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PROGRESS REPORT OF THE INTERNATIONAL GEOLOGICAL CORRELATION PROGRAMME (IGCP)
GEOLOGICAL CORRELATION

is a series of reports issued by UNESCO for the International Geological Correlation Programme (IGCP), a scientific enterprise carried out in co-operation with the International Union of Geological Sciences (IUGS). The numbers of the series will be issued with individual pagination at irregular intervals – there will be no arrangement in volumes. Geological Correlation contains information on National Committees, reports on sessions, lists of accepted projects, annual reports of the Scientific Committee and the Board, composition, work plans and progress reports of project working groups, current bibliographies of IGCP publications, secretariat news, reports of IGCP meetings held and announcements of forthcoming ones, and summaries of final reports on projects. New material and announcements will be published under the author’s (submitter’s) responsibility for the scientific contents. Supplementary material will be published in Episodes (IUGS). All contributions to Geological Correlation should be addressed to:

The IGCP Secretariat, Division of Earth Sciences,
UNESCO, 1, rue Miollis
75732 Paris Cedex 15
Fax: (33.1) 45 68 58 22
e-mail: igcp@unesco.org

Editors: F. Wolfgang Eder, IGCP Secretary
M. Patzak, SC/GEO
Editorial Assistant: D. Armand, SC/GEO

IGCP home page:
http://www.unesco.org/science/earthsciences/igcp/

LIST OF ABBREVIATIONS

AGI American Geological Institute
CCOP Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas
CGMW Commission for the Geological Map of the World
CIFEG Centre International pour la Formation et les Échanges Géologiques
COGEODATA Committee on Storage, Automatic Processing, and Retrieval of Geological Data
EGT European Geotravers
ESCAP Economic and Social Commission for Asia and the Pacific
GGT Global Geoscience Transsects
IAGOD International Association on the Genesis of Ore Deposits
IAME International Association for Mathematical Geology
ICL Inter-Union Commission on the Lithosphere
ICS International Commission on Stratigraphy
ICSU International Council of Scientific Unions
IGC International Geological Congress
IGCP International Geological Correlation Programme
ILP International Lithosphere Programme
INQUA International Union for Quaternary Research
IOC Intergovernmental Oceanographic Commission
IUGG International Union of Geodesy and Geophysics
IUGS International Union of Geological Sciences
OET IGCP project ‘On Extended Term’
OSNLR Ocean Science in relation to Non-Living Resources
RCMNS Regional Committee on Mediterranean Neogene Stratigraphy
SCOPE Scientific Committee on Problems of the Environment
SEATRAD South-East Asian Tin Research and Development Center
UNEP United Nations Environment Programme
UNESCO United Nations Educational, Scientific and Cultural Organization

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Report of the thirtieth session of the IGCP Scientific Board

The IGCP Scientific Board assembled at UNESCO Headquarters, 1 rue Miollis, Paris, from 4 to 8 February 2002.

1. List of Participants

Scientific Board Members (*new Members):
Ian Dalziel, Chairperson (United States)
Max Deynoux (France)
Maurizio Gaetani (Italy)
Alexander Gliko (Russia)
Sylvi Haldorsen (Norway) *
Sospeter Muhungo (Tanzania)
Prabhas Pande (India) *
Victor Ramos (Argentina)
Nobutaka Shimada (Japan)
Jim Teller (Canada)
Susan Turner (Australia)
Marjorie Wilson (United Kingdom) *
Gerhard Wörner (Germany)
Zhenyu Yang (China)
Cari Zazo-Cardena (Spain) *

Scientific Board Member absent
Rasool Okhravi (Iran) *

Ex officio members:
Walter Erdelen ADG/SC, representing the Director-General of UNESCO
Eduardo de Mulder President of IUGS (The Netherlands)
Attilio Boriani Secretary-General of IUGS (Italy) – President 32nd IGC Committee

Observers:
S. A. Aghanabati Geological Survey of Iran
Song Ailing Institute of Karst Geology (China)
Genevieve Apaloo Permanent Delegation of Ghana to UNESCO
Philippe Bouysse Commission for the Geological Map of the World (France)
Jean-Paul Cadet Commission for the Geological Map of the World (France)
Yuan Daoxian Institute of Karst Geology, IGCP Project 448 (China)
Gabriele Castillo Permanent Delegation of Costa Rica to UNESCO
Chen You Fang Ministry of Land and Resources (China)
Edward Derbyshire Past IGCP Chairperson (United Kingdom)
Ariel W. Gonzalez Permanent Delegation of Argentina to UNESCO
Ren Jishun Institute of Geology, Chinese Academy of Geological Sciences
Noor Azmi Ibrahim Permanent Delegation of Malaysia to UNESCO
Pei Rongfu Chinese Academy of Geological Sciences
Alexander Plevako Permanent Delegation of Ukraine to UNESCO
Philippe Rossi Commission for the Geological Map of the World (Italy)
Reimar Seltmann IGCP Project 373, NAM, London (United Kingdom)
Mohammed S. Sheya Permanent Delegation of the United Republic of Tanzania to UNESCO
Akiko Shimada Fukuoka, Japan
Christophe Valia-Kollery  Commission française pour l’UNESCO
Yao Yupeng  National Natural Science Foundation of China
Zhao Xun  Chinese Academy of Geological Sciences

**IGCP National Committees:**

- Prof. Károly Brezsnýánszky  IGCP National Committee of Hungary
- Prof. William Cavazza  IGCP National Committee of Italy
- Prof. Léon Dejonghe  IGCP National Committee of Belgium
- Prof. Shuwen Dong  IGCP National Committee of China
- Prof. Abdolazim Haghipour  IGCP National Committee of Iran
- Prof. Werner Janoschek  IGCP National Committee of Austria
- Dr Peter Königshof  IGCP National Committee of Germany
- Prof. Kirsti Loukola-Ruskeeniemi  IGCP National Committee of Finland
- Prof. Marjorie Wilson  IGCP National Committee of the United Kingdom
- Prof. Simon Pirc  IGCP National Committee of Slovenia
- Prof. Denis Vaslet  IGCP National Committee of France

**Observers from UNESCO:**

- Salvatore Arico  SC/ECO
- Alice Aureli  SC/HYD/HPC
- Janos Bogardi  SC/HYD/SWR
- Howard Moore  DIR/SC/EO

**Members from UNESCO, Division of Earth Sciences:**

- Wolfgang Eder, Director, IGCP Secretary
- Denise Armand
- Yolanda Berenguer
- Pilar Chiang-Joo
- Sophie Laryea
- Robert Missotten
- Soren Malling
- Hélène Papa
- Margarete Patzak
2. Introductory remarks by the Chairperson

The IGCP Chairperson, Prof. Ian Dalziel, in opening the meeting, emphasized the cooperative nature of the IGCP as a joint venture of UNESCO and IUGS, and welcomed the officers of the IUGS (President E. de Mulder, retiring Secretary-General A. Boriani, and Treasurer and Secretary-Elect W. Janoscheck). He also extended a warm welcome to four new Board Members present (Prof. S. Haldorsen (Norway), Dr P. Pande (India), Prof. C. Zazo-Cardeña (Spain) and Prof. M. Wilson (United Kingdom) as well as to Dr R. Okhravi (Iran) who was unable to attend. He also welcomed those present as members of National IGCP Committees (Austria, Belgium, China, Finland, France, Germany, Hungary, Iran, Italy, Slovenia, United Kingdom). The Chairperson recorded with deep regret the deaths of Ms Sally Cochrane, who had served the IGCP Secretariat for 12 years, and Professor Chris Powell (Australia) former leader of IGCP Projects and distinguished member of the Scientific Board. Finally, he invited the Assistant Director-General for Natural Sciences of UNESCO, Mr Walter Erdelen, as representative of the Director-General Mr Matsuura, to deliver his opening address to the Board.

3. Opening address to the Scientific Board on behalf of the Director-General of UNESCO

Mr Walter Erdelen, Assistant Director-General of the Natural Sciences Sector of UNESCO, welcomed the participants on behalf of the Director-General, Mr Koïchiro Matsuura, to the 30th anniversary of the Scientific Board of the International Geological Correlation Programme. He expressed his conviction that the coming days would provide an opportunity to engage in constructive reflections and debates on key issues of the Earth Sciences and Society, and assessment of the 40 projects of the IGCP.

He extended a special welcome to the representatives of IUGS, IGCP’s cooperation partner. A special welcome also went to the four new members present of the IGCP Scientific Board, starting their four-year term, Prof. Haldorsen (Norway), Dr Pande (India), Dr Zazo-Cardeña (Spain), and Prof. Wilson (United Kingdom). He greatly appreciated the considerably increased participation of women in this scientific body, and was glad to welcome three highly qualified female scientists among the new members. During the coming days, all of them would have the high responsibility of assessing the achievements and quality of ongoing IGCP projects and to evaluate new project proposals.

He further expressed a particular pleasure in welcoming numerous representatives of IGCP National Committees to an extent never seen in the history of IGCP Board Meetings. Through their contribution he expected a positive and very enriching exchange of ideas and stimulating discussion which would certainly give new impetus to the Programme.

He recalled that IGCP was launched 30 years ago, as a joint UNESCO-IUGS Programme in the geological sciences, at the 24th International Geological Congress (IGC) in Montreal, Canada, in 1972. Its primary aim was to encourage and facilitate world-wide collaboration between scientists working on the solid earth and its resources. In fact, the roots of the IGCP go back further. The IGCP was to have been proposed during the 23rd International Geological Congress in Prague which was disturbed by the events on 20 August 1968 when Soviet tanks invaded the city. After Prague, an international panel was set up to advance the proposal. It was this panel that laid down the foundations and structure of the IGCP as it is known today, with its characteristic discrete projects and ‘seed’ financing.

The 30 years since the ‘official’ birth of the IGCP have been marked by a number of changes – political, economic and social. The Programme has responded to these forces. Respecting as well as changing priorities within UNESCO, IGCP has moved increasingly towards emphasizing multidisciplinary initiatives and global approaches to major environmental problems. In 1995 it adopted its new sub-title ‘Geoscience in the Service of Society’, reflecting the above change.

But the latest most visible change is still to come: the change of the IGCP name to the ‘International Geoscience Programme’, which has been proposed by the Board members at the 29th session one year ago, in agreement with the IUGS. The Director-General of UNESCO and himself have agreed to the proposal, which is now prepared for final approval by the Executive Board of UNESCO. ‘International Geoscience Programme’ would reflect more precisely the IGCP changing aims as had just been mentioned.

The challenges emanating from globalization and from the new trends in many areas are becoming ever more complex, often driven by scientific and technological insights and breakthroughs, and they carry manifold implications. Policies to address these challenges increasingly demand scientific advice based on analysis, understanding, sharing and anticipation. More than ever, at the beginning of the twenty-first century, decision-making and the formulation of scientific policies must be fully informed as to their scientific underpinnings and consequences, drawing on input from the natural sciences.

He invited the IGCP to contribute to the principal priorities of UNESCO’s programmes for the period 2002 to 2003 – Education for All, water and human security, the ethics of science and technology, cultural diversity and pluralism, the free flow of ideas and universal access to information. The overarching crosscutting theme of poverty eradication links the Organization’s actions to the wider priorities of the United Nations system as well as to the difficult realities facing many Member States. The second crosscutting theme of information and
communication technologies will engage it with the dynamics of creating a knowledge society.

The IGCP is in a unique position to contribute every year through about 40 projects in a multidisciplinary effort to the adaptation of countries towards knowledge societies. The exchange taking place concerning scientific findings and research, and encouraging the transfer and sharing of this knowledge ensures equitable benefits for all societies.

In consonance with UNESCO’s mission and the theme for its present strategy, the quest for sustainable development will remain a central guiding principle of the Organization’s activities. Water resources and supporting ecosystems will be of the highest priority for UNESCO’s activities between 2002 and 2007, as the timeliness and urgency of addressing freshwater issues have become widely recognized as a key component of human and environmental security. The IGCP should consider directing activities towards this priority.

UNESCO has a standard-setting function. Civil society, partnerships, policy dialogue and intercultural understanding have been words on everyone’s lips. In the aftermath of the terrorist attacks of 11 September the reaction of the international community has demonstrated still more strongly the role of the Organization as the guardian of peace through the implementation of its programmes. UNESCO, since its inception, has never ceased to promote peace – often with considerable success. And the Natural Science Programmes have indeed greatly contributed to this. UNESCO does not deal in politics, nor does it have arms. Its weapons are education, culture, science and technology which bring people together.

The Earth sciences need to further contribute to this dialogue by an improved understanding of geological, geochemical, mineralogical and geophysical parameters so as to bolster sustainable development through adequate monitoring. The modelling and forecasting of the impact of environmental and climate change calls for the introduction of new and more sophisticated technologies and related capacity-building as well as the collection of pertinent data.

The IGCP contributes to enhancing knowledge on earth sciences with a view to applying it to the management of natural resources and to serving as a catalyst for international cooperation in support of sustainable development and environmental monitoring. As such, it is a contribution to the Rio+10 Conference, the World Summit on Sustainable Development (WSSD), to be held later this year in Johannesburg, Republic of South Africa.

The IGCP provides the core of UNESCO’s earth science contribution to environmental science and development. In the 30 years since its inception, the IGCP has made substantial contributions to our knowledge of the solid earth – contributions that range from detailed understanding of how and why deserts expand and retreat, to data bases for the whole globe documenting the type and concentration of chemical elements of the Earth’s surface that are essential for agriculture, industry and human health. One of the latest activities focuses on the impact of geology and the natural environment on human and animal health. IGCP at present clearly clusters projects around the groups ‘climate change and desertification’ and ‘structure, tectonics and drifting continents’, reflecting the fact that the Scientific Board does not commission projects, but holds fast to its tradition of operating in response mode. The Assistant Director-General for Natural Sciences strongly encouraged the members at this meeting to further orient and re-shape the Programme’s focus towards actual topics and principal priorities to our society, and UNESCO’s priority areas.

Finally, he wished every success in the meeting and brainstorming, which might open important new avenues for the future. And, in conclusion, he left them with the words of Albert Camus, the French novelist and playwright: ‘Every achievement is a servitude. It drives us to a higher achievement.’

4. Welcome address by the President of the International Union of Geological Sciences (IUGS)

Prof. Ed de Mulder, President of the International Union of Geological Sciences (IUGS), expressed his pleasure in having the possibility to attend the IGCP Scientific Board Meeting in this year of celebration of IGCP’s 30th anniversary. This is an unprecedented milestone, not only in the geosciences but in the history of international sciences in general. Its present age is approaching geological dimensions already but, nevertheless, IGCP is still vital and, what is even more important, IGCP has good prospects for the future.

He further questioned the manner in which, as IUGS, to anticipate IGCP’s future. He emphasized that it could be seen detached from the future of the geosciences in general. After a quarter of a century of recession several indicators are getting green colours now which demonstrate that a more promising era for the geosciences is on its way. For example, after a steady decline in the 1980s and the early 1990s a stabilization and even a modest increase of the number of incoming students in the geosciences in several countries during the last few years was noticed. After a long period of stagnation, universities now start to employ younger colleagues.

Budgets for both applied and fundamental geoscientific research have experienced reductions to a level of only 1% of the total global R&D budgets in the world.
However, promising indications of increasing budgets are to be observed: for example, the 400 million-dollar project Earth Scope in the United States and significantly larger budgets for fundamental research on the subsurface processes in the Netherlands.

He went to regret that, as to job opportunities, dramatic cuts in geoscientific staff positions in oil and mining companies during the past decade had taken place. Many of the geo-research departments in the industry were closed down. Simultaneously, however, such companies still need the results of geoscientific research and have sourced this out. Many new but smaller research groups have sprung up and a significant number of these are doing quite well.

Against this current and rather promising background of the development and performance of the geosciences, IUGS thinks that IGCP has good perspectives for the future. But Prof. De Mulder then proposed to first look back and see how IGCP has performed over the past decades.

- How international is the International Geoscience Programme?
- How many scientists are involved in IGCP?
- How many international meetings were held and in which regions?

Since geoscientists are used to work with samples he had sampled one typical year in the 30 years history of IGCP. This is 1996. In that year some 40 projects were running in 146 countries. If the period 1988-1993 had been taken 100 such projects active in 155 countries would have been counted. On average in each project scientists of some 30 countries are involved. In any of these 146 countries on average over 8 projects have been active in 1996.

However, the spread of the projects is not well balanced over the regions, nor is its leadership. It is to be noticed that many more projects are active in European and particularly in the North American countries, than in for example Africa and the Arabic countries. The same picture is seen as it comes to leadership. A somewhat better balance is to be noticed for the global spread of hosted international meetings. But still, he doubted if there is any other scientific Programme that could compete with these numbers. IGCP manages to get every year over 20,000 scientists all over the world involved in a real grass-roots programme. In his opinion these numbers very well show that IGCP is one of the most successful, most international and, with an investment of only 15 Euro per scientist, also one of the cheapest programmes in science development that have ever existed.

