Application of MapGIS COM Technique in Mineral Resource Evaluation

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Abstract—The task of mineral resource evaluation is to block out metallogenetic zones by studying in detail the regional geological features, geophysical signatures, geochemical properties and remotely sensed data so as to find the relationship of the metallogenetic probability and to provide advice for further prospecting. In this paper we applied COM technique based on MapGIS to design a mineral resource evaluation system. We designed modules to extract metallogenetic factors, to analyze significance of metallogenetic factors, to calculate metallogenetic probability on basis of weight-of-evidence model and to display the final result visually. At the end of this paper, we applied our system to evaluate a manganese ore in Guangxi province of China. We blocked out 5 bigger and 3 smaller manganese prospective belts. The result shows the perfect effect of our system in mineral resource evaluation.

Keywords- COM technique; MAPGIS; mineral resource evaluation;   weight-of-evidence model; manganese ore

1. Introduction

GIS(Geographic Information System) is a computer system for capturing, managing, analyzing, and displaying all forms of geographically referenced information. MAPGIS is a GIS platform developed by ZONDY CYBER Co. which is a large intelligent system including the most advanced graphics, image, geology, geography, remote sensing, mapping, artificial intelligence and computer science. MAPGIS is widely used in mineral resource evaluation work in China for its strong ability of dealing with special data.

COM technique brings a new breakthrough to program designing. It is a development tendency of future programming. COM technique injects new vitality to the application of GIS. From the user's perspective, COM is a series of software modules which are easily assembled to construct a powerful software t according to our needs.

In this paper, we designed a mineral resource evaluation system using COM technique based on MapGIS. We selected Delphi as our programming language and the well known weight-of-evidence model as our special analysis method.

2. Principle of COM technique based on MapGIS

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2.1. Characteristic of component object in MapGIS

Componentized MapGIS integrates more advanced technique. It's more powerful and more convenient for second development. It can be extended infinitely.

MapGIS provides perfect functions of GIS such as high quality to manage spatial database, complete data analyzing tools, categorical data analysis tools, network analysis tools, multi-source images analysis and processing tools, 3-D model displaying tools and map editing tools, etc.

As a component-based GIS software development tool, MapGIS supports many programming languages such as Visual C++，Visual Basic，Delphi，Script and InterDev in component plus object form.

2.2. Hierarchy of MAPGIS components platform

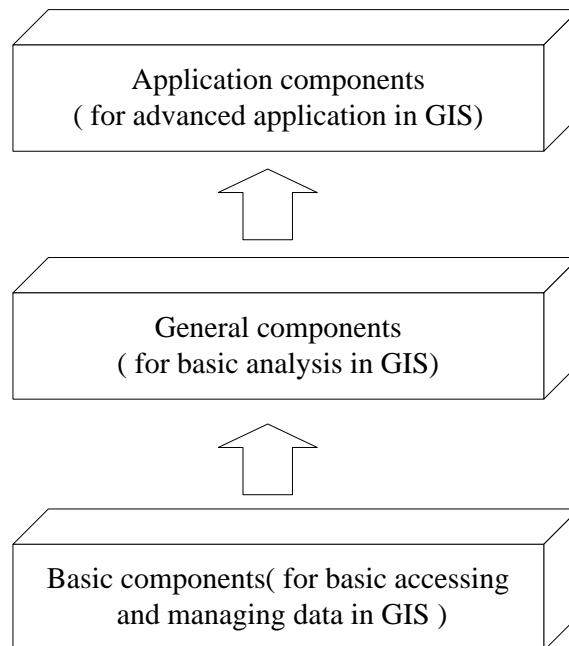The MapGIS components platform involves three levels as is shown in Fig. 1.

Fig.1. Hierarchy of MAPGIS components platform.

Basic components

The basic components are at the bottom layer. They are the core of the whole system. The main functions of the basic components are to store and manage spatial data, to provide basic interaction and to provide flexible ways to connect with database.

