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Biochronology and Quantitative Stratigraphy

Halifax, Canada, October 11-14, 1983 and
Kharagpur, India, December 12-17, 1983

IGCP 148 has been concerned with the development and application of new quantitative stratigraphic techniques and algorithms which "think" along stratigraphic lines of reasoning. Theoretical and practical testing of such methods to develop biozonations include seriation, ranking and scaling, unitary associations, multivariate clustering and lateral tracing. Data sets developed and analyzed by these methods, commonly include microfossil distribution in deep-sea drilling and commercial boreholes.

In 1983, the final year of its existence, IGCP 148 was concerned with developing numerical time scales to quantify geological processes, one goal in stratigraphic correlation being isochron contouring. This research involves calibration and linkage of fossil and other unique geological events to a common chronostratigraphic scale and stretching of this to create a geological time scale measured in million year (Ma) units. In the absence of direct radiometric estimates for many stratigraphic boundaries, geological and statistical techniques have been developed to allow reliable estimates to be made of the numerical age of stage boundaries, especially for the Mesozoic and Cenozoic. Senior oil company geologists now stress the practical importance of these techniques developed in IGCP 148.

The Halifax conference on "Biochronology and Stratigraphic Correlation" was attended by over 100. It began with a contribution by W. Riedel on rating and scoring the widely varying quality of palaeontologic information used to make zonations and correlations. The art of doing this and of comparing events that score equal points based on different characteristics, needs to be further developed. After all, the input is what largely determines the results, or as L. Edwards put it, "any method will work with superior data." The two methods now used to construct range charts by stretching the true range between the lowest and highest observed relative positions, and by averaging the range (taking into account all the relative highest and lowest occurrences observed) may yield the same answer. This is especially so when more sections are added to the standard, and when care is taken to separate consistent from isolated first and last occurrences.

Normality testing of individual sequences of events relative to the RASC (Ranking and Scaling) standard, as a means to improve zonations and correlations, was demonstrated by F. Gradstein and F. Thomas. G. Williams found that the use of RASC for subsurface palynology zonations, provided a good estimate of the spacing of the taxon events over the successive zones. The clear and concise presentations by S. Mohan and S. Nederbragt showed the value of combining simple palaeontologic and stratigraphic data by using sedimentation and subsidence rate functions. Mohan showed that tectonic forces may have controlled the main subsidence of the Bombay High.

A key theme was the manner in which time scales from Triassic through Cenozoic are made, and their properties for quantitative geology. E.T. Tozer staunchly defended the use of classical ammonite stratigraphy to erect detailed intercontinental zonations. In his view, the history of ammonites

is one punctuated by disasters or other discontinuities, which acted in the same way in widely different localities. In this sense the classical ammonite zones represent chronozones of supra-regional significance.

G. Westermann used the standard ammonite zonation to subdivide Jurassic time. As clearly outlined by J. Van Couvering, the use of equal duration of zones is only one of several approaches to measuring time over the chronostratigraphic scale. More direct, but also more difficult to use for older events due to larger absolute errors, is the radiometric dating of ash beds and plutons injected close to stage boundaries. A variant method tries to link radiometrics and bio- or magnetostratigraphic events. In several Cretaceous and Tertiary land and ocean sections, magnetic reversals have now been tied to biostratigraphic events and to radiometric dates, as demonstrated by J. Hazel. The powerful, indirect technique outlined by D. Kent and F. Gradstein uses the assumption of constancy of seafloor spreading over 10 Ma or more to stretch the marine magnetic reversal record.

F. Agterberg presented a new method to estimate the age of chronostratigraphic boundaries, using a maximum likelihood

Figure 1: Comparison of spline-curve ages with other recent age estimates for the Jurassic. See text for explanation.

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function to interpolate all radiometric ages relevant to a stage boundary. When the likely ages of a number of chronostratigraphic boundaries have been estimated, the geological time scale can be further interpolated using cubic spline smoothing functions.

Figure 1 shows the Jurassic time scale, as presented by different authors, using slightly different methods. To the left is the 1982 scale advocated by Harland and his colleagues using the equal duration of stages concept. Key ages or tiepoints are outside the scale shown in column 1. Columns 2 and 3 are spline curve interpolations using equal stage and equal zone duration between the base of the Hettangian (208 Ma) and Jurassic/Cretaceous boundary (138 Ma). If the key age of 156 Ma for Oxfordian/Kimmeridgian boundary is used, the scale of column 4 is generated. This is close to the multiple scale in column 5. Given that there are absolute errors in Jurassic radiometric dates of 5-10 Ma, the different scales are remarkably close.