As to potential future directions for IGCP he referred to the research agendas of the United Nations which are steered now by the drive for Sustainable Development.

Many Sustainable Development issues are firmly rooted in the geosciences, such as food, shelter, safety and water. Many of such issues are already addressed well in the current International Geoscience Programme, directly or indirectly. IUGS would very much like to see IGCP more strongly connected to the International Hydrological Programme (IHP), run by UNESCO. He stressed that IUGS thought that this IHP Programme provides excellent opportunities to both UNESCO and IUGS to extend their cooperation through IGCP. He invited the members of the Board to explore these opportunities and build on a proven solid foundation of 30 years of collective professional experience concentrated in IGCP. In conclusion, Prof. de Mulder congratulated IGCP, its leadership and its researchers, in the name of IUGS.

5. Address to the Scientific Board by the Treasurer and Secretary-General Elect of IUGS

Dr Werner Janoschek expressed his great pleasure and honour to address a few words of welcome to the participants and introduced himself. For a year and a half he had had the great pleasure to be Treasurer of the International Union of Geological Sciences (IUGS) and for a couple of days he had been Secretary-General-Elect of the Union. The reason for this was that Professor Boriani had resigned, because he had been nominated President of the 32nd International Geological Congress 2004 in Florence. Dr Janoschek conveyed the regrets of Prof. Boriani not to be able to participate in the opening of the meeting, but he would be joining it later.

Dr Janoschek went on to inform the members of the Board on behalf of the Treasurer and the Secretary-General that the IGCP was in very good condition, though the terrible events of 11 September had brought about indeed much stress into most of the IGCP projects. He therefore felt happy that together with their major partners at UNESCO and in the United States they could find a suitable solution to postpone the deadlines for reports and financial statements for some of the running projects.

He also stressed that through an excellent cooperation between the Division of Earth Sciences of UNESCO and the internal IUGS bodies such as the Secretary-General, the Permanent Secretariat in Trondheim in Norway and the Treasurer the administration of the IGCP projects could be considered as really good. It was also invaluable to acknowledge the cooperation with the United States National Academy of Sciences and the International Science Council (ICSU).

The procedure which keeps the IGCP projects running sounds more complicated than it is in reality: If the project proposals are adopted by the Scientific Board, the contracts are prepared by UNESCO. After signature by the project leader the Treasurer of IUGS is informed
to start the financial transactions. He has to collect the funding from UNESCO, from the United States Academy of Sciences through ICSU and from IUGS itself. As IUGS is a rather small and non-bureaucratic entity it happens frequently that funds to project leaders are transferred before the money from the partners has been credited onto IUGS accounts. That procedure is partly based on written agreements and signed contracts, but partly also on a gentleman agreement basis which is followed by signed contracts. So far things have run smoothly. Then the scientific reports and the financial statements are collected jointly at UNESCO and IUGS, checked and forwarded for review to the Scientific Board. Summarized reports and financial statements are prepared and forwarded to UNESCO, the IUGS Bureau and Executive Committee, to ICSU and to the United States Academy of Science in order to obtain the financial support for the following year.

The IGCP is an old programme compared to other scientific programmes, but it is one of the most efficient: Very few administrative procedures, immediate and permanent review of an excellent experts group and with a tremendous effect of multiplying the funds which are distributed by IUGS and UNESCO. The renovation of the IGCP which started a few years ago is on a very good track; the inclusion of an increasing number of projects summarized under the slogan ‘In the Service of Society’ shows clearly the intention.

Before coming to an end, Dr Janoschek remarked that the IGCP, this excellent and biggest geoscientific programme, is practically unknown to the public. It is funded by public money. The public has to be informed about the programme in a language it can understand. The scientific level of IGCP must be kept or be increased permanently, but scientists should speak simultaneously to decision-makers, to the fund-raisers and collectors, to the politicians and to the public in general.

He hoped that IGCP will continue as the most successful geoscientific programme for many years and that the high level of cooperation and mutual understanding between UNESCO and IUGS could be kept or even enhanced for the future.

6. Address by the Director of the Division of Earth Sciences

Mr Wolfgang Eder, Director of the Division of Earth Sciences, addressed the floor in terms of the greatest pleasure in welcoming all the participants, in his double capacity as Director of UNESCO’s Division of Earth Sciences and as the Secretary of IGCP. He expressed a special welcome to the five new elected members of the IGCP Board (Dr Rasool Okhravi, Iran – absent; Prof. Sylvi Haldorsen, Norway; Prof. Cari Zazo-Cardena, Spain; Dr Prabhas Pande, India; Prof. Marjorie Wilson, United Kingdom).

He further echoed the words that had been expressed since the beginning of the session. Natural Sciences, including Earth Sciences, are set to play a prominent role in global efforts to maintain the earth surface as a place where it is worth living on, to reduce human suffering or to limit damage to the natural and built environment. He wished to recall (what Mr Erdelen had already pointed out) that the course humanity takes in the years to come will largely depend upon whether crucial goals in sound management of the environment and sustainable development are reached.

Through its Earth Sciences programme, including the IGCP, UNESCO aims at increasing the knowledge on our ‘Restless Earth’. Themes like:

- Understanding the changes taking place on the (Changing) Planet Earth
- Earth and space science in the service of society
- Risk reduction of geological disasters
- Protection and promotion of the Earth’s heritage are needed for effective environmental policy-making and the promotion of sustainable development.

Mr Eder stressed the point that ten years after the United Nations Conference on Environment and Development (UNCED), held in 1992 in Rio de Janeiro, the World Summit on Sustainable Development of Johannesburg, South Africa, in August 2002, would try to renew the global political commitment on sustainable development.

As confirmed in 1999 at the World Conference on Science in Budapest, a world-wide effort to increase investment in scientific research and to build up the scientific capacity of developing countries is also needed. This is well reflected within the IGCP strategy. He further commented that special attention should be given also to activities devoted to ‘Science Education’ and ‘Popularization of Sciences’.

He then expounded that discussions during the coming days would underline the ways in which partnership of IGCP with other UNESCO intergovernmental or international scientific programmes on water (IHP), oceans (IOC), biodiversity and ecosystems (MAB), coastal zones (CSI) and urbanization problems (MOST) have been or could be developed. Priority problems connected with issues like urban geology, geo-environment and health, pollution of groundwater, water and land-management in mining areas, karst-ecosystems, floods and landslides will be explained during the coming days in several projects.

As director of the Division of Earth Sciences, he went on to explain that he had participated for the tenth time in an IGCP Board Meeting and was curiously looking forward to another exiting event.
7. Scientific Symposium

- The IGCP: retrospect and prospect by Professor Edward Derbyshire (past IGCP Chairperson, United Kingdom)
- Geology and Geohydrology of Karst and its Relevance to Society by Yuan Daoxian, (Institute of Karst Geology, CAGS, Guilin, China)
- Ore-bearing Granites of Eurasia: a Network Experience by R. Seltmann (United Kingdom)
- IGCP and Global Geoscience by I. Dalziel (United States of America, Chairman, IGCP Scientific Board)

8. Reports of IGCP National Committees

Representatives from ten IGCP National Committees gave brief summaries of their activities in 2001 sent to the IGCP Secretariat. Prof. Pirc (Slovenia) reported on cooperation with HELP Programme, where also geologists are participating. Prof. Dejonghe (Belgium) said that IGCP activities in Belgium are continuing as in the past and that geoscience projects from Universities get easier access to governmental funding with the IGCP label. Prof. Brezsnynánszky (Hungary) highlighted good relations to the UNESCO National Commission. His government is financially supporting quaternary research and environmental geology. Prof. Haghipour (Iran) requested new programmes on geology related to human needs. Further, he announced the printing of the Seismotectonic Map of the World showing three thousand years of seismotectonic history. He proposed a workshop at the 32nd IGC for earthquake prediction/mitigation. Prof. Cavazza (Italy) reported on the recently established website – soon be linked to the IGCP site – and informed that the National IGCP and IUGS Committee was directed by the same persons but does not receive funding from the Italian government. Prof. Loukola-Ruskenenemi (Finland) reported advantages of obtaining funding for Universities if research projects are endorsed under the IGCP. Dr Königshof (Germany) confirmed that the IGCP has a high reputation in Germany, which makes the obtaining of governmental funds easier. He informed about intense discussion going on in Germany on geosites/geoparks topics and that 6 October 2002 is declared a "Day of Geosites" in the framework of the Year of Geosciences. Prof. Vaslet (France) stated that the French IGCP Committee was astonished that IGCP was absent in UNESCO priorities. Prof. Dong Shuwen (China) presented the Chinese annual report to the IGCP Board. Prof. Janoschek (Austria) said that his government pays special attention to IGCP and Geopark activities.

9. Joint meeting with cooperating UNESCO programmes and organizations

(IOC, MOST and ICSU, not represented)

Man and the Biosphere Programme (MAB)
Salvatore Arico

Biosphere reserves are areas of terrestrial and coastal ecosystems under a particular management regime (and set of approaches) known as the ‘biosphere reserve model.’ They are internationally recognized within the framework of the UNESCO’s intergovernmental programme on Man and the Biosphere (MAB), and remain under sovereign jurisdiction of the States where they are located. Biosphere reserves are united globally into the World Network of Biosphere Reserves, and as of January 2002 there are 411 sites established in 94 countries. Ideally, fully functioning biosphere reserves perform three main roles:
- conservation in situ of natural and semi-natural ecosystems and landscapes, as well as the diversity therein
- establishment of demonstration areas for ecologically and socio-culturally sustainable (land and) resource use, and
- provision of logistic support for research, monitoring, education, training and information exchange related to conservation and sustainable development issues.

Research activities in biosphere reserves are often part of a specific assessment process. In this context, the assessment defines the use of data and the effect of potential threats or impacts in order to propose policy solutions.

Monitoring activities carried out within biosphere reserves represent integrated monitoring for multiple objectives. They deal with and elucidates aspects of sustainable development, focuses on the understanding of cause and effect (in this context, it includes human-environment interactions, behavioural responses, attitudes, public perceptions, etc.), uses more specific variables, gives priority to use of readily available data, is flexible and adaptive. involves, involves scientists, policy-makers and the public in the development of an integrated monitoring scheme and has multiple applications and long-term relevance. Part of the data collected and assessed through long-term monitoring programmes is ‘communicated’ and shared with the policy-making community and different stakeholders in order to serve as a basis for policy advice.

The representative of MAB went on to expound their belief in cooperation between MAB and IGCP in order to seek addressing both levels, i.e. research on and monitoring of issues that are at the interface or that involve both the living and the non-living. In this regard, they are very pleased to see that environmental activities are being strengthened in the IGCP context.

He finally briefly referred to a very promising cooperative effort that involves MAB and another of UNESCO’s intergovernmental programmes: the
International Hydrological Programme. The two programmes are collaborating successfully in the implementation of a series of activities under a joint budgetary line of action. They believe that this kind of arrangement should be made with IGCP as well. He concluded by saying that the sixteenth session of MAB’s International Coordinating Council will be held in March this year, which will provide a perfect occasion to bring to the Council’s attention any recommendation the IGCP Scientific Board might produce in relation to cooperation between IGCP and MAB.

International Hydrological Programme (IHP)
A report was presented by Mr J. Bogardi and Mrs A. Aureli. Mr Bogardi reminded the Board that IHP operated on a 6-year plan basis, as a general rule, and that the following five themes are currently being pursued:

- Water research assessment in the light of Global Change,
- Catchments and aquifer dynamics (an area in which IHP and IGCP interaction is particularly appropriate),
- Land habitat hydrology, involving earth, water and plant relationships (linked to MAB but with clear relevance to IGCP),
- Water and Society, paying close attention to the use and value of water and also human security (geologically based risks also being present here),
- Water, education and training.

In addition, two cross-cutting theme projects are in hand.
1. Flow regimes for international network data.

Mrs Aureli (in charge of the groundwater aspects of IHP) presented certain highlights of the Programme, and expressed the view that dialogue with IGCP colleagues should be an everyday event. In addition to the main groundwater work, several new developments were noted, including:

- The establishment of an international groundwater research Data Centre (in collaboration with the Government of The Netherlands).
- A joint venture with the Atomic Agency on isotope applications in hydrology.
- Aquifer recharge management, especially in karst terrains, including the question of shared aquifer resources. This is a topic with good potential for IHP-IGCP cooperation. An inventory needs to be set up and IGCP help is invited. Groundwater is clearly a growth issue in IHP.

In the ensuing discussion, the National Representative of Iran drew attention to the question of water quality (as distinct from water quantity). Prof. Haldorsen drew the attention of the Board to the importance of the link between global change and palaeohydrology, raising many possible areas for cooperation with IHP.

Commission for the Geological Map of the World (CGMW)
The CGMW was presented by Dr Rossi. He reported that the Commission envisages to speed up the production of thematic maps, and improve its visibility and increase sales through different CGMW products and by a new marketing policy. Cooperation shall be strengthened with UNESCO (Earth and Water Sciences IUGS, IGC). The CGMW plans to further improve relations with countries (only 42 are currently CGMW member) and, with the help of a new specific products, open up new target groups and audience, like school teachers. Dr Rossi stated that the CGMW wants to orient its activities towards ocean mapping (Atlantic Ocean, Caribbean) and to produce geophysical and energy maps. The following maps are to be finalized by its mapping programme in the near future:

- 2002 Structural Map of the Indian Ocean (1 : 10 000 000)
- 2003 Hydrogeological Map of the World (1 : 25 000 000)
- 2004 Metamorphic and Structural Map of the Alps (1 : 1 000 000)
- 2004 Geodynamic Map of the Mediterranean (1 : 5 000 000)
- 2004 International Tectonic Map of Africa (1 : 5 000 000)
- 2004 International Tectonic Map of Asia (1 : 5 000 000)
- 2004 International Geological Map of Europe (1 : 5 000 000)
- 2004 Superlarge Mineral Deposits Map of the World (1 : 25 000 000)

10. The World Conference on Science and follow-up activities

Mr Howard Moore stressed the message of the World Conference on Science (1999) involving a commitment for and by Science. He mentioned two particularly important documents, namely the Declaration and the “Science Agenda, a Framework for Action”. UNESCO expected to lead the follow-up activities by

1. Modifying its own science policies, and
2. Acting as a ‘clearing house’ (with ICSU) for information from nations on how they have positively amended their science priorities and modes of operation.

An analytical report will emerge during mid 2002 in the form of a conference retrospect and a consideration of future actions. The principal recommendations are:

- Recognition of the greater need for interdisciplinarity, and the universal need for capacity building. Most nations are seeking better qualified and educated people and this embraces the need for much wider science popularization. It also implies improved equitable access to scientific research and data.
UNESCO is very active in the ethics of science and technology, paying particular attention to women and young people in science, and science decision-making. The integration of indigenous knowledge is taken into account as well as the question of partnerships with NGOs, etc.

Mr Moore noted that IGCP had already modified its programme in cognizance of the World Conference on Science. He stated that IGCP had generated some appropriate interdisciplinary projects, including landslide amelioration and medical geology, for example. Mr Moore went on to express the view that the Volga-Caspian Basin Project proposal is in line with these changes in UNESCO policy and is commended to the Board for discussion. In conclusion, he expressed considerable satisfaction with the work IGCP has undertaken in recent years.

In the following discussion, the question was asked about follow-up information on the World Conference on Science, and how high a priority had been accorded to the ethics of Science by UNESCO. Mr Moore replied that regional responses are expected following publication of the follow-up report (mid-2002). In response to the second point, he stated that the Universal Declaration of Human Rights had been a UNESCO initiative and that UNESCO has continued to advance awareness in this area as in its World Commission on the Ethics of Science and Technology (COMEST), which had already produced very well received reports on Water, Outer Space, and the Information Society. It continues to explore ethics in other topics.

11. The International Geological Congress 2004 (IGC)

Prof. Attilio Boriani, as IGC President, outlined the latest information on the Congress to be held in Firenze, Italy, 20-28 August 2004. He noted the following programme details. Sessions will run from 0840-1200 hours, with no formal coffee break. Oral papers will be limited to 20 minutes. Plenary Lectures will be delivered daily at 1200-1230 hours, followed by lunch 1230-1400 hours. The afternoon sessions will run, also without any formal coffee break, 1400-1620 hours. This will be followed by time allocated to the Poster Sessions. (The question of free beer or free Chianti during these latter session was deferred to allow for further consultation.)

