CONFERENCE REPORTS...

Use of Computers in Resource Evaluation

Meeting and workshop, Ottawa, Canada, October 23-24, 1981

The use of computers in mineral resource evaluation was the timely theme of the Tenth Geochautauqua on Computer Applications in the Earth Sciences. Over 100 participants representing 10 countries from four continents attended the meeting, which was preceded by a three-day workshop on multivariate and image analysis in mineral resource evaluation. Internationally-known authorities presented papers on such topics as computer-based systems for resource analysis, computer simulation of ore-forming processes and multivariate statistical analysis of geoscience data.

SOME COMPUTER-BASED TECHNIQUES FOR MINERAL RESOURCE ESTIMATION

A two-day "Geochautauqua" on computer applications in the Earth Sciences has been held annually since 1972. (The word "chautauqua" originates from a summer school, first held in 1872 at Lake Chautauqua, New York.) The first eight Geochautauquas were held at Syracuse University, New York, and the ninth was held at the University of Miami, Florida.

Oil and Gas: J.C. Davis, Kansas Geological Survey (U.S.A.) and J.W. Harbaugh, Stanford University (U.S.A.), reported on a statistical evaluation of oil and gas prospects in the Outer Continental Shelf (OCS) of the United States Gulf Coast. They developed simple statistical relationships between size, shape and other attributes of structurally-controlled traps that can be detected and mapped by seismic techniques before drilling. They were also able to incorporate information about the presence and size of petroleum and natural gas reservoirs associated with the traps. Pre-drill predictions based on regressions between seismic structural properties and reservoir volumes revealed significant correlations. The authors argued that such a technique was simpler and less expensive than the present method for evaluating Gulf Coast OCS lease tracts by the Department of Interior using a Monte Carlo simulation procedure.

Turning from large to small oil fields, J.H. Schuenemeyer, University of Delaware (U.S.A.), and L.J. Drew, U.S. Geological Survey, took up the problem of estimating the parent population of oil and gas fields as revealed by the study of "economic truncation". Concern over oil shortages and rising oil prices has focussed attention on the smaller fields. Although they constitute a small percentage of the total oil and gas identified, they represent a large percentage of the oil and gas remaining to be found in many basins. For this reason, it is important to estimate the number of undeveloped fields subject to economic truncation.

On the topic of oil and gas exploration, J.E. Robinson and V. Singh, Syracuse University (U.S.A.) presented results of their studies on computer-aided recognition of geologic prospects. Using historical data from Kansas, U.S.A., they concluded that direct tests against known production, such as the location of residual highs from structural contour maps, offered the best indication for exploration prospects. Where previous exploration permitted a direct test for the optimum residual, the goodness-of-fit variance seldom produced the best result. Thus, data reduction techniques involving the application of trend analysis to structure contour maps can produce invalid results.

The extent to which a given area has been explored for a particular resource was taken up by D. Gill and R. Gabasi, Geological Survey of Israel. They examined the chances that a resource target of a particular size could remain undetected in an area tested by drilling. The authors selected the Southern Hashephela region of Israel and evaluated the degree to which resource targets have been thoroughly explored by past exploration. It was determined that there was a 50 per cent probability that a field the size of the largest known to date could remain undetected, and on this basis it was concluded that the area has not been completely explored.

Uranium: D.P. Harris and F.J. Carrigan, University of Arizona (U.S.A.), described the results of investigations on how estimates of uranium endowments made by a geologist using an appraisal system based on a formalization of geoscience and decision rules, compare with estimates made by informal and unconstrained intuitive processes. Estimates of the uranium endowment of the San Juan Basin in NW New Mexico were studied, and the results suggested that the more decomposed and formalized the estimation procedure, the greater the expected value and the greater the variance of uranium endowment.

D.M. Blanchfield, U.S. Department of Energy, Grand Junction, and C.E. Ford, Union Carbide Corporation (U.S.A.), described the National Uranium Resource Evaluation (NURE) program's subjective assessment approach. The methodology was based on the need to answer three questions about each geologically defined area deemed favourable for uranium deposits: Does the area actually contain undiscovered uranium deposits? Assuming some undiscovered deposits do exist, how much uranium do they contain? What portion of the contained is likely to be recoverable under various economic conditions?

