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FROM MATHEMATICAL GEOLOGY TO GEOINFORMATICS

Abstract

The mathematical geology was born in 1960's to evaluate geological data and construct geological models by applying mathematical and statistical methods with computers. It was applied in many branches of geology to solve various geological problems. It has not only supplied new tool for geology, but also integrated the geology from empirical science to theoretical science. According to the development of computer and related IT technology in last two decades, it became possible to apply various new methods in informatics to geological researches, such as collection, accumulation, search, evaluation and communication of data, together with modelling and simulation of geological processes. The more integrated studies became available in geology by applying informational theories and methods, which is the birth of the geoinformatics.

***Keywords**: Mathematical Geology, Geoinformatics, Observation, Evaluation, Modelling, Simulation, Prediction*

1. Mathematical Geology

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2. Geoinformatics

According to the development of computer and related IT technology in last two decades, it became possible to apply various new methods in informatics to geological researches, such as collection, accumulation, search, evaluation and communication of data, together with modeling and simulation of geological processes. The more integrated studies became available in geology by applying informational theories and methods, which is the birth of the geoinformatics (Wadatsmi, 1990). The following section includes some examples of informatics application to geology are introduced.

3. Informatics Application

3.1 Database/Archive

Geology is a natural science which is based on the accumulated data in the past, major part of which cannot be obtained again. According to the development of technology in 20th century, the size and variation of geological data was rapidly increased, and it is necessary to manage the data by using the database for efficient and complete reference of past data. Also the archives of past researches are more important than other natural sciences because geology has the characteristics as a historical science. In the early stage of geoinformatics, the main target was to construct geological databases which can be used by geologists in the world, not only by collecting geological data but also by developing specific DBMS for geology because of specific data structure of geological data. According to the recent advances of informatics, there are many excellent and powerful DBMS, such as object-oriented and/or network type, and they can treat the geological data without any specific options. It is important to apply these data management technologies to geology, which leads the more integrated use of geological data.

3.2 Remote Sensing/Geophysical Exploration

Data from traditional methods, such as field survey and laboratory analyses, are the basis of geology, but many new methods of collecting data are available according to the development of technology. The remote sensing is now a important source of geological data, and their application to structural geology, mineral exploration, environmental analyses, and many other branches in geology were reported. Also many physical/chemical elements were used in geology, which are obtained from new observation methods. In the early stage, geologist should develop original tools and program to use these data to convert observed values to geological elements. Remote sensing and other observation methods are rapidly developed in concordance with the IT technology, and it is now easy to apply these methods to geology without any specific options. It is valuable to add new types of data to geology which leads the more integrated study in geology.

3.3 3D Technology/ Image Processing

Geological events should be analyzed in 3D spaces, and geologists analyzed geological problems by imaging 3D models with the help of many kinds of diagrams, such as panel diagrams, serial sections, and others. Many geologists tried to use computers for the 3D analyses, but it was not because it require much space and time to treat 3D data. According to the development of hardware and software of computers, especially those of image processing, it is

now available to apply 3D analyses to many branch of science. Even if geological data have more complex data structure and larger size of data than other sciences, recent 3D technologies can accept and analyse geological data and display the 3D image of analyzed result. The application of 3D technologies has made the geological models more visible and more realistic than before, which is efficient to be understood by other branch of science.

3.4 GIS/Web GIS

Geological events should be described and analyzed on the geographical co-ordinates, and geologists tried to use the co-ordinates by developing specific programs. However it require much time and labour to add the co-ordinates, only limited areas were digitized in individual research and it was difficult to connect with different areas. The GIS systems were developed in the last two decades, together with the DEM models, and the GIS were applied to many sciences. Many geologists have contributed to this development as a major part of GIS users. According to the development of the Web GIS systems in recent years, its application has been rapidly expanded from science to our ordinal life. The GIS systems can be applied to geology not only for the research, but also for the publication of the results on the GIS format. The use of the GIS system will help the more proper understanding and evaluation of geological information not only in science but also in the society.