The FIRST CIRCULAR is scheduled for release (by both post and website) during late March/early April 2002. It will contain a questionnaire (deadline for responses October 2002). Production of the Second Circular will then proceed. Abstracts will be submitted by both postal and website methods, the deadline being October 2003. Acceptance of abstracts will be notified by January 2004. The intention is to place the Third Circular on the website in May 2004. More than 100 field excursions will be offered in the First Circular, 30% of which will take place outside of Italy. The Congress venue will be in the 16th Century fortress in the heart of Firenze, which is close to the railway station. GeoExpo will be open throughout the Congress. Symposia will fall into one of three categories, namely Special (all speakers being by invitation), Topical (involving both invited and contributing speakers), and Open (involving contributing speakers only). Attention was drawn to the paucity of symposium proposals from China, Japan and South America, and these nations were urged to respond.

Prof. W. Cavadza, IGC Secretary-General, stressed that the GeoMediterranean Consortium should be regarded as very important for the Congress, and not just for Italy. Some 30 countries are involved. Each nominates a representative and these scientists act as conduit for proposals for field excursions, etc., for consideration by the IGC. On the matter of the Registration Fee, it was stated that it would be no higher than prevailed at the Rio 2000 IGC, and it would effectively be lower because lunches would be included in the Fee.

12. Topics for general discussion

The Volga-Caspian Basin Project Proposal

Mr Bogardi briefly outlined the nature of this proposal. He informed the Board that a special meeting of interested parties, including some high-level Russian Government officials, is to take place in Paris in the week beginning 11 February 2002. The meeting will require both clear and hard-headed negotiation. In response to Prof. Gaetani’s question about the difficulties likely to emerge in dealing with the number of countries bordering the Caspian Sea, Mr Bogardi emphasized the initial need to stress the priority of the Volga (with its water and pollution inputs into the Caspian). This will make it possible to launch the project with operations in just one country although, as a non-geologist, he did not feel able to say where the optimal geological input should be placed. He stated that MAB, IHP and IOC are to input some funding as well as expertise.

There was some discussion regarding the level of any IGCP funds that might be offered to the project, with some suggestion of the equivalent of one normal IGCP project, although no decision was taken at this stage. Attention was drawn to the fact that sea level changes had been rapid in the Caspian over the past decade (rise estimated as high as ca. 5m), with clear implications for pollution and water management. Dr Wörner, accepting that this proposal was certainly a great vision, stated that the only way IGCP could input into this programme would be to consider suitable projects in the normal way, i.e. as project proposals which would have to be evaluated and suitable finance awarded (low,
medium, high) following normal procedures. It was further asked if some proposals for evaluation and some existing projects might be formally linked to the Volga-Caspian project. Certain existing IGCP projects might be encouraged to establish a formal link.

The IGCP Secretary mentioned that the Division of Earth Sciences felt the obligation to contribute to the project, but that a contribution within the framework of IGCP (i.e. IUGS and UNESCO) would respond more appropriate to the recommendations of the Steering Committee of the five scientific programmes of UNESCO. It was noted that he would present the case at the IUGS Executive meeting in New Zealand, 25 February 2002.

This item was again put on the agenda during the closed session on 6 February.

**International Landslide Initiative**

Mr Eder addressed the Board on the collaborative International Landslide initiative. This is a project without financial cost to IGCP although it is an initiative with roots in IGCP 425. Ten days ago in Kyoto, Japan, a meeting had been held involving UNESCO, WMO, International Strategy for Natural Disaster Reduction (ISDR) and other bodies. The International Landslide Forum will integrate Science and Technology, Education and training aims, and protect cultural and natural features of high social value. It will coordinate international expertise and activity in landslide studies. The Scientific Board was asked to support this global, multidisciplinary initiative, as the Earth Science Division would like to promote this development in the UNESCO Executive Board as a transdisciplinary initiative. In answer to the Chairperson’s question concerning any discussions in this group on the question of limitations to the lengths one should go to protect property, Mr Eder replied that the cost – benefit approach is currently under discussion. The main aim is to coordinate as much activity as possible in the future as the present situation is one of low level coordination in this field of research. The Scientific Board expressed general interest in this initiative which is already included in UNESCO’s 31.C/5.

**Regional centre on karst ecology**

Mr Eder also spoke about the proposal to establish an international research centre on karst ecology in China. This has obvious potential for integration of scientific inputs. This idea is still under discussion but he asked the Scientific Board to give general support to this proposal. This was agreed.

**Regional Meetings**

*Regional meeting in Montevideo, November 2001.* Dr Ramos explained that this meeting was held within the framework of the Latin-American Geological Congress which is a year event. It had been a notable success. It was noted that many people attended this regional meeting. It appears that regional meetings are needed in South America and that they appear to be economically feasible. Evidently the IGCP might play a key role in such meetings. The first section involved invited former leaders sharing their experiences. The second section was concerned with the question of means of motivating good people to become involved in IGCP. Several stimulating items were discussed:

1. Palaeoseismic work in relation to Andean uplift. This has led a group to set up a new IGCP project proposal.
2. Economic evaluation of geological risk (led by a Colombian expert) Losses due to the Val de Ruiz landslide etc. had proved greater than those incurred as a result of the guerrilla war.
3. Global change. This has also stimulated a new proposal. The new directions within IGCP had been very clearly evident to the young scientists attending the meeting.

The third section dealt with Geoparks. Dr Ramos reported that a park in Patagonia could duplicate its number of visitors by including geological features into its programme.

**European Regional meeting scheduled for the United Kingdom September 2002.** Prof. Derbyshire reminded the Board that a proposal, developed by Prof. C. Wilson (Open University, United Kingdom), Mr Eder and himself, had been approved at the Board meeting in February 2001. Prof. Wilson had kindly volunteered to organize the event, and Mr Eder had offered an Earth Sciences Division contribution of US$15,000 towards running costs. This was intended to be on a “dollar to dollar” basis, with United Kingdom (host country) national funding making up the deficit. Unfortunately, and despite the fact that early action had been taken in requesting this support by way of the Science Committee of United Kingdom – UNESCO (the responsible body attached to the UK Department for International Development), no funding had been awarded by January 2002 at which time it was decided that too little time remained to mount the programme successfully in September 2002. This is disappointing and somewhat embarrassing for the UK initiators. Representatives of the UK geological community remain willing to invite their continental European IGCP colleagues to meet in the United Kingdom but, realistically, this cannot now be before some date in 2003. Prof. Derbyshire agreed to continue his efforts to raise the necessary UK funds and to keep in touch on this issue with the Scientific Board.

**Geological Society of America, IGCP regional meeting.** The Chairperson reported briefly on a regional meeting of IGCP held during the Geological Society of America annual meeting in Boston, November 2001. This had been very successful. The GSA meeting had been attended by between 6000 and 8000 geoscientists, thus providing good visibility for IGCP.
13. Closed sessions

The Board touched a number of important items regarding its mode of work and returned to several open questions to be discussed during its closed session on 6 and 7 February of which the main points are reported below.

Meetings of chairmen of the five scientific programmes of UNESCO

Prof. Derbyshire represented the IGCP at the meetings of the chairpersons of the Five Science Programmes of UNESCO:

- 1999 the first of the five chairpersons took place, lack of horizontal structures and no lateral discussions was recognized before the document emanated from the meeting
- 2001-2002 meetings, with document of recommendations issue. The Steering Committee which was formed comments on matters of policy within UNESCO and has advisory status with direct access to the Director-General of UNESCO.

The Steering Committee expressed its concern that the new workplan of UNESCO contained only two cross-cutting themes (Poverty eradication and Information communication) and was lacking sustainable development as an overarching strategy. Among others, the Volga-Caspian project was the type of effort to support. In this respect, the ADG/SC, Mr Erdelen, was asked to have the Steering Committee of the Five Chairpersons to act in an advisory capacity for the Volga-Caspian project proposal and other projects.

Volga-Caspian project

Possible ways of contributions of IGCP to the Volga-Caspian project (see also item 11) were discussed. The Board recognized that IGCP could be helpful in providing its advisory capacity because it is relatively small, flexible and diverse, with expertise in many areas of geoscience. IGCP could be a focal factor of ideas. The IGCP considers its practical cooperation and how geosciences may be involved and potentially contribute some funds. Prof. Derbyshire and Prof. Haldorsen noted that there have been and now are topics and experts who could provide expertise/projects related to the Caspian-Volga project.

It was questioned how cooperation could work practically, regarding the usual way of functioning of the IGCP proposals. Difficulties were expressed to see how IGCP could contribute to such a regional project, taking into account that IGCP is international. It was discussed that potential project cooperation could begin with a gear, but might run for decades, an IGCP financial contribution would only come after the Board has contemplated the geoscience concern of any proposal. Input from the Russian government was reported 35 million US$ but not confirmed. The involvement of IGCP in the Volga-Caspian project was considered to be a good vehicle to raise the interdisciplinary banner and could be of real interest of IGCP. The IGCP name could have a catalytic role, and have a ‘seed money effect’. The majority of Board members agreed that IGCP has to be involved. There could be an international input into a regional basin. The Board could consider to use its contacts around the world to come up with an IGCP proposal for the next Board meeting. Geoscience proposals for the Volga-Caspian project should be more professional, e.g. include topics on provenience, sediment mass balances, climatic change, and groundwater, done by the means of IGCP, the project has to meet the standard.

The question was raised about nature and extent of an IGCP financial contribution. The Board should expect that it can help fashion the outcome of the Volga-Caspian project if IGCP provides a contribution. The IGCP Secretary preferred to have the Volga-Caspian project under the IGCP instead of running it under the Division of Earth Sciences only, and proposed a possible contribution of about US$10,000, feeling at the same time, that this sum could then go toward the support of IGCP projects. In response to this proposal the Board insisted that if money would be put into the programme, it should go through the IGCP Board to assess its scientific validity. The cooperation should be undertaken by the means of the IGCP and that any project would have to meet IGCP standards. The Board felt that it should be used for IGCP science, with IGCP input into the Geoscience aspect of the Volga-Caspian.

The IUGS representative noted that their contribution has been for the support of projects and questioned how IGCP could make a significant (financial) contribution given the vast scale of the Volga-Caspian project. It was discussed that it could be run within existing IGCP projects, with interested actual leaders.

Further steps and coordination of activities seemed be put under the responsibility of the Chairperson. The IGCP Secretary stressed again that IGCP has to be involved, may be not in the traditional form and function. E.g. consultancy input. IGCP normal project would be probably of less effect.

Soliciting proposals, proposal submission, communication

The point was raised again concerning the discussion on UNESCO’s priority themes which took place earlier. Several Board members agreed that IGCP should have targeted proposals in areas of special importance, encourage the submitting of proposals, also through the help of active IGCP National Committees and UNESCO regional offices. It was also requested that International Geoscience Societies, Geological Surveys and IUGS should be solicited for ideas, and perhaps industry. Geological Societies, via IUGS, would be a good source for advice on target areas.
The need was recognized that IGCP has to encourage the submission of proposals from countries which are not active, especially developing countries such as in Africa to participate in any target areas.

The Board stated that there is a big potential to enhance communication with project leaders, especially with respect to improve the scientific quality of incoming project proposal (e.g. include other qualified scientists, bridge to other initiatives). The establishment of an earlier deadline for the submission of proposals was also discussed. It was suggested to include into the guidelines the information that quality assistance can be given on request, prior to the official submission of a proposal. The IGCP Chairman suggested, in order to improve quality of individual projects, also during their lifetime of five years, that members of the Board might serve as “watchdogs” for projects. This idea was immediately welcomed and several members spontaneously presented themselves as watchdogs during the assessment of the projects.

In order to save costs, speed up and simplify the distribution of 40 annual reports and 12 project proposals to the 16 Board Members and IUGS, the Board agreed unanimously to the planned establishment of a website forum hosted at the IGCP website, with access reserved only for Board members. The proposals and reports could then be downloaded electronically as soon as they would arrive at the IGCP Secretariat.

Prof. Teller submitted a proposal “Building on our strengths”
“For 30 years, IGCP has been active, prominent, successful, and respected. It is important to retain the basic foundation on which IGCP was built, including INTERNATIONAL GEOLOGICAL CORRELATION. To this effect we should continue to encourage our colleagues in the international community to submit proposals on the geological topic of their choice, supporting those that best address IGCP principles.

Because times and attitudes change, however, we must be responsive to the needs of science and society, especially those identified by UNESCO. We must be perceived as relevant and known to be working in important areas of geoscience. In order to assure that we maintain our vitality, visibility, and impact, I propose that we periodically identify ‘target’ areas of importance. Subsequently, we should identify specific individuals or groups of individuals who can lead and participate in the target project, and then encourage them to formulate a proposal in harmony with our target objectives. In order to identify target areas, and also after target areas are identified, the input and advice from IGCP National Committees, the Advisory Board, and others should be sought. Submitted proposals could be reviewed by the Advisory Board and/or others. As part of this target strategy, IGCP should consider the collaborative and linkage potential of these projects with existing groups outside of IGCP. Emphasis on the geoscience interface with society, especially in developing countries, should be fostered in this new guided-proposal initiative. Proposals in target areas where research funding is already in place, where ‘new’ programme monies may soon become available, or where ‘matching’ monies may be available, especially in developing countries, could be encouraged. Additional money to support this new IGCP target programme should be sought, in order to minimize the impact on our existing established programme of funding.”

Duration of the sessions of the IGCP Board
The question came up if the length of time for the Scientific Board meeting could be reduced from 4 to 3 days. The Chairperson suggested this could be achieved in working more efficiently, perhaps reducing some aspects, electronic reviews in advance may help. Reducing time to 3.5 days could for example permit Board members in Europe to return home on 4th day, while others will receive per diem for 4 days plus travel. Another proposal was whether the IGCP business could be done in 3 or 4 days, with an additional half day for additional matters.

Day 1 Day for basic information
Day 2-3 IGCP work
Day 4-5 Optional business, e.g. Geoparks

After a lengthy discussion, the Board wished to state the intention to conduct its core business within 4 days (former five days), which already represents a shortening of the length of the time of the Board. An additional day might be devoted to optional activities of UNESCO and IUGS.

It was approved by the Board to invite leaders of excellent IGCP projects to report on their achievements during the first day.

Young Scientists Programme
The idea to initiate a Young Scientists Project Award was born at the 29th session of the IGCP Board in 2001 (see Geological Correlation No. 29, 2001, on pp. 17-18). Concern was expressed that better definition and rules are needed before launching such an award, like for example, definition of what is the purpose of this award, it must be also certain that proposals really originate from young scientists. On the other hand, it may be difficult for young scientists to comply with IGCP proposal regulations – that probably demands too broad an undertaking, students may be too busy on research to coordinate meetings and travel.

On request of the Board, Dr Wörner and Profs. Haldorsen and Muhongo were asked to draft some rules for the award, named “Young Scientist Project”.
Proposed guidelines for the Young Scientist Project within the framework of the IGCP-programme
by S. Haldorsen, S. Muhongo, G. Wörner

The IGCP Young Scientist Project aims to foster international cooperation between prospective young scientists from developing and developed countries early in their careers. It is expected that this will recruit and train young scientists to establish future international cooperative projects within and even beyond the framework of IGCP.

Proposals will be received by individuals and evaluated by the IGCP Scientific Board. Guidelines will be made public by the IGCP Secretariat using appropriate means of publication (IGCP website, "Geological Correlation"). Proposals should be submitted by the IGCP end-of-year deadline.

Proposals and projects should follow these guidelines:
1. Proposers should be within 10 years of their Ph.D.
2. Proposers should provide a CV and need to present a record of at least one international publication in their field.
3. Proposers are encouraged but not required to find an experienced scientist as advisor to help guiding the project.
4. Proposers need to demonstrate an affiliation to a research institute, university, geological survey or equivalent organization for the duration of the project. According to (3) the proposers will have to present a letter of support for their project by a member of their host institution.
5. Projects may but do not need to be linked to an existing international (IGCP) project.
6. The proposal needs to give a detailed description and work plan of the research project.
7. The project duration is three years, the project should involve at least three young scientists from a minimum of two countries. The principal proposer must be from a developing country.
8. The Young Scientist Project will be awarded a maximum of US $5,000 per year.
9. These funds are provided to support:
   - to organize field meetings with at least five participants, which should include the group leaders.
   - travel to IGCP-organized or any other international scientific conference
   - participation of training courses
   - research equipment (max 20% of the allocated funds).

Geoparks and the IGCP
Progress on geopark activities were discussed during the 29th session of the IGCP Board (see Geological Correlation No. 29, p. 18). There it was reported that the Division of Earth Sciences has included geological heritage in its current work plan, envisaging bilateral cooperation with Member States who express interest in receiving UNESCO’s patronage for national geological parks. Taking this into account, UNESCO’s Division of Earth Sciences encourages to build up an International Network of National Geological Parks (Geoparks). In 2001, the following Board Members have agreed to continue to contribute in their personal capacity to the geological heritage activities: P. Jakeš (Czech Republic), A. Kampunzu (Botswana), V. Ramos (Argentina) and X. Zhao (China). During the current session of the Board, in addition, S. Turner (Australia) and S. Muhongo (Tanzania) and G. Wörner (Germany) volunteered to join this group of geopark experts. The Board further suggested to involve on the national level museums and others who have already established Natural Parks or “open-air museums”. The procedure for requesting UNESCO’s patronage for a geological park is not yet defined but guidelines for application are in preparation. These forms will have to be submitted from a high level, e.g. government, to Earth Sciences Division, UNESCO, who seek advice from an independent group of experts in geological heritage, including IGCP Board Members.

