DEVELOPMENT OF EXPLORATION GEOPHYSICS
AND ITS INFORMATION ACTIVITIES

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Traces the development of exploration geophysics as a scientific discipline and discusses the factors responsible for its development. Recent trends in geophysical research are discussed briefly. Details of professional societies and their role in controlling the information activities are given. Publication trends of two leading journals in exploration geophysics are presented in tabular and graphical forms.

INTRODUCTION

Earth sciences have a large data base and rich literature. Since geological information retains its value for a considerable period of time, the data and information are stored in a variety of forms as permanent record for future consultation, correlation and utilization for further studies. Like other sciences, earth sciences have been accumulating a vast amount of data and the process is exponential since last three decades.

Geophysics has contributed a major proportion of data to earth sciences. Exploration geophysics is still a very young scientific discipline, but has been developing very fast since last two decades. The growth of data and information has accelerated of late because of new ventures in offshore prospecting and availability of technology.

DEVELOPMENT OF EXPLORATION GEOPHYSICS AS A SCIENTIFIC DISCIPLINE

Before the information activities are discussed, it would be helpful to discuss the various aspects of development in exploration geophysics as the development of exploration geophysics as a scientific discipline is directly related with the development of information activities in this field. The points like formation of professional societies and associations, their activities for the promotion and progress of the discipline, publication of journals, state-of-art reports of geophysical data and other forms of literature and information would be considered later. Here, I would like to discuss the aspects of development of the subject as an independent discipline and factors responsible for the growth of data and information in exploration geophysics.

HISTORICAL DEVELOPMENT

Methods of geophysical prospecting in a way as we see them today started about 1923 for mineral exploration and since then they have become increasingly important because of oil exploration. Mediaunin[6] has given a good historical account of the development of geophysics and has argued that exploration has emerged as an independent scientific discipline. De Golyer[3] has reviewed the development of gravity and seismic methods in early thirties of this century. Heiland[5] and Rust[7] described some of the early attempts to employ electrical methods. Eckhardt[4] a pioneer in the field has given an excellent historical account of instruments and techniques used in gravitational methods. Schriever[8] recounts the experimental work attempting to develop the reflection seismic methods in early 1920s. Weatherby[9] has given a general historical account of seismic methods. The early developments in the methods of exploration geophysics have been described by these authorities. Later developments have been reviewed by the experts in the various issue of professional journals of exploration geophysics. The most interesting review articles appeared in Geophysics in the years 1955 to 1958. Although these articles are addressed to the scientists but they are equally important and
interesting for the librarians and documentalists to prepare state-of-art reports on various topics in exploration geophysics. The fourth in the above mentioned series is one by White[10] who has reviewed technological developments in exploration geophysics. Another paper of Born[1] highlights the developments of geophysical instrumentation. The progress of the development of geophysical methods – instrumentation, data processing and interpretation, achievements in exploring more oil fields etc. are reviewed in one of the issues of Geophysics every year.

The most interesting thing to note from all these reviews is that the development of geophysical prospecting methods was steady upto 1940 and thereafter it started accelerating at a faster rate and this rate has been very fast during the last twenty years. Another point of interest to note is that every geophysical method has had its period of initial trial, followed by its peak commercial application over a period of few years. As areas amenable to a particular method have been studied and covered, the popularity or application of the method decreased and it was replaced by other methods. The succession of one method after another sometimes followed rapidly. At other times there has been considerable lapse of time between peak applications of various methods. Each method has had a limited period of maximum commercial utility and activity because it: either eventually covered the most amenable areas, or else was succeeded by a narrower technique (modified/refined) having economic advantages. A nice and detailed description regarding the discoveries of new fields and relationship with development of new ideas and method is given in the Bulletin of American Association of Petroleum Geologists in 1958 in its fourth issue.

FACTORS RESPONSIBLE FOR THE DEVELOPMENT OF EXPLORATION GEOPHYSICS

Important characteristics of modern sciences in their development is their utilitarianism. Today, earth sciences are of tremendous importance providing the minerals as raw materials for industry. The data of earth sciences help to ensure the most profitable and expedient interaction of human society and nature. Over the ages, this interaction has been growing ever more deep and diversified. Through this diversity two important tendencies can be traced: firstly, the utilization of natural resources, and secondly, reasonable consideration and utilization of the properties of the natural environment affecting man’s activity.

Utilization of natural resources

- Utilization of the total resources of useful minerals in industry is rapidly increasing;
- Energy consumption by human society is increasing in leaps and bounds;
- Accelerating productive forces for economic development;
- Transforming the nature in the interest of man.

