Lithologic mapping test for gravity and magnetic anomalies
A case study of gravity–magnetic anomaly profile in the eastern segment of the China–Mongolia border

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A B S T R A C T
An inversion calculation is usually needed to map lithologies with gravity–magnetic anomalies. A lithological–physical property correspondence can be established by combining data of regional rock density and magnetic susceptibility to build topological equations. In this study, topological calculations were performed using inversion data and combined with physical property data to interpret and map lithologies. Gravity–magnetic profiles from the eastern segment of the China–Mongolia border were used (Jining–Bainaimiao–Ha’ernaode geological–composite geophysical profile) in this paper. Based on gravity–magnetic anomaly inversion, the rock density and magnetic susceptibility data of Bainaimiao and Jining were adopted for lithological inversion. Distribution characteristics of four major types of magmatic rocks within 50 km of the lower half space were obtained, and results of lithologic mapping and tectonic framework were analyzed. The position of convergence between the North China Plate and Siberian Plate was confirmed. Two tectonic stages were identified, namely, interplate squeezing and intraplate deformation. Regional gravity–magnetic field properties were analyzed to discuss the orientation and date of andesites and diorites in the northern part of the survey line. We believe that they have a northeast–southwest orientation similar to gravity–magnetic anomalies of Erenhot–Xilinhot. They resemble the igneous rock near Erenhot because they both indicate magmatic intrusion during the early Carboniferous.

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1. Introduction
The main goal of geophysical inversion is to explore the physical property distribution of the lower half space of the ground surface. For example, it can be used to study the velocity distribution in underground media with seismic inversion and its resistivity distribution with electromagnetic inversion. However, the gravity and magnetic inversions, which are commonly used at present, are usually used in the study of the distribution of density and magnetization of the lower half space. Recent breakthroughs have resulted in better methods for lithological identification based on the inversion. Kanasewich and Agarwal (1970) succeeded in lithological identification of underground lower half space using the ratio of magnetic susceptibility to density in the wave number domain. Dransfield et al. (1994) found the gradient correspondence between gravity and magnetic anomalies using Poisson’s equation. Price and Dransfield (1995) then applied this new method to lithological identification and made additional progress. In 2007, Williams and Dipple established a theoretical model with reference to a priori geological information. They carried out alteration mineral mapping according to the distribution of magnetic susceptibility and density with the use of drilling data. Kowalczyk et al. (2010) constructed a 3D model of density and magnetic susceptibility, from which they identified the cross relation between lithology and physical properties. Furthermore, the lithologic units were differentiated with the method.

In this paper, the author combined a large number of physical property statistics with inversion results on the basis of gravity and magnetic anomalies. First, the rock density and magnetic susceptibility near the survey line were summarized, and the lithology was divided into six types. Thus, a correspondence between lithology and physical properties was defined to some extent, the results of which were presented in the form of an alternating diagram. Different topological equations were established according to the physical properties for each lithology. Based on the equations, the lithology was identified through gravity and magnetic inversions. The intersection set of lithologic maps from two methods mentioned above was calculated. Hence, lithology was identified by mapping with higher credibility. This paper summarized the experimental methods as specific technological processes and achieved the “transparentization” of the lower half space of the gravity–magnetic
profiles in the eastern China–Mongolia border region. Considering regional geological conditions, the characteristics of gravity–magnetic fields and the geotectonic framework, an analysis of the pattern of plate convergence between the north China plate and the Siberia plate was made based on the distribution of andesite rock mass. The results show that there were extensional and reversal tectonic stages during plate convergence. The long-term existence of tectonic stress controls multiple stages of magmatic intrusion and leads to the formation of the Xing’an–Mongolian orogenic belt. Based on the distribution of lava in Erenhot and regional gravity–magnetic field characteristics, magmatic events accompanied by the diminishing of Paleo-Asian Ocean and the subduction of Paleo-Asia Oceanic plate are manifested as lithologic combinations of andesite and diorite at the northern end of survey line. This position is identified as part of a compressed belt related to ocean closure.