Summary of IGCP National Committee Reports
As of 4 February 2002, the following 36 IGCP National Committees have sent their annual report to the IGCP Secretariat:

Australia | Cyprus | New Zealand
Austria | Czech Republic | Russia
Argentina | Finland | Slovak Republic
Belarus | France | Slovenia
Belgium | Germany | South Africa
Brazil | Hungary | Spain
Bulgaria | Italy | Sweden
Canada | India | United Kingdom
China | Iran | Ukraine
Congo (DR) | Japan | Venezuela
Costa Rica | Kazakhstan | Viet Nam
Croatia | Korea Rep. of | Yugoslavia

Prof. Wilson summarized the Board’s comments who had studied the National Committee reports. It was stated that relatively few developing countries submitted a report. The nature of the reports is extremely variable. Some are very informative, enabling the Board to evaluate the level of activity within the IGCP and the effectiveness of the National Committee in promoting IGCP projects within the national geoscience community. A number of reports provide information about additional sources of funding raised to support IGCP projects and output performance indicators in the form of lists of publications and organization of national/international symposia. IGCP activities are clearly strongly supported in some countries, whilst in others there appears to be minimal interest in the programme at national level.

The report of the Italian IGCP National Committee is commended as a model which could usefully be adopted by all IGCP members countries. This report is presented...
in the form of an attractive newsletter, supported by a website. The newsletter is widely circulated within the Italian geoscience community and appears to be an extremely effective way of encouraging increased participation within IGCP. It includes a useful summary of sources of funding for geological research in Italy, brief descriptions of new IGCP projects and a comprehensive list of all current IGCP projects. Names and e-mail addresses are given for all project leaders. Also included as a useful summary of the minutes of the 2001 IGCP Scientific Board meeting.

The Board also commends the following National Committees for submitting extremely informative and comprehensive reports: Brazil, Australia, France.

A significant number of National Committees have now established their own websites. This is an excellent and low-cost way of disseminating information about the IGCP and encouraging wider participation in IGCP projects; those which have not done so yet are encouraged to set up websites at the earliest possible opportunity.

Re-election of the IGCP Chairman
The Board agreed unanimously, that Prof. Dalziel, whose term at the IGCP Board would finish at the end of 2001, will continue to serve as Chairman and member of WG 4 for two more years.

IGCP and Deposit Modelling Workshop
The IGCP Secretary suggested for the next Board meeting 2003, to consider a joint workshop of IGCP and the Deposits Modelling Programme for about 1/2 a day.

Any matters arising
During the course of the assessments of annual reports and new project proposals, important financial matters were raised. As the IGCP budget is shared between UNESCO and the IUGS, Dr Janoschek, the IUGS Treasurer, who attended the closed sessions representing the IUGS Secretary-General (Ex-officio member of the Board), suggested that the Board should also invite the Treasurer of IUGS to attend the meetings, so that the IUGS financial status of support for IGCP can be properly conveyed. The Board agreed to this proposal.

UNESCO Headquarters, 3-7 February 2003.

The Chairman thanked all Members of the Board and closed the meeting at 17:20 hours.

15. Report of the IGCP Secretary for 2001
Introductory remarks
"Reluctantly, I take the sad task to start this report with the news of the sudden passing away of dear Sally Cochrane in December 2001, thus ending several years of suffering and at the same time never complaining. Sally has worked for 12 years for the IGCP and retired in November 2000. In the name of the colleagues and friends, we have expressed our deepest sympathy to her family at this time of profound grief and loss. Many of you have known Sally, she was a most precious friend and colleague to all of us. We will cherish the memory of her radiant presence among us.

The sudden passing away of the former IGCP Board Member and Co-Leader Professor Chris Powell (IGCP 440) in July was another major moral setback happening in 2001. The members of his project dedicated a special volume to his tireless efforts in uniting scientists worldwide to the cause of Rodinia. I would like to thank Professor Derbyshire of having contacted the widow of our dear friend.

Coming back to business as usual:
In 2001, basing on the important decision taken by the 29th IGCP Board, to change the name of the International Geological Correlation Programme (IGCP) into International Geoscience Programme, the IGCP Secretariat undertook an enquiry at its National Committees (see attachment 1). I recall that the change was proposed in accordance with both, the IUGS Executive Council which agreed to it at its session in Hyderabad, India, February 2001 and with the Director-General of UNESCO. An overwhelming majority of 38 Committees out of the 44 which have replied, supported the idea of a change, whereas five National Committees were against it and the Chinese Committee suggested to adopt a different name (International Geoscience Cooperation Programme). Now, for the name change to take effect, the matter will be submitted for decision to UNESCO’s Executive Board at its 164th Session in Spring 2002. Until the Executive Board’s final decision, the IGCP remains the International Geological Correlation Programme.

The Secretariat further undertook steps to improve the annual reporting procedure. In order to obtain more detailed information and facilitate the editing of Geological Correlation, the format or the IGCP Report Form was slightly modified (see attachment II). Special attention is now drawn to website addresses, and educational, training or capacity building activities.

After more than two years, the vacancy in the IGCP was finally filled by Margarete Patzak who was appointed as the IGCP Assistant Secretary. She has been working for the Programme since January 1996."

Thanks to the outgoing members of the Scientific Board
In 2001 five members of the Scientific Board retired: WG 1: Stratigraphy, Palaeontology, Sedimentology, Fossil Fuels
Dr Edward Robinson (Jamaica)
WG 2: Quaternary, Environmental and Engineering Geosciences
Prof. Edward Derbyshire (United Kingdom), the Board’s Chairperson
Dr Isabelle Niang-Diop (Senegal)
Prof. Nozar Samani (Iran)

WG 3: Mineral Deposits, Petrology, Volcanology, Geochemistry
Dr Petr Jakes˘ (Czech Republic)

New members of the Scientific Board
Five new members to the IGCP Scientific Board have been appointed out of about 100 nominees for the term 2002-2005, by a joint decision of the Director-General of UNESCO, Koïchiro Matsuura and the President of the International Union of Geological Sciences (IUGS), Prof. Ed de Mulder. With regard to an increased participation of women in our scientific body, I am glad to announce that three highly qualified female scientists are among the new members.

WG 1: Stratigraphy, Palaeontology, Sedimentology, Fossil Fuels
Prof. Rasool Okhravi (Iran)
WG 2: Quaternary, Environmental and Engineering Geosciences
Prof. Sylvi Haldorsen (Norway)
Dr Prabhas Pande (India)
Dr Caridad Zazo-Cardeña (Spain)
WG 3: Mineral Deposits, Petrology, Volcanology, Geochemistry
Prof. Marjorie Wilson (United Kingdom)

Ongoing projects in 2001
Below are listed the project numbers of 37 ongoing and four O.E.T. projects, according to the year of their termination.

O.E.T in 2001: 386, 393, 405, 406 (four)
2001: 373, 410, 414, 415, 418, 421, 431, 432 (eight)
2002: 408, 411, 413, 419, 420, 425, 426, 427, 428, 429, 442 (eleven)
2003: 434, 436, 437, 440 (four)
2004: 430, 433, 443, 448, 449, 450, 453, 454 (eight)
2005: 447, 455, 457, 458, 459, 464 (six)

Extension requested by projects
O.E.T. (on extended term) status, extension of the duration of projects without funding for one year, has been requested by the leaders of IGCP projects 410, 414, 418, 421.

Publications
The English version of the IGCP annual report ‘Geological Correlation No. 28’ was published in Summer 2001 and distributed to IGCP National Committees, IGCP project leaders, various geoscience institutions worldwide as well as interested individuals. The French version is in print. The English version of Geological Correlation No 29 was printed in January 2002.

Websites and home pages
Most IGCP projects have now established websites which are linked with the IGCP homepage: http://www.unesco.org/science/earthsciences/igcp/index.htm
The IGCP homepage is regularly updated with the latest events
The IGCP homepage is also linked with IUGS, Episodes and the few IGCP National Committees which have established their website. (Australia, Austria, China, Czech Republic, Germany, Hungary, republic of South Africa, and Spain and Turkey).
Links are established with all IGCP projects having their home pages available on the world wide web:

Finances
The statistics of IGCP project’s financial situation from 1988 to 2001 is listed in Table 1.

Table 1

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Table 2

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</table>

Since 1994, over 30% of the IGCP budget has been decentralized. In 2001, 11 projects have been decentralized to the UNESCO Offices in the following cities: Jakarta (4 projects), Montevideo (2 projects), Cairo (2 projects) and Nairobi (3 projects). A separate contract was established with one individual project, for administrative reasons.
Project proposals received in 2001

No.
title, project leader(s), duration

463 Upper Cretaceous marine red beds
C. Wang (China), M. Sarti (Italy), R. W. Scott (United States), L. F. Jansa (Canada)
2002-2006

465 Drought and excess rainfall: associations with teleconnection patterns (ENSO and NAO)
S. M. Jafar Nazemosadat (Iran), Nozar Samani (Iran), S. Amin (Iran)
2002-2006

466 Characterization of active faults in slowly deforming regions
J. Gomberg (United States), E. Schweig (United States)
2002-2006

467 Triassic time
M. J. Orchard (Canada)
2002-2006

468 Archaeometry of ancient metals
G. Walach (Austria)
2002-2005

469 Variscan floristics and palaeoenvironments
C. J. Cleal (United Kingdom)
2002-2006

470 The 600 Ma Pan-African belt of Central Africa
F. Toteu (Cameroon)
2002-2006

471 Evolution of Western Gondwana during the Late Palaeozoic
C. O. Limarino (Argentina), L. A. Buatois (Argentina)
2002-2006

472 Étude et valorisation des argiles (EVA) en zone Intertropicale
(Study and valorization of clays in the Intertropical region)
L. R. Okitaudji (RD Congo)
2002-2006

473 GIS Metallogeny of Central Asia (Young Scientists Proposal)
R. Seltmann (United Kingdom), 5 young scientists
2002-2006

IGCP Secretary’s missions in 2001

F. W. Eder participated in conferences and/or international meetings and promoted the IGCP on missions to: Tokyo (Japan), Strasbourg (France), Cairo (Egypt), Edinburgh (UK), Beijing (China), Nicosia – FOREGS (Cyprus).

Prof. Victor Ramos, Argentina, organized in cooperation with Fernando Repetto a Regional IGCP Workshop at the XII International Geological Congress of Latin America, held from 12 to 16 November 2001 in Montevideo, Uruguay.

Annual Reports from IGCP National Committees

Out of 102 listed IGCP National Committees the following 34 countries have reported as of 1 February 2002:

Australia  Czech Republic  Slovak Republic
Austria  Finland  Slovenia
Argentina  France  South Africa
Belarus  Germany  Spain
Belgium  Hungary  Sweden
Brazil  Italy  United Kingdom
Bulgaria  Iran  Ukraine
Canada  Japan  Venezuela
Congo (DR)  Kazakhstan  Viet Nam
Costa Rica  Korea Rep. of  Yugoslavia
Croatia  New Zealand
Cyprus  Russia

IGCP projects active in 2001
(O.E.T. – on extended term)

373 Correlation, Anatomy and Magmatic-Hydrothermal Evolution of Ore-Bearing Felsic Igneous Systems in Eurasia
R. Seltmann (Germany), R. Grauch (United States), A. A. Kremenetsky (Russia)
1997-2001

386 Response of the Ocean/Atmosphere System to Past Global Changes
H. Strauss (Germany), D. M. Banerjee (India), L. A. Derry (United States), Z. Sawlowicz (Poland), L. R. Kump (United States)

393 Neritic Middle-Upper Eocene
E. Caus (Spain)

405 Anthropogenic Impact on Weathering Processes
P. Sulovský, J. Zeman (Czech Republic)

406 Circum-Arctic Palaeozoic Vertebrates
M. V. H. Wilson (Canada), T. Märs (Estonia), P. Männik (Estonia)

408 Rocks and Minerals at Great Depth and on the Surface
F. P. Mitrofanov (Russia), D. M. Guberman (Russia), H.-J. Kümpel (Germany)
1998-2002

410 The Great Ordovician Biodiversification Event
B. D. Webby (Australia), F. Paris (France), M. L. Droser (United States)
1997-2001

411 Geodynamics of Gondwanaland-derived Terranes in E and S Asia
S. Hada (Japan), I. Metcalfe (Australia), J. H. Kim (Korea), Tran Van Tri (Viet Nam), Jin Xiouchi (China)
1998-2002
413 Understanding Future Dryland Changes from Past Dynamics
D. Thomas (United Kingdom),
A. K. Singhvi (India)
1998-2002

414 Seismic Ground Motion in Large Urban Areas
G. F. Panza (Italy)
1997-2001

415 Glaciation and Reorganization of Asia’s Drainage
J. T. Teller (Canada), R. Vaikmae (Estonia)
1997-2001

418 Kibraran Events in Southwestern Africa
R. M. Key (United Kingdom),
R. B. Mapeo (Botswana)
1997-2001

419 Foreland Basins of the Neoproterozoic Belts in Central-to-Southern Africa and South America
M. Wendorff (Botswana), P. L. Binda (Canada)
1998-2002

420 Phanerozoic Crustal Growth
Bor-ming Jahn (France), N. L. Dobertsov (Russia)
1998-2002

421 North Gondwanan Mid-Palaeozoic Biodynamics
R. Feist (France), J. A. Talent (Australia)
1997-2001

425 Landslide Hazard Assessment and Cultural Heritage
K. Sassa (Japan), P. Canuti (Italy),
P. Carreno (Peru)
1998-2002

426 Granite Systems and Proterozoic Lithospheric Processes
J. S. Bettencourt (Brazil), O. T. Rämö (Finland),
W. R. Van Schmus (United States)
1998-2002

427 Ore-Forming Processes in Dynamic Magmatic Systems
C. M. Lesher, S.-J. Barnes (Canada),
H. M. Prichard (United Kingdom)
1998-2002

428 Climate and Boreholes
V. Čermák (Czech Republic), H. N. Pollack
(United States), C. Clauser (Germany)
1998-2002

429 Organics in Major Environmental Issues
J. Pašava (Czech Republic),
J. Jeník (Czech Republic)
1998-2002

430 Mantle Dynamics and Natural Hazards
M. F. J. Flower (United States), V. I. Mocanu
(Romania), R. M. Russo (United States),
Nguyen Trong Yem (Viet Nam),
Ma Zongjin (China)
2000-2004

431 African Pollen Database
A. M. Lezine (France), A. Sowunmi (Nigeria)
1998-2002

432 Contourites, Bottom Currents and Palaeocirculation
D. A. V. Stow (United Kingdom), I. N. McCave
(United Kingdom), J.-L. Faugeres (France)
1998-2001

433 Caribbean Plate Tectonics
M. A. Iturralde-Vincent (Cuba),
E. G. Lidiak (United States)
2000-2004

434 Land-Ocean Interactions during the Cretaceous in Asia
H. Hirano (Japan)
1999-2003

436 Pacific Gondwana Margin
R. J. Pankhurst, (United Kingdom),
J. D. Bradshaw (New Zealand),
L. Spalletti (Argentina)
1999-2003

437 Coastal Environmental Change during Sea-Level Highstands
C. V. Murray-Wallace (Australia)
1999-2003

440 Rodinia Assembly and Breakup
C. McA. Powell (Australia) deceased 2001,
S. Bogdanova (Sweden),
H. Kampunzu (Botswana)
1999-2003

442 Raw Materials of Neolithic Artefacts
D. Hovorka (Slovak Republic),
G. Trnka (Austria)
1999-2002

443 Magnesite and Talc-Geological and Environmental Correlations
M. Radvanec (Slovak Republic), W. Prochaska
(Austria), A. C. Gondim (Brazil),
Cai Kequin (China)
2000-2004

444 Proterozoic Molar-tooth Carbonates
X. Meng (China), D. G. F. Long (Canada),
R. Bourrouilh (France)
2001-2005

448 World Correlation on Karst Ecosystems
Yuan Daoxian (China), C. Groves (United States),
G. Messana (Italy)
2000-2004

449 Global Correlation of Late Cenozoic Fluvial Deposits
D. Bridgland (United Kingdom)
2000-2004

450 Proterozoic Sediment-Hosted Base Metal Deposits of Western Gondwana
S. S. Iyer (Canada), A. F. Kamona (Namibia),
A. Misli (Brazil), J. Cailteux (DR Congo)
2000-2004

453 Modern and Ancient Orogenes
J. B. Murphy (Canada), J. D. Keppie (Mexico)
2000-2004

454 Medical Geology
O. Selinus (Sweden), P. Bobrowsky (Canada)
2000-2004
455  Basement Volcanoes Interplay and Human Activities
A. Tibaldi (Italy), M. Garcia (Spain),
A. M. Lagmay (Philippines), V. V. Ponomareva (Russia)
2001-2005

457  Seismic Hazard and Risk Assessment in North Africa
D. Benouar (Algeria), G. Panza (Italy),
A. El-Sayed Attia (Egypt), T. Benaissa (Morocco),
M. Chadi (Tunisia), S. Abdennur (Libya)
2001-2005

458  Triassic/Jurassic Boundary Events
J. Pálfy (Hungary), S. P. Hesselbo (United Kingdom), C. McRoberts (United States)
2001-2005

459  Terrestrial Carbon Cycle
J.-L. Probst (France), L. François (Belgium),
P. J. Depetris (Argentina), J. Mortatti (Brazil)
2001-2005

464  Continental Shelves During the Last Glacial Cycle: Knowledge and Applications
F. L. Chiocci (Italy), A. R. Chivas (Australia)
2001-2005

Funded projects 37
O.E.T. 4
Total 41
Summary of major past achievements
of the Project

IGCP 368 started in February 1995 and ended formally in February 2001. However, its activity culminated in October when the summary symposium of the project, the International Symposium on the Assembly and Breakup of Rodinia and Gondwana, and Growth of Asia (ISRGGA) was held in Osaka jointly with IGCP 411 and 440. IGCP 368 continues to be active, aiming to publish the proceedings volumes of its meetings. During the past seven years since the start of the project, important contributions were made to the understanding of Proterozoic tectonothermal events and tectonics in East Gondwana, especially on the India-Antarctic sector. Exchange of ideas and information among members of the project were facilitated through two kinds of newsletters (IGCP 368 News Letter and Gondwana News Letter) and several international as well as regional meetings. Through these activities, international collaboration started, especially research on the Precambrian Indian Peninsula, Antarctica, and South Africa. As a result of the scientific activities, 15 memoir volumes or similar kind of publications, 5 symposium proceedings, 12 field guidebooks, and 7 special issues of international journals were published. Several volumes or thematic issues of international journals are in progress.