Shortly after the Halifax conference, the 7th international meeting of IGCP 148 was held at the Indian Institute of Technology, Kharagpur, with as many as 180 scientists attending. Among papers of note was one by B.K. Ghose and B.C. Jaiprakash that analysed palaeontologic time series based on abundance data of foraminifers, which came from DSDP core sites located in the middle of the Indian Ocean at about 10°S. Depth plots of total abundance of planktonic forams display an abundance peak at a depth of about 5.7 meters, indicating warmer water in this region 0.4-0.6 Ma ago. Other peaks were observed and cyclical patterns established by performing harmonic analysis of time series for individual species, notably *Orbulina universa*. Different locations of peaks in the power spectra were used to estimate local differences in rates of sedimentation.

In a session on quantitative lithostratigraphy, A. Mukherjee, M. Mohan, N. Vashist and V. Raiverman proposed time-strati-

graphic classification by the quantitative analysis of contemporaneous and post-depositional sedimentological processes. Irreversible processes like progressive dissolution of complex mineral suites, compaction and lithification can provide a stratigraphic clock for marking geologic time on an ordinal scale. Examples were given from the Cenozoic sequences of the Himalayan foothills and the Indo-Gangetic plains. Automatic computer plots were displayed for percentages of heavy mineral assemblages arranged according to their order of stability. Systematic changes in the mineral suites from the oldest to the youngest aided in sediment classification and stratigraphic correlation.

W. Schwarzacher considered possible causes of complex cycles in carbonate sequences. Limestone-marl sequences frequently contain cycles consisting of between 5-7 marl-limestone couplets. The thickness of such a group of beds is of the order of 1-3 meters. Power spectra show that the pattern of these cycles is remarkably similar in sequences ranging in age from the Carboniferous to the Pliocene. Schwarzacher tentatively suggested that the basic 1-meter cycle may be related to the 100 000 year periodicity of the Milankovitch cycle, because no other mechanism capable of producing such a persistent pattern seems to exist.

The 4th International Short Course on Quantitative Stratigraphic Correlation, which followed the Kharagpur conference, covered many quantitative methods in biostratigraphy. The participants were provided with a copy of "New Concepts and Methods of Stratigraphy," which also constitutes the first draft of a guidebook to be published by Unesco in 1985.

*From reports by F.P. Agterberg, Ottawa, Canada
and F.M. Gradstein and M. Williamson,
Dartmouth, Canada*

Groundwater Development in the Third World

London, U.K., October 11, 1983

The International Drinking Water Supply and Sanitation Decade has focussed the attention of governments and financial donors on meeting the Decade targets of providing potable water and adequate sanitation facilities for all by 1990. However, although these issues have received much attention from both engineers and economists, an estimated 1 500 million people still do not have access to these basic needs. This one day conference was aimed at reviewing the level of groundwater development in the Third World and suggesting ways of meeting the Decade targets.

The first contribution was from S.M. Niaz of the World Bank (Washington, D.C.), who provided the link between the financial and technical facets of groundwater development. He outlined the Bank's cycle of project identification, preparation, negotiation, implementation, completion and evaluation, pointing out that in general World Bank schemes use only proven technology, although a limited amount of new technology may be included on a trial basis.

J.W. Lloyd (University of Birmingham, U.K.) discussed the difficulties of groundwater assessment in the volcanic-

sedimentary environment of Central Java. Lithological inhomogeneity, does not allow easy aquifer delineation and also makes the construction of dams to retain the high rainfall difficult. Only major dewatering schemes can substantially add to the groundwater resources of the area and then only after careful long-term planning.

The problems of locating groundwater resources in African basement complex were outlined by L. Clark (Water Research Centre, U.K.) and M.J. Jones (International Geotechnical Engineers, U.K.). Clark suggested that as the groundwater occurs in the upper, weathered zone of these rocks, there are no regional aquifers and the groundwater reservoir is, therefore, structurally controlled. However, Jones had a distinctly different view, considering the weathered zone to be hydrogeologically very uniform. The outcome of this controversy will determine whether or not traditional hydrogeological techniques are suitable for locating groundwater resources in such regions.

