A Hybrid PCG- Bat Algorithm for 2D Gravity Inversion: Applications for Ore Deposits Exploration and Interpretation of Sedimentary Basins

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METHODOLOGY

The gravity anomaly of a model built of M prisms and computed for a station *i is expressed as follows* (Last and Kubik, 1983):

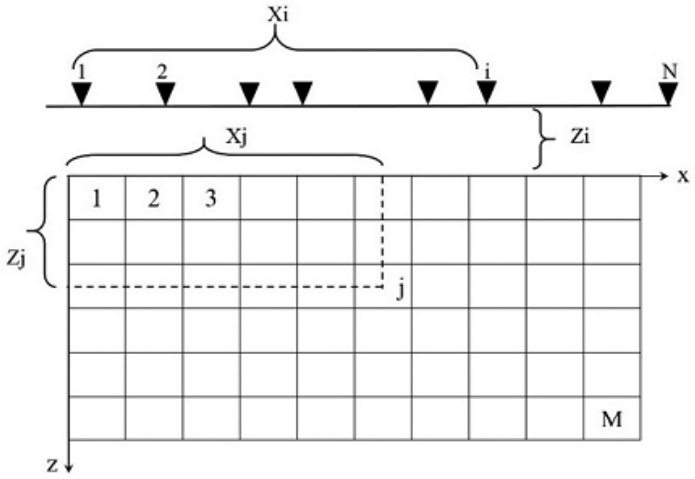
$$d_i = \gamma \sum_{j=1}^{M} \rho_j G_{ij},$$

where Gij is geometrical effect of block j of station i and ρj is density of j prism. For N stations it can be rewritten in matrix form :

$$d = G\rho,$$

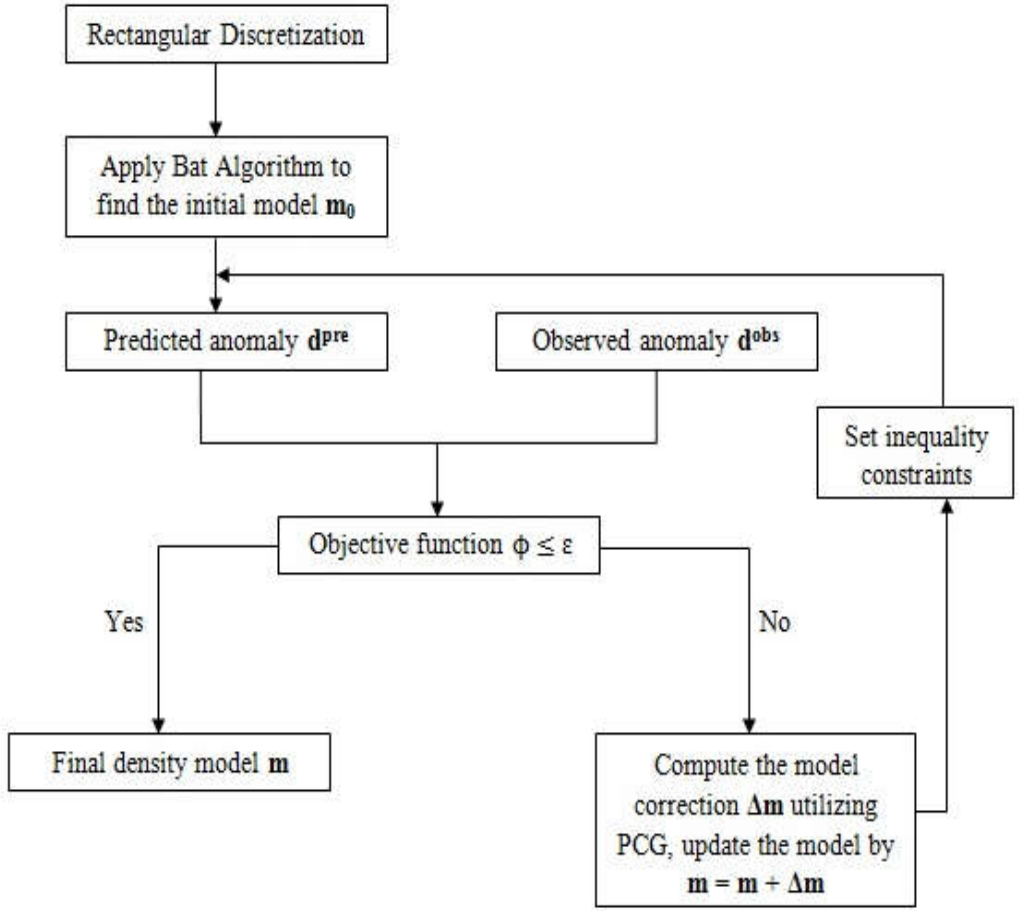
where $d = (d_1, d_2, d_3, \ldots, d_N)$ is a vector of N station gravity anomalies, $\rho = (\rho_1, \rho_2, \rho_3, \ldots, \rho_M)$ is a vector of densities of M blocks and G is the $M \times N$ kernel matrix which translates densities to gravity anomalies.

Rectangular Discretization



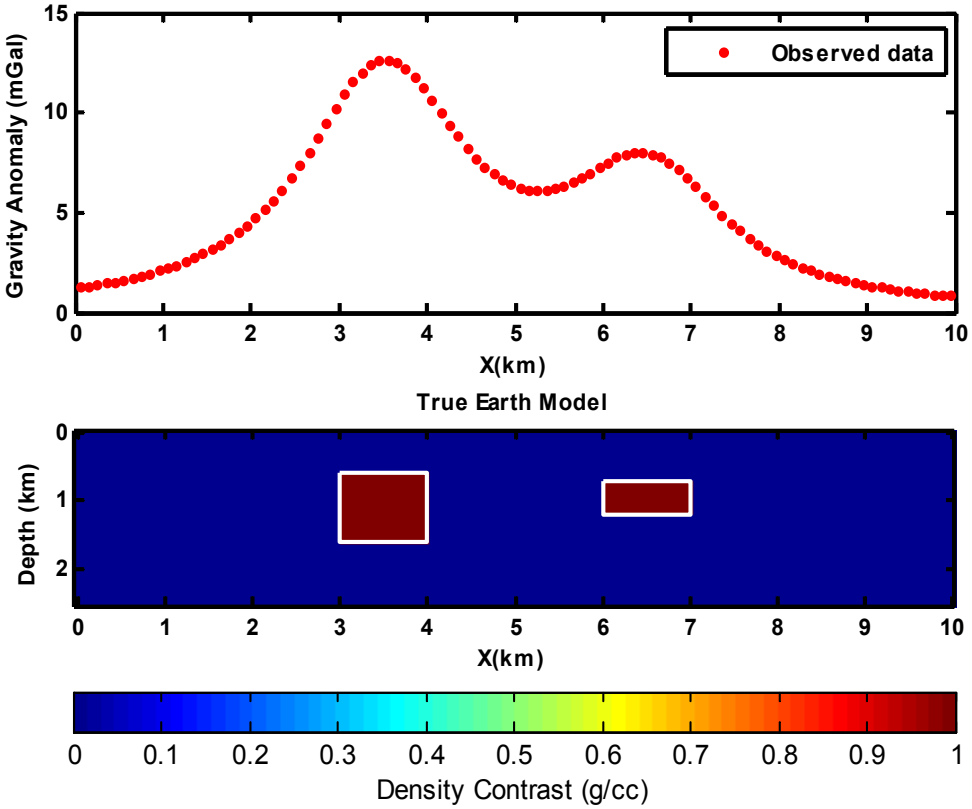
The 2-D model, showing data point i and prism j.