Many scientists from developing countries joined the project, attended its meetings and were encouraged to join international joint research programmes as well. Through the activities of the project, an international society related to the Gondwanaland research (International Association for Gondwana Research, IAGR) was established and a new international geoscience journal (Gondwana Research) was inaugurated (17 published issues since October 1997 to the present). This journal has stimulated research related to Gondwanaland, and encouraged scientists from developing countries to approach this international journal. The journal has been indexed/abstracted in SCI Sci. E, ISI Alerting Service, Current Contents, Georef., Chemical Abstracts, Mineralogical Abstracts etc. Since 1995, over 29 students/young scientists from developing countries were admitted, by the activity of the members of the Japanese Working Group of the project, to study in Japan either to join the IGCP project, or to study in other fields of geosciences.
Achievements of the project
from October 2000 to October 2001

General scientific achievements

1. Pan-African Amalgamation of East Gondwana: A growing new idea

Delineation of a Pan-African orogen or a suture at Larsemann Hills have drastically changed the classical idea that East Gondwana assembled during ca 1.0 Ga. Grenvillian Circum East Antarctic Orogeny to a radical view that East Gondwana no more existed during most of the Neoproterozoic, but assembled during the Pan-African orogeny paralleling in time with the formation of West Gondwana. Following the identification of the Pan-African orogeny at Larsemann Hills, some scientists delineated a Pan-African suture running through the Prydz Bay area to Leeuwin Complex of Western Australia, and tried to delineate a suture along the present crustal boundaries between Antarctica, India and Sri Lanka, having stressed the amalgamation of East Gondwana during the Pan-African period. Other researchers proposed the double stage closure of sutures from west to east, i.e. first the East African Orogeny along the Mozambique Belt, and second, the KUUNGA Orogeny having taken place between the Mawson Protocontinent and India-Madagascar-Sri Lanka-Coastal East Antarctica continent.

Fitzsimons (2000, op cit) proposed to differentiate the Grenvillian aged coastal areas of East Antarctic shield into three segments divided by two major Pan-African sutures. He identified that the so far recognized Grenvillian belt surrounding East Antarctica (the Circum East Antarctic Orogen) could not be regarded as one continuous mobile belt, but should be differentiated into three distinct and different crustal segments. They are, based on ages of high-grade tectonic events, the Maud (1090-1030 Ma), Rayner (990-900 Ma) and Wilkes (1330-1130 Ma) provinces from west to east. A Pan-African East African Orogen including the wide areas from Lutzow-Holm Bay to Central Dronning Maud Land, and the Prydz-Denman-Darling orogens have been identified to have had a principal role in assembling the above three provinces with broad Grenvillian ages. The idea of Fitzsimons (2000) was promptly followed by several papers of continental configurations during the Neoproterozoic, incorporating the idea of the dispersal of East Antarctica in earlier ages than Pan-African times. However, the data supporting the new model are as yet insufficient as discussed below.

The idea of the amalgamation of three different crustal blocks with broad Grenvillian ages along the East Antarctic coast took place during the Pan-African times (Fitzsimons, 2000) clearly presents a summary of recent studies by several authors, which stress distinct and strong Pan-African events in Lutzow-Holm Bay, Prydz Bay, and Central Dronning Maud Land. As discussed above, the development of Pan-African tectonothermal events in the above areas as well as the Leeuwin/Darling-Dannman Glacier area have been well recognised, and the areas with the Pan-African ages can be regarded as Pan-African orogens, especially those areas such as the Lutzow-Holm Bay area, Central Dronning Maud Land and Prydz Bay area, where related convergent tectonics have been clearly identified. The extent of these belts having some hundreds km wide as demonstrated by Fitzsimons (2000) appears also reasonable from the field data as well as a common sense of ordinary orogenic belt. However, the point to be noticed is the principal signature of the orogenic belt, i.e. either it was intracratonic, intercratonic, and if the latter case, the separation was small or big.

There is good correlation of the Adelie Land and southern Australia, this sector forms a distinct Paleoproterozoic continental block. This part may form the Mawson Protocontinent, although there are no sufficient data to make it separate from East Gondwana during the Grenvillian time. Existence of different Pre-Grenvillian histories are generally expected signatures to a composite shield assembled by the Grenvillian Orogeny; thus, both Enderby Land and Western Dronning Maud Land also apparently show distinct pre-Grenvillian geo-histories. Regarding the remaining segments, there is as yet no sufficient data to convince us to recognise two or three different Grenvillian-aged provinces. Throughout these segments, there are indications of the Grenvillian events with an age range of ca 0.9 0 Ga to 1.20 Ga. In the Wilkes Land-SW Australia segment, there is good correlation of the Albany-Flaser belts with western Wilkes Land (ca 1.15-1.40 Ga) in the east, which is the combination of early events in the Flaser Belt and later events in both the Flaser and Albany belts. The Pinjara (Darling) Belt is continuous with the Obruchev Hills-Denman Glacier area (ca 1.02-1.08 Ga) in the west and this belt is somewhat younger. The late Grenvillian age range of ca 1.0-1.2 Ga, developed in the western part of the Australia-Antarctic segment as mentioned above, has a general conformity with the ages of Rauer Group. There are also similar ages (of ca 1.0-1. Ga) from Rayner Complex, Lutzow-Holm Bay area, and Dronning Maud Land. The Rayner Complex of Enderby Land was affected by the intrusions of late orogenic granitic/charnockitic rocks and thus ca 900-1000 Ma ages are dominant.

It is evident that extensive Pan-African orogenic belts run cutting across the Circum East Antarctic Orogen as demonstrated by Fitzsimons (2000). However, almost all these Pan-African areas carry distinct evidence of Grenvillian components of the above age range, strongly suggesting the continuation of the Grenvillian Belt (Circum East Antarctic Orogen) surrounding East Antarctica from Western Dronning Maud Land to the western Wilkes Land which branches into the Pinjara Orogen to the north as well as the Albany Belt to the east (the latter may be the intracontinental belt). There are also 1050-1080 Ma K-A ages from the central
Wilkes Land suggesting the development of an intracontinental branch of the Albany Belt to extend further east along the Antarctic coast. Ca 1.3-1.4 Ga events in the Wilkes Land-Albany Flaser Belt segment representing the early phase of the Circum East Antarctic Orogeny only developed at this sector; similar two phases of Grenvillian Orogeny have been reported in other Grenvillian terrains.

During the Pan-African time, much of these areas suffered extensive metamorphism and deformation, although intensity of deformation and grade of metamorphism varied. The Pan-African Leeuwin Complex/Darling Belt-Denman Glacier belt is considered to be underlain by a Grenvillian Pinjara (Darling) Orogen which is traced from the Northampton Complex to the Obruhev Hills east of the Denman Glacier through the basement of Perth Basin. Possible comparison of the Palaeoproterozoic events in the Central Indian Tectonic Zone with those of the Caprorn Orogen in northwestern Australia as well as the ca 1.0-1.2 Ga events in the former with those in the Albany Belt appear to indicate an important role of the Pinjara Orogen for the changing shape of configuration in time of East Gondwana during the Grenvillian Central East Antarctic Orogeny.

Based on the synthetic considerations of all the above arguments, the Pan-African events are mostly the superposition-reworking of pre-existent crust as has been suggested by earlier studies. Distinct Pan-African orogens delineated through the southern Prydz Bay area may be interpreted as the intracratonic orogens. Shackleton Range-Dronning Maud Land zone possibly represents a principal suture, along with the Zambezi Belt in southern Africa, to continue from the Mozambique Belt. However, further studies from both areas as well as critical palaeomagnetic studies are awaited. The model of the intracratonic Pan-African rejuvenation above is considered similar to that, which included various structural disturbance such as thrust-nappe structures, horizontal shearing, and extensions, associated with various magmatic and metamorphic events, principally under the intracratonic conditions.

2. Possible Approach to Constrain the Role of Pan-African Events in East Gondwana

Regarding the assembly of major parts of East Gondwana during the Pan-African period, it is pointed out that the present stage of knowledge concerning East Gondwana is still insufficient to accept the new model. To further constrain the role of Pan-African events within East Gondwana, that is, within and around East Antarctica, detailed geological, palaeomagnetic, and geophysical research is required. Such detailed structural studies associated with petrological and geochronological work as shown by several recent papers as cited above will provide good constraints to the role of Pan-African events in East Gondwana – those studies should be accompanied with careful examination of SHRIMP data from those areas. It is specifically noteworthy that zircon grows under low grade fluidus conditions especially with K-rich fluid. Pan-African zircon ages such as from the Lutzw-Holm Bay, western Rayner Complex, Prydz Bay area and Mawson Escarpment etc. do not necessarily show the extensive high grade metamorphism in these areas, but low grade fluidus and/or high shearing metamorphism. Similarly, inappropriate conditions for the zircon growth should also be taken into consideration; dry and less deformed conditions prevent the zircon growth even under high-grade conditions.

Palaeomagnetic studies, if appropriately conducted, may be decisive for the configuration of East Gondwanan crustal fragments during the Pan-African period. The extent of the actual separation of cratons on both sides of a suture running from the Shackleton Range to Mozambique Belt through Dronning Maud Land can only be ascertained by palaeomagnetic studies. However, palaeomagnetic studies in Precambrian terrains involve great difficulties in the sparse occurrence of appropriate rocks, as well as uncertainties of time of magnetisation especially related with remagnetization phenomena due to metamorphic, and even often polymetamorphic character of these terrains. Detailed petrology-related geochronology should be therefore associated with palaeomagnetic studies. Buchan et al. (2000, Tectonophys., 319) recently pointed out that there are only a few reliable palaeomagnetic data to be useful for Precambrian –Early Palaeozoic supercontinental reconstructions, and Meert (2001, op cit) stressed that the present database from Proterozoic East Gondwana is quite insufficient to present any definite model for the palaeogeography during Proterozoic times. Torsvik et al. (2001, op cit) suggested that East Gondwana no more existed during most of the Neoproterozoic times and that it should have assembled during the Pan-African period. However, data supporting their argument are very scarce, and some are not conclusive on the age of magnetisation. Reports of Rathor et al. (1999, Gondwana Res., 2) on Malani igneous rocks and Suwa et al. (1994) from Seychelles, have provided a possibility of Late Pan-African rejuvenations, and may throw a critical question on their age of magnetisation that were regarded to be ca 750 Ma in recent palaeomagnetic studies. Geophysical data especially geomagnetism and gravity are expected to provide valuable constraints to the above problem. Seismological studies to exemplify deep crustal transect crossing critical orogenic belts may also provide a decisive evidence. Further intimate collaborative studies of geology with palaeomagnetism and geophysics are the most important and urgent requisite for the unravelling the Neoproterozoic tectonics of East Gondwana.

Meetings held (October 2000 – October 2001)

23 December 2000: Student Symposium of UNESCO-AIEJ (Association of International Education in Japan) Youth Exchange Programme, 2000-2001. It was held at
the Department of Geological Sciences, Jadavpur University, Calcutta, India. About 50 scientists and students from India, Japan, Nepal and Sri Lanka joined, and 9 presentations were delivered.

27 December 2000: AIEJ/UNESCO/IGCP368 General Symposium on the Central Indian Tectonic Zone and Related Areas. It was held at the Department of Geological Sciences, Jadavpur University, Calcutta, India. About 40 scientists from 5 countries attended and 8 presentations were delivered.

17-19 January 2001: International Geoscience Symposium on Tectono-Metamorphic History of East Gondwana, Geochronological and Petrological Approach. Held at Simulation Science Center, Okayama University of Science, Okayama, Japan, sponsored by the Research Institute of Natural Sciences, Okayama. 38 presentations were given, and about 60 scientists from 5 countries participated.

17-25 March 2001: International symposium and field workshop on Tectonics and Mineralization in the Arabian Shield and its Extensions, sponsored by IGCP-368. It including the symposium in Jeddah for 2 days and field workshop from Jeddah to Lyad for 6 days. About 300 scientists from 12 countries assembled the symposium, and 25 scientists from 10 countries joined the field workshop. The volume of 38 extended abstracts for the symposium appeared as a special issue of Gondwana Research, and the proceedings volume collecting full papers are in progress and will shortly appear as a special issue of Gondwana Research.

4-6 June Special session of “Assembly and Breakup of Rodinia and Gondwana: Crustal and Mantle Processes” during the 2001 Japan Earth and Planetary Science Joint Meeting, Tokyo. About 50 scientists attended and 15 presentations were given.

18-19 October Tokyo, 21st Symposium on Antarctic Geosciences. About 100 scientists attended.

19 October–3 November 2001: International Symposium on the Assembly and Breakup of Rodinia and Gondwana, and Growth of Asia and related field workshops. About 340 scientists from 31 countries assembled in the symposium, and about 80 scientists joined to 5 field trips attached with the symposium. Some details are given in separate report of ISRGA. 272 Extended abstracts were assembled in a special issue of Gondwana Research, and 22 late abstracts were collected as Miscellaneous Publication (No. 12) of Gondwana Research Group.

List of most important publications

Publications are grouped in the following categories:

* Contribution from IGCP-368, with a clear indication on the cover or first page etc.

# Contribution from the joint organization with IGCP-368, with indications on the cover or in the first page of the book

@ Contributions by other group/organization in which many members of the project joined


@Polar Geoscience, No. 13, 2000, National Institute of Polar Research, Tokyo, 203 pages. 7 papers by IGCP-368 members are included.


@Polar Geoscience, No. 14, 2001. National Institute of Polar Research, Tokyo, 264 pages. 10 papers by the IGCP-368 members are included.

@Rogers, J. J. and Santosh, M. (eds), 2002, Mesoproterozoic Supercontinent. Special Issue, Gondwana Research, 5, 3-255. Seventeen papers by IGCP-368 members were included.

*Santosh, M., Biju-Sekhar, S. and Shabeer, K. P. (eds), Rodinia, Gondwana and Asia (extended abstracts, ISRGA), special issue of Gondwana Research 4, 555-850.


R. Seltmann, Natural History Museum, Department Mineralogy, Cromwell Road, London SW7 5BD, United Kingdom, e-mail: rs@nhm.ac.uk

R. I. Grauch, United States Geological Survey (USGS), MS 973 Denver Federal Center, Box 25046, Denver, Colorado 80225, United States, e-mail: rgrauch@usgs.gov

A. A. Kremenetsky, Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements, 15 Veresaeva Str., 121 357 Moscow, Russia, e-mail: krem@imgre.iitp.ru

Website of the project
http://www.nhm.ac.uk/mineralogy/seltmann/IGCP/index.html

Participating countries
(*indicates the countries active 2001)


Summary of major past achievements of the project

The project achieved all its goals and exceeded with its products the originally set objectives (three monographs, 7 reference guidebooks, 3 maps, about 300 mostly peer-reviewed original research papers). During the 5 funded years of IGCP 373 about 300 scientists from 45 countries were involved or contributed to the project research. The project has successfully brought together researchers with expertise on the origin and evolution of silicic ore-bearing magmatic systems, mainly to catalyze collaboration and ‘know-how’ exchange of specialists from the states of the former Soviet Union with “the rest of the world”. The approach is multidisciplinary and multi-methodological and focuses on the Trans-Eurasian metallogenic belt related to Variscan granites.