The progressive development of well design in Pakistan was described by R.F. Stoner (MacDonald & Partners, U.K.), and

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W. Moffatt (Loughborough University of Technology, U.K.) discussed the hydrogeology and optimum design of wells for the coastal aquifer of North Yemen.

The final contribution was from E.P. Wright (British Geological Survey, U.K.) on the role of the hydrogeologist in the provision of water supplies for rural African communities. Dr. Wright maintained that, contrary to recent thought, considerable attention needs to be given to the design and construction of rural groundwater schemes. A further significant issue discussed was the need for hydrogeologists and

water engineers to be more aware of the social and institutional difficulties that could arise in an African culture as a result of their work.

Further details of this meeting may be obtained from the Geological Society of London, Burlington House, Piccadilly, London W1V 0JU, U.K.

K.M. Baxter
Medmenham, U.K.

10th Caribbean Geological Conference

Cartagena, Colombia, August 14-20, 1983

Coordinated by INGEOMINAS, the Colombian Instituto Nacional de Investigaciones Geológico-Mineras, this meeting was attended by some 250 geologists from the Caribbean community and beyond. The three themes: tectonics and structure, stratigraphy and marine geology, and petrology and geochemistry attracted 120 papers.

The first theme included discussions of new tectonic models currently proposed for Caribbean geology. For example, R. Alonso-Harris (Puerto Rico), E.A. Krieg, and A. Meyerhoff (U.S.A.) showed that the Puerto Rico Trench exhibits evidences of a post-early Pliocene graben origin rather than one associated with a subduction zone. In contrast D. Elston and R. Krushensky (U.S.A.) argued that palaeomagnetic data indicate that Puerto Rico was an exotic terrane, which had originated at about the latitude of Ecuador and Peru in the Cretaceous.

Among the papers of note on stratigraphy and marine geology, was one by F. Maurrasse, (U.S.A.) presenting new biostratigraphic information on the Eocene-Oligocene boundary in Barbados, and another by R.D. Liska (Trinidad) on the equivalence of Bolli's *Globorotalia menardii* zone with the *Globorotalia acostaensis* zone in Trinidad. All the discussions confirmed once more that the Caribbean is very complex and still far from being fully understood.

During the conference, the 4th Regional IGCP Meeting was held to review progress on 21 projects with activities in Latin America. Another session dealt with the coordination of activities under the IUGS-sponsored project on the metallogeny of mafic and ultramafic rocks of the Circum-Caribbean region. The Council of Directors of Latin American Geological Services also discussed ways of encouraging geological research in the region through co-operation among the various national geological surveys. Representatives from Venezuela, Nicaragua, Dominican Republic, El Salvador, Mexico, Costa Rica, Barbados, Cuba, Guatemala and Colombia attended this meeting together with observers from Argentina, United States, Ecuador, and Trinidad and Tobago.

Barbados was designated as the site for the next Caribbean Geological Conference to be held in 1986. INGEOMINAS agreed to provide a temporary secretariat in Bogota for the conferences in order to improve the coordination of future activities.

*From report by H. Duque-Caro,
Bogota, Colombia*

Rocks for Buildings

Nairobi, November 15-19, 1983

A regional workshop on use of rocks for building materials was held recently in association with a major symposium on appropriate materials for low cost housing. The workshop, which took place within the framework of the Unesco project Geology for Development, aimed at informing African geologists on the exploration, evaluation and exploitation techniques for rocks as the basis for building and construction materials. Rocks, in this sense, include not only building stone but also clays, sands, and pozzolanas.

In his opening address the Commissioner of Mines and Geology for Kenya, Mr. C.Y.O. Owayo, pointed out the relative

neglect of industrial minerals in construction despite the potentially great advantages of exploiting local deposits for local markets and end uses, often substituting for more expensive imported materials. To correct this situation, however, demands a greater awareness on the part of geologists of the role and uses of stone, clays and limestones, as well as an appreciation of their properties and methods of processing.

Country papers from Botswana, Ethiopia, Kenya, Nigeria, Tanzania and Uganda reviewed briefly the geology of each country's construction and building material resources, to-

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gether with a brief run-down on status of the extraction and processing industries based on these minerals. Specific case studies examined marble quarrying in Nigeria, and a small open glass-sand mining operation in Malawi. A local company near Nairobi showed the participants a range of mineral products and processing operations based on limestone and marble, dimension stone, gypsum, kaolin and feldspar.