For many areas, quantitative assessment of uranium is premature and it is sufficient to delineate favourable areas for further exploration. Along this line, G. Bonham-Carter and C.F. Chung, Geological Survey of Canada, described the results of a study to integrate geological, geochemical and geophysical data collected in the Kasmere-Whiskey Jack Lake area in NW Manitoba, Canada. Using discriminant analysis, the authors were able to "recover" from the geophysical and geochemical data a geological map comprising 33 geological map units.

R.G. Garrett, Geological Survey of Canada, discussed a case history of regional geoscience data integration for the purpose of uranium resource appraisal in the Kasmere Lake area. Using geophysical and geochemical data, he developed an empirical index to indicate the favourability for uranium occurrences associated with metasedimentary rocks. The favourable areas were then examined in terms of the known geology. Results showed that the majority fell in areas that

would also be considered favourable by geologic models for mineral occurrence.

Mineral Deposits: A.F. Gunter and colleagues, Carleton University and Earth Physics Branch, Energy, Mines and Resources (Canada), described the paleogeographic distribution of marine sedimentary phosphorite deposits. The computer program HYPRMAP was used to construct paleogeographic maps for specific geological time intervals in order to determine the optimum arrangements of continents and oceans for phosphorogenesis. HYPRMAP uses digitized present continental edges and bathymetry in conjunction with paleopole data and information on rotation of discrete continental structural blocks.

H.C. Helgeson and W.M. Murphy, University of California, in Berkeley (U.S.A.), discussed the changes in mineral and solution composition accompanying reactions in geochemical processes computed as functions of time and surface area, taking into account constraints imposed by conservation of mass and charge, partial and local equilibrium, and the rate control by surface reactions. They were able to show that the requisite mass transfer equations expressed for isothermal-isobaric processes involving stoichiometric minerals stand for an incremental change in the over-all progress variable for the process.

J.W. Lyon and J.M. Duke, Geological Survey of Canada, each discussed aspects of modelling and its application to the study of the genesis of stratiform sulphide deposits and ore formation. It was found that the degree of chalcophile element depletion occurring during the fractionation of a sulphide-saturated magma was related to the relative amount of sulphide segregated from the magma. Results of mineral analyses from several nickel-producing areas in Canada and Australia demonstrated a practical application to exploration.

R.B. McCammon, J.M. Botbol and R. Bowen, U.S. Geological Survey, and R. Sinding-Larsen, Norwegian Institute of Technology, discussed the use of the characteristic analysis com-

Temporarily distracted from the use of computers are (l-r): J.A. Botbol, R.G. Garrett, Zhou Di, J. Griffiths and R.B. McCammon.

puter program (CHARAN), which offers the exploration geologist a wide variety of options for integrating regionalized multivariate data. In Norway, characteristic analysis has been applied to a set of exploration data related to undiscovered stratabound sulphide deposits. At the time of presentation, confirmation by drilling of proposed drill-sites based on characteristic analysis was anticipated.

Data Management and Analysis: G. Gabert, Federal Institute of Geosciences and Natural Resources, (Federal Republic of Germany) described an integrated system for geoscience data being used at that institution. Emphasis is placed on methods to integrate and interpret various types of geoscience data. Other speakers presented papers on statistical and mathematical techniques applied to oil, gas, mineral resources, and the analysis and presentation of data. All papers will be published in the journals of *Mathematical Geology* and *Computers and Geosciences*.

F.P. Agterberg
Geological Survey of Canada

R.B. McCammon
U.S. Geological Survey

Geoscience Information Workshop

Regional Mineral Resources Development Centre, Economic & Social Commission for Asia and Pacific
Bandung, Indonesia, May 1981

The workshop was organized and led by J. Hepworth of RMRDC in collaboration with the Association of Geoscientists for International Development. Thirty participants from ESCAP member countries and RMRDC attended. Topics ranged from conceptual and managerial problems to operational and technical matters, including the uses of information, bibliographic databases, word processing and computers. A major result was a long list of conclusions and recommendations.

J. Hepworth (U.K./Indonesia) outlined some of the major driving forces behind the increasing concern for "information", particularly the proliferation of information sources and technology. The conceptual and organizational difficulties were emphasized, as was the need to examine and understand real requirements before attempting to develop solutions.

A.R. Berger (Canada) also elaborated on the importance of management, funding and organization, as opposed to technical matters. He illustrated this point with an examination of the extent to which the major international bibliographic databases (GeoRef, Geoarchive, Pascal-Geode) meet the needs of developing countries.