General components

The general components are made up of the basic components. They are of general functions, which simplify the user's developing course. For example the graphic displaying and editing component, attribute browsing component, image analyzing component are all general components. They are packaged to make secondary development easier.

Application components

The purpose of designing application components is for actual engineering application. So the application components have the general GIS function as well as some special function aiming at the general features in different areas. These general features are packaged as component, which makes secondary development work greatly simplified.

2.3. Sketch map of the relationship between components in MapGIS

Components in MapGIS are independent from the selected programming language, so they can be embedded in some general developing environments to implement the GIS function. Other special function can be fulfilled either by using these general developing environments or by inserting other professional components. Each module can mutually be related to other to process data together. What's more these

modules can be operated independently. So we can develop high effective and seamless GIS application system by using MapGIS components.
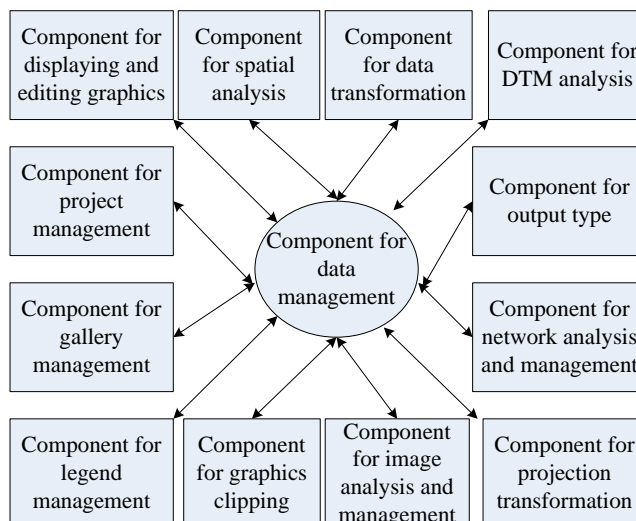

Fig.2. Sketch map of the relationship between components in MapGIS.

2.4. Component files in MapGIS

MapGIS components based on COM technique are involved in a series of windows dynamic link library (DLL) files. The ActiveX components are involved in a series of OCX files(.ocx). The following shows the MapGIS component files:

MapGISBasCom1.dll, MapGISBasCtl.dll, MapGISBasCtl1.dll, MapGISBasCtl2.dll, MapGISDspCom.dll, MapGISLayerCom.dll, MapGISMapCom.dll, MapGISDBSCom.dll, MapGISRasterCom.dll, EditView.ocx, MapTree.ocx, AttStruEdit.ocx, GisAttEdit.ocx

Before using these components, we should firstly register them.

2.5. Registering MapGIS components

Before using MapGIS components, we must register them in windows register table. Run setup.exe in MapGIS secondary development package, then the components can be registered automatically.

2.6. Application of component files in MapGIS

After the component files are registered, we can use the MapGIS component in our developing environment. The steps to use these components are shown as follows:

a) Embed MapGIS object types library.
b) Establish MapGIS object.
c) Use MapGIS object and other object in developing environment.
d) Release MapGIS object.

3. Theory of mineral resource evaluation

3.1. Concept of mineral resource evaluation

Mineral resource evaluation is to analyze regional metallogenetic conditions and prospecting information by applying theory of basic geology and deposit geology as well as relevant technique, to infer possible deposit and its basic characteristics.

3.2. Application of GIS in mineral resource evaluation

GIS is widely used in process of mineral resource evaluation. With the help of GIS we can easily obtain, manage, analyze, simulate and show spatial data. We can easily analyze comprehensively the information of geology, mineral, geophysical exploration, geochemical exploration and remote sensing. The mineral resource evaluation work with the help of GIS will be more effective.

3.3. Mathematical method in mineral resource evaluation

The process of mineral resource evaluation is to collect information, to analyze and to extract metallogenetic information, to analyze comprehensively the different kinds of metallogenetic information using some mathematical methods and to show the results visually. The core in mineral resource evaluation is the mathematical methods selecting for comprehensive analysis. In this paper, I selected the well known weight-of-evidence method to do this work.

