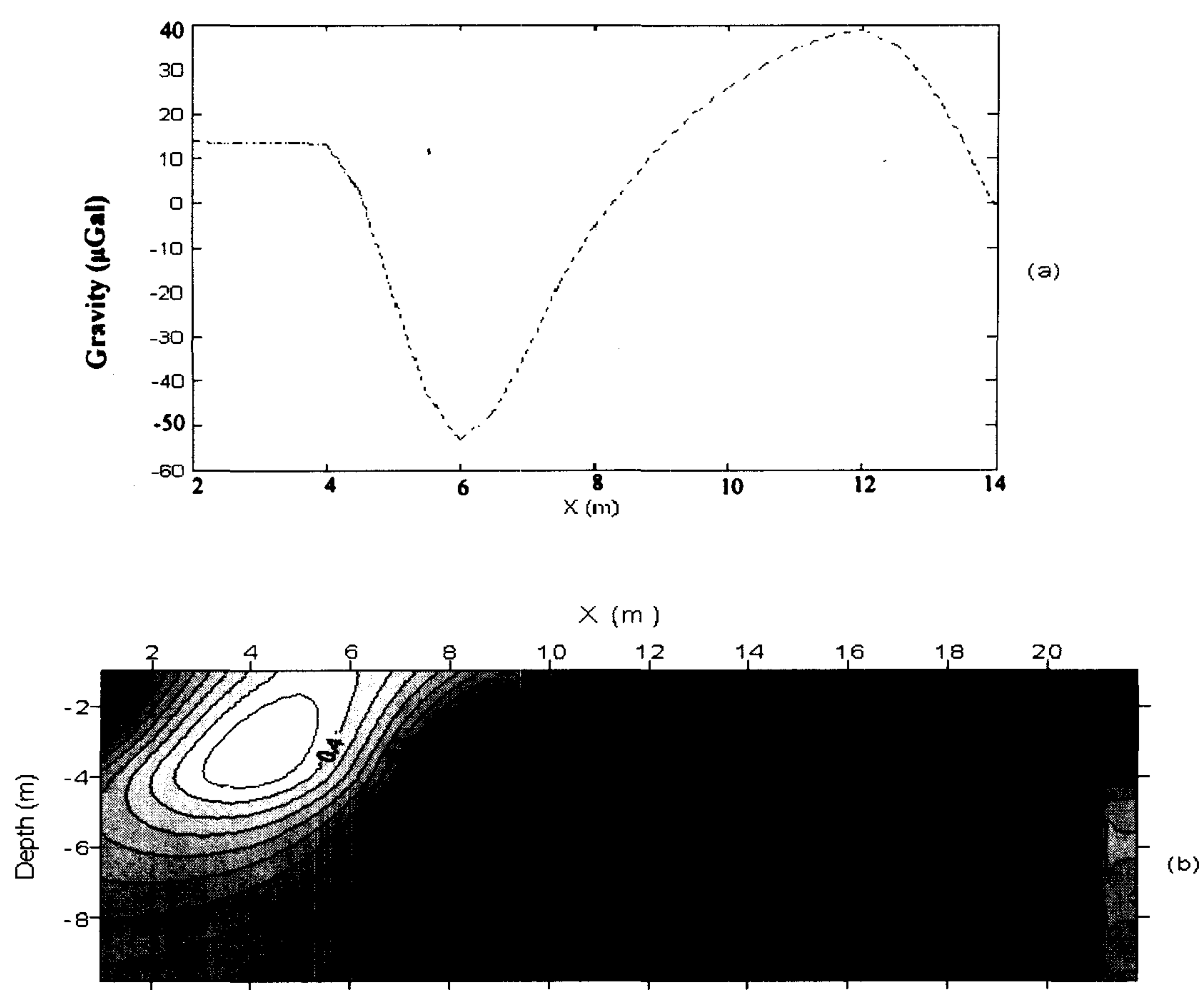


**Figure 8.** a) The gravity effect of the tunnel and b) the NFG.