Flowchart



Results

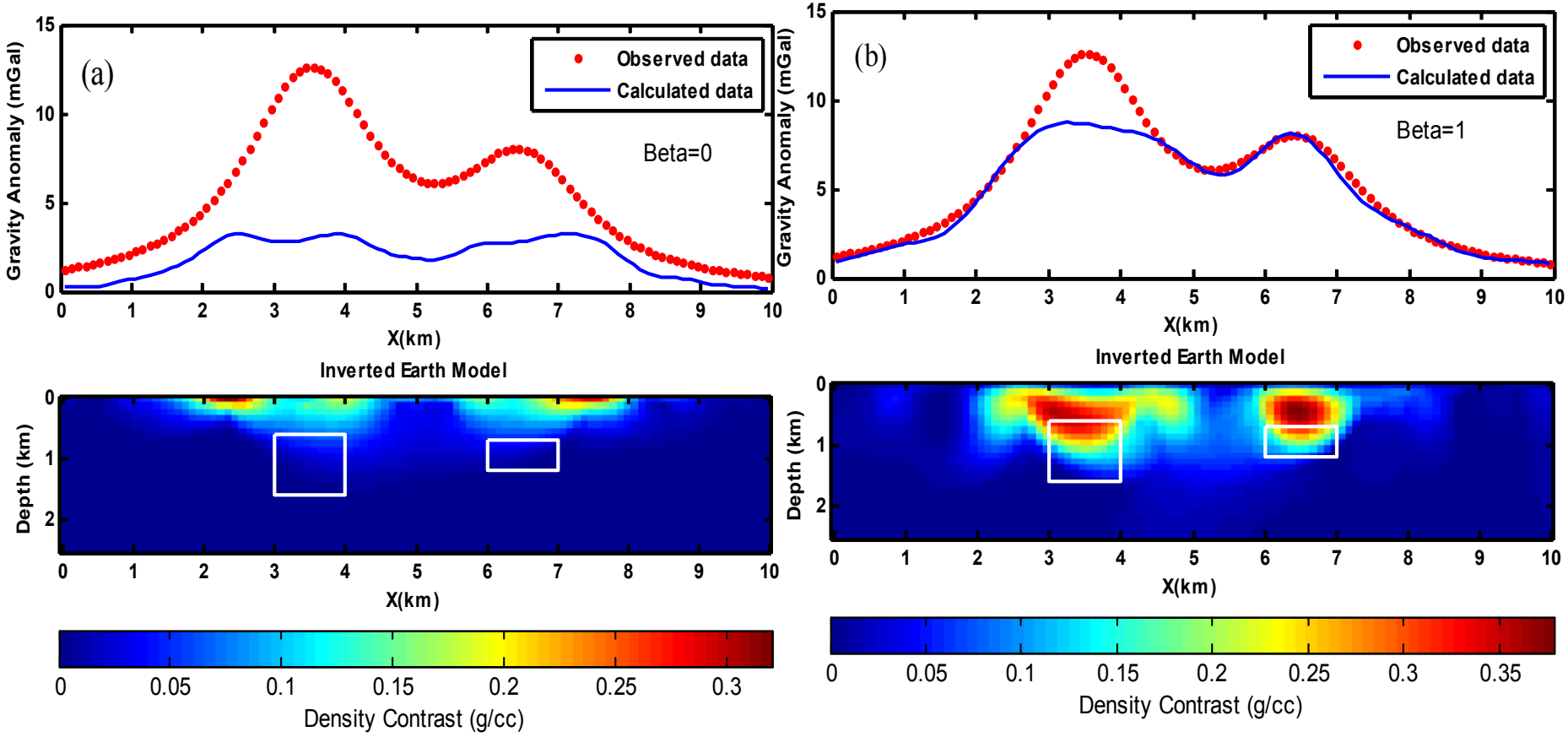
➢ Synthetic example 1



- The prism size is 100 m × 100 m hence the number of prisms used is 100 in x-direction and 25 in z-direction (i.e., 2500 cells) in forward and inversion modeling.
- The condition number of the coefficient matrix of this model is 6.5664*10^20.