2. Geologic setting

In the research area, outcrops of Archaeozoic–Cenozoic strata are widespread. The Archaean stratum is mainly composed of the Jining metamorphic rock group. Stratum of Proterozoic to Middle Proterozoic mainly consists of carbonate and clastic rocks, while igneous rock is mostly found in Paleozoic, Mesozoic, and Cenozoic strata. There are regional metamorphic rock series of different types and different scales, ranging from Archean to Late Paleozoic. The majority of mineral resources in the study area are distributed in the Mongolia–Hinggan Orogenic belt. The Bainaimiao mining area in the south of the profile is located within the Wuliji–Oubugela–Xilinhaote Proterozoic metallogenic belt. The regional tectonic location of the study area is within the joint area of the Xing’an–Mongolian orogenic belt and along the northern margin of the North China craton.

3. Data sources and sorting out

The profile examined in this article is part of the Jining–Bainaimiao–Ha’ernaode geological–composite geophysical profile, which lies in the corridor region along the eastern segment of the China–Mongolia border. The survey line is perpendicular to the main structural trend and cuts across two significant faults (Fig. 1). The profile is close to the...
Erlian–Hegen Mountain–Arun Banner deep-rooted fault at the northern end of the survey line. Field testing was completed from 2010 to 2012, over a total length of 380 km, with 4886 gravity and magnetic measuring points and 651 gravity and magnetic check points. Mean square error in gravity measurements was ±0.036 × 10⁻³ m/s², while the mean square error in magnetic measurements was ±3.62 nT. Field gravity measurements were carried out in strict accordance with “Regional Gravity Research Regulations” (DZ/T0082-2006, DZ/T0082-93), “Gravity Research Technology Regulations (1:50000)” (DZ/0004-1991), and “Geophysical and Geochemical Exploration Engineering Regulations” (DZ/T0153-95). Field magnetic measurement was carried out in strict accordance with “Regulations of Surface High Precision Magnetic Measurement Technology” (DZ/T0071-93), “Surface Exploration Technology Regulations” (DZ/T0144-1994), “Regulation for Geophysical and Geochemical Engineering Measurement” (DZ/T0153), and “Geophysical and Geochemical Exploration Engineering Regulations” (DD2004-03). Figs. 2 and 3 illustrate the computations of Bouguer gravity anomaly and ΔT magnetic anomaly, respectively.

The data show that most magnetic anomalies vary from −500 nT to 500 nT. Anomalies fluctuate more in the southern part of the profile (from southern Jining to Bainaimiao), and show minimal variation in the middle area. Low anomalies are occasionally seen, while an obvious high anomaly is observed at the northern end of the profile. The gravity anomaly ranges from −120 mGal to −200 mGal in most areas along the survey line except for three low anomalies in the middle part where the lowest gravity value (−190 mGal) is observed.

4. Principle of the method

Based on the gravity and magnetic inversion over the measured profile, the physical properties surrounding the survey line are summarized as the lithology–density–magnetic susceptibility alternating distribution. Inversion data and the variation rule shown in the alternating distribution diagram are subject to topological calculations, which identify lithologies of the lower half space. The technological route is summarized in Fig. 4.

4.1. Gravity and magnetic data inversions

4.1.1. Inversion principle

A number of inversion algorithms for gravity–magnetic data are available. The gravity–magnetic inversion method established by Li and Oldenburg (1996, 1998) is adopted in this article. The underground is considered as a grid system with uniform physical properties (density or magnetic susceptibility). The goal of the inversion is to calculate the property for each grid, which means constructing a model, m, using the following equation:

\[ G_m = a^{obs} \]