Hepworth then summarized and compared these databases, pointing out various advantages, limitations and recent developments, such as improved coverage of Asian literature by Pascal-Geode and GeoRef. It was noted that the two major

regional databases, AESIS (Australia) and AGE (Thailand), were too specialized for general use by ESCAP member countries, and that for the moment few such modern information tools were available because of the lack of a telecommunications network.

An overview of computerized data handling was presented by M. Sherwood (Australia/Thailand), who stressed the need to assess all costs and benefits before committing resources to automation programs: "At the outset automation never costs less money, it costs more". There was also a demonstration of modern word processing equipment.

Participants described a variety of information activities in ESCAP member countries, including those associated with libraries, data centres, mineral and environmental data systems, mining statistics and geoscience surveys. The actual and potential impact of modern information technology was stressed throughout.

Some 17 general and specific conclusions or recommendations dealt with the need for an ESCAP regional geoscience database, information services, computerization, libraries and referral centres.

C.F. Burk, Jr.
Geological Survey of Canada
(Extracted from RMRDC Newsletter,
No. 4, September, 1981, p.2-15).

Sweden Hosts Mid-Cretaceous Conference

IGCP Project 58, 7th International Conference, August 17 - 21, 1981
Uppsala, Sweden

Participants at the Mid-Cretaceous Events (MCE) conference felt that after seven years of activity MCE still had great potential, that many areas of research had not yet been sufficiently treated and that the increasing number of participants was an indication that the project had not yet reached its limit. It was decided that MCE would continue for at least another five years, although the conference was the last meeting for MCE's Project Working Group, which will gradually reduce its activities in 1982.

Members of the Working Groups presented the results of their work: T. Matsumoto (Japan) discussed the work of the transgressions and regressions group. They have been looking at the possible causes of relative changes in sea level, sedimentary cycles in the intracontinental, non-marine basins in comparison with the marine basins, and the major sedimentary cycles in the Circum-Pacific mobile belt compared with those in stable regions.

F. McCoy (U.S.A.) outlined the work of the History of South Atlantic Ocean Group whose results have been summarized in the form of a set of paleogeographical maps of the South Atlantic, in which the land geology is being integrated with the work of the Deep Sea Drilling Project.

P.-Y. Berthou (France) reported on work of the Biological Events Working Group on large foraminifers, planktonic foraminifers and ostracods. The discussion on the ostracod atlas and the taxonomy of Cretaceous ostracods centred on the need to establish a better order in the systematics of this important group in a manner similar to that achieved for the planktonic foraminifers. Berthou also outlined the activities of France's very active regional group which, in addition to continuing activities in France, Portugal and Spain, has organized a field project in the Algerian Sahara.

A.-F. Poignant (France) discussed the work of a new group whose aim is to investigate the phenomenon of Cretaceous bauxitisation, considered to be a peculiar kind of lateritic weathering involving petrographic, geomorphologic and climatic factors. Karstic bauxites have a sedimentary origin; transportation and deposition occur in an aqueous environment. The Mediterranean area, rich in middle Cretaceous karstic bauxites, is a suitable study area.

Most of the work of the Central European Regional Group is done under a unified regional program involving Austria, Hungary, G.D.R., F.R.G., and Czechoslovakia. H.A. Kollmann (Austria) reported that activities are concentrated on detailed stratigraphic determination of major sedimentological changes in sections resulting from tectonic movements and eustatic pulses. Research is also being done on the classical sections of the Gosau area, the flysch sequence of the Unterengadin and the Err-Bernina areas.

I. Premoli-Silva (Italy) outlined the work of Italian scientists who are focussing their research in two areas: age, nature and origin of organic-rich facies, and detailed biostratigraphical studies. Detailed studies of the organic-rich facies, which are widespread in the Mediterranean region, have been carried out on the micropalaeontological content (planktonic and benthonic foraminifers, calcareous nannoplankton, palynofacies), fish, sedimentology, geochemistry (including isotopes), and organic geochemistry.

Detailed biostratigraphical studies, with the exception of the investigation on Aptian-Albian tintinnids, have focussed on

the calibration of magnetic stratigraphy of several sections from the southern Alps and the central Apennines. As a result, it has become possible to apply mid-Cretaceous magnetic stratigraphy in reconstructing plate movements in the Pacific Ocean.