Importance of the properties of the natural environment

Man’s environment - the terrain, mineral resources, climate etc. greatly influence his activity and sometimes determines various aspects of it.

Geophysics among earth sciences and applied geophysics have contributed their share for these causes in general and several other factors in particular. A few factors for the progress of exploration geophysics and related information activities are discussed as below:

1. Chiefly due to stiff commercial competition, exploration geophysics is a dynamic art continually changing and increasing;

2. The main incentive to modern exploration geophysics was the search and its success for oil during the early years of this century. An increased demand of oil and the inadequacy of the haphazard methods of the early “wild catter” in meeting the demand forced the development of the new science of petroleum geology and with it the effective tools of geophysical exploration;

3. Geophysical methods have been successful in the search for oil primarily because of their ability to determine the geologic structures and mapping conditions favourable for oil accumulation;
In its struggle to keep up with ever increasing demand for its products, the oil industry is expending great effort and enormous sums of money to find new oil and gas resources - directly or indirectly invested in the development of exploration geophysics;

Developments in physics, electronics, and other scientific disciplines have directly influenced the development of exploration geophysics;

Development in modern technology, to mention a few, computer technology, satellite communication, aviation and shipping transport means;

Geophysical instrumentation depended upon the development of electronics and mechanical engineering, designing, developing and construction of instruments was largely influenced by the development of these fields;

Techniques of recording were improved with the improved quality and means of recording. Computer technology has been mainly responsible for this progress. Airborne and shipborne recording has improved enormously with the development of technology. Better means of communication have mostly influenced this development;

Techniques of data processing and interpretation have tremendously improved with the increasing application of computers and computer graphics;

Modelling and simulation techniques have developed to the same extent for the similar reasons and ability of equipments and better facilities available in the laboratories;

Offshore ventures and the recent success of geophysical methods to discover more reserves, and ability of modern technology to tackle hazardous problems of offshore production has boosted the progress of exploration geophysics. Now more funds, more people (scientists and technologists) are available for the development of this science.

In short, it could be said that the science and art of exploration has in general kept pace with the advance of civilization and the improvement in methods for refining and conserving mineral resources. The development of exploration geophysics is global and it is expected that the present trend would continue even at a faster rate in the coming years.

Recent Research Trends in Exploration Geophysics

The combination of the future development, differentiation of sciences and the development of geophysics led to an independent scientific discipline, namely Exploration Geophysics which is characterised as a particular research subject and a set of particular techniques. Now the future development in the methods of exploration geophysics, improvement and development of new instruments, new techniques of measurement, processing and interpretation are not conceivable without further expansion and use of theory of exploration geophysics and corresponding physical and geological principles. Therefore, there is a shift in thinking from the previous concepts of accumulating data and facts only to the new trend of explaining them. Some new trends of research in exploration geophysics are discussed below:

Field Recording

The normal field recording for commercial purposes continues with more refined techniques and more sophisticated materials and instrumented. New techniques like remote sensing and holography are being experimented. Emphasis is more toward offshore surveys,

Study of physical and physico-chemical parameters of rocks and real media on which the various geophysical methods are based

Complex investigations of physical properties of rocks under both natural and laboratory conditions (under varied temperatures and pressures) are being performed in order to understand relationships between geological and geophysical characteristics. Theoretical principles of direct and indirect methods for prospecting are being formulated.
The study of characteristics and properties of the various geophysical fields: (modelling studies)

New means for exciting geophysical fields based on model studies are being examined. Models of various features of the earth are constructed and tested to ascertain their response to given variation in physical parameters. Studies are aimed to predict geophysical fields in complex models of real media.

The study of the relation between geophysical fields and the medium, construction of improved models of media and development of interpretation methods

Based on the investigations above, new methods of interpretation are being developed.

Computer Softwares are being developed to solve complex problems of data processing and interpretation and also displaying the various kinds of maps and sections.

Development of instruments

There is a new trend of thinking, designing and developing more sophisticated electronic equipments - mostly computer based - more compact and portable and capable of recording more and more information of complex nature.

One could very distinguishingly note that the recent research and development trends in exploration geophysics are of the same nature as should have been for any scientific discipline of applied nature. To summarise the above research and developments, two features could be noted with interest:

1. Trend for conducting fundamental or academic research which includes laboratory experimentation, model and simulation studies;

2. Trend for Research and Development type of studies which include designing and developing instruments, improvements in the materials used, development of computer softwares for automatic data acquisition, processing and interpretation and graphical display of results of interpretation.

