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Research Paper

Estimating the Mineral Mass Volume of the Ileh Region by Magnetic Field Analysis and Pseudo-Gravity Data Inversion Using the Improved Global Particle Swarm Optimization Algorithm

Heidari M.[1], Meshinchi Asl M.[2*], Mehramuz M.[2], Heidari R.[2]

1- Ph.D Student, Dept. of Earth Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran

2- Assistant Professor, Dept. of Earth Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran

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Abstract: In the current research, the buried causative body of a magnetic field anomaly was modeled using Encom ModelVision software and its depth was estimated using deconvolution Euler and energy power spectrum methods. The magnetic data of Iileh region of Taybad city was used for modeling. In addition, an optimization algorithm was explained as the Improved Global Particle Swarm Optimization (IGPSO). The obtained results showed IGPSO is acceptably resistant to the corrupted synthetic gravity data by noise. Using this optimization algorithm, the pseudo-gravity data of Iileh region was analyzed to determine the structural parameters of the causative body of the anomaly such as depth, radius, density contrast, origin point coordinate and shape factor. The determined shape of the causative body of the anomaly was a sphere with a radius of 56.2 m and a density contrast of 1.93 gr/cm3. The estimated depths of the center of the sphere by Encom ModelVision software and IGPSO method were 120 m and 111.8 m, respectively. While the drilling results in this area shows an average depth of 103.2 m for the center of the iron mineral body. This indicates the introduced IGPSO method obtained better results.

Keywords: Iileh, Improved global particle swarm optimization algorithm, Magnetic field, Model vision, Pseudo-gravity.

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*Corresponding Author Email: *m.meshinchi@srbiau.ac.ir*

INTRODUCTION

The interpretation of magnetic field data is widely used in underground mineral bodies exploration with various depths, shapes, volumes and magnetic susceptibilities. Different magnetic and gravity interpretation methods are proposed by researchers to determine the physical properties and the geometry of underground causative bodies. One of these methods is the simplex algorithm for estimating the magnetic parameters of simple geometric structures [1]. Abdelrahman et al. developed a method to simultaneously determine the depth and shape of causative body from second moving average residual magnetic anomalies [2]. Essa and Elhussein applied Particle Swarm Optimization (PSO) for the interpretation of magnetic anomalies caused by simple geometrical structures [3]. The PSO is a stochastic, population-based algorithm that simulates some features of the social learning process as sharing information and evaluation of behavior [4]. In this research, the Improved Global Particle Swarm Optimization (IGPSO) method is described and used to interpret the pseudo-gravity data.

METHODS

The IGPSO is an optimization technique based on stochastic population, inspired from the social behavior of a swarm of birds, flocking bees, and fish schooling. The fundamental concept of the IGPSO algorithm is that the potential solutions tended toward the best solutions. Assigning the search ranges for unknown parameters, the initial populations (groups) are set stochastically (initial Pbest). The IGPSO algorithm chooses the best population based on the obtained minimum error through checking the solutions of the groups (initial Gbest). IGPSO improves the best region in the group which is known as *Gbest* (best value in the group or global best value) among the *Pbest*, during an iterative process, as successfully leads to a global optimum.

Two properties, position *x* and velocity *v*, are associated with each particle. The next position of the *i*th particle (parameter) from jth model $x_{i,j}^{k+1}$ is determined by the current position of the parameter $x_{i,j}^{k}$ and the its velocity at the *k+1* iteration,

$$x_{i,j}^{k+1} = x_{i,j}^{k} + v_{i,j}^{k+1} \tag{1}$$

The next velocity of the *i*th particle (parameter) from *j*th model $v_{i,j}^{k+1}$ is estimated by the current velocity $v_{i,j}^{k}$ and position $x_{i,j}^{k}$ of the parameter, the best position of parameter which has been experienced up until now $p_{i,pbest}^{k}$ and the best position of parameter among the group $p_{i,gbest}^{k}$,

$$v_{i,j}^{k+1} = A[1+(r\times\delta)] \tag{2}$$

Here

$$A = \left[wv_{i,j}^{k} + c_1 r_{1,j}^{k} \frac{\left(p_{i,pbest}^{k} - x_{i,j}^{k}\right)}{rms^{-1}} + c_2 r_{2,j}^{k} \frac{\left(p_{i,gbest}^{k} - x_{i,j}^{k}\right)}{rms} \right] \tag{3}$$

If the value of *A* is larger or smaller than the upper or lower range of the investigated parameter, the value of δ is given as -1 and 1, respectively, otherwise δ=0. Each one of the $r_{1,j}^{k}$ and $r_{2,j}^{k}$ produces a random number between 0 and 1, c_1 and c_2 (learning factors) are positive constant numbers known as cognitive coefficient and social coefficient, respectively, which control the individual and the social behavior and *w* is an inertial coefficient whose value is usually slightly less than 1 [3].