where \( a^{obs} \) is the observation data and \( G \) is the kernel matrix. As for potential field data inversion, underground half space is divided into \( M \) blocks; the observation data is an \( N \)-dimensional vector, and the kernel matrix \( G \) is an \( N \times M \) matrix (\( M \gg N \)). Therefore, a successful inversion solves the objective functions:

\[
\varphi_{ref}(m) = \alpha_v \int w_v \left( \frac{\partial}{\partial z} \left[ w_v(z) \right. \left( m - m_{ref} \right) \right]^2 \, dv \\
+ \alpha_x \int w_x \left( \frac{\partial}{\partial x} \left[ w_x(z) \right. \left. \left( m - m_{ref} \right) \right]^2 \, dv \\
+ \alpha_z \int w_z \left( \frac{\partial}{\partial z} \left[ w_z(z) \right. \left. \left( m - m_{ref} \right) \right]^2 \, dv \\
\]

where \( m_{ref} \) is the reference model; \( w_v(z) \) is a depth weighting function; \( w_x \), \( w_v \), and \( w_z \) are weighted functions; \( \alpha_v \), \( \alpha_x \), and \( \alpha_z \) are weighting coefficients. The first part of the objective function is the smallest model, which is also the closest to the reference model. The model presented in two parts later is the smoothest model, which makes the model smooth in horizontal direction (\( x \)) and the vertical direction (\( z \)). Coefficients \( \alpha_v \), \( \alpha_x \), and \( \alpha_z \) measure the ratios of the smallest to the smoothest models.

At greater depths, the potential field data rapidly attenuates. A depth weighting function is introduced to counteract the attenuation of the data. Due to a lack of in-depth information on the potential field, a physical property anomaly in the default inversion results is distributed near the surface, which is inconsistent with most real geological conditions. Thus, to ensure that the inversion results better reflect the real geological conditions, we introduce the depth weighting function into the objective function for inversion at each depth. Generally the depth weighting function is in the following form:

\[
w_r(z_j) = \left( \frac{1}{z_j + z_0} \right)^\beta
\]

where \( z_j \) is the depth of the \( j \)th block; \( \beta \) and \( z_0 \) are the adjustable parameters used in the attenuation of the potential field data with depth. In general, when gravity inversion is performed, \( \beta = 2 \), and for the magnetic inversion, \( \beta = 3 \).

4.1.2. Gravity–magnetic data inversion

Density of the lower half space is stratified as shown in Fig. 5 gravity inversion results. Many parts of the subsurface exhibit density inhomogeneity with staggered and zonal distribution of gravity and magnetic properties. Below 20 km in the lower half space, the density shows high and low alternating distribution patterns. Results of magnetic measurement for the lower half space are distributed unevenly with great variability. The middle area corresponding to Bainaimiao and Siziwang Banner has a zone of low magnetic value along the whole survey line. Inversion results of the whole line are smooth and show good convergence.

![Fig. 2. Bouguer gravity anomaly profile.](image)
There is a large difference between gravity structure and magnetic structure in the lower half space below the survey line. However, the results of the gravity and magnetic inversions are both smooth with good convergence. Geological meanings cannot be inferred solely from physical property inversions. More comprehensive analyses that combine results of the inversions with the geological setting are needed. Lithologic mapping by these methods result in a so-called “geological interpretation”.

As is known to all, the results of inversion always have a lower value than the real, so we compared the results of inversion with the known profile and let the inversion result minus the difference. And then we can do the following work.