A series of presentations related to low cost cementing materials (other than Portland cement) dealt with natural and artificial pozzolanas, laterite and gypsum. Lime production using small vertical shaft kilns was also reviewed, particularly from the point of view of selection and assessment of suitable raw materials and testing of the final product for a variety of end uses. There were also presentations on industrial clays for the metallurgical manufacturing and processing industries, and clays for structural ceramics, such as bricks, tiles and aggregates.

The workshop concluded that there should be a continuing regional program of workshops and field courses dealing with the practical aspects of industrial and construction minerals. Information on techniques of resource assessment and evaluation, mineral processing and industrial applications should be shared regionally, and there should be access established to international sources of related information. Regional co-operation on these issues, the workshop concluded, would benefit from the appointment of a full-time coordinator. National mineral development policies should help to bridge the gap between resources and their industrial utilization by providing relevant services and an environment in which small mining and mineral-based business can flourish.

Figure 1: Pyroclastic volcanics being quarried for building stone, near Nairobi.

Further information on the Nairobi workshop and on activities related to small mining in eastern Africa may be obtained from F.R. Almond, Intermediate Technology Industrial Services, Myson House, Railway Terrace, Rugby CV21 3HT, U.K.

From ITIS press release

IGCP: Annual Review and Financial Constraints

Paris, February 6-17, 1984

Like many other organizations Unesco now faces serious funding problems. These were very much in the minds of the Scientific Committee and Board of the International Geological Correlation Programme, which met recently in Paris. As E. Seibold, President of IUGS, pointed out, the IGCP is one of the strongest components of the "S" in Unesco's acronym. The financial support provided by IGCP was always understood to provide seed money for its projects. But "half a seed will not sprout," so that any further reductions in the overall budget of Unesco should not be applied linearly across all its programs.

R.W.R. Rutland, Chairman of the Scientific Committee, emphasized that the current level of funding available to IGCP (planned at close to \$300 000 US for 1984) was below the reasonable level of credibility, even for the present level of activity. It was a critical constraint on increasing the involvement of less-developed countries in IGCP. Board members also pointed out that the funds available to IGCP have become less and less adequate to meet even the modest needs of individual projects. The present funding hardly justifies the time and effort by project leaders, national committees or by Board and Scientific Committee members. A substantial increase of funds to at least three times the present level, would be needed if international cooperation in high priority projects is to be adequately stimulated.

The financial problems must not be allowed to become even more acute in the event that the total funds for Unesco are cut, for example by the planned withdrawal of the United States. The IGCP is widely regarded as one of the more successful scientific programs in Unesco, and its Earth Sciences Division should be in a strong position to argue for maintaining present funding levels even if the overall budget is cut.

The Secretary of IGCP, E. von Braun, reported that three major publications were issued in 1983 by the secretariat; Geological Correlation No. 11, the Second Interim Report (1978 to 1982), and the second volume of the IGCP Catalogue. The latter is an indexed bibliography of some 10 000 titles produced by IGCP projects. Of 50 ongoing projects in 1983, 40 had requested and received grants to hold annual meetings. Eight projects were scheduled for termination in 1983, and 14 proposals for new projects were received. There are now 81 established national committees of which 32 had submitted reports on their activities in 1983. Two regional meetings took place in 1983, one in Bangkok that resulted in the proposal for two new regional projects, and one in Sri Lanka.

The Board decided to admit seven new projects to the IGCP:

- 211- Late Palaeozoic of South America (Project leaders:

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- A.J. Amos and S. Archangelsky, Argentina);
- 215- Proterozoic Fold Belts (R. Caby, France);
- 216- Global Biological Events in Earth history (O.H. Walliser, F.R.G.);
- 217- Proterozoic Geochemistry (K.C. Condie, U.S.A.);
- 218- Quaternary Processes and Events in SE Asia (N. Thiramongkol, Thailand);
- 219- Comparative Lacustrine Sedimentology through Space and time (K. Kelts, Switzerland);
- 220- Tin and Tungsten Granites in SE Asia and the Western Pacific (S. Suensilpong, Thailand and T. Nozawa, Japan).

This brings the number of ongoing IGCP projects in 1984 to 48 and those "on extended term" to nine.