The normal process of generating geoscientific information is collection of data from the field by collecting samples or by observations or recordings; processing the data in the laboratories and computer centres; interpreting the processed data in geological terms; and then finally submitting the report of investigations with final results and recommendations.

Most of geophysical data are accumulated by recording natural or artificially created geophysical phenomenon by very sophisticated electromechanical instruments. The normal output of data is a reading or observation noted in the field note books, or paper record or now mostly in a tape record. The field data thus obtained in large quantity are preserved in the headquarters of most organizations and institutes and retrieved whenever required for reprocessing and reinterpretation manually or in most cases now by computers. Processed data in the forms of graphs, charts, sections or maps etc. are separately collected and preserved for interpretation purposes and retrieved later for reinterpretation purposes. Final reports of investigations are then deposited in the central repository. Most of the data of this kind is of commercial and classified nature and kept confidential within the organization for long time, released later after a certain period for academic and public use. This kind of literature, i.e. Report Literature is difficult to access and acquire for general consumption. Since this data is important and of commercial value and use, it is very systematically gathered, processed, organised, stored, maintained and retrieved but rarely disseminated. Another kind of data is the normal primary literature published through scientific journals or patented with the patenting authorities. Broadly, geophysical information could be classified into two categories:

1. Commercial Information (field data, processed data and reports of investigations);

2. Scientific Information (primary research findings).

Scientific information has all the same characteristics and forms and its bibliographic control as we observe in other disciplines of science and technology. Characteristics of
Development of Exploration Geophysics

Geoscientific literature are described by Craig[2]. Geophysical information can be described as: Geophysical Information = Data + Literature in all its forms.

Following discussion would be useful and helpful to understand and appreciate the role played by professional societies in promoting the organization of geoscientific literature in general and geophysical literature in particular.

Professional Associations and Societies

Professional associations and societies play a very important role, promoting the scientific interest of their members; promoting the development of areas and disciplines to which they are concerned with; disseminating knowledge of science among members; maintaining professional standards; developing educational and training programmes for the students and for developing competent manpower; establishing contacts between the members and conducting many such activities.

There are more than 100 such associations and societies in earth sciences all over the world. Gale's Encyclopedia of Associations mentions about 28 associations in United States alone. These organizations can be categorized in their scope as national, regional and international. Some of them cover broad field of earth sciences, some of them geophysics and a few of them represent highly specialised fields like exploration geophysics. The details of few organizations which are directly or indirectly and partially concerned with exploration are given in the following section:

Society of Exploration Geophysists (SEG)

Address: Box 3098, Tulsa, Oklahoma, 7401
(USA)

Founded in 1930; Members: 9442 (1975);
Staff: 15; Local groups: 24

Donald C Barton organized society of Economic Geophysicists in 1930, with 46 geologists and geophysicists. The Society of Petroleum Geophysicists was founded in late 1930, held its first convention in March 1931 with Association of American Petroleum geologists. Only 57 papers were published during 1930-1935, and there were only 189 members in 1935. The society started its own journal - Geophysics in January, 1936. Today, SEG's membership is more than 10,000 representing more than one hundred countries. It is primarily an international organization of exploration geophysicists. Table 1 gives the data on membership of the society which is self explanatory to give an idea of its growth.

Table 1

<table>
<thead>
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<th>Year/period</th>
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<tr>
<td>1930</td>
<td>46</td>
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<tr>
<td>1935</td>
<td>189</td>
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<td>1955</td>
<td>4,764</td>
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<tr>
<td>1975</td>
<td>9,442</td>
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<td>1980</td>
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Table 2

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<td>1930-1935</td>
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<tr>
<td>1936-1945</td>
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<tr>
<td>1946-1955</td>
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<tr>
<td>1956-1965</td>
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<td>1966-1975</td>
<td>733</td>
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<tr>
<td>1976-1980</td>
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Table 3

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<th>Period</th>
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<td>1953-1955</td>
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<tr>
<td>1956-1965</td>
<td>290</td>
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<tr>
<td>1966-1975</td>
<td>417</td>
</tr>
<tr>
<td>1976-1980</td>
<td>239</td>
</tr>
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Note: Year to year distribution of publications of 'Geophysics' and 'Geophysical Prospecting' is shown in Figure 1.

Following figures give an idea about the diversity of membership:

40% members represent petroleum companies;
20% members represent private geophysical contractors/consultants
20% members represent mining and engineering companies;
20% members represent academics.
Fig. 1: Frequency Distribution of Publications in Exploration Geophysics: 1930-1980
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Society consists of 14 different committees to look after the various affairs of the society.