4.2. Summary of petrophysical characteristics

The lithologic mapping based on gravity–magnetic inversion can be affected by many factors, such as non-uniqueness of inversion results, data errors, coverage of physical property, and accuracy of the physical property data. These factors cannot contain more details than descriptions of the mineral constituents on the surface. In this study, petrophysical characteristics were measured along the corridor area of the profile. Data from 1101 survey points and covering Jining, Xilinguole, Mt. Lang in Bameng, and the Bainaimiao area were used for mapping. Lithology was divided into ten types (Table 1) which are considered in the calculation, after excluding some exceptionally high or low values, and the correspondence between lithology and physical parameters. Each type contains a variety of rock types, such as diorite includes granodiorite and quartz diorite, granite includes two mica granites, biotite granite, white mica granite, potash feldspar granite, giant porphyry granite and so on. However, the physical property data of other types, such as quartz veins and granite inclusions, fluctuate strongly and the quantity was too small to summarize in a meaningful quantitative manner; therefore, data for these types were ignored in this article. In addition, the lithological identification results of gravity depends on the identification result of magnetic method, that is because a different rock has the same range of density. It can be identified according to the magnetic inversion-based mapping result.

In this experiment, a correspondence between lithology and physical property was established by inspecting the range of density and magnetic susceptibility, which becomes the basis for lithologic mapping. Table 1 presents the range of densities and magnetic susceptibility for various rock types, while Fig. 6 illustrates the relationships between properties in individual samples.

Fig. 6 shows the correspondence between density and magnetic susceptibility of ten rock types:

1. Diorite, very high density, very high magnetic susceptibility.
2. Granite, very high density, high magnetic susceptibility.
3. Rhyolite, very high density, medium magnetic susceptibility.
4. Andesite, very high density, medium magnetic susceptibility.
5. Slate, schist and sandstone, very high density, low magnetic susceptibility.
6. Quaternary deposits, ultra low density, ultra-low magnetic susceptibility.
7. Diabase, very high density, very high magnetic susceptibility.
8. Porphry, high density, very high magnetic susceptibility.
9. Diorite–porphyrite, very high density, very high magnetic susceptibility.
10. Tuff, high density, medium magnetic susceptibility.

4.3. Lithologic mapping

The accuracy of lithologic mapping depends on the accuracy of inversion and physical property data. The implementation method is to establish topological equations by using computer programs. First, lithologic maps are constructed from gravity inversion and magnetic inversion data, and then the intersections of lithologic maps are calculated to obtain the final map. Gravity and magnetic grids obtained from inversion are calculated using topological equations.
For andesite, the topological equations are as follows:

\[
\begin{align*}
\text{[m, n]} &= \text{find (gra} > 2.709 \& \text{gra} < 2.833) \cup \text{[m1, n1]}
= \text{find (mag} > 350 \& \text{mag} < 450)
\end{align*}
\]

For rhyolite, the topological equations are as follows:

\[
\begin{align*}
\text{[m, n]} &= \text{find (gra} > 2.504 \& \text{gra} < 2.636) \cup \text{[m1, n1]}
= \text{find (mag} > 430 \& \text{mag} < 530)
\end{align*}
\]

For diorite, the topological equations are as follows:

\[
\begin{align*}
\text{[m, n]} &= \text{find (gra} > 2.607 \& \text{gra} < 2.928) \cup \text{[m1, n1]}
= \text{find (mag} > 620 \& \text{mag} < 720)
\end{align*}
\]

For granite, the topological equation is as follows:

\[
\begin{align*}
\text{[m, n]} &= \text{find (gra} > 2.560 \& \text{gra} < 2.590) \cup \text{[m1, n1]}
= \text{find (mag} > 620 \& \text{mag} < 720)
\end{align*}
\]

For slate, schist and sandstone, the topological equation is as follows:

\[
\begin{align*}
\text{[m, n]} &= \text{find (gra} > 2.627 \& \text{gra} < 2.988) \cup \text{[m1, n1]}
= \text{find (mag} > 25.5 \& \text{mag} < 75)
\end{align*}
\]

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**Table 1**

Ranges of physical property data used for lithologic mapping-based topological equations.