Experience shows that successful IGCP projects tend to share certain characteristics. They focus clearly on specific scientific problems and do not suffer from a diffusion of ideas and opinions. They identify timely problems that are amenable to advances, and the potential for advancement was apparent before the project began. They provide a vehicle through which field, laboratory and theoretical studies are brought together. Successful projects have provided a base on which

future studies can proceed, emphasizing the education and training aspects. They are also distinguished by the high quality of their leadership. Good leaders are not only knowledgeable and active scientists who are widely respected, highly productive and intellectually aggressive, but they are also prepared to devote a good deal of time, effort and thought to the success of the project. The final characteristic is that successful projects have typically closely interwoven the "basic" and "applied" aspects of their projects.

The Board repeated its concern at the lack of projects involving geophysics and the marine geosciences. There was a continuing problem in getting substantial geophysical input into IGCP projects, though care must obviously be taken that there is no overlap with ongoing ILP projects. The Board also considered other gaps, which are largely interdisciplinary and relate to the interaction between geology and biology, meteorology (climatology), hydrology, and hazard prediction and mitigation. The first three of these subjects could well be included in the planned ICSU project on the biosphere and geosphere (see Episodes, 1983/4, p. 29-30).

- from IGCP documents

First International Conference on Palaeoceanography

Zürich, Switzerland, July 19-21, 1983

In the early days of the earth-science revolution, marine geologists were either geophysicists or micropalaeontologists. They had all the fun, interpreting magnetic anomalies and dating the sediments above the ocean crust, and they were the heroes who upheld the seafloor spreading theory. Sedimentologists then had the thankless task of describing hundreds and hundreds of meters of pelagic oozes, which looked all alike - a routine that could be done by any high school graduate.

Micropalaeontologists used to get together in international meetings called Planktonic Conferences, held every three years. The first was instrumental in straightening out the zonation of planktonic foraminiferas, and the second the zonation of nannoplanktons. At the third conference, in Kiel (1974), there was a shift in emphasis, and many micropalaeontologists turned to isotope geochemistry. Analyses of the oxygen isotopes of foraminiferas yielded palaeo-temperatures, though few seemed to understand what the carbon isotopes meant.

No more planktonic conferences have been held since then. Biostratigraphical zonation still had its problems, but the first flush of excitement was over. Palaeoceanography was developing as a new earth-science discipline, though few thought of themselves as palaeoceanographers.

The idea of a meeting to compare notes and exchange ideas was first discussed, with the idea of calling it the Fourth Planktonic Conference. However, on the advice of Bill Haq it became the First International Conference on Palaeoceanography. This was held last year under the sponsorship of the Geological Institute of the Swiss Federal Institute of Technology, the IUGS Commission on Marine Geology, and by ICL Working Group 7.

During the three day meeting, the latest results and ideas were presented on such general themes as ocean circulation,

palaeoclimates, ecology, sea-level changes and sedimentological processes. There were also workshops on biostratigraphy, numerical ages, and stable isotopes. The conference ended with a three-day field trip to the Southern Alps, during which discussions were held on the evolution of the southern continental margin of the Tethys Ocean and the impact of oceanography on the Mesozoic Tethyan sediments.

Sedimentologists, geochemists and micropalaeontologists, many of them shipboard friends on Glomar Challenger during the DSDP, joined efforts at the Conference to present the results of this newest interdisciplinary field of research. Analytical techniques have now advanced so far that a few foraminiferal tests can be used to provide a meaningful signal. Numerical ages of biostratigraphic zones were worked out, with correlative accuracies down to 10^5 years. Detailed records of surface, intermediate, and bottom temperatures were compiled, many of the data points spanning time intervals of 10^4 years or shorter. The history of surface and bottom circulations of the world's oceans was unravelled, and the interplay between tectonics, ocean circulation and climate, and their influence on biologic productivities were examined.

Bill Berggren and his colleagues at Woods Hole Institution of Oceanography were given the task of organizing the Second International Conference on Palaeoceanography to be held there, September 8-12, 1986. The themes for meeting will include ocean palaeochemistry, flux rates and mass balance, evolution and the marine record, deep-water palaeocirculation and biotic response, marine geochronology, Palaeozoic-Mesozoic oceans, Cenozoic oceans, eustatic sea-level changes, Late Neogene climates and polar seas. Information on this second conference can be obtained from Dr. W.A. Berggren, WHOI, Woods Hole, MA 02543, U.S.A.

K.J. Hsü and J.A. McKenzie
Zürich, Switzerland