The weight-of-evidence method is a statistical method proposed by F.P. Agterberg, a famous Canadian geologist. The weight-of-evidence method predicts metallogenic prospective zone by superimposing relevant metallogenic information. Each geo-information is viewed as evidence and its contribution to mineralization is decided by its weight.

Assume that for a particular region, m binary maps are known and are to be used as predictors of mineral potential. These maps expressed as $Z_j (j = 1,2,\cdots,m)$. Y is the binary target variable to be predicted. It is usually be used to describe the output state of deposit.

$$Z_j(x) = \begin{cases} Z^+ & \text{the j-th character is present at position } x \\ Z^- & \text{the j-th character is absent at position } x \end{cases} \tag{1}$$

$$Y(x) = \begin{cases} Y^+ & \text{the target variable is present at position } x \\ Y^- & \text{the target variable is absent at position } x \end{cases} \tag{2}$$

Firstly we consider the situation when $m = 2$. The posterior probability can be given by bayesian equation.

$$p(Y|Z_1Z_2) = \frac{p(Z_1Z_2|Y)p(Y)}{p(Z_1Z_2)} \tag{3}$$

Where $p(Y)$ is the prior probability of Y.

The posterior odds is given as follows:

$$o(Y|Z_1Z_2) = \frac{p(Y^+|Z_1Z_2)}{p(Y^-|Z_1Z_2)} = \frac{p(Y^+)p(Z_1Z_2|Y^+)}{p(Y^-)p(Z_1Z_2|Y^-)} \tag{4}$$

If Z_1 and Z_2 are independent with respect to the mineral occurrence points, that is:

$$p(Z_1Z_2|Y) = p(Z_1|Y)p(Z_2|Y) \tag{5}$$

then we have:

$$\ln[o(Y|Z_1Z_2)] = \ln[p(Y^+)/p(Y^-)]$$
$$+ \ln[p(Z_1|Y^+)/p(Z_1|Y^-)]$$
$$+ \ln[p(Z_2|Y^+)/p(Z_2|Y^-)]$$
$$= w_0 + w_1 + w_2 \tag{6}$$

Similarly, if more binary predictor maps are used, they can be added provided that they are also conditionally independent with respect to the mineral occurrence points. In general, with $Z_j, j = 1,2,\cdots,m$ binary predictor maps, the log posterior odds are:

$$\ln[o(Y|Z_1Z_2\cdots Z_m)] = \sum_{j=0}^{m} W_j \tag{7}$$

where

$$W_j = \ln[p(Z_j|Y^+)/p(Z_j|Y^-)] \quad (j=1,2,\cdots,m) \tag{8}$$

The above equation can then be written as:

$$W_j^+ = \ln[p(Z_j^+|Y^+)/p(Z_j^+|Y^-)] \quad (j=1,2,\cdots,m)$$
$$W_j^- = \ln[p(Z_j^-|Y^+)/p(Z_j^-|Y^-)] \quad (j=1,2,\cdots,m) \tag{9}$$

where + is for presence, - is for absence. These expressions use an asymptotic result which assumes that the number of occurrences is large.

For each predicted map, $C = W^+ - W^-$ gives a useful measure of correlation with the mineral occurrence points. When C is positive, it means the occurrence of the j-th map is a positive spatial association with mineral occurrence.

The posterior probability can be calculated as follows:

$$p(Y|Z_1 Z_2 \cdots Z_m) = \frac{o(Y|Z_1 Z_2 \cdots Z_m)}{1 + o(Y|Z_1 Z_2 \cdots Z_m)} = \frac{\text{Exp}(\sum_{j=0}^{m} W_j)}{1 + \text{Exp}(\sum_{j=0}^{m} W_j)} \tag{10}$$

The variance of the posterior probability can be calculated as follows:

$$s^2[p(Y|Z_1 Z_2 \cdots Z_m)] = p^2(Y|Z_1 Z_2 \cdots Z_m) s^2(o) \tag{11}$$

4. Mineral resource evaluation system based on MAPGIS component technique

4.1. Main modules of the system

Combined with the specialties of mineral resource evaluation, we developed software based on MapGIS component technique and weight-of-evidence algorithm. Our system involves many modules such as information extracting module, information integrating module, results showing model and so on.