Rock textural features, specifically fluid saturation textures, help constrain pT conditions used in modeling fluid-rock reactions and the genesis of granite-related ore deposits. Using a complex pattern of signatures to evaluate textural and chemical characteristics of the anatomy of the studied plutons have, in most cases, yielded significant conclusions on their ore-bearing potential. High-level granitic systems and their volcanic counterparts are characterized by advanced fractionation processes and intensive fluid/rock reactions. Volatile components such as H2O, CO2, F, Cl, B, P and Li have a fundamental influence on melt structure and viscosity, with implications for magma ascent and intrusion. Their effects on the melt phase and presence in exsolved fluids result in a wide spectrum of features including:

- textural: rhythmic mineral zonation, magmatic foliation, quenching fabrics, subsolidus recrystallization, breccia pipes,
- physical: phase separation, hydraulic fracturing, explosive degassing, and
- chemical: unusually trace-element-enriched melt compositions, formation of brines, rare-element mineralization, etc.

Furthermore, volcano-plutonic systems strongly affect the atmosphere and hydrosphere through their release of a variety of gases into the atmosphere. Studies of the mechanics of degassing and magma dynamics provide the means to interpret gas compositions and periodicity of gas release from volcanoes and high-level intrusions.

Achievements of the project this year

Since 2001 IGCP 373 is coordinated from the new Center for Russian and Central Asian Mineral Studies (CERCAMS) at NHM London and the initiative to form CERCAMS is itself a result of this project. There is close cooperation between currently European scientists and teams from the former Soviet Union. Most recently scientists from the mining industry joined the project due to its relevance for basic and applied research on prospecting and exploration targets in the former Soviet Union, specifically in the Urals, Siberia and Central Asia. Project participants attended the successful meetings in Germany, Poland and Kyrgyzstan and contributed to publications. Case studies on the anatomy, textures and magmatic-hydrothermal evolution of ore-bearing granitic systems were continued in Eurasian rare-metal provinces and mineralized porphyry systems to correlate deposit controls in different mineralized settings. About 50 original papers have been published under the auspices of the project during 2001. Impact publications were papers in Tectonophysics, in the SEG Newsletter, the Balkema Proceedings of the Krakow meeting (with 37 edited papers), the reference guidebook on gold mineralization in the Tien Shan, and new metallogenic maps (Urals, Kyrgyzstan). The latter will be presented as IGCP products at the IAGOD Symposium in Namibia. Forthcoming meetings in 2002 (OET) will be in Namibia, Germany and England (business meeting and workshop organized from the UK team). A final IGCP 373 publication is under preparation for the Special Publication Series of the Geological Society of London.
General scientific achievements

The societal relevance of this project arises from the fact that many economically important resources are hosted by these granites, which is specifically vital for the development of the mineral potential of ‘transition economy’ states that are within the focus of the project’s research. A number of achievements have emerged from studies of the anatomy, textures and magmatic-hydrothermal evolution of ore-bearing granitic systems that have been carried out in rare-metal provinces of Eurasia that are related to collisional orogens. The relations between crustal structure, geodynamic position in the orogenic cycle, and the role of fluids during granite fractionation have been shown to be the fundamental parameters in the formation of granite-related ore deposits. A complex of correlation criteria has been developed to compare/correlate the geotectonic, petrodeposits. Individual case studies on ore-related, genetic and metallogenic characteristics of rare-metal granites have been prepared and a reference guidebook printed as a guidebook to document the progress in the understanding of the Central Asian gold belt, its mineralized granites, geodynamic controls and environmental impact of mining activities in the Tien Shan. Sustainable use of mineral resources is and will be a major factor to develop the transition economy in the Central Asian countries of the CIS, addressing know-how transfer through training and cooperation the major societal benefits. Field conference topics (for further details see conference website) were:

- Types and features of gold mineralization generated in different geodynamic environments
- Petrology, mineralogy and geochemistry of mineralized series and related host rocks
- Ore mineralization and wallrock alteration related to granites and porphyries.

Meetings


This international workshop was coorganized by the German team of IGCP 373 to study and compare the relationship of tectonics and magma processes on the example of Lusatian and Bohemian granites, and dedicated to Hans Cloos who initiated granite tectonic research in modern style (70 participants from 10 countries).

Outcome: Special issue of IGCP 373 in Zeitschrift fuer Geologische Wissenschaften (peer-review, volume in print), partial support through German NC IGCP.


The 5th annual field conference of IGCP 373 was attended by 70 participants (workshop sessions at Kyrgyzaltyn Bishkek); the field excursion had about 40 participants from 19 countries. Selected trip participants (20) from the former Soviet Union and China were co-sponsored by IGCP-IUGS-UNESCO, IAGOD, SEG, SGA, Royal Society, DFG, RAS-RFFI and mining companies. The German Foreign Ministry contributed through the German National Committee for IGCP towards the organizational expenses. The overall budget of the conference exceeded again the 60,000 USD level (subsidized travel expenses of participants from former Soviet Union, preparation expenses, conference budget with accommodation and meals, conference hall rental, transport expenses including two charter flights to remote gold deposits in the Tien Shan, and publication of reference guidebook and new metallogenic map of Kyrgyzstan). Beside the IGCP 373 office at NHM CERCAMS London, the Institute of Geology of the National Academy of Sciences of the Kyrgyz Republic and the Kyrgyz Geological Survey were the main organizers. Major mining companies active in the gold province provided financial support to cover the budget of the venture ( Cameco-Kumtor, Kyrgyzaltyn, NOROX, Newmont, Alex Stewart Assayers, Indochina Gold/Ivanhoe Gold Mining). A new Metallogenic Map of Kyrgyzstan was prepared and a reference field guidebook printed as a monograph to document the progress in the understanding of the Central Asian gold belt, its mineralized granites, geodynamic controls and environmental impact of mining activities in the Tien Shan. Sustainable use of mineral resources is and will be a major factor to develop the transition economy in the Central Asian countries of the CIS, addressing know-how transfer through training and cooperation the major societal benefits. Field conference topics (for further details see conference website) were:

- Types and features of gold mineralization generated in different geodynamic environments
- Petrology, mineralogy and geochemistry of mineralized series and related host rocks
- Ore mineralization and wallrock alteration related to granites and porphyries.

3. Joint Biennial SGA-SEG Conference in Krakow, Poland, 26-29 August 2001 and Final IGCP 373 Symposium, Session 5.1 ‘Mineralizing systems associated with acid and intermediate magmas’ (60 papers/participants, for programme see: http://galaxy.uci.agh.edu.pl/~sga/).

Report of the national group of the Slovak Republic

(Dr Pavel UHER)

Activities in 2001:

- Organizing of the Eurogranites international field meeting 2001 in Slovakia
- Field working meeting and sampling of mineralized granites of the Krušně Hory Mts., Czech Republic and Spiš-Gemer Mts. Slovak Republic
- Presentation of research results in the Podlesí international workshop, Czech Republic (Phosphorus-and fluorine-rich granites), international conference of the Czech tectonic group, Donovaly, Slovakia and domestic seminars.

Planned activities in 2002:

• Participation on the Eurogranites 2002 international field meeting in Italy, September 2002.
• Field and lab study of rare-element granites (Krušné Hory Mts., Spisšsko-gemerské Rudohorie Mts.).
• Publication of scientific results in international and domestic journals, active participation on conferences.

Publications:

List of most important publications (including maps)

Activities planned

General goals


Meetings

1. 11th Quadrennial IAGOD Symposium in Windhoek/Namibia, 22-26 July 2002, with an IGCP 373 Session (jointly with IAGOD-WGTT) and project business meeting; major participation of African geoscientists is expected (see also http://www.geoconference2002.com/). The aim is to summarize petrological and geochemical progress on architecture of ore-bearing plutons.

2. Participation at the Workshop ‘Physical geology of subvolcanic systems: Laccoliths, sills and dykes (LASI)’ to summarize textural and physical (rheological) progress on mineralized shallow systems http://www.geo.tu-freiberg.de/dynamo/LASI.htm

3. A final project business meeting shall take place at NHM London and is planned for Autumn 2002 along with a weekend field trip to Cornwall. Project co-leaders and key researchers from Russia, Germany, France and other countries will be invited.


H. Strauss, Geologisch-Paläontologisches Institut und Museum, Westfälische Wilhelms Universität Münster, Corrensstrasse 24, 48149 Münster, Germany, e-mail: hstrauss@uni-muenster.de

D. M. Banerjee, Department of Geology, Delhi University, Chattra Marg, Delhi 110007, India, e-mail: dhiranjanjali@id.eth.net

L. A. Derry, Department of Geological Sciences, Cornell University, 2122 Snell Hall, Ithaca, NY 14853-1504, United States, e-mail: derry@geology.cornell.edu

Helmut H. J. Geldsetzer, Geological Survey of Canada, 3303-33rd St. NW, Calgary, Alberta T2L 2A7, Canada (deceased in April 1998)
Z. Sawlowicz, Institute of Geological Sciences, Jagiellonian University, ul. Oleandry 2, 30-063 Krakow, Poland, e-mail: zbyszek@ing.uj.edu.pl

Description: Global geochemical perturbations of variable magnitude and on different time-scales are reflected in the geological record of marine sedimentary rocks. In addition, corresponding traces are also present in terrestrial sediments, all together linking the ocean-atmosphere system. The aim of the project was to utilize isotope ratios (carbon, oxygen, sulphur, strontium) and elemental abundance (notably PGE) as proxies for these changes in oceanic and/or atmospheric chemistry. Possible causes for these perturbations include geotectonic processes, biotic crises, and/or extraterrestrial impacts. Research of IGCP 386 focused on four time windows in the Palaeozoic with known global geochemical changes: the Lower Cambrian, the Ordovician-Silurian boundary, the Middle Devonian to Lower Carboniferous time interval, and the Permian-Triassic boundary.

Participating countries

Australia, Austria, Belgium, Canada, China, Czech Republic, Denmark, Estonia, France, Germany, Hungary, India, Poland, Russia, Slovenia, Switzerland, United Kingdom, United States.

Summary of major past achievements of the Project

The earth system evolution was punctuated by a series of distinct events, such as major geotectonic processes, dramatic climatic changes, distinct palaeogeographic scenarios or extraterrestrial impacts, many of which are correlated with significant biological changes which in turn serve as biostratigraphic markers. Such prominent time-boundaries are frequently also characterized by major perturbations of the global ocean/atmosphere system, as recorded through distinct variations of geochemical proxy signals. These variations are of variable magnitude and duration. Activities concentrate on four Palaeozoic time windows with known distinct geochemical and isotopic signals of global importance, notably the Lower Cambrian (545-528 Ma), the Ordovician-Silurian boundary (443-437 Ma), the Middle Devonian to Lower Carboniferous (380-345 Ma), and the Permian-Triassic boundary (260-245 Ma). Geochemical proxies (i.e. the isotopic compositions of carbon, oxygen, sulphur, strontium, abundances of PGE, REE) from relevant sedimentary sequences are utilized to trace the geochemical responses to major processes affecting the earth and its surface environments. Work included the compilation of existing and generation of new data, followed by modelling of reservoirs and fluxes.

General scientific achievements

Global geochemical perturbations of the ocean/atmosphere system are reflected in the geological record of marine and terrestrial sedimentary rocks by unusual variations of elemental abundances and isotopic compositions. Research groups affiliated with IGCP 386 successfully refined available temporal trends for the isotopic compositions (carbon, oxygen, sulphur and strontium) of seawater (and continue to do so). Efforts in respect to modelling the resulting datasets have been quite successful with regard to long-term changes, not so much however with regard to the extremely short-term fluctuations.

Meetings

1996: The inaugural meeting of IGCP 386 was held in conjunction with an SEPM/IAS meeting in Wildhaus, Switzerland. Discussions centred around the research objectives of the programme. The meeting was attended by 40-50 scientists from nine different countries.

1997: A field workshop was held in Spiti Valley, India, in order to study and sample the sedimentary sequences in the Tethys Himalaya of Himachal Pradesh. Rock units ranged in age from terminal Neoproterozoic to Early Cretaceous. 14 participants from 5 countries attended the field workshop. The purpose of this Field Workshop was to involve geoscientists from several disciplines in a cooperative study of some of the best exposed and least deformed Phanerozoic sedimentary successions of the Tethys Himalaya. Located in the exotic northern boundary of India, amidst cold Himalayan desert like environment, the Spiti region provided a unique window to several stratigraphic boundaries along a single geological section. Two major stratigraphical sections were sampled for in-depth study of geochemical signals in the rocks. These are Permo-Carboniferous and Permo-Triassic boundaries. Other boundary intervals were not systematically sampled because the Neoproterozoic-Cambrian contact was concealed under the glacial debris and Ordovician-Silurian and Silurian-Devonian boundaries were affected by palaeontological hiatuses. Following the field workshop, a one-day symposium was held at the Indian National Science Academy Auditorium in New Delhi. Presentations included those related to the regional geology, stratigraphy and paleontology of the Spiti area and correlative sequences in the Himalaya, as well as studies on the chemosтратigraphy of various boundary sections worldwide. The meeting was attended by 40 scientists from five countries and additional 10 students from Delhi University.

1998: A symposium was held at the 8th V.M. Goldschmidt Conference in Toulouse, France, presenting the objectives and scientific achievements of IGCP 386 to an international scientific audience. 60 scientists attended the full-day symposium with 17 oral and 9 poster presentations. Of these, 20 scientists from
12 countries were members of IGCP 386. Following the Goldschmidt Conference, 12 scientists from six countries participated in the 2nd field workshop of IGCP Project No. 386 “Middle Devonian to Lower Carboniferous in Belgium and Germany”. The central issue of this field workshop was a discussion of stratigraphic correlation and global geochemical perturbations within the given time interval, exemplified through typical sedimentary successions in Western Europe.

1999: A Geochemical Modelling Workshop was held two days prior to the 9th V.M. Goldschmidt Conference at Harvard University, Cambridge, MA, U.S.A. 14 scientists from seven countries attended the 1.5 days workshop, in which basic aspects of geochemical modelling as well as practical applications were presented. A final discussion in respect to solving practical problems related to time series analysis of geochemical data concluded the meeting.

2000: No formal project meeting was held during this year. An informal get-together of the co-leaders was arranged at the 31st International Geological Congress in Rio de Janeiro, Brazil. In addition, Special Symposium C-6 “Evolution of the Atmosphere, Hydrosphere and Biosphere” at the 31st IGC was co-sponsored by IGCP 386. Both co-conveners (Ján Veizer and Harald Strauss) and several speakers within this symposium are active participants of this IGCP project.

2001: The project officially terminated in 2000. Extension was granted solely for holding the final meeting in June 2001. Colleagues from Tallinn, Estonia, had volunteered to host this final conference. However, the meeting was cancelled due to an apparent lack of interest in the scientific community and a resulting expected low attendance.


F. P. Mitrofanov, Geological Institute KSC RAS, 14 Fersman Str., Apatity, Murmansk Region, 184209, Russia, e-mail: felix@geoksc.apatity.ru

D. M. Guberman, Scientific and Industrial Centre ‘Kola Superdeep’, 17 Yubileynaya Str., Zapolyarny, Murmansk Region, 184415, Russia, e-mail: kolasd@com.mels.ru

H.-J. Kümpel, GGA-Institut, Stilleweg 2, D-30655 Hanover, Germany, e-mail: kuempel@gga-hannover.de

Description: The Kola Super Deep Borehole KSDB-3 near Zapolyarny in Russia is the deepest borehole in the world (12,261 m). The collection of core material recovered from the borehole (the common length is 4,700 m) is unique in its completeness, in the quality of the preserved material and in the variety of the crystalline rocks and formations present. The scientific aim of the project is to study among others the mineralogy, geochemistry and physical properties of the rocks at great depth and their equivalents occurring at and near the surface, by using state-of-the-art analytical techniques. The wealth of information that will be obtained from the Kola and other super deep boreholes will be used to gain greater insights into four problems in the geosciences:

- geomechanical stability of the continental crust
- potential and risks for waste disposal at great depth
- localisation of ore deposits in the middle crust
- geological interpretation of geophysical measurements.

To solve these problems five international thematic working groups have been created: geology-geophysics, mineralogy, isotope-geochemistry, physical properties and borehole measurements.