<table>
<thead>
<tr>
<th>Rock type</th>
<th>Density range (g/cm³)</th>
<th>Magnetic susceptibility range SI (10⁻⁵)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granites</td>
<td>2.560–2.590</td>
<td>620–720</td>
</tr>
<tr>
<td>Andesites</td>
<td>2.709–2.833</td>
<td>350–450</td>
</tr>
<tr>
<td>Deposits</td>
<td>1.116–1.709</td>
<td>0–50</td>
</tr>
<tr>
<td>Rhyolites</td>
<td>2.504–2.636</td>
<td>430–530</td>
</tr>
<tr>
<td>Diorites</td>
<td>2.607–2.928</td>
<td>750</td>
</tr>
<tr>
<td>Sandstone, slate and schist</td>
<td>2.627–2.988</td>
<td>25.5–75</td>
</tr>
<tr>
<td>Diabase</td>
<td>2.808–2.974</td>
<td>1540–1560</td>
</tr>
<tr>
<td>Porphyry</td>
<td>2.537–2.611</td>
<td>605–625</td>
</tr>
<tr>
<td>Diorite–porphyrite</td>
<td>2.624–2.797</td>
<td>1790–1810</td>
</tr>
<tr>
<td>Tuff</td>
<td>2.341–2.399</td>
<td>964.5–980</td>
</tr>
</tbody>
</table>

---

For granite, the topological equation is as follows:

\[
\begin{align*}
\text{[m, n]} &= \text{find (gra} > 2.560 \& \text{gra} < 2.590) \cup \text{[m1, n1]}
= \text{find (mag} > 620 \& \text{mag} < 720)
\end{align*}
\]
For Quaternary deposits, the topological equation is as follows:

\[ m, n \frac{1}{C138} = \text{find gra} N \leq 1.116 \text{ and } m1, n1 \frac{1}{C138} = \text{find mag} \leq 50 \]

For diabase, the topological equation is as follows:

\[ m, n \frac{1}{C138} = \text{find gra} N \leq 1.116 \text{ and } m1, n1 \frac{1}{C138} = \text{find mag} \leq 50 \]

For Porphyry, the topological equation is as follows:

\[ m, n \frac{1}{C138} = \text{find gra} N \leq 1.116 \text{ and } m1, n1 \frac{1}{C138} = \text{find mag} \leq 50 \]

For diorite–porphyrite, the topological equation is as follows:

\[ m, n \frac{1}{C138} = \text{find gra} N \leq 1.116 \text{ and } m1, n1 \frac{1}{C138} = \text{find mag} \leq 50 \]

where gra represents the density data stored in the gravity inversion grids, and mag is the magnetic susceptibility data stored in the magnetic inversion grids. The values of \( m, n, m1, \) and \( n1 \) that meet the density and magnetic susceptibility within a certain range are located on a Matlab platform. On the other hand, \( m, n, m1, \) and \( n1 \) are stored in a matrix that is equivalent in size to the inversion grid. Each type of rock is then coded with different numbers (i.e., diorite 4, rhyolite 3, andesite 2, granite 1, and the unidentifiable 0) from which the lithologic maps based on gravity inversions and magnetic inversions are drawn (Fig. 7). The intersection of these two maps is then calculated, and a lithology identification map is obtained.

5. Lithology distribution map

According to the final mapping results, the underground half space lithology varies significantly from north to south. In the northern area, it mainly consists of diorite and andesite in a good occurrence state featuring great depths and wide distribution. In the middle area, it is predominately composed of andesite with a special double horseshoe-shaped andesite rock mass at 150 km. The lithology is complex in the south of Chaganhada in Damao Banner–Wenduermiao–Xilamulun River deep-rooted fault. Rhyolite, granite, and andesite are distributed below 40 km; granite is mainly distributed below 20 km and above 40 km, and above 20 km is the association of granite and diorite.