Synthetic example 1

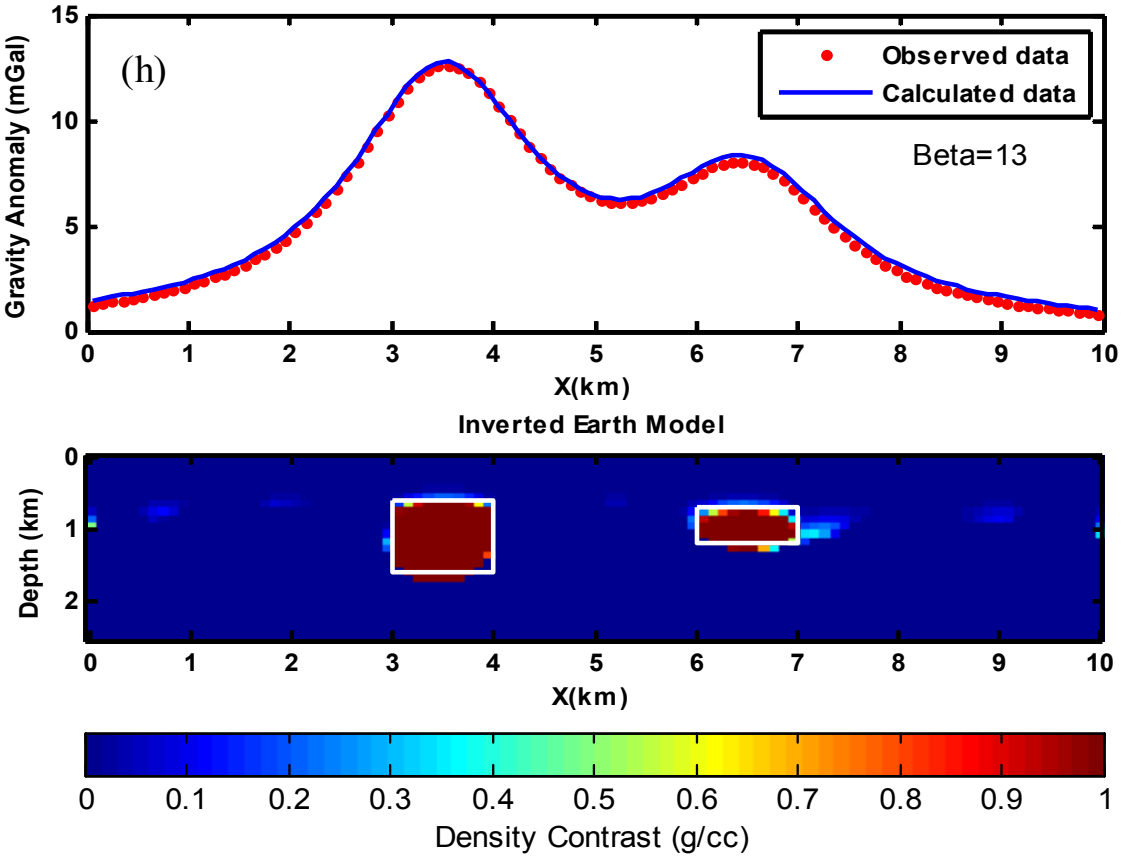
Beta value effect



Synthetic example 1

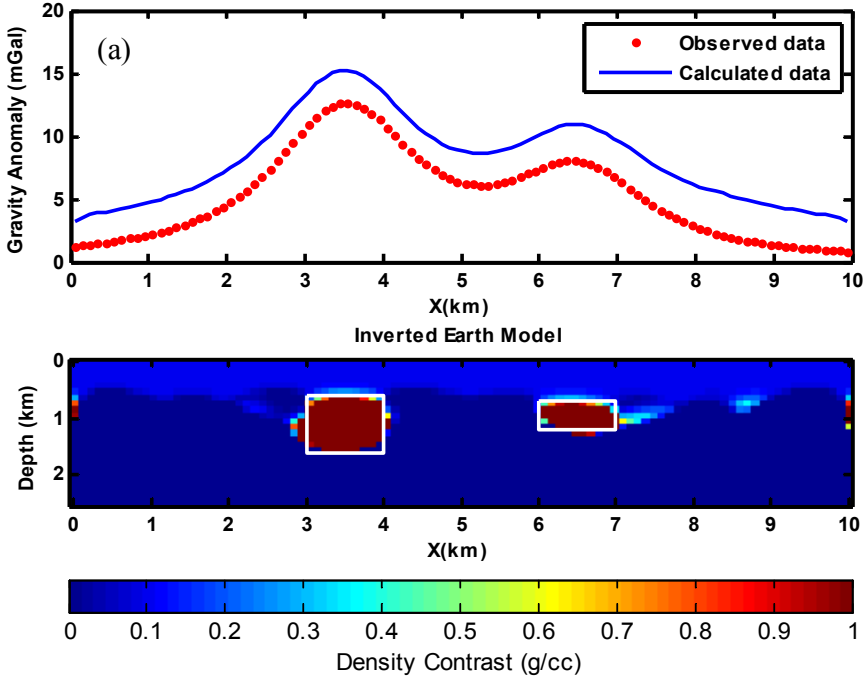
Beta value effect

Beta (β) value	*Misfit error (%)*	*Correlation factor (r_{corr})*
0	6.4702	-0.0004
1	1.3652	0.3309
2	0.6133	0.5775
3	0.3587	0.6854
4	0.2570	0.7320
5	0.0090	0.7543
6	0.0126	0.7683
7	0.0407	0.7923
8	0.1040	0.8008
9	0.7513	0.8033
10	0.8433	0.8331
11	1.4064	0.8172
12	0.8336	0.8549
13	1.1002	0.9314



