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利用航磁数据识别浅覆盖区地质体的方法研究

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摘 要: 在浅覆盖区,常规填图方法填制的地质图,由于信息量少导致整体质量不高。利用勘查技术方法来提高覆盖区地质填图的效率、质量和地质研究水平,具有重要的现实意义。航磁方法是其中的一种重要方法,但航磁测量获取的数据是磁异常迭加的综合反应,而区域地质填图仅描述地表附近的地质情况,直接利用航磁数据辅助地质填图是不合理的。因此,基于插值切割、数理统计和灰色关联度分析等方法,提出了一种剔除深部影响,利用浅层岩石磁性分布规律和磁性差异来识别浅覆盖区地质体的新思路。经选用黑龙江省塔河地区数据进行验证,识别效果明显。

关键词: 浅覆盖区; 航磁数据; 地质填图; 插值切割法; 塔河
中图分类号: P 631.2+22 **文献标识码**: A

0 前言

我国无基岩露头的覆盖区面积约占全国陆地面积的 1/3,其中相当一部分地区为覆盖层厚度不超过 100 m的浅覆盖区。在浅覆盖区地质填图工作中,常规填图方法由于基岩露头少而受到很大限制,利用转石或局部零散露头填制的地质图信息量少,整体质量不高。所以,必须有效地借助勘查技术方法,来提高浅覆盖区地质填图的效率、质量和地质研究水平。航磁方法是一种重要的区域地球物理方法,我国开展过大面积航磁测量,积累了大量的数据和基础资料,探讨利用这些已有的数据服务于地质填图,具有重要的实用价值。

航磁测量获取的数据是居里面以上,自地表到 20 km～40 km深度范围内的一种立体的、迭加的、大规模的综合信息,而区域地质填图仅描述了地表附近的地质情况。因此,直接利用航磁数据计算其磁性分布的规律,来识别地质体是不合理的。考虑到剔出深部影响,作者在本文中提出一种基于插值切割法,利用浅层岩石磁性分布规律和磁性差异来识别浅覆盖区地质体的新思路。

1 方法原理

插值切割法是一种空间域划分区域场与局部异常的新方法。它采用与磁场曲率变化有密切关系的切割算子,利用局部异常与区域场在波长、振幅或位置上存在的明显差异,连续进行插值切割,把复杂磁异常中凹凸不平、长短不一的目标异常逐步除掉,得到有一定光滑程度的区域异常。最后从原始磁场中间减去区域异常,得到局部异常[1～3]。切割算子构造方法如下:当切割半径为 R,测点的磁场值为 $Z(X, Y)$时,切割算子 $Q = \overline{Z} + 0.5 \times a \times (Z - \overline{Z})$,详细的步骤请参考文献[1]。

不同岩石间的磁性差异很大。一般在古老地台区,多半呈宽缓正异常,且方向性不明显;沉降带呈负异常;褶皱区呈正负交替条带状异常,且具有明显的方向性;花岗岩区常表现中等或弱磁性,不同时代的花岗岩磁性具有很大的差别,最新的花岗岩磁性最强;玄武岩区高磁性且变化大,有跳变异常;沉积岩区为稳定弱磁场;火成岩为中等 (或强

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的)磁异常且有一定的跳动[4~6]。

依据岩石间磁性差异规律,参照统计方法,确定统计变量(见表 1)。选定合理的最小统计单元,利用插值切割法,获取的局部磁异常数据统计计算各统计单元磁性分布规律,然后计算各统计单元磁性分布规律参数与典型地质体已知磁性分布规律参数的灰色关联度[7~9]。

灰色关联度的计算公式为

$$\xi^i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + 0.5 \max_i \max_k |x_0(k) - x_i(k)|},$$

$$r^i = \frac{1}{n} \sum_{k=1}^{n} \xi^i(k)$$

绘制灰色关联度等值线图,根据路线地质调查中所查明地质体部分的已知界线点坐标,或者等值线值突变处确定阈值,认为灰色关联度大于该值的区域为同一地质体。

表 1 磁异常分布规律参数的统计描述、数学表述和意义

Tab. 1 The statistical numerical and physical desciption of magnetic anomaly distribute parameters

序号	统计描述	数学表述	意义
1	均值	$\mathrm{mean}(X_{(n,m)})$	强弱
2	极大值~极小值	$\max(X_{(n,m)}) - \min(X_{(n,m)})$	范围
3	极大值	$\max(X_{(n,m)})$	极大值
4	正值个数/负值个数	$\mathrm{number}(\mathrm{plus}(X_{(n,m)}))/\mathrm{number}(\mathrm{negative}(X_{(n,m)}))$	跳动幅度
5	峰度	$\mathrm{kurtosis}(X_{(n,m)})$	数据陡缓程度
6	偏度	$\mathrm{skewness}(X_{(n,m)})$	分布对称性