6. Geological analysis of lithological identification results

Based on the geological and geophysical data, Chaganhada in Damao Banner–Wenduermiao–Xilamulun River deep-rooted fault converges with Linhe–Jining–Kalaqin Banner deep-rooted fault in the lower crust. It is inferred that the complex association of igneous rocks is...
Fig. 8. Bouguer gravity anomaly map in the middle of Inner Mongolia. (① Linhe–Jining–Kalaqin Banner deep-rooted fault; ② Chaganhada in Damao Banner–Wenduermiao–Xilamulun River deep-rooted fault; ③ Ailige Temple–Sonid Left Banner–Alideer fault zone; ④ Erlian–Hegen Mountain–Arun Banner deep-rooted fault; ⑤ the main ridge of Mt. Daxinanlin fault zone).

Fig. 9. Satellite magnetic anomaly map in the middle of Inner Mongolia. (① Linhe–Jining–Kalaqin Banner deep-rooted fault; ② Chaganhada in Damao Banner–Wenduermiao–Xilamulun River deep-rooted fault; ③ Ailige Temple–Sonid Left Banner–Alideer fault zone; ④ Erlian–Hegen Mountain–Arun Banner deep-rooted fault; ⑤ the main ridge of Mt. Daxinanlin fault zone).
formed through multistage reformation with the convergence of the two deep-rooted fault zones. However, it is impractical to get a more reliable geological interpretation from lithologic mapping using a single survey line. Thus, in this article, the lithology distribution trend and the formation age of the lower half space is summarized based on characteristics of the gravity and magnetic fields and the tectonic setting. Fig. 8 shows the Bouguer gravity anomaly in the study area.

By observing the Bouguer gravity anomalies, an extensive low gravity zone is located along Hohhot–Huade–Duo lun–Sonid Right Banner and extends westward with a minimum of ~180 mGal. A relatively high gravity anomaly belt is located along Erenhot–Sonid Left Banner–Xilinhot. In the north of the Sonid Left Banner, the gravity anomaly gradually rises up to about ~125 mGal. The highest gravity anomaly of about ~90 mGal occurs near the West Ujinqin Banner and is related to deep tectonic divisions. The giant gravity gradient belt corresponds to the zone with an abrupt change in the crust’s thickness, which is also called the mantle slope zone. Slope zones are often low density zones of the upper mantle.

The Satellite magnetic anomaly map of the study area shows that the area, bounded by the Erenhot–Xilinhot–west Ujinqin Banner–Holingol in the north and the Xilamulun River in the south, features a small-amplitude negative magnetic anomaly that is higher in the west and lower in the east. The average negative magnetic anomaly is between 50 and —100 nT. In this context, positive anomalies in an N–E trend are superimposed with amplitudes from 0 to 150 nT in the east; positive anomalies are superimposed in an E–W direction with amplitudes from 0 to 100 nT. In the south of the Xilamulun River fault, the eastern tectonic zone corresponds to the positive magnetic anomaly zone in a strip-like or mass-like pattern, while the western region is the negative magnetic anomaly belt. The amplitude ranges from about —150 to 180 nT, as shown in Fig. 9.