The 45 members of the Japanese Regional Group have been active in the past three years on the following topics: integration of ammonite and inoceramid zonations in the Upper Cretaceous of Japan for correlation with the international scale; coordination of macro- and microfossils in the Cretaceous biostratigraphy of Japan; Upper Cretaceous of the Monobe area, Shikoku; geology and palaeontology of the Shimanto Belt; correlation of the marine and non-marine of Japan and adjacent areas; and geochronology.

W.J. Kennedy (U.K.) reported on the work of a special project on the integration of global macrofossil zonation. Work on this special project has shown that current concepts on the stage boundaries in the Upper Cretaceous need extensive reinterpretation, particularly the Cenomanian-Turonian boundary.

P. Marks (Netherlands) outlined the work of the second special project dealing with the integration of microfossil zonation. Research on microfossil biostratigraphy of the Cretaceous has now reached a level where it can complement the more traditional biostratigraphy based on ammonites, belemnites, inoceramids and other groups of macrofossils.

Further refinement could be attained by intercorrelating and integrating biozonations based on different groups of microfossil taxa, and perhaps attempting to integrate these with the standard ammonite and belemnite zonations. This could be done by having specialists work on identical samples from measured sections. Several groups in England, southern France and the Netherlands have been working toward providing first-order correlations between the vertical ranges of different groups of fossil organisms.

The subgroup for planktonic foraminifers has tried to establish its zonation on successions of bio-events within homogeneous groups. The ammonite zonation for the Boreal mid-Cretaceous is adapted to the same ideal. The mid-Cretaceous of the Boreal Realm is relatively poor in planktonic foraminifers. Several attempts have been made by various authors to integrate zonations based on benthonic foraminifers with those of the Atlantic zones. One of the difficulties in doing so has been the absence of a uniform approach toward zonal definition and nomenclature. A working group on the homogenization of the zonal value of smaller benthonic foraminifers could be useful.

Other scientific presentations given at the meeting ranged from the astronomical influences upon mid-Cretaceous pelagic sedimentation (P.L. de Boer, Netherlands), to the regional correlation in Europe using benthonic foraminifers (M.B. Hart, U.K.). There was also some discussion of the problem of integrating ammonite and inoceramid zonations in Europe, Brazil and Japan.

The final official meeting of MCE will be held in conjunction with the 2nd symposium on the German Cretaceous in Munich, June 1-6, 1982, following which the results of MCE will be summarized and published in the form of a textbook.

(Summarized from report by B. Bengtson, Paleontological Institution, Uppsala, Sweden)

Quantitative Methods and Data Processing in Geological Correlation

IGCP Meeting, Ottawa, Canada, October 23, 1981

About 50 geoscientists from nine countries participating in IGCP's Division No. 4 (Quantitative methods and data processing in geological correlation) met last October as part of the 10th Geochatauqua on Computer Applications in the Earth Sciences in Ottawa, Canada, (see related article this issue EPISODES). The purpose of the meeting was to review current work, discuss co-operation between projects, and plan future activities.

D.F. Merriam (U.S.A.) opened the meeting with a general discussion of IGCP and its relationship with IUGS. In the past IAMG and COGEODATA have offered advice on quantitative aspects of IGCP projects and should continue to be involved in all aspects of data collection and analysis. Various large data bases are becoming available, and Merriam emphasized that it is important to ensure that these will be maintained in the future. Because all quantitative IGCP projects will end in a few years, he recommended that one or more replacement projects be proposed. It will be especially important to continue the work on quantitative stratigraphic correlation after completion of Project No. 148 (Quantitative stratigraphic correlation techniques) in 1983.

R. Sinding-Larsen (Norway), who is a member of IGCP's scientific committee in charge of quantitative projects, reported on Projects No. 98 and No. 154. Project No. 98 (Standards for computer applications in resource studies) no longer exists, but scientists in several countries are continuing its work. Sinding-Larsen proposed that a new project be created to fill the vacuum and urged COGEODATA and IAMG to become involved in the new Lithosphere Program. Project No. 154 (Global exchange and processing of information in geochemistry) began in France and focusses on Hercynian two-mica granites. Links are established with data banks on two-mica granites and associated rocks from various orogens in other countries.

F.P. Agterberg (Canada) outlined the activities of Project No. 148. Computer-based biostratigraphic correlation techniques have been developed by scientists in different countries working along parallel lines. Specific problems are tackled by establishing regional standards of ordered strati-

graphic events and performing correlations based on these standards. Quantitative methods of lithostratigraphy are also being evaluated.