Websites of the project
http://icdp.gfz-potsdam.de

Participating countries
(*indicates countries active this year)


Achievements of the project this year

In 2000-2001 the data available on Kola were expanded and published on an English/Russian website comprising general information on the super deep borehole and on IGCP 408. The data are incorporated into the Information Network of the International Continental Scientific Drilling Programme. During 2001, an information-analytical system ‘Petrology of Pre-Cambrian rocks from the Kola Superdeep Borehole section (riftogenic complex)’ was created in the framework of a thematic task of the Russian Ministry for Natural Resources and with the support of IGCP.

The study of iron-magnesia phlogopites and low-alumina biotites from metamorphosed ultrabasic and basic rocks (crystalline schists, amphibolites) of the KSDB Archean complex at depths ranging from 7,930 to 11,340 m and their surface homologues in the Allarechka region (St Petersburg, Russia) showed that structures of micas with the same fm values have higher values of the unit cell volume than those for the synthetic members of the phlogopite-annite series (‘structural looseness’). The ‘looseness’ degree for the surface micas is higher than that for the micas from the borehole. The clinopyroxene composition of the picrites from the Kola super deep drillhole has been investigated and their mineralogical and petrological data compared with those from the outcrops in the surrounding area (Slovak Republic).
Microprobe analyses of mineral phases showed (Apatity and Zapolyarny, Russia) that ore minerals from deep horizons contain a substantial quantity of Ni, Co, PGE in sulphides, and Mn, V, Ti in oxides, while in the zone nearer to the surface their composition is more stable.

The comparison of the results obtained from the Kola superdeep and KTB boreholes indicated that fluid migration is mainly restricted to tectonic fracture systems like fissures, cracks, fault zones and veins. In order to understand the genesis and development of palaeofluids and palaeofluid systems under hydrothermal conditions, secondary minerals and their associations crystallized in these fracture systems have been investigated (Giessen, Hanover, Germany; Zapolyarny, Russia).

About 20 rock samples from the Proterozoic and Archean sections of KSDB as well as their surface homologues have been dated by the Sm-Nd method on a mass spectrometer Finnigan-MAT 262 (RPQ). 10 amphibolite samples from KSDB yielded Sm-Nd model ages (DM) of 2.16-2.94 Ga. Six samples of biotite-tonalite gneisses from Garsjo, Svanvik and Varanger were considered to be homologues of KSDB rocks, yielded Archean Sm-Nd model ages (DM) of 2.78-2.94 Ga. Two amphibolite samples from the Garsjo gneisses (considered to be homologues of KSDB rocks) and two metadiabase samples from KSDB yielded Proterozoic Sm-Nd model ages (DM) of 2.1-2.4 Ga.

On the basis of geological and geochemical data the correlation between the KSDB Archean complex and the Late Archean granite-greenstone area of the Svanvik-Lotta segment from the Kola-Norwegian block has been established (Trondheim, Norway; Apatity and Zapolyarny, Russia). The KSDB Archean rocks formed a bed of the Pechenga riftogenic structure and as compared to the surface homologues they have been greatly altered during the Proterozoic rift genesis. Fluid reworking of the Archean rocks over the subalkaline melt hearths that are parent for the Pechenga volcanites caused the process of the Proterozoic granitization of 2.15-2.22 Ga.

Crustal reflections of seismic profiles may be the result of compositional layering, shear zones, anisotropy, fluid filled cracks, fractures or the combination of the above, combined with layering which enhances reflectivity with a stronger effect than individual reflection coefficients (Laramie, United States and Karlsruhe, Germany).

The study, conducted in Kiel (Germany), Moscow, Apatity and Zapolyarny (Russia) investigates the effect of pressure and temperature on seismic and density properties of core samples recovered from the Proterozoic and Archean units and their analogues exposed at the surface. Pronounced pressure (crack) sensitivity of P- and S-wave velocities indicates strong deformation in the core, due to drilling-induced damage and rapid pressure and temperature release during core retrieval. Marked velocity anisotropy and shear wave splitting are present in the foliated Proterozoic and Archean gneisses and amphibolites, due to oriented micro cracks and lattice (crystallographic) preferred orientation (LPO) of the constituent mica and hornblende minerals. The experimentally determined intrinsic velocities and anisotropy compare fairly well with corresponding calculated data, based on the LPO and the single crystal properties of the major minerals. It has been revealed that high anisotropy of the continental crust’s deep horizons results from tectonic and metamorphic processes. It is precisely anisotropy that has a profound impact on cavernosity and deviation of super deep boreholes.

With regard to the block and geological structure of the regions’ rock massifs, a comparative analysis of the rock massifs’ stressed-strained state in the KSDB and KTB site areas has been conducted (Apatity, Russia). The primary azimuth of the greatest compression tectonic stresses in the KSDB site was established to be 320° and in the KTB site area – 310-335°. It was shown that in the interior parts of the platform at a depth over 3.5 km, high temperature hydrothermal systems have been developed. There are similarities in thermodynamic parameters and geologic structure with hydrothermal-magmatic systems of the ocean-continent transition zone. The Pechenga deep hydrothermal system was used as an example to show that it could be useful in the study of geotechnical conditions for the isolation of various nuclear materials when they are stored and buried just in natural objects.

Meetings

The Plenary Meeting was held in Windischeschenbach, Germany, from 5 to 9 September 2001. The total number of participants was 37 from seven countries. The conference included a visit to the KTB borehole, KTB site in Windischeschenbach and KTB core storage facility in Wackersdorf. excursions to the geological outcrops in Eastern Bavaria, Germany, 5-7 September 2001.

Educational, training or capacity-building activities

In 2001, an educational textbook Material homologues of metamorphites from the lower parts of the Kola SG-3 Archean section (IX unit in a depth range of 11,411 m to 11,708 m) in the outcrops of the Zatuloma structure of the Kola-Norwegian domain was published in Russian and partly in English by the Murmansk State Technical University. The main task of the investigations conducted by the authors was to identify surface homologues of the KSDB Archean rocks. The textbook is of interest for geologists, teachers of different geological disciplines, post-graduate students and students studying geology.
Most important publications

– Kozlov, N. Ye.; Avedisyan, A. A.; Ivanov, A. A. et al. 2001. Material homologies of metamorphites from the lower parts of the Kola SG-3 Archean section (IX unit in a depth range of 11411 to 11708 m) in the outcrops of the Zatuloma structure of the Kola-Norwegian domain. (Educational textbook), Murmansk State Technical University, Murmansk, 65 pp. (In Russian and partly in English).

Activities planned

General goals

Mineralogical, isotope, geochronological and other analyses of core and surface samples, petrophysical measurements of rock samples are planned together with laboratory and field studies. Operational phase of continuous fluid level, microseismic, stress field monitoring in the KSDB, verification of working plans. Preparing publications within the international working groups for Episodes, Newsletter of ICDP, Terra Nova and other reviewed journals.

Meetings

Plenary meeting in Zapolyarny and Apatity, Russia, September 2002 and fieldwork at the Pechenga structure and surroundings.


B. D. Webby, Centre for Ecostratigraphy and Palaeobiology, Department of Earth and Planetary Sciences, Macquarie University, North Ryde, NSW 2109, Australia, e-mail: bwebby@laurel.ocs.mq.edu.au

F. Paris, UPR du Centre national de recherche scientifique (CNRS) « Géosciences », Université de Rennes I, 35042 Rennes Cedex, France, e-mail: florentin.paris@univ-rennes1.fr

M. Droser, Department of Earth Sciences, University of California, Riverside, CA 92521, United States, e-mail: mary.droser@ucr.edu

Description: The project sought to examine the nature and processes responsible for coastal changes during sea-level highstands, with the ultimate aim of applying the results to the management of present and future coastal change. The history of coastal environmental changes during the past few thousand years, up to the present day, were compared with similar intervals of sea level highstands in the longer geological record (e.g. comparison of the Last Interglacial Maximum or interstadials with the present Holocene Interglacial). During these episodes, sea level was at its highest or next to its highest points in the most recent period of Earth history. Thus, the changes which have occurred during similar sea-level highstands, during the last few hundred thousand years were also examined as a framework to model possible future change in the environmentally sensitive and extremely dynamic setting of the coastal zone.

This globally based project has an overall goal to fully appraise all known records of preserved biotas in Ordovician rocks, as a basis for a comprehensive evaluation of the manner in which the greatest diversification of marine life on Earth took place. The approach to achieving this primary goal requires a focus also on the following tasks:
- identify the significant global (and regional) bioevents
- establish the onshore-offshore biofacies profiles within each latitudinal belt
- assess, on a group-by-group basis, diversity trends for each major taxonomic group
- find possible physical or chemical causes (e.g. whether they be related to changes in climate, sea level, volcanism, plate movements, etc.), and
- evaluate economically significant Ordovician organic-matter assemblages of contrasting deeper pelagic and shallow, intracratonic oil-shale deposits.

Websites of the project
http://www.es.mq.edu.au/MUCEP/igcp410/index.htm (for information about the project)
http://homepages.uc.edu/~millerai/welcome.html (for details about the database)
http://www.geosciences.univ-rennes1.fr/www/ch/paris/default.htm (other information)

Participating countries
(*indicates the countries active this year)

Achievements of the project this year

General scientific achievements

This year IGCP 410 held its eighth, ninth and tenth international meetings on aspects of Ordovician biodiversity – first, there was a clade team meeting in Riverside (California, United States), and then the two field meetings in Novosibirsk and the Siberian Altai (Russia), and in Ulaanbaatar and Southern-Central Mongolia, respectively. All these meetings were well attended and productive, and as in previous years have been largely supported by finances provided by UNESCO and IUGS. They were meetings held in areas not previously visited, which had the effect of widening our regional focus on Ordovician biodiversity to other parts of Asia. Most of our regional team work programmes continued to make some progress, but the European/North African team was again the most active and productive. In some areas of Europe, for example, in the Czech Republic, the biodiversity work programme has now virtually been completed, with the results of particular importance because they show patterns of diversity in marine environments of higher palaeolatitudes through Ordovician time. Again, this year, a very large number of papers have been published on Ordovician biodiversity and related topics by participants of IGCP 410 worldwide (see details listed below).

The clade team meeting held in Riverside last June (and more fully reported below) brought together the leading Ordovician experts worldwide for presentations of their clade group specialities, but also to join in wider discussions about how the major results of this IGCP 410 teamwork should be published. It was agreed that all the biodiversity results should employ the same standardized global time scale, and use the same diversity measures for plotting patterns of diversity change. The work continued towards providing the most highly resolved and well-calibrated Ordovician time scale for correlating the biodiversity data, and this year, with the calibration work of Peter Sadler (Riverside, California) and Roger Cooper (Lower Hutt, New Zealand), was advanced further by a computer-generated constrained optimization programme that achieved even greater refinement. Sadler and Cooper’s startling results were presented at the Riverside meeting. Agreement was also reached at the Riverside meeting that the same types of diversity measures should be applied to all clade groups in the global survey. Consequently, there now exists the basis for fullest possible analyses of all the Ordovician clade groups using the same time scale, and the same diversity measures, which will remove at least two serious sources of error in assessing on a group-by-group basis, diversity trends of each major taxonomic group.

The project has added significantly to global efforts to achieve a more highly resolved time scale, and has provided a dramatically increased awareness of the significance of the greatest sustained diversification of marine life on earth.

Meetings

1. Ordovician clade group meeting, University of California (Riverside, United States)

The eighth international meeting of IGCP 410 was held in the University of California, Riverside, 22-24 June. Over the three days of the meeting, 35 talks and posters were presented, covering a wide range of global and regional biodiversity topics including the following clade groups – acritarchs, brachiopods, bryozoans, chitinozoans, corals, echinoderms, graptolites, machaeridians, radiolarians, stromatoporoids trace fossils, trilobites and vertebrates – as well as a contribution on a more fully integrated Ordovician time scale. Some 45 scientists from 13 different countries participated. A 14-page book of abstracts was published as a special issue of *PaleoBios* by the Museum of Paleontology, University of California, Berkeley.

Just before the meeting participants were advised by the Science Editor of the Columbia University Press that the book plan for the publication of the clade team results had been accepted – a single volume to be entitled ‘The Great Ordovician Biodiversification Event’, and to appear in the publishers ‘Perspectives in Paleobiology and Earth History Series’. This volume will be edited by the three IGCP 410 Project Co-Leaders, B. D. Webby, M. Droser and F. Paris. Consequently, wide-ranging discussions were held on topics such as: contents, authorship, timetable and deadlines, publishers guidelines, global time scale and diversity measures to be employed. The book will comprise: (1) an introductory section with brief outlines relating to Ordovician time and the Ordovician world (topics such as plate tectonics, palaeoclimates, palaeoceanography, sea levels, isotope signatures, volcanism, orogeny, a possible superplume, and end-Ordovician glaciation); (2) about 35 chapters documenting the diversity patterns of the clade groups (with more than 50 authors); and (3) a concluding part, with one or more, summary-type global biodiversity syntheses. The publication of a book of about 370 pages is expected to take place during 2003.

2. Combined IGCP 410 and 421 field meetings to South-West Siberia and Southern and Central Mongolia

Siberia: The first of the two meetings was to be held in conjunction with IGCP 421 (North Gondwana Mid-
Palaeozoic biodynamics). The field trip from 5 to 19 August focused on: (1) aspects of Ordovician to mid-Palaeozoic sequences and biotas in relation to transgression/regressions events; (2) relationships between the clastic and carbonate facies development, and community associations in the shelf margins of the Siberian block during Ordovician to mid-Palaeozoic time; and (3) to testing recent ideas about how (and when) the mosaic of accreted terranes of the Altai-Sayan folded area became a part of the shelf margin of the Siberian craton. The 40 participants included representatives from 9 different countries. The field excursion involved travel into a large area to the south and east of Novosibirsk – in the Altai Mountains, Salair and the Kuznetsk Basin. During the first few days in the North-West Altai there were opportunities to examine the mainly Caradocian and Ashgillian clastic successions with their mixed graptolite and shelly faunas, as well as a deeper water succession of Early Ordovician age with associated radiolarians and conodonts. And later, in the Central Altai, the Ordovician-Silurian group examined the shallow-water Tremadocian succession at Kamlak Creek, containing brachiopods, trilobites and conodonts. Other Ordovician localities were visited in the second half of the field trip, in North-East Salair (near Gur’yeysk). Sections at these isolated localities included: (1) across the Late Cambrian to Early Ordovician transition, some particularly rich trilobite associations identified by Petrunina, (2) a Middle Ordovician succession with key graptolite species, and (3) richly diverse shelly faunas (especially trilobites) in a long-celebrated, Caradocian to early Ashgillian sequence (Weber Formation).

Mongolia: This joint IGCP 410/421 field meeting commenced with a one-day indoor meeting in Ulaanbaatar on 22 August in the Conference Hall of the Mongolian Technical University; a session of ten talks and a poster were then presented by the delegates that covered a wide range of topics relating to Ordovician biodiversify, North Gondwanan mid-Palaeozoic bioevents, biogeographic affinities, taxonomy (Asian charophytes) and Mongolian crustal (magentic) events. Particularly relevant were the papers dealing with the Ordovician biodiversity of the Barrandean area of the Czech Republic by Olda Fatka and others, the Early Ordovician conodont and graptolite biostratigraphy of Argentina by Guillermo Albanesi, the Late Ordovician corals of Mongolia by Ch, Minjin and J. Undarya, and the Ordovician biotas and biofacies patterns in Eastern Australia by Barry Webby and Ian Percival.

Other Meetings – Copenhagen and Lille

IGCP 410 was also involved in the sponsorship of two other meetings in Europe during 2001. The first was a meeting of the Working Group on the Ordovician Geology of Baltoscandia (WOGOGOB), from 16-20 May, in Copenhagen (Denmark) with an accompanying field trip near Lund (Sweden). This meeting was attended by 45 delegates from 8 European countries, and included a session of talks on the theme ‘Biodiversity changes in the Ordovician of Baltoscandia’. A 47-page abstract volume edited by D.A.T. Harper and S. Stouge included papers on Ordovician biodiversity topics.

A second meeting, entitled ‘Early Palaeozoic Palaeogeographies and Biogeographies of Western Europe and North Africa’ was held in Lille, France, from 24-26 September, attended by 101 scientists from 16 countries. Two field excursions were organized, each with published guide books, the first to examine Lower Palaeozoic stratigraphy and sedimentology in Belgium (Brabant Massif and Condroz inlier), and the second, focusing on Early Palaeozoics of the Southern Montagne Noire in France.

List of most important publications

- Bultynck, P.; Sarmiento, G. N. (In press.) Reworked Early-Middle Ordovician and autochthonous Late Silurian to Early Devonian conodonts from Khemis’n’Ga (Moroccan Meseta) Depositional environmental and palaeogeographic implications. Courier Forschungsinstitut Senckenberg.


Lefèvre, B.; Gutiérrez-Marco, J. C. (In press.) New Ordovician mitrocystitidan mitrates (Echinodermata, Stylophora) from the Central Iberian Zone (Spain). *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*.