2 基本计算步骤

(1) 按照原始采样线距和点距,对数据进行网格化处理,使其成为矩阵。确定切割半径,并对数据进行扩边处理。

(2) 采用插值切割法求局部异常,然后去除扩边数据。

(3) 确定合理的最小统计单元,求各统计单元磁异常分布规律参数。

(4) 确定研究区内拟识别的地质体类型及其磁性分布规律参数。

(5) 利用分布规律参数,求各统计单元与某一典型地质体的灰色关联度。

(6) 根据路线地质调查中所查明地质体的已知界线点坐标,或者灰色关联度等值线值突变处,来确定阈值,并将灰色关联度大于该值的划定为地质体。

(7) 对不同的典型地质体类型,重复步骤(5)和步骤(6),划定出不同地质体边界。

3 应用实例

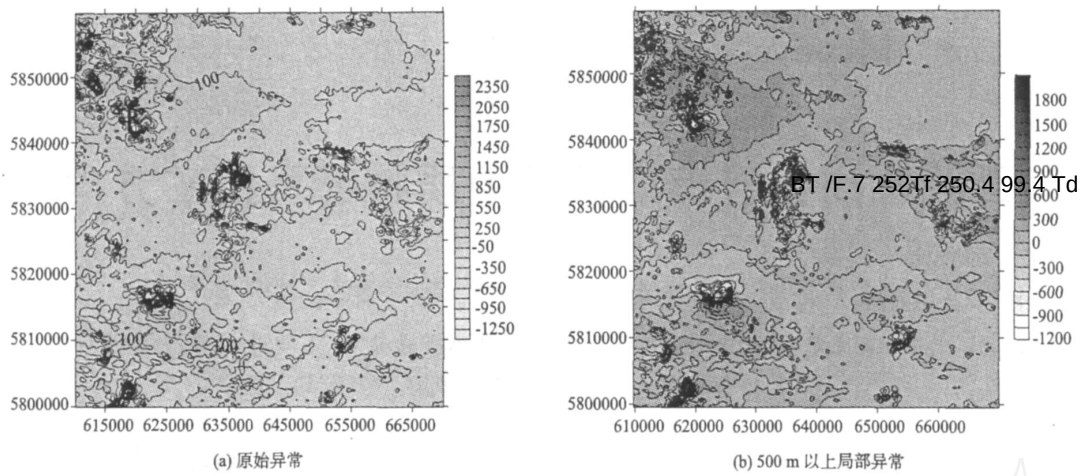
选用黑龙江省塔河地区 1∶50 000航磁数据进行方法试验。该区位于大兴安岭与伊勒呼里山交汇处,属低山丘陵地形,植被发育,除陡峭而窄细山脊及河堑、路堑等处见有少量露头外,山间谷地至山顶均被植被和残坡积层覆盖,属典型浅覆盖地质调查区。航磁原始数据采样点距为 80 m,线距为 200 m。按照上述步骤,采用插值切割法以 500 m 为切割深度,求得局部异常(见下页图 1),选定 10×4的网格作为统计单元,计算磁异常分布规律参数。选择研究区内几个较大地质体(塔木兰沟组 J_3t、花岗岩 γO_2、二十二站组 J_2e、绣峰组 $J_{1-2}x$、早白垩世 K_1l)作为识别对象,求得灰色关联度,绘制其等值线图。根据步骤(6)的原则,确定地质体边界(见下页图 2(b))。

与已有的地质资料(见下页图 2(a))对比表明,本方法对用以验证的几个地质体识别效果较明显,能够初步划定它们的边界。新边界与原地质体边界存在的微小误差,应该与地质体的隐伏情况有关。经研究发现,塔河县附近花岗岩体(图 2(b)中 γO_2-1)与永庆林场附近花岗岩体(图 2(b)中 γO_2-2, γO_2-3)的磁异常特征是不同的,γO_2-2 和 γO_2-3 的磁异常特征也略有不同。在野外工作中曾发现,塔河县附近花岗岩体中包含一定量的闪长岩捕虏体,认为是其导致了上述差异。γO_2-3 地区构造较发育,导致了该区与其它二区花岗岩体的磁性区别。研究还发现,二十二站组 J_2e 和绣峰组 $J_{1-2}x$ 的边界与已知地质资料有较大不同,原因是沉积岩区为稳定弱磁场,相互之间区别不明显。

4 结论

综上所述,基于插值切割、数理统计和灰色关联度分析方法,提出的剔除深部影响,利用浅层岩石磁性分布规律和磁性差异来识别浅覆盖区地质体的新思路,能够识别地质体且效果明显。实例表