Last May, project members conducted a short course entitled "New Concepts and Methods in Stratigraphy" (see related article this issue EPISODES). An expanded five-day version of this course will be held in June 1982, in Calgary, Canada, immediately preceding the annual general meeting of the American Association of Petroleum Geologists. The next meeting for Project No. 148 will be held in Geneva, Switzerland, during November 1982, and the final international meeting is to be held in India in December 1983.

F. Chayes (U.S.A.) discussed recent progress made in Project No. 163 (Design and generation of a world data base for igneous petrology). The goal of this project is to design an archival retrospective data base for rocks of all kinds and ages. There is extensive international professional collaboration in gathering data and researching literature. Chayes also noted that systematic long-range support from national and international EDP facilities is required not only during development but also for the future administration of the data base.

About 5 000 specimen descriptions are now being maintained in electronic card-image files in the central office in Washington, D.C., and about 7 500 samples are in the base in one form or another.

The final presentation was made by C.F. Burk, Jr. (Canada), who recently published a list of 82 publicly available geoscience source data bases that can be accessed through government or commercial services. Copies of this list were distributed by the IGCP Secretariat in Paris to all project leaders to help make them aware of modern information storage and retrieval techniques. He also reported that a new COGEODATA task group has been formed to update the list and to establish a mechanism for keeping geoscientists informed about the availability of computer-processable geoscience data.

F.P. Agterberg
Geological Survey of Canada, Ottawa

Early Crustal Genesis

**Lunar and Planetary Institute Workshop,
November 13-17, 1981, Virginia, U.S.A.**

The Lunar and Planetary Institute of NASA held the last of three workshops to explore ways in which multidisciplinary studies of the Earth can contribute to a more general understanding of the origin and early evolution of planetary crusts. The five-day workshop was also intended to help formulate a long-term NASA research project which could develop and define a set of testable models for the formation and evolution of the crusts of terrestrial planets, highlighting both their similarities and major differences.

The question of funding for projects was a topic of major concern. Most of the 98 earth scientists present were disappointed to learn that NASA will not be able to provide funding for Early Crustal Genesis projects before 1985, if at all. The U.S. National Science Foundation indicated that it would consider funding for ECG projects, especially applications from multidisciplinary groups. The U.S. Geological Survey expressed only marginal interest in the ECG project

but is considering limited assistance for work on Archean rocks in the U.S.A.

On the scientific side, the workshop revealed a lack of reliable field data for many Archean terrains and it was emphasized that much field-oriented work of a multidisciplinary nature was needed to improve the Archean data base. There is a possibility that future workshops will be organized as biennial field meetings in Archean terrains.

Geophysicists seemed to be divided on the issue of Archean plate tectonics, particularly because they have been unable to arrive at a satisfactory explanation for the subduction triggering mechanism. One view is that Archean rocks are geochemically similar to modern marginal basins and island-arc settings and therefore display direct evidence of subduction. Others disagree and, based on field relations, see significant differences in Archean and Phanerozoic tectonic

settings. One group suggested that Archean radioactive heat production need not have been significantly greater than current heat flow, and that thick (~ 25 km) Archean ocean crust was easily subducted. Others consider this unlikely and favour a thin, positively buoyant oceanic lithosphere and some form of "ice-floe tectonics."

It was noted that the Archean tonalite-trondhjemite-granodiorite suite apparently is not geochemically compatible with

modern calc-alkaline batholiths, and that biased sampling in the past has given the erroneous impression that K-rich plutonism did not occur in the early Archean. It was suggested that the present non-plate tectonic regime on Venus could be a guide to understanding Archean earth tectonics.

A. Kröner
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New Approaches and Methods in Stratigraphy

May 14-15, 1981, Calgary, Canada

Several concepts have emerged in the science of stratigraphy during the past decade that substantially increase the capacity for problem-solving and for synthesizing large and complex data sets. Much of this work has been carried out under the auspices of the working group of IGCP Project No. 148 - Quantitative Stratigraphy. These concepts include the following lines of thought and method:

- Viewing stratigraphic correlation as a problem of probability, which gives stratigraphers the opportunity to use multiple working hypotheses in biozonation and correlation.
- Quantifying litho- and biostratigraphic methods, previously only used qualitatively, thus allowing large data sets to be handled and improving the quality of solutions.
- Organizing diverse stratigraphic and paleoecological data in a linear, numerical fashion in the direction of the "arrow of time" and calibrated to the geochronologic scale.