Synthetic example 1

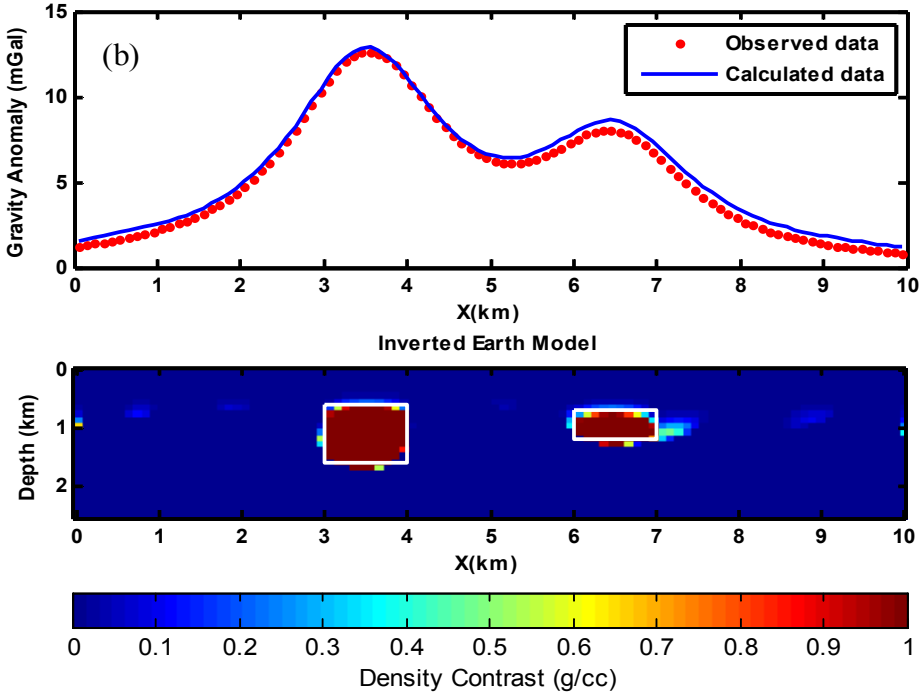
PCG solution



r=0.87

PCGBAT solution

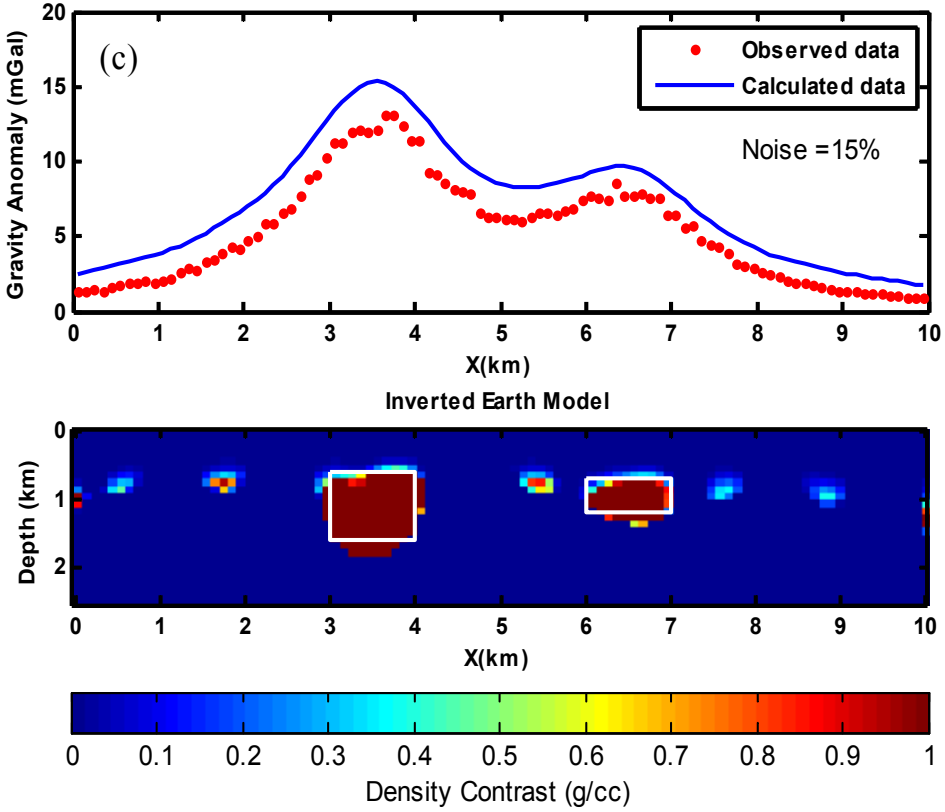
r=0.9314

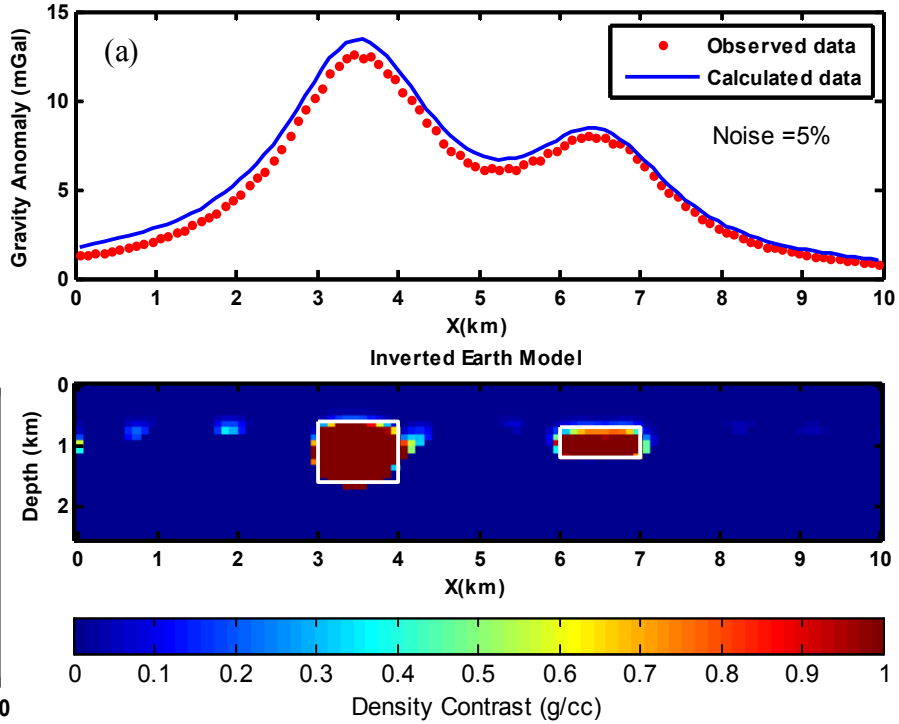


Synthetic example 1

Noise addition

r= 0.8445

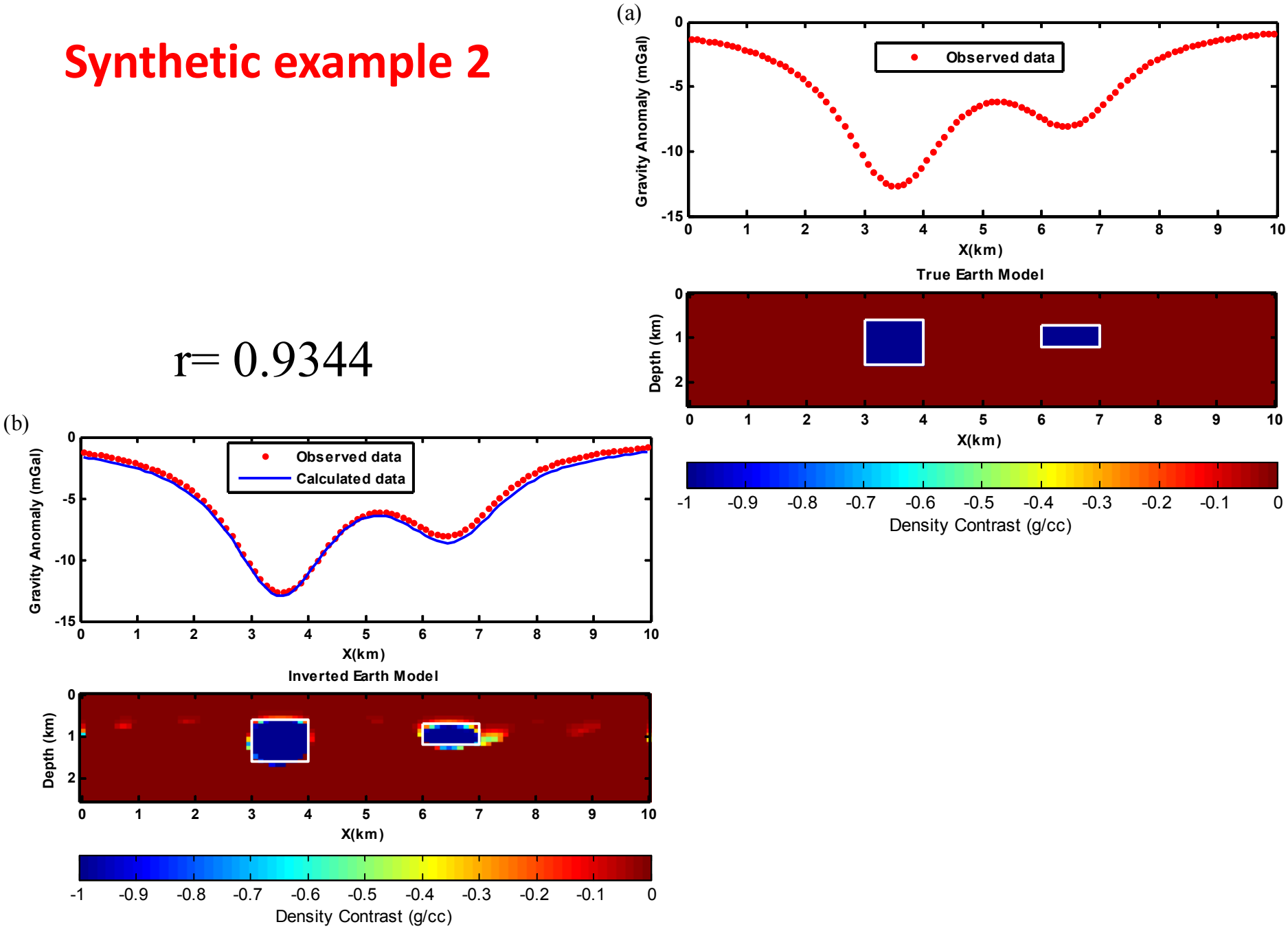




r= 0.9232

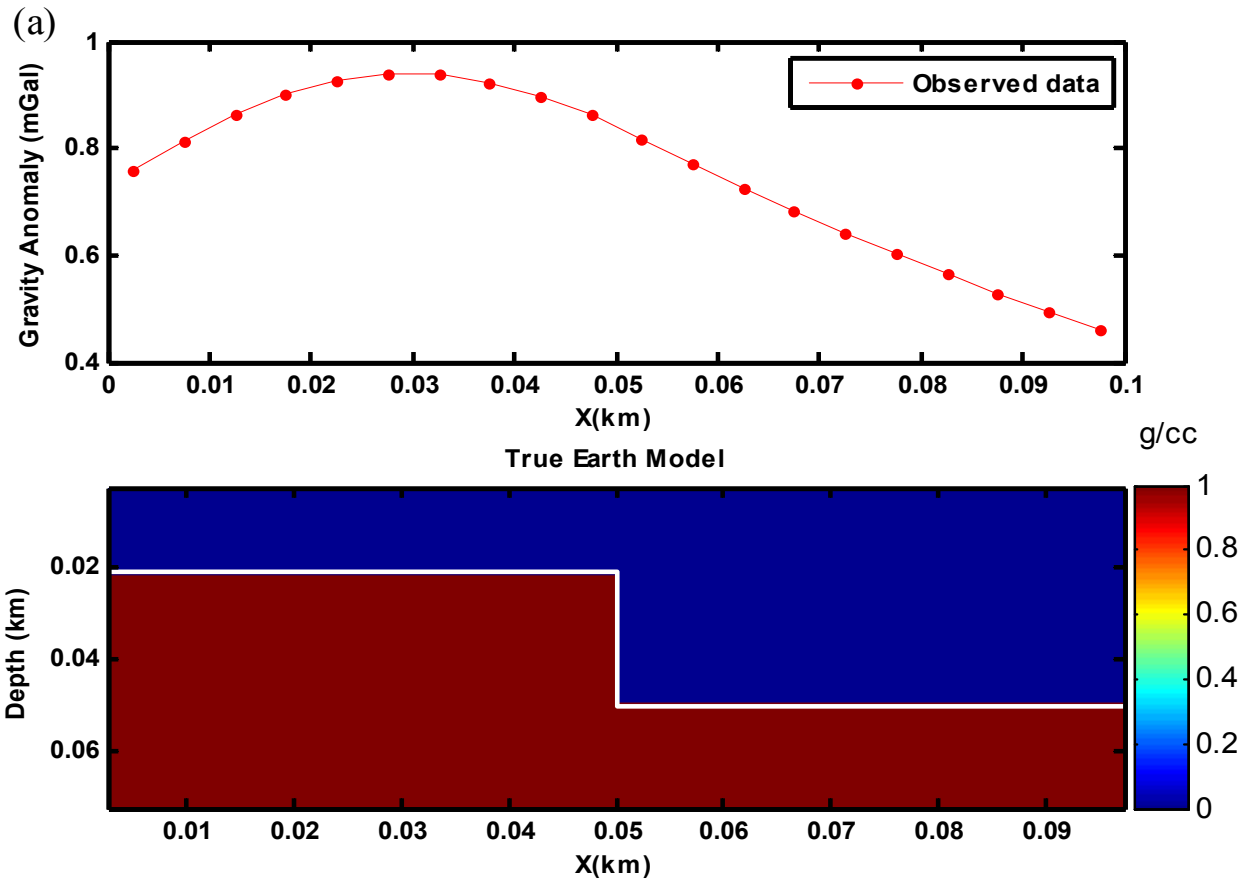
Synthetic example 2

r= 0.9344

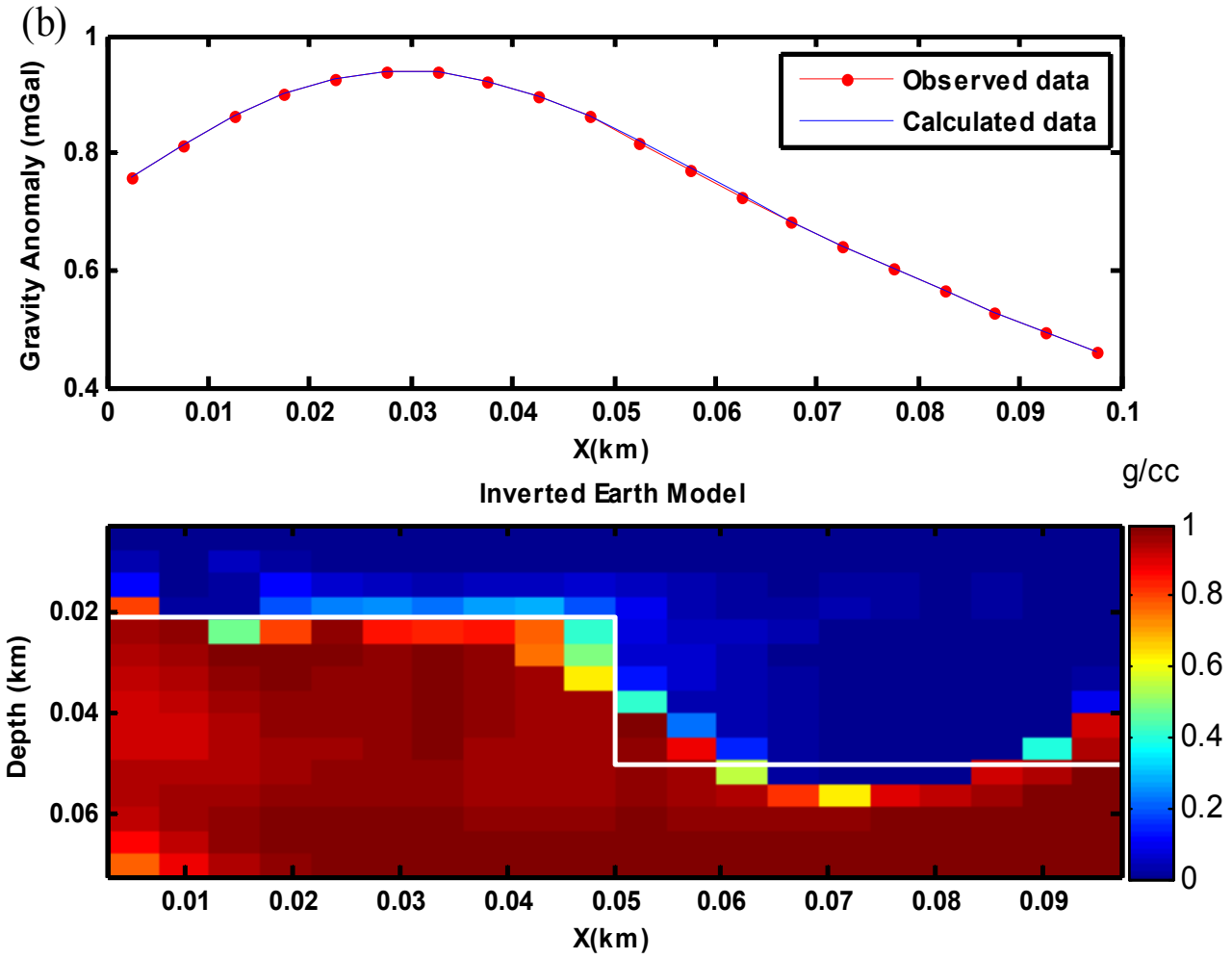


Synthetic example 3

• This model considered by (Portniaguine and Zhdanov, 1999). The prism size is 5 m × 5 m hence the number of prisms used is 20 in x direction and 15 in z-direction (i.e., 300 cells) in forward and inversion modeling.