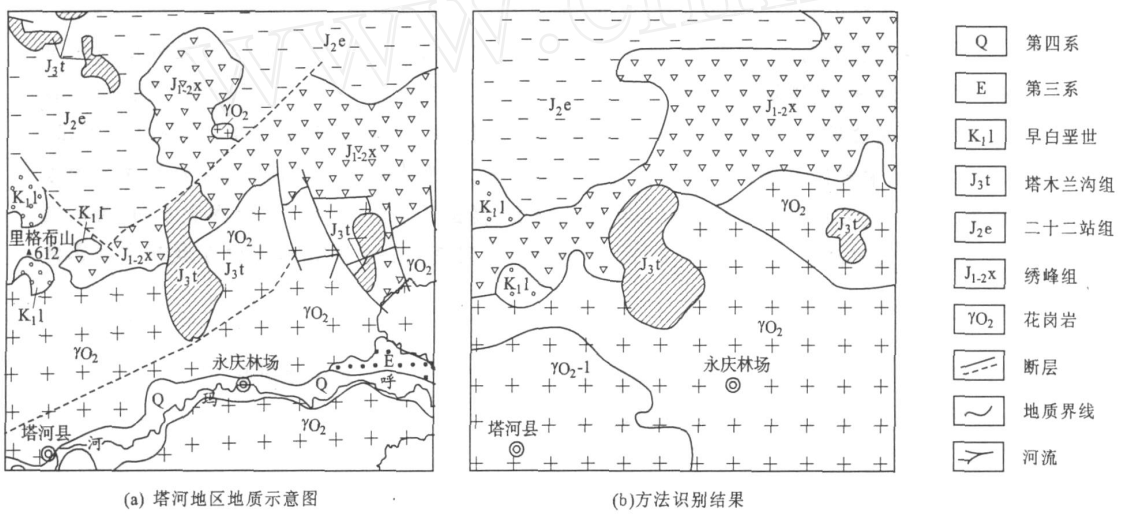
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(a) 原始异常　　(b) 500 m 以上局部异常

图 1　利用插值切割法进行塔河地区航磁数据局部异常划分的结果对比

Fig 1　A division result of Tahe area's aeromagnetic data based on interpolating cut method



(a) 塔河地区地质示意图　　(b)方法识别结果

图 2　方法识别结果与塔河地区地质示意图对比

Fig 2　The conparison of identification result and Tahe area's simple geologic map

明,该方法对于划分花岗岩与花岗岩、花岗岩与沉积岩效果较好,而对于划分沉积岩与沉积岩效果较差,需要进一步研究。另外,切割深度和统计单元大小,需要结合地区的实际情况确定,不能相互套用,统计参数也可以根据实际情况进行增减。

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The patterns of $C_4 \sim C_7$ fingerprint hydrocarbons illustrate the similarity of the source - rock of the survey regions of Xinchang, Hexinchang and Xiaoquan in the western Sichuan depression, and the organic matter of gas source rock is mainly of II_2 and III types based on systematic sampling and analysis of natural gas $C_4 \sim C_7$ fingerprint hydrocarbons. Through analysis of the distribution of aromatic hydrocarbon contents in vertical profile, the authors argue that the long migration of natural gases as dissociative forms in Penglaizhen formation, natural gas migration as mixed forms in middle jurassic formation and short migration to form gas reservoir in the upper trassic T_3X^4 and T_3X^2 of Xujiahe formation.

Key words: western Sichuan depression; $C_4 \sim C_7$ finger - print; kerogen; migration phase

THE APPLICATION OF POLYGON CONSTRUCTION USING AZIMUTH ANGLE IN RESERVE CALCULATION

LIU Ji-yu, WEI Hua-bin, LI Li-li, et al (Daqing Petroleum Institute, Daqing Heilongjiang 163318, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2008, 30(2): 0117

In the process of reserve calculation using volumetric method, to confirm oil - bearing area is in fact to calculate polygon area. When coordinate analytic method is used to calculate polygon area, The paper presents a forward polygon construction using bearing arithmetic for the purpose of order arrangement of polygon acme. The principle of the arithmetic is to make main - well as jumping - off point to point at accessorial - well along the radial and calculate the azimuth angle. Then by arranging those azimuth angle in a order from small to large, an accessorial - well serial can be obtained, and the connection of those accessorial - wells to consists a polygon. Now, the method has been used to production.