FINDINGS AND ARGUMENT

Considering the the density contrast of 1.8 gr/cm3 and magnetization of 14 A/m, the pseudo-gravity map of the studied area was generated to determine the depth of the center of the causative body (Figure 1). The pseudo-gravity data were sampled as 65 stations with an interval of 2 m.

The variations of the observed pseudo-gravity data and those computed using the obtained model via the IGPSO inversion are shown by the red cross marks and the blue curve, respectively (Figure 2A).

The curve in Figure 2B shows the difference between the observed pseudo-gravity data and the computed ones at the measuring points. The maximum difference is about 0.082 mGal. One can infer from the estimated shape factor q=1.463 that the underground structure can be geometrically analogized to the sphere with a radius of 56.2 m (Figure 2C).

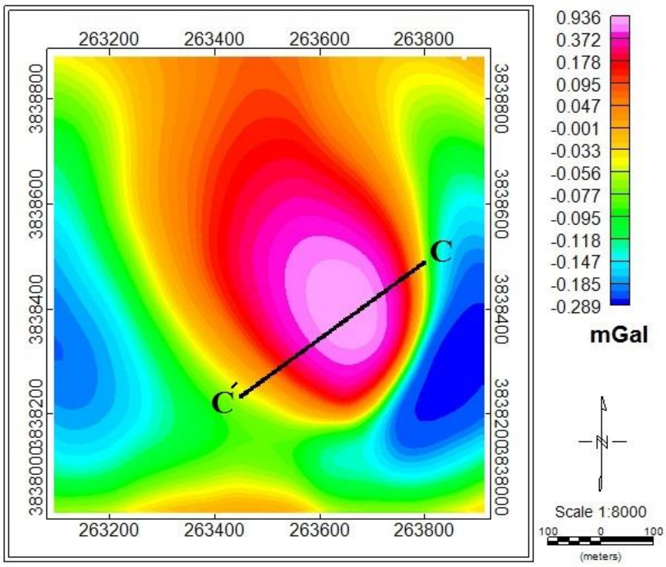

Figure 1. The pseudo gravity map of the area under investigation

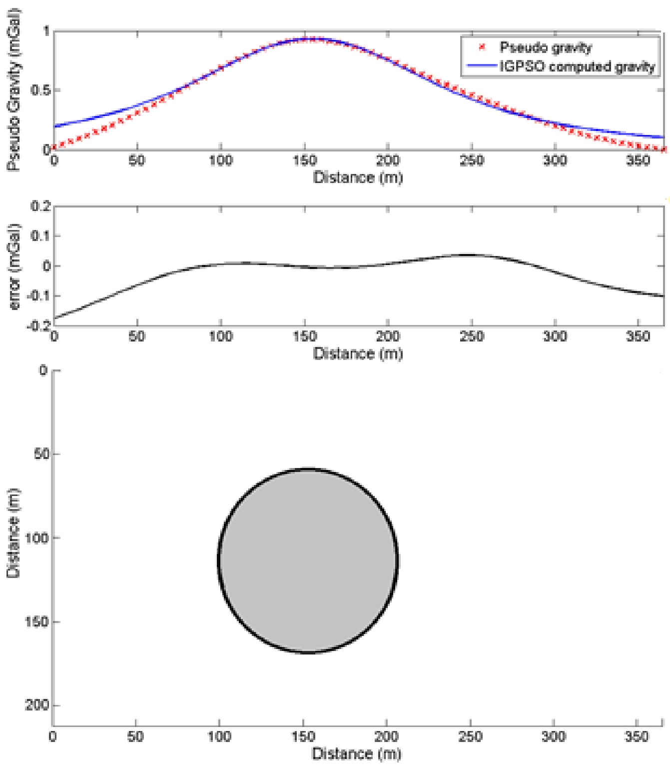

Figure 2. A: The pseudo gravity data along the profile (red dots) and computed gravity data using the IGPSO inversion (blue curve) **B:** The difference between the observed and computed gravity data **C:** Inferred structure

CONCLUSIONS

Using the drilling results of Iileh region, we demonstrated the IGPSO gives better results than Encom ModelVision software for a pseudo-gravity inversion. The determined shape factor for the causative body of the magnetic anomaly was 1.463 corresponded to a sphere. The obtained depth of the center of the sphere was 111.8 m.

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