3.5 Network/INTERNET

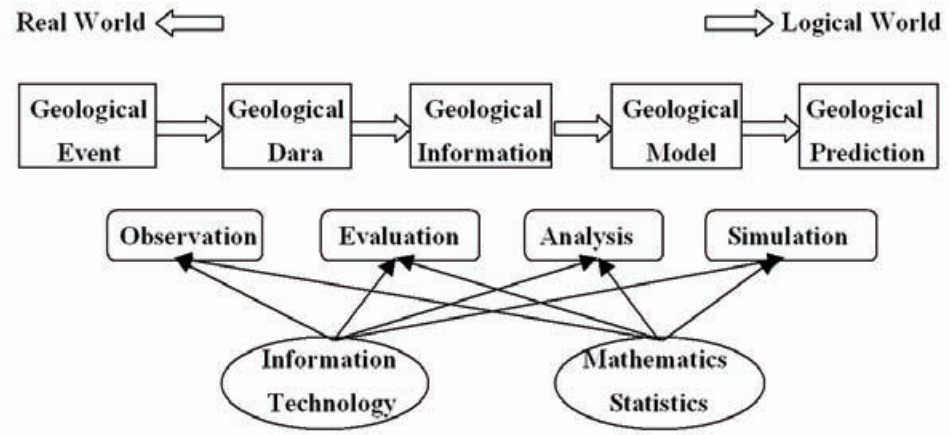
The communication of data and information in geological community is important for the development of geology as the base of research. Rapid and wide-spread communication became available by using the information network system, and the more detailed and synthesized discussion contributed to the more integrated study of geological problems. The INTERNET has made another drastic effect on the communication of information not only in scientific community but also in the human society. The information can be rapidly and easily circulated within scientific communities without any specific techniques, which promote the discussion and cooperation and the more integrated studies. The new information can be published on the INTERNET for publication, which was accessed by any people without any restriction. The rapid and accurate publication of geological information is the key of understanding and acceptance of geological models and theories by the human society. The geologists should use the INTERNET not only for the scientific research but also the popularization of geology.

4. Mathematical Geology and Geoinformatics

The mathematical geology has developed many new mathematical modes and analytical methods for solving geological problems. It is, however, difficult to apply current mathematical models directly to geological problems, as they are not concordant to the characteristics of geological data, such as, 3D distribution, time-controlled, enormous amounts, global and local factors, qualitative and quantitative variables, etc. The models developed by mathematical geology can be used not only in geological sciences but also other natural and social sciences. New types of data are required to approve new mathematical models, and it is necessary to add new data by developing new measurement techniques, searching databases, and converting data, which are mainly in charge of the geoinformatics.

The geoinformatics will improve the processing of geological data by introducing new techniques in informatics. In its early stage it was necessary to develop geological options of current informatics techniques, but in recent years such optional developments is not always necessary according to the progress of the informatics. It is, however, important for the geoinformatics, in conjunction with other sciences, to continue the development of new techniques according to the progress of informatics. It may be required in the course of such development to introduce new mathematical models, which are mainly in charge of mathematical geology.

The following figure shows the relationship of the mathematical geology and the geoinformatics, given in the general flow line of informational research from the real world to the logical world. That is, the geological data were obtained by the observation and/or measurement of geological events, the geological information were extracted by the evaluation of geological data, the geological models were constructed by the analyses and synthesis of geological information, and, the geological prediction and forecasting were established by the simulation based on the geological models. The mathematics and statistics are used as the theoretical basis mainly in the latter processes, and the information techniques provide the tool of data analyses in the former processes. Consequently, the mathematical geology and the geoinformatics are supporting the data and information processing in geology.



5. Past and Future

In the past the geological information was common only within the geological community, but in present the major part of geological information is opened to public through the INTERNET. The data is necessary to evaluate the geological information, and also some part of geological data will be opened to public in the future for the direct use by the human society. The geologist should supply not only the data and application software to use the data, but also the criteria to evaluate the data. Inappropriate use of data by the non-specialists should be avoided by popularizing the geological knowledge in the human society.

In the past the geologists should develop optional programs to treat the geological information by general application software of informatics, which need much time, labor and costs. In present, many general informatics systems can accept geological data and information only with setting parameters without any special option, and it is possible various informatics models can be directly applied to geology. It is partly because the geologists have joined the development of many systems, as the geology is one of important branch of science which need the data and information for its development. The more application of informatics to geology will lead the wider and more integrated analysis of geological information.

It is, however, important to develop geological models based on the geological data and theories, as the geological data have special characteristics, such as time-controlled element as a historical science. It is dangerous to accept general informatics models without detailed examination on the applicability to geology, as it may lead wrong models and theories which does not concordant with the geological principles.

6. Summary

The geoinformatics was born in early 1970s in Japan with the leadership of Prof. Wadatsumi who was a mathematical geologist and an excellent informatics specialist. He promoted the project to include the informatics technology into geology, such as databases, remote sensing, 3D analysis, and others. A research group on geological data processing was created from this project, and the Japan Society of Geoinformatics was established in 1990 by this group. The society has been continuing efforts to expand geoinformatics by applying new informatics models to geology (Nishiwaki, 1998).

The mathematical geology has already been accepted as the theoretical basis of geological analysis and modeling in many branches of geological sciences. The geoinformatics is still providing new methods and techniques for geological information to the future, together with the development of informatics, and contribute to the development of geology.

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