Key words: geologic reserves; volumetric method; oil - bearing area; azimuth angle; polygon

SEISMIC SAFETY EVALUATION OF ENGINEERING SITE AND ITS APPLICATION

SHI Lin-ke, SUN Yi-fei, YUE An-ping, et al (North China Institute of Water Conservancy And Hydropower, Zhengzhou 450011, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2008, 30(2): 0120

According to the national request of seismic safety evaluation of engineering site, the evlution technique, seismic geological investigate, seismicity analysis, seismic geology background, attenuation relationship of seismicity of solid rock, seismic risk analysis with probability, the design parameters of ground motion etc. are discussed in detail by combining an engineering instance. The research suggests that the dangerousness is existent for taking place 7 degree earthquake according to the geology background; The soil type of the site is medium soft and its category is III. At the same time, design parameters of ground motion are obtained, and they can be provided to the design section as references.

Key words: site; seismic safety evaluation; design parameters of ground motion

A STUDY ON LITHOLOGIC IDENTIFICATION IN SHALLOW COVER AREAS FROM AEROMAGNETIC

ZHAO Yu-yan, WU Yan-gang, HAO Li-bo, et al (Collage of Geo - exploration Science and Technology, Jilin University, Changchun 130026, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2008, 30(2): 0125

In shallow coverage areas, the geologic map plotted with the conventional method has a characteristic that the credibility is low, the information is lacking and the overall quality is poor. So that using exploration techniques to enhance the efficiency, quality and level of geological research of the geologic mapping in coverage areas is of great realistic significance. Although the aeromagnetic method is one of the important methods, the aeromagnetic survey data describe the superposition of the magnetic anomalies over the courie surface, while the regional geologic

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mapping only describes the surface geologic information. So that it is obviously unreasonable to use the aeromagnetic survey data to aid geologic mapping directly. In this paper, a new method that identifying geologic body in shallow coverage areas with rock magnetic distribution is studied based on interpolating cut method, mathematical statistics and gray relationship analysis. The efficiency of recognition is verified with the data of Tahe of area.

Key words: shallow coverage areas; aeromagnetic data; geologic mapping; interpolating cut method; gray relationship analysis; Tahe

GEOLOGICAL CHARACTERISTICS AND PROSPECTING TARGET OF THE PUQIONGLANG IRON DEPOSIT, TIBET

ZOU Guang-fu[1,2], ZHENG Rong-cai[1], CHEN Huaan[2], et al. (1. State Key Laboratory of oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China; 2. Chengdu Iinstitute of Geology and Mineral Resources, Chengdu Sichuan 610082, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2008, 30(2): 0128

On the basis of the mineral resource survey of the Puqionglang in LinZhou of Tibet, this paper deals with the geological settings, geological characteristics, geophysical characteristics, ore genesis and prospecting perspective of Puqionglang iron deposit. The study results show that the early Himalayan Period was an important metallogenic epoch for rich iron deposits in the Gangdise arc orogen of tibet. The Puqionglang iron deposit is located in the skarn and skarnization limestone in contacting belt of the Jubuzhari granite body in the early Himalayan Period, and is a postmagmatic meso. The ore bodies are mainly in veins, lenses and layered in marble. The ore bodies is strictly controlled by carbonate rock of the Permian Luobadui and mengla formation and the E - W orientation fracture zones in stratum layer. The host rocks are mainly skarn and skarnization limestone of the permian luobadui and mengla formation. Ore minerals are mainly magnetite, chalcopyrite and azurite etc.. Vein minerals are mainly in quartz, Calcite, diopside and garnet etc.. The potential resource quantity of Puqionglang iron deposit is huge and proposed prospect searching for the same type iron deposit in the outside, too. Based on the geological features, ore - controlling factors, prospecting criteria and target for iron deposit in this region are discussed. The discovery of Puqionglang iron deposit initiate a new idea and a important foundation for prospecting for the type of iron deposit in the Gangdise Arc orogen of tibet.

Key words: puqionglang iron deposit; geological characteristics; geophysical characteristics; genesis of deposit; prospecting target; Linzhou county in Tibet

A STUDY ON THE 2.5 - D ELECTROMAGNETIC MODELING BY THE FINITE ELEMENT METHOD AND THE WAVE NUMBER SELECTION

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A finite element method is developed for simulating frequency domain electromagnetic responses due to a dipole source in the presence of the 2 - D conductivity structures. Computing costs are considerably minimized by reducing the full three - dimensional problem to a series of two - dimensional problem. This is accomplished by Fourier transforming the problem into y - wave number (K_y) domain, for the y - direction is parallel to the structural strike. In the K_y domain, two coupled partial differential equations for H_y and E_y has been derived. For the requisite number of K_y values, the coupled equations are solved by the finite element method on the isoparametric element on the x - z plane. Application of the inverse Fourier transform to the K_y domain solutions provide the electric and magnetic fields in real space. The formulations derived can be applied to general com-

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