Publications
- Geophysics (scientific and professional journal - now monthly);
- Yearbook;
- Monographs, glossaries, indexes and items of academic and professional interests;
- Proceedings of conventions and annual meetings conference.

European Association of Exploration Geophysicists

Address : 30, Carl Van Bylandt laan, The Hague (Netherlands).
Founded : December, 1951; members: 2,500 (1975)

The association was founded with 300 active members which doubled in a year. Now, there are more than 3,000 members from sixty countries. The percentage distribution in 1964 was as below:

- France : 35%
- Germany : 21%
- U.K. : 19%
- Holland : 14%
- Italy : 6%
- Others : 5%

Publications
- Geophysical Prospecting (1953- quarterly journal);
- Occasional papers;
- See Table 3 for distribution of publication (1953-1980)

American Geophysical Union

Adress : 1909, K St., N.W.
Washington D.C. 20006 (USA)
Founded in 1919; members : 12,000

Sections : Geodesy, geomagnetism, Paleomagnetism; Hydrology; Meteorology; Oceanography; Planetology; Seismology; Tectonophysics; Volcanology; Geochemistry and petrology; and Exploration Geophysics;

Publications
- Journal of Geophysical Research (3/month);
- EOS Transactions (monthly);
- Water Resources Research (biomonthly);
- Reviews of Geophysics and Space Physics (quarterly);
- Radio Science (monthly)

Some Russian journals are translating them cover to cover:
- Izvestiya: Atmospheric and Oceanic Physics, (monthly);
- Izvestiya: Physics of the Solid Earth, (monthly);
- Geodesy and Aerophytography (bimonthly)
- Geotectonics (bimonthly)
- Oceanology (bimonthly)
- Soviet Hydrology and Selected Papers (bimonthly)
- Soviet Antarctic Expedition Information Bulletin (irregular).

American Geological Institute

Address : 5205, Leesburg Pike, Falls Church, VA 22041 (USA)
Founded in 1948; members : 18

American Geological Institute is a federation of 18 national scientific and technical societies in the field of geology, geochemistry and solid earth physics.

Aims
- career guidance programmes;
- to improve teaching of geological sciences in public schools; colleges and universities;
- seeks to maintain high standards of professional training;
- sponsors documentation and translation services for geological sciences.

Publications : several of international standards;
- operates GEO-REF, a computer based reference file of world-wide geological literature.
International Union of Geological Sciences (IUGS)

Address: P.O. Box 379, HAARLEM (Netherlands)

Founded: 1961; Members: Representatives of national committees for geological science;

Aims: International cooperation in geology and related science;

Publications: Geological newsletter (quarterly);

Geoscience Information Society

Address: C/o American Geological Institute, 5205, Leesburg Pike, Falls Church, VA 22041 (USA)

Founded: 1965; Members: 250; librarians, documentalists, information specialists, editors, geologists, and other earth scientists;

Aims:
- to promote the exchange of information in the earth sciences;
- to seek to recruit technically trained people in the profession;

Committees
- Earth science union list committee;
- Field reference guide books committee;
- Subject headings committee;
- Theses Committee;

Publications
- Newsletter (4/year)
- Proceedings (annual)
- Directory, bibliographies, union lists and scholarly publications.

Geological Information Group (GIG)

The group was founded in 1971 by Geological Society of London to study geological information in all its aspects including the principles of recording, indexing, collation, storage, retrieval, dissemination, editing and communication.

Association of Earth Science Editors

Address: C/o American Geological Institute, 5205, Leesburg Pike, Falls Church, VA 22041

Founded 1967; Members: 100; editors, managing editors and others in editorial management positions of publications in the field of earth sciences;

Aims:
- to promote effective publications of journals, reviews, monographs, abstracting periodicals and services, indexes, microcards and other publications which disseminate knowledge on earth sciences;
- to be affiliated with AGI and EDITERRA (European Association of Earth Science Editors);

Publications: Blueline (quarterly)

CONCLUSIONS

The development of exploration geophysics has accelerated in recent years. The main reason of this fast development is commercial application of geophysical methods in search of mineral resources. Information activities are mostly controlled by the professional societies. Two of the societies (SEG and EAEG) are mostly concerned with the science of exploration geophysics. Both of them are international in their scope of membership and activities. The next three organisations discussed are indirectly or partially related to exploration geophysics.

Association and organizations mentioned next are directly concerned with the geoscience information activities - publishing, documentation, and dissemination and editorial activities. A further study of trends of growth in size, volume, number of authors and kinds of materials etc. would be more useful. Citation analysis study of the literature could be useful to determine the usage pattern of the information sources.
REFERENCES