The article is focused on gravity and magnetic anomaly belt along Erenhot–Xilinhot–west Ujinqin Banner–Holingol, of which Erenhot–Hegen Mountain fault belt has a higher anomaly that most scholars believe is the suture of the Paleo-Asian Ocean. The accretion orogenic belt extends from the Siberia Platform in the north towards the south. Another accretion orogenic belt extends from the North China Platform in the south towards the north. Our study indicates that the strong magnetic anomaly in the belt is related to ophiolites and granites of early Carboniferous age, while mapping shows that andesites and diorites were formed during the Carboniferous. From the perspective of regional tectonics, the igneous rock associations found from mapping agree with the tectonic characteristics of the suture of the Paleo-Asian Ocean around the Erenhot. This is also the typical rock association related to the subduction of passive continental crust beneath the oceanic crust. The Erenhot–Hegen Mountain ophiolite belt, and the ophiolite suite and glaucophane-schist belt along Wuyitai in Sonid Left Banner and Ulaan Ovoo correspond to the assemblage of passive continental margin and paleo-subduction zone. The north of the survey line corresponds to the passive continental margin and the subduction of oceanic crust. Geologic mapping between Linhe–Jining–Kalaqin Banner deep-rooted fault and Chaganhada in Damao Banner–Wenduermiao–Xilamulun River deep-rooted fault indicate that a large accretionary complex exists, in which the formation ages of the ophiolite suites become younger from north to south. Our study suggests that the extensive ophiolite belt is the accretionary zone of the Siberia plate and that the North China plate is under strong structural compression. We identified a double-horseshoe-shaped andesite rock body within 20–50 km under the accretionary zone during lithologic mapping. The diagenetic metamorphism of the andesite and the structural feature both confirm the tectonic setting, that is, the strong tectonic stress field generates the andesite rock mass, which is deformed into a horseshoe-shaped structure through interplate squeezing. We suggest that the southward subduction of the Siberia plate spanned over a period of time and is divided into two stages: interplate squeezing and intraplate deformation. The larger horseshoe-shaped rock masses in the map were formed at the beginning of plate convergence. After that, they were deformed into small horseshoe-shaped masses due to continuous intraplate tectonic stress. The continuous intraplate deformation also contributes to the multistage magmatic intrusion, which is consistent with the complex high magnetic anomaly in the south of Chaganhada in Damao Banner–Wenduermiao–Xilamulun River deep-rooted fault.

Indications are that the granite and diorite rock series are associated at different depths in Jining and the adjacent areas. According to the geological data, the large granite areas at the north margin of the North China platform are often associated with island arcs, and most magmatic intrusions occurred between the Carboniferous and the Permian. Hence, it can be inferred that the diorite and granite from depths of 5–40 km were generated by the emplacement of the magma during the Carboniferous to the Permian along Linhe–Jining–Kalaqin Banner deep-rooted fault. Magma later converged with Chaganhada in Damao Banner–Wenduermiao–Xilamulun River deep-rooted fault, resulting in an andesite rock mass that corresponds to the strong tectonic stress field. The two faults control the ore deposits in Bainaimiao and the adjacent areas.

7. Conclusion

1. Lithologic mapping was conducted in two dimensions, in this study, because of data limitations for physical properties and gravity and magnetic susceptibility. But this study still shows some valuable geological information. The relationship between Erenhot–Hegen Mountain fault belt and Paleo-Asian Ocean is demonstrated by the lithologic mapping. And the process of interplate squeezing was distinguished from the process of intraplate deformation by the form of andesite.

2. Our results indicate that this method can be a valuable tool for mineral prediction at great depths. The group which is composed of granite and diorite is similar with the bonanza in Bainaimiao. So we can improve this study in mineral exploration. And it can be extended to refine three-dimensional geologic research in different areas.

3. Due to the low vertical resolution of the gravity–magnetic inversion, more detailed geologic information must be used to achieve “transparentization” and more accurate inversion results within the lower half space.

4. The method shows promise for lithologic mapping and geologic characterization, especially if more accurate physical property data and inversion results can be acquired.

5. The physical properties we collected in study is insufficient, and there is a serious overlap in the density information which is a hard obstacle for our study. But this article provides a new way of thinking, that is, in the presence of density information overlap, we can first identify lithology information by magnetic susceptibility, and then bring the results to lithology identification among gravity inversion, which greatly improves the accuracy of identification of lithology. In addition, for the physical properties, we must fully consider the relationship between the location of rock outcrops and the study area, if outcrop with the measured area is too far away, there is no use value, and we must fully consider the impact of weathering for outcrops.

6. The core of this approach is that gravity and magnetic inversion methods and the study of the physical properties, that these two tasks determine the accuracy of the mapping, and with the progress of gravity and magnetic inversion method, the accuracy is improved gradually. If the combination of adequate information and detailed study of the physical properties, we believe that the rock identification will have a more brilliant performance in different stages.

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Further Reading


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