In the information extracting module, we realized some functions related to extract and preprocess all kinds of information including geology, geophysics, geochemistry and remote sensing. Also we realized buffer analysis function. With these functions, we can extract what we are interested for further use.

In the information integrating module, we allow user to grid the research area, to calculate prior probability, to calculate the weight of every evidence, to test conditional independence, to calculate posterior odds and to calculate probabilities for mineralization.

In the results showing model, we allow user to display the results as forms of blocks of color map.

4.2. Application of our software in Manganese forecasting in Guangxi Province of China

We applied the software to forecast Manganese potentiality in Guangxi Province of China. After studying the metallogenic condition of this area, we extracted information from geology, geophysics, geochemistry and remote sensing and calculate their weights. Then we selected 14 binary predictor maps which had bigger weights as our final evidences to calculate the posterior probability for Mn-ore. Fig.3 shows the result of our application. According to the probability anomaly, we blocked out five major Mn-ore prospective zones marked A, B, C, D, E and 3 minor Mn -ore prospective zones marked a, b, and c.
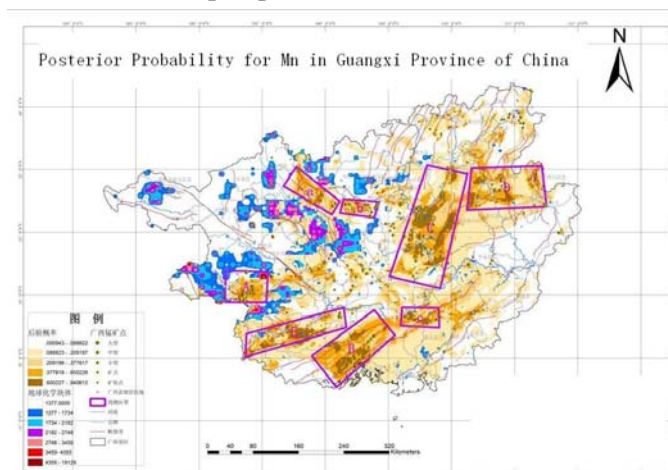

Fig.3. Posterior probability for Mn in Guangxi Province of China.

5. Conclusions

e) Our mineral resource evaluation system is experimented to be an effective and handy tool for those experts who dedicate to evaluate mineral resource potentials.

f) We selected weight-of-evidence model as our information integrated method. This method requires that a number of representative mineral occurrences are known in the study area..

g) Weight-of-evidence model is a data-driven method. If we do not have enough knowledge in the study area, we can not use this method to predict. To solve this problem, we allow expert to modify weight calculated by our software according to his knowledge.

6. References

[1] G. F. Bonham-Carter, F. P. Agterberg and D. F. Wright, "Weights of evidence modeling: A new approach to mapping mineral potential," //Agterberg F P, Bonham-Carter G F(eds). Statistical Application in the earth Science. Geological Survey of Canada Paper 89-90, 1989, pp. 171-183.

[2] J. X. Liu, "Application of MapGIS to mineral prospecting". Land & Resources Herald, Mar. 2006, pp. 125-127.

[3] Y. Q. Chen, P. D. .Zhao, "Extraction and integration of geoanomaliies associate with mineralization". Earth Science—Jurnal of China University of Geosciences, vol. 34, Feb. 2009, pp. 325-331.

[4] E. J. Carranza, "Weights of evidence modeling of mineral potential: A case study using small number of prospects," Natural Resources Research, vol. 13, Mar. 2004, pp. 173-188.

[5] F. P. Agterberg, G. F. Bonham-Cater and Q. Cheng, "Weight of evidence modeling and weighted logistic regression for mineral potential mapping," In: Davis, J C and Herzfield, U C(eds). Computer in Geology—25 Years of Progress. New York: Oxford University Press, pp. 13-32, 1993