The development of methods to apply these concepts has been greatly facilitated by three factors: the advent of high-speed computers, successful collaboration between geomathematicians and stratigraphers, and reliable and detailed calibrations of biostratigraphic zonation to the geochronologic scale, with units of precision measured in millions of years for some parts of the geologic column.

Because of the novelty of these concepts, the unfamiliarity of many stratigraphers with statistical methods and a lack of insight by many stratigraphers concerning the advantages and disadvantages of new approaches, IGCP Project No. 148 recently organized a short course entitled "New Concepts and Methods in Stratigraphy" involving some 30 paleontologists, geomathematicians, stratigraphers and computer experts. The course focussed on an overview of quantitative methods in biostratigraphy, the meaning and application of probabilistic stratigraphy, quantitative models for sedimentation patterns and lithological correlation, and geohistory diagrams and synthetic seismostratigraphic sections.

J. Brower (U.S.A.) gave a detailed account of available techniques for quantifying and solving biostratigraphic problems. They can be grouped into four basic categories:

- Index fossils, which were used long before Darwin's time, even though the measurement of the attributes of an index fossil did not begin until the 1960s;
- Analysis of assemblage zones, usually achieved with multivariate statistics;
- Numerous methods available for determining the most likely sequence of biostratigraphic events recorded in different stratigraphic sections; and
- Analysis of evolutionary sequences, a numerical approach requiring morphometric statistics used with time-series algorithms.

Several simple techniques that could be used to help convince non-quantitative biostratigraphers to try numerical techniques were also reviewed. One used a conservative sequence of events while the techniques of another were borrowed from archaeological sequencing. Both schemes produce range charts and correlations of the samples. It was emphasized that over the next decade quantitative biostratigraphers should use case studies to evaluate systematically the available algorithms and find out which techniques provide the best results with various types of data. Brower urged

participants to ensure that the 1980s was a decade of consolidation and not one dominated by development of new algorithms.

F.M. Gradstein (Canada) talked about the reason for and application of certain ranking and scaling techniques in biostratigraphy, using large data sets. The Ranking and Scaling (RASC) computerized model was originally developed for a comprehensive biostratigraphic zonation of the Canadian Atlantic margin, using as much foraminiferal and nanofossil data as possible. The model focusses on the problem of "simultaneous" events, indeterminate order in part of the data matrix, and threshold conditions to eliminate uncertainties in the results.

The second day of the course began with a brief discussion of the range-chart method using the concurrent-range zone concept. In dealing with quantitative correlation W. Schwarzer (U.K.) discussed a well-established procedure of matching, which determines the similarity between two sections.

Schwarzer dealt with recently-developed sedimentation models used in stratigraphic correlation. The objective was to predict an unknown section from known profiles by means of computer simulation. To make this quantitative, data on the correlation structure of stratigraphic profiles are needed before extrapolation can be performed by computer simulation. So far, only two-dimensional simulation models have been considered, with distance between profiles plotted in one direction and time in the other. There should be no difficulty, however, in expanding this approach to three-dimensional space-time models.

The question of how much can be gained by treating real situations with vastly simplified models based on the correlation structure has not yet been investigated. Nevertheless, the new simulation approach gives practical results which complement the matching procedures commonly used in lithostratigraphic correlation. Some of the techniques for matching and extrapolating were demonstrated on a mini-computer.

The last speaker, J. Van Hinte (Netherlands) gave two informal lectures on geohistory diagrams and a synthetic seismic section derived from chronostratigraphic data. He used many examples to illustrate that a linear time perspective significantly clarifies geologic history and, therefore, exploration geology. The basic difference in his approach, compared to conventional ones, is that the data from wells or sections are organized in a linear fashion and rates are expressed in years, thousands of years, or even larger time units. This approach requires good calibration of zonations to the geochronologic scale, but because it is only looking for trends, individual errors in calibration are less important.

The response to the short course was favourable. Participants agreed that it filled an important need and a request was made by the Indian delegate, B.R. Ghose, to repeat the course in India in 1983. In future, participants will be encouraged to bring their own coded data sets for analysis.

F.M. Gradstein
Geological Survey of Canada