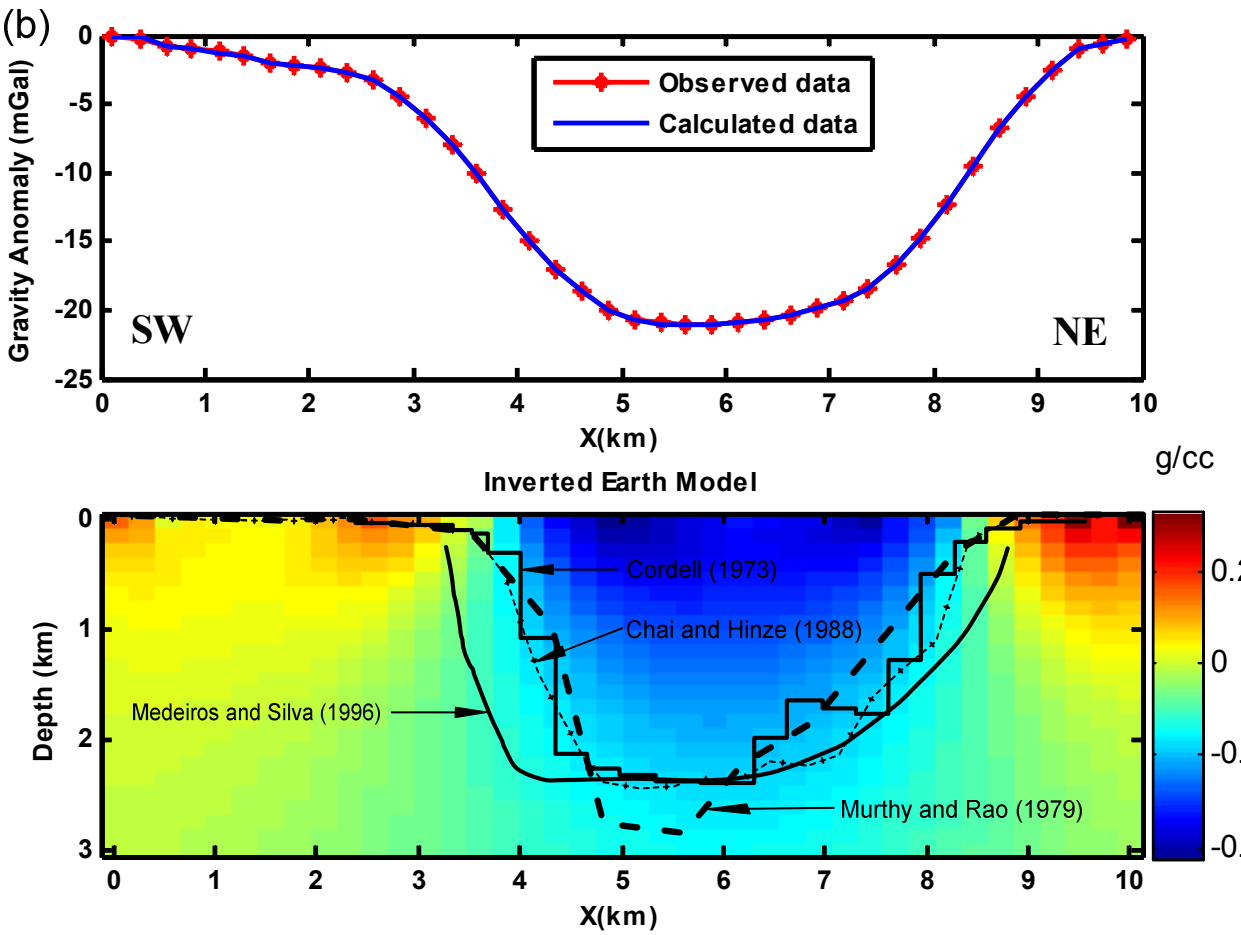
Synthetic example 3 *Inverted results*



- The gravity response was calculated every 5 m on the surface so 20 data points and 300 prisms were used in the inversion process and the dimensions of the kernel matrix is 20×300.
- β=6 & r= 0.9175

Field examples

1- San Jacinto Graben, southern California, USA



- A basement complex represented by pre-Tertiary schist and gneiss.
- This graben is filled with fragments sedimentary rocks of Pliocene and Pleistocene.
- In almost all cases, the *highest depth* to basement is about 2.4 km.
- Prisms (24 x 40)
- β=0.05 by trial and error.

2-Sierra Mayor - Sierra Pinta Basement Outcrops (Profile D – D')

•This profile has a length of **17 km** and gives evidence that *Laguna Salada* is a ***down-dropped fault block or graben structure*** between the ***Sierra Mayor*** and the ***Sierra Pinta*** as noticed from the response of gravity anomaly through this profile. The pre-tertiary basement rocks represented by granitic intrusive, schist and gneiss, and the sediments filling this graben of Pliocene and Pleistocene are sandstone, conglomerate and alluvium.

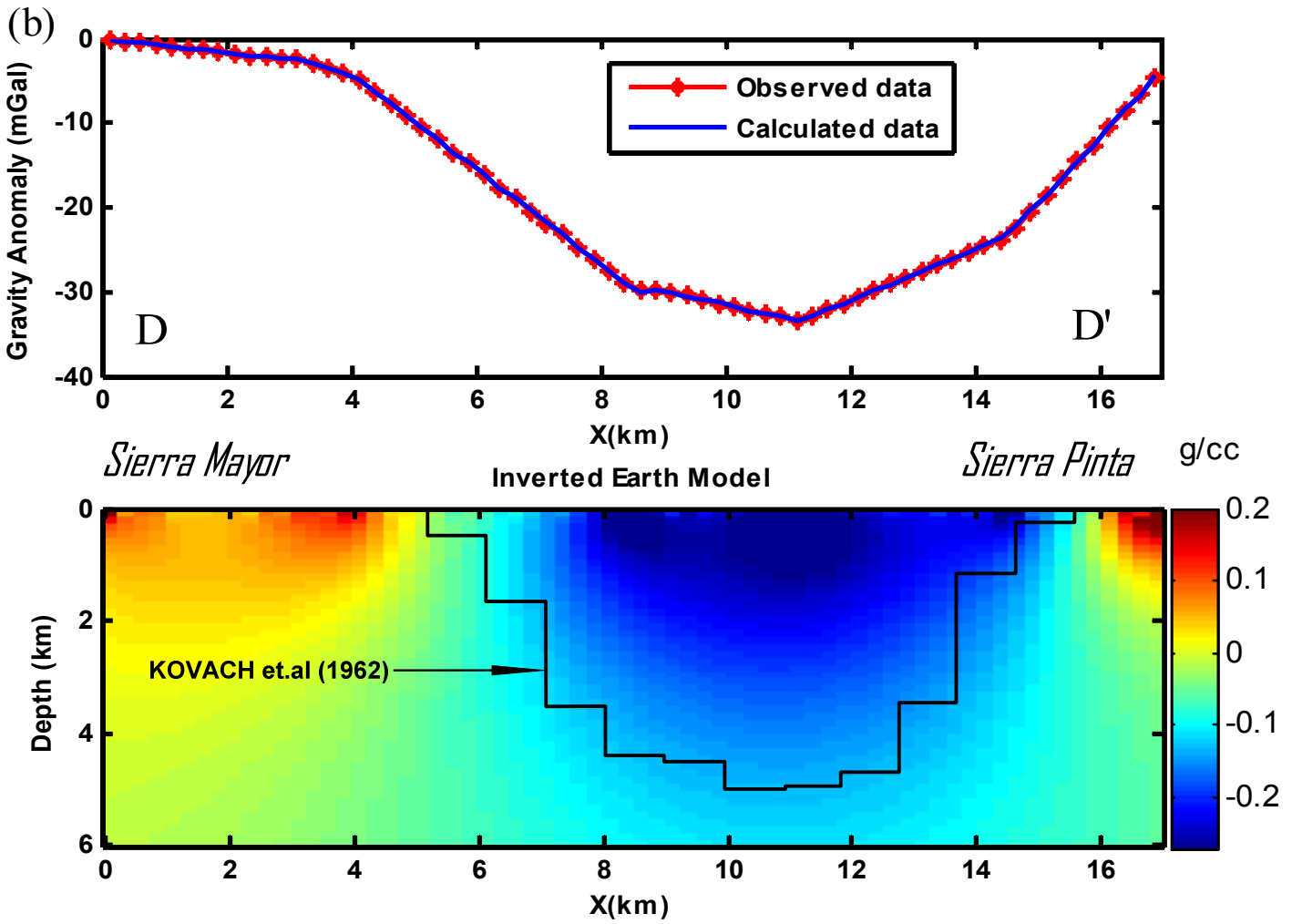
• The subsurface earth model was discretized into a grid of prisms **(48 x 68)** and the scale of each prism is **250 m and 125 m** along the ***horizontal*** and ***vertical*** directions, respectively. The number of gravity data points is 68, and the number of cells is 3264.

•The best β value was found **β=0.05** by trial and error.

2-Sierra Mayor - Sierra Pinta Basement Outcrops (Profile D – D')

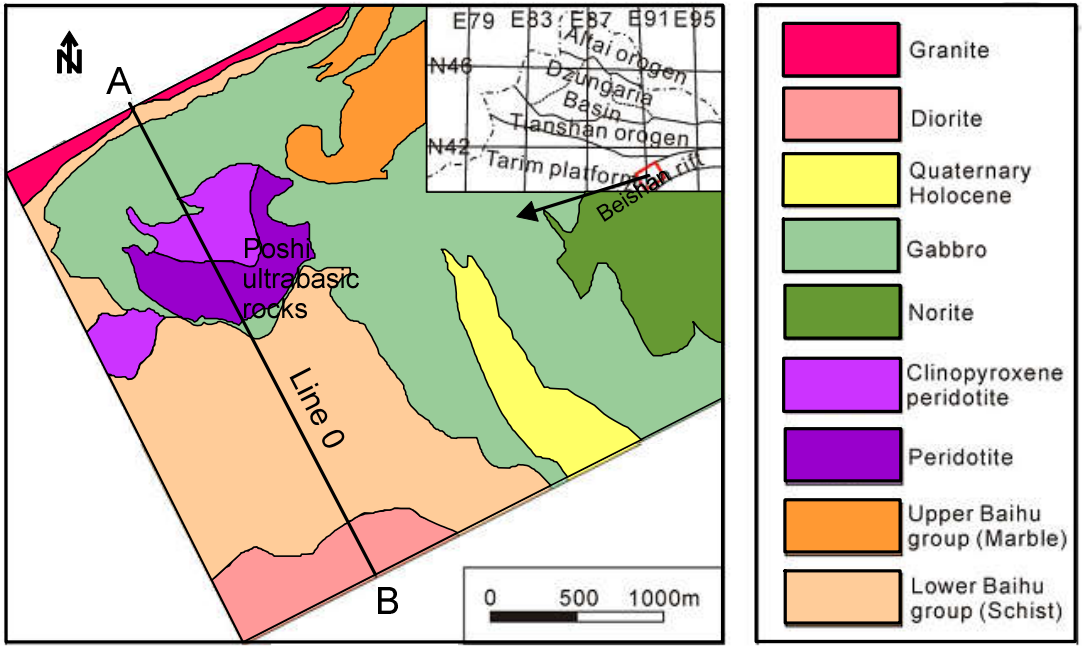
- Inversion results of gravity data of Sierra Mayor - Sierra Pinta Basement Outcrops (Profile D – D') Mexico – USA Border in comparison with this obtained by (Kovach et al., 1962).

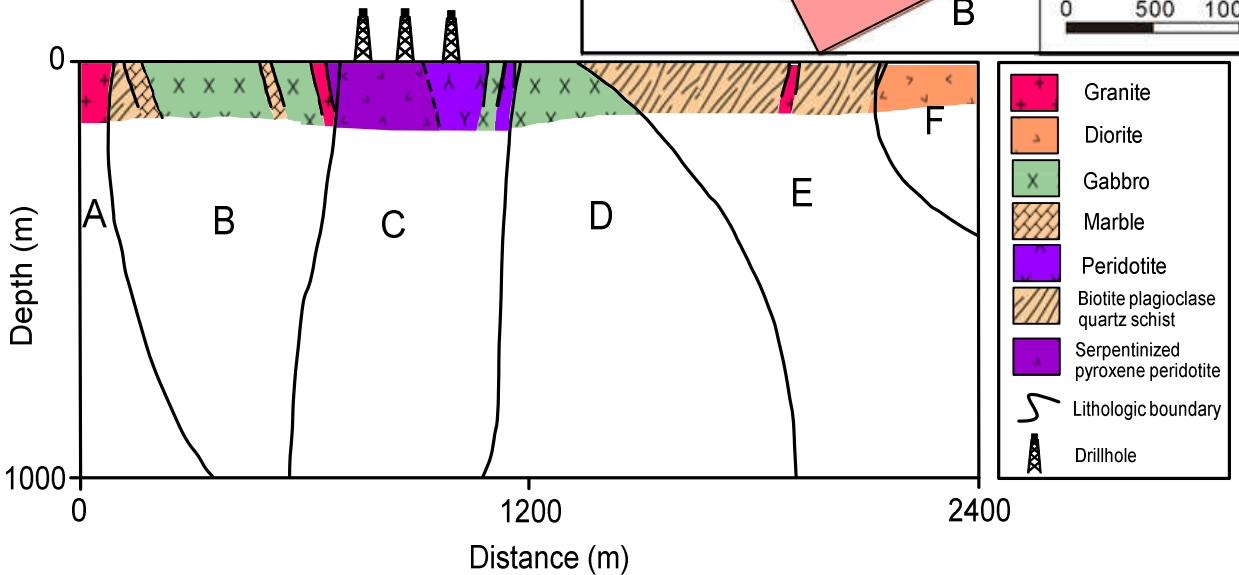
- There is a good correlation for the basement topography.



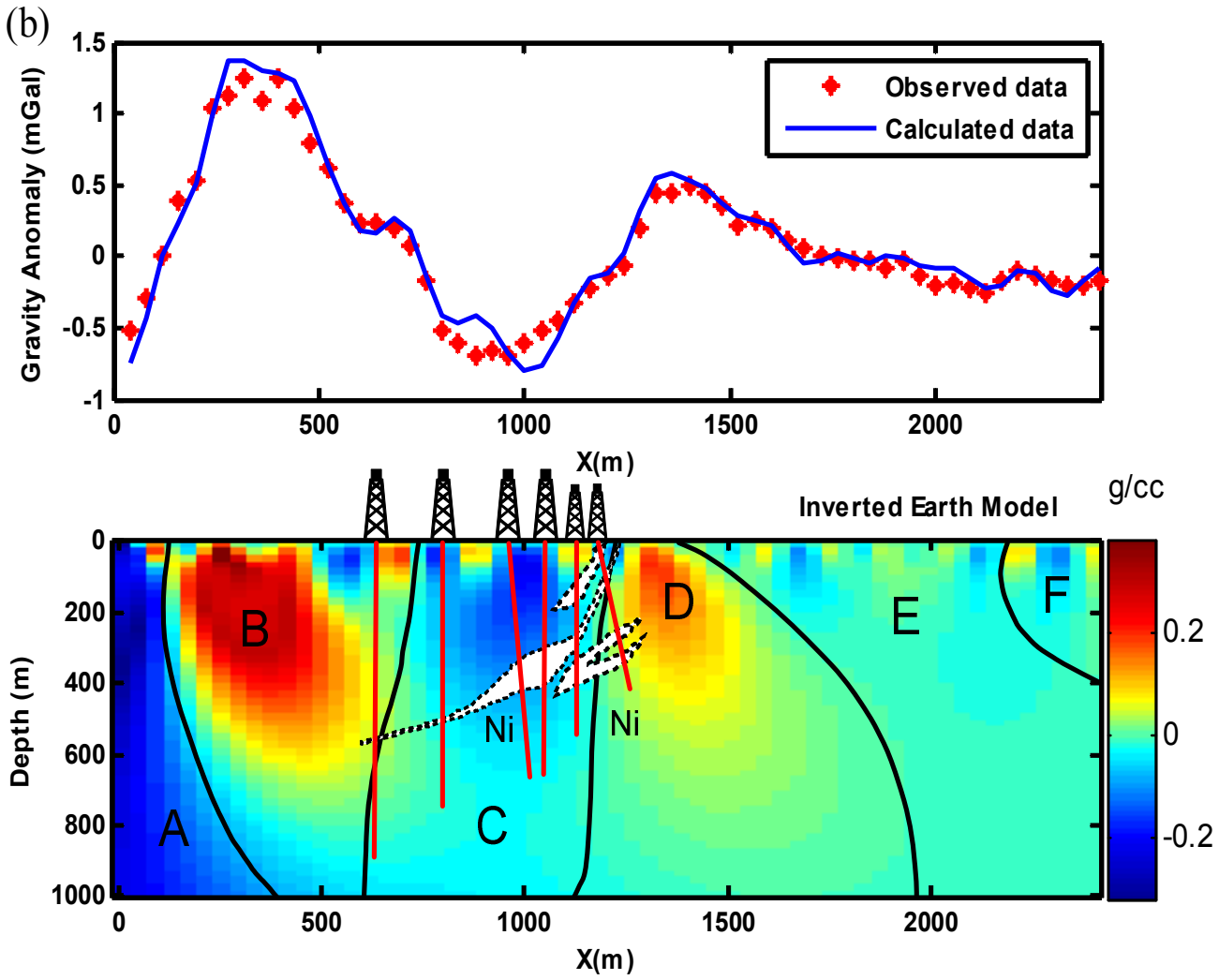
3-Prospecting of the Poshi Copper-Nickel deposits, Xinjiang, northwest China

- Modified geological map after (Liu et al., 2015).
- Modified surface geological cross-section that built using the outcrops of rocks (Modified after Liu et al., 2015).





3-Prospecting of the Poshi Copper-Nickel deposits, Xinjiang, northwest China



- Line 0 is taken to cross the ultrabasic rocks and situates at the center of the Poshi deposits. We digitized the gravity data of Line 0 from (Liu et al., 2015).
- The number of observed data points is 60.
- Prisms (50 x 60)
- Low gravity anomaly in areas where the ultrabasic rocks exposed at the earth surface.

Summary

- The validity and applicability of PCG-BA algorithm are applied to real residual gravity anomalies across the San Jacinto graben in southern California, USA, 2-Sierra Mayor - Sierra Pinta Basement Outcrops (Profile D – D'), and prospecting of the Poshi Cu-Ni deposits, Xinjiang, northwest China.

- The inverted results of real data reflect the effectiveness of the method in interpretation of sedimentary basins and investigations of ore deposits (i.e., copper-nickel deposits).


THANK YOU!

Any Questions?