Activities planned for 2002

General goals

The requested extension of one year (2002) will give the project participants time to complete the remaining global and regional Ordovician diversity syntheses for publication, and allow the final meeting to be held in association with the first International Palaeontological Congress in Sydney, Australia, in July 2002.

Meetings

Two international meetings are planned during 2002. The first will be in support of the ‘Early Life’ symposium being held in association with the Geological Association of Canada’s Annual Congress in Saskatoon, Saskatchewan (Canada) in late May 2002. The session will ‘explore the patterns and processes of biotic radiation, mass extinction, and post-extinction recovery, and their relationships to the evolving lithosphere, hydrosphere, and atmosphere during the Early Palaeozoic Era’.
A second (and final) IGCP 410 meeting will be held in Sydney in conjunction with the First International Palaeontological Congress (IPC), for congress details see web site:


S. Hada, Research Institute for Higher Education, Kobe University, Nada-ku, Kobe 657-8501, Japan, e-mail: hada@kobe-u.ac.jp

I. Metcalfe, Asia Centre, University of New England, Armidale NSW 2351, Australia, e-mail: imetcalfe@metz.une.edu.au

J. H. Kim, Department of Geological Science, Seoul National University, Seoul, 151-742, Korea, e-mail: jhk@plaza.snu.ac.kr

Tran Van Tri, Department of Geology and Mineral of Viet Nam, 6 Pham Ngú Lào St., Hanoi, Viet Nam, e-mail: GSV@bdvn.net

Jin Xiaoch, Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, People’s Republic of China, e-mail: jinxchi@public.bta.net.cn

Description: The major scientific objective of the project is to understand the processes that led to the final assembly of Gondwanaland-derived terranes in East and South-East Asia. It will adopt an interdisciplinary approach including the study of igneous activity, metamorphism, sedimentation, tectonics, palaeobiogeography, palaeomagnetism, metallogenesis, and petroleum and coal geology. Apart from Japan and Russia, the main activities will take place in the developing countries of the South-East Asian region. An important goal is to produce a tectonic Map of East and South-East Asia at 1:10 million, which will be compiled in GIS format by various geological surveys in the region. The societal benefits of the project are related to metallogenesis in each terrane, and development of hydrocarbon- and coal-bearing sedimentary basins during the final emplacement of the terranes.

Website of the project http://www.hku.hk/earthsci/411.htm

Participating countries
(*indicates countries active this year)


Achievements of the project in 2001

A framework for understanding the various tectonic blocks originating from Gondwana and now accreted to, and amalgamated within, Asia is now rather well established. Efforts continue in order to improve a detailed understanding of the timing of dispersal and accretion events. A better apprehension of the correlation of rock units and tectonic events between the blocks that make up the framework of Asia will lead to enhanced models for the discovery and recognition of geological resources.

Meetings

The International Symposium and Field Workshop on ‘Assembly and Breakup of Rodinia and Gondwana, and Growth of Asia’, Osaka City University, 26-30 October 2001 was the 3rd International Symposium and Field Workshop of IGCP 411, held in cooperation with IGCP 368 and 440 (over 200 geoscientists from ten countries participated). The IGCP 411 business meeting was held at Osaka City University on the evening of 27 October. Twenty-one scientists from nine countries attended the meeting.

Most important publications

– The Proceedings of the Yichang Symposium in 1999 have now been published as a Gondwana Research Special Issue, volume 4/1.
– Extended abstracts of the meeting were published as a special issue of Gondwana Research, 2001, Vol. 4, No. 4, 889 pp. The programme and late abstracts were published in GRG/GIGE Miscellaneous Publication No. 12, ISBN4-938925-08-7(C) 61 pp. Full papers from the meeting will be published as several special issues of Gondwana Research in due course.

Other publications

– Ando, A.; Kodama, K.; Kojima, S. 2001. Low-


- Shi, G. R. 2001. Possible influence of Gondwanan glaciation on low-latitude carbonate sedimentation


– Shi, G. R.; Shen Shuzhong. 2001. A biogeographical zone in the eastern China continent. Han Baofu and his collaborators studied the emplacement mechanism of the Linglong granitoid complex (the greatest in North China), Shandong province, and found out that the granitoid complex intruded along a low angle thrust near the giant fault zone – the Tancheng – Lujiang fault granitoid complex intruded along a low angle thrust near the giant fault zone – the Tancheng – Lujiang fault sector – the giant fault zone – the Tancheng – Lujiang fault sector – the giant fault zone – the Tancheng – Lujiang fault sector – the giant fault zone – the Tancheng – Lujiang fault sector – the giant fault zone – the Tancheng – Lujiang fault sector – the giant fault zone – the Tancheng – Lujiang fault sector – the giant fault zone – the Tancheng – Lujiang fault sector – the giant fault zone – the Tancheng – Lujiang fault sector.


Reports from working groups

China (Dr Wan Tianfeng)

Stratigraphy, sedimentology, palaeontology, magmatism and tectonics of the Qinghai-Tibet Plateau have been continuously studied. Jin Xiaochi and his group continued working on the geology of the Changning-Menglian belt in Western Yunnan, China. The occurrence of cherts and its sedimentological implication, the lithological sequences of the belt and their environment of formation are the main points of this year’s work. Li Maosong studied the Ordovician-Carboniferous boundary in the Sino-Korean plate. This work helps to clarify the main characteristics of major plate in the Eastern Asian continent. Wan Tianfeng and his collaborators studied the emplacement mechanism of the Linglong granitoid complex (the greatest in North China), Shandong province, and found out that the granitoid complex intruded along a low angle thrust near the giant fault zone – the Tancheng – Lujiang fault zone in the eastern China continent. Han Baofu and his collaborators studied the Louzidian normal fault near Chifeng, Inner Mongolia: master fault of a quasi-metamorphic core complex. Liu Shaofeng together with other collaborators studied the process of rifting and collision along the plate margins of the Qinling orogenic belt and its geodynamics. Their findings enriched tectonic data in the Sino-Korean and Yangtze plates. M. F. Zhou and other experts focused on the melt/rock interaction and melt evolution in the Sartohay high-Al chromite deposit of the Dalabute ophiolite (North-West China). J. C. Aitchison and his group continued to study the Middle Ordovician (Llandeilan) radiolarians from West Junggar, Xinjiang, the Palaeogene island arc collision-related conglomerates, the Yarlung-Tsangpo suture zone, Tibet, the inter-shell casts of enatactinid radiolarians from the Devonian of South-West China, and Early Palaeozoic radiolarian biozonation.

Australia (Dr Metcalfe)

The Australian Working Group for IGCP 411 continued to work on the geodynamic evolution of Eastern Asia, in particular on suture zones of the region and on palaeobiogeography and palaeogeography. The two most active groups are G. R. Shi and co-workers at Deakin University and I. Metcalfe and co-workers at the University of New England. Over the past two years, the Deakin group has maintained their research programme on the Late Palaeozoic biogeography of the Asian-western Pacific region, with findings from the Australian Research Council and Deakin University. Emphasis has been given to the Permian transitional faunas from the Peri-Gondwanan (South-East Asia and Tibet) and NE Asia (NE China, Russian Far East and Japan). This research has particular relevance to the IGCP 411 as it attempts to elucidate the origin of the mixed biogeographical nature of these faunas in relation to Permian regional and global palaeogeography, plate/terranne configurations, and palaeoclimatic conditions. The University of New England group continues to work on the suture zones of eastern Asia and on palaeobiogeography and palaeogeography of East and South-East Asia. Work on the Digital terrane map of East and South-East Asia continues in collaboration with Koji Wakita of the Geological Survey of Japan.

Japan (Dr Wakita)

– Stratigraphy, Palaeontology and tectonics of South and North Kitakami terranes and Hayachine belt with special reference to the Kurosegawa belt
– Tectonics of East and South-East Asia
– Palaeozoic and Mesozoic radiolarian biostratigraphy and taxonomy of Thailand
– Carboniferous radiolarians from Southern Thailand
– Research on linkage between pelagic chert and shallow marine limestone in Jurassic accretionary complexes of the Inner Zone of South-West Japan
– Stratigraphy, age and environment of the clastic layer in chert
– Stratigraphy, age and environment of the shallow marine limestone
– Research on high resolution age determination method for rocks of the Indus suture zone, Radakh Himalaya, India
– Fieldwork on Zhuravlevka terrane (Cretaceous turbidite) in the Russian Far East for correlative research of tectonic units between the Russian Far East and Japan on Research on fusulinacean biostratigraphy, stratigraphy, palaeontology, palaeoclimate, and tectonics of East and South-East Asia
– Research on Kurosegawa and Chichibu Belts in Kochi, Japan,
– Research on the Akiyoshi Belt in Yamaguchi, Japan
– Research on the Kurosegawa belt. 
Japanese members of IGCP 411 started the cooperative research work with the Geological Survey of Viet Nam and the Hong Kong University in Viet Nam. The research is focusing on the issue of the relationship between the Indochina and South China continental blocks.

Philippines (Dr Yumul)
A field geological survey was conducted in the western coast of Zamboanga City, Mindanao, in April 2001 which mapped the western extension of the study area. Previously studied critical areas were also remapped (e.g., Batorampon and San Ramon areas) and consequently, their stratigraphy and geology were modified based on the recognition of new stratigraphic units (e.g., Pantalon Volcanics and Limpapa Melange). A few 1:50,000 scale geological, structural and sample location maps are under preparation showing this modification in the stratigraphy and geology. In addition, prospect evaluation was conducted in the zeolite-bentonite deposit in Sibuco, Zamboanga del Norte. For the Sibutad gold mineralization in the northeastern portion of Zamboanga del Norte, a large-scale laboratory research was conducted on drill core and surface pit samples. Research on the Sibutad gold mineralization was carried out on the LaLAB orebody, one of the two main orebodies, and the more economically viable in terms of tonnage and grade.

Malaysia (Dr LEE Chai Peng)
Dr LEE Chai Peng has successfully carried out cooperative field research with Drs Robin Cocks and Richard Fortey from the British Museum Natural History on the Ordovician-Silurian shelly fauna of Langkawi, Kedah and north Perak. They were able to extend their fieldtrip into South Thailand with the kind assistance of the Thai Department of Mineral Resources geologists, Mr Adoon Wanapeera and Mr Deecha Maneenai arranged by the Thai IGCP 411 representative Mr Adichat Surinkum. Drs Cocks, Fortey and Lee are preparing a paper on ‘A review of Lower and Middle Palaeozoic biostratigraphy in western Malaysia and southern Thailand in its context within the Sibumasu terrane’ based in part on their research findings.

Further cooperative work between Malaysian and Thai geologists has been carried out in the past year by the Malaysia-Thailand Border Joint Geological Survey project. The completed report on ‘The geology of Gubir-Sadao Transect’ was presented to the main committee, and work on the new transect ‘Batu Melintang-Sungai Kolok’ was scheduled to start in July-August 2001 and be completed by August 2002.

Thailand (Drs Somsak Potisat and Adichat Surinkum)
– The petrochemistry of the Chiang Khong-Tak volcanic belt, a possible southern extension of the Lincang-Jinghong belt, was studied by Panjasawatwong and other geologists in order to clarify its tectonic setting. The rocks compositions range from basalt to andesite of tholeitic affinity and formed in a Tertiary intercontinental volcanic arc.
– Chonglakmani has studied the Permian Saraburi Group and separated it into six formations. It is composed of various facies belts representing the shelf or platform, basin margin and deep basin environments. However, no oceanic crust is found in the Saraburi Basin indicating that the basin was narrow and not a true deep basin. Rather it was part of a back-arc basin.
– Hin Tang intrusive rocks in the Wang Nam Keow area, Nakorn Ratchasima, were studied by Buparamanee and others. They are I-type granite-granodiorites.
– Kongsumit and other collaborators studied the red sandstone in Changwat Loei, Northeastern Thailand. Stratigraphically there are three formations, namely Sao Khao, Phu Phan and Khok Krut which were deposited in fluvio-lacustrine, alluvial braided streams and fluvio-lacustrine environments respectively.
– Charusiri and other geologists studied the causes of earthquakes in Thailand using TL-methods. Results show that earthquakes were closely related to particularly active faults. Four possible seismic risk zones can be identified.
– Marine Triassic sediments were investigated by Srinak and his group along the Mae Sariang-Ban Mae Sam Lab highway. The sediments contain high Cr and low TiO₂ detrital chromium spinels indicating that the sediments were of the Alpine-type lying between fore-arc and ocean floor settings.
– The second phase of the joint survey by Thai and Malaysian geologists was carried out during September and October 2001. There are at least four new mineral potential areas: gold, chromite, base metal and kaolinite, located in this study area.

Activities planned

General goals

1. Igneous and metamorphic activity: Distribution and characterization of igneous and metamorphic rocks in the collision zone, consuming plate margin and post-orogenic magmatism, and tectonic setting of their activities and characterization of metallogenesis.
2. Sedimentation: Spatio-temporal changes of depositional environment in and around continental
3. Biotic distribution: Regional correlation, determining biogeographical distributions and palaeoenvironmental analysis of both marine and land organism.

4. Palaeomagmatism: Detailed information on the movements and deformation of continental blocks, and the changing spatial distribution of seas and oceans.

5. Tectonism: Comparative studies of regional tectonic features and recognition of small terranes in collision zones, and characterization of shear zone development and final emplacement of accreted terranes by the on-going plate motion including the collision between India and Asia.

6. Natural resources potential: Time-space distribution, geodynamic and tectonic setting of useful natural resources, and their tectonic features in each terrane.

7. Results of the project will be prepared as a Digital Terrane Map of East and South-East Asia.

Meetings

The Fourth International Symposium and Field Workshop will be held in Thailand in October 2002. A field workshop is being planned in Northern Thailand.


D. S. G. Thomas, Department of Geography, University of Sheffield, Sheffield S10, 2TN, United Kingdom, e-mail: d.s.thomas@sheffield.ac.uk

A. K. Singhvi, Co-leader, Earth Science Division, Physical Research Laboratory, Ahmedabad, 380009, India, e-mail: singhvi@prl.ernet.in

Description: The key objectives of IGCP 413 (successor to IGCP 349) are to develop an enhanced understanding of the processes controlling the timing and amplitude of dryland environmental changes, together with the nature of these changes, and an advanced understanding of the linkages relevant to dryland changes. This will be done in the context of the relationship between dryland changes and global system changes, and in the context of environment-society links. The overall expectation is to provide a realistic synthesis of the sedimentary record of climatic changes with process-based interpretations to provide a more meaningful input for geological correlations and climate modelling experiments.

Website of the project
http://www.shef.ac.uk/~igcp413/

Participating countries (new in 2001 shown in italics)

Argentina, Armenia, Australia, Belgium, Botswana, Canada, China, Denmark, Egypt, Ethiopia, Finland, France, Germany, Iceland, India, Iran, Ireland, Israel, Jordan, Kuwait, Mauritania, Mexico, Netherlands, Nigeria, Poland, Russia, South Africa, Switzerland, Tanzania, Turkey, Turkmenistan, Saudi Arabia, Spain, Sweden, United Arab Emirates, Uganda, United Kingdom, United States.

Achievements in 2001

Canada

The Canadian component of the project is linked to the national initiative to address climate change impacts and adaptation. The Canadian correspondent to IGCP 413 was seconded from the University of Regina to the Prairie Adaptation Research Collaborative (PARC). PARC is the first node in the national network of climate impact and adaptation research centres. It is responsible for the sub-humid Canadian plains, where the rates and impacts of climate change are expected to be greater than in other regions of Southern Canada. Other Canadian participants in IGCP 413 are involved in the national climate change programme. Canadian contributors to IGCP 413 are involved in research on the impacts of climate change and variability on the soil landscapes of the Canadian plains. The focus of this work is the reconstruction of drought and its impacts on aeolian and fluvial geomorphic systems.

China

A new Holocene project for Arid Central Asia, supported by the National Science Foundation of China, commenced in 2001 for four years. This project, closely linked to IGCP 413, focuses on the climatic/environmental history in the region. In the spirit of the collaborative goals of IGCP 413, cooperative research between China and Germany will be enhanced after the establishment of the Sino-German Joint Research Centre on Arid Environments and Palaeoclimatology, at Lanzhou University. In Mongolia and Western China, research into interactions between glacial, periglacial and dryland systems continues on several fronts, including Indian, German and United States workers in collaboration with those from China. Research on dust flux and loess accumulation continues to be significant, with China-German efforts of note. New novel research includes collaboration between Chinese, Indian and American researchers, to conduct luminescence dating loess infills of ice wedge casts in cold regions. The dating of ice wedge fill to 15,600 years indicates a reduction of mean annual air temperature by at least 3.8°C and confirms the model calculations that indicate a similar temperature drop in these cold arid regions.

India

IGCP 413 research in India has focused on the reconstruction of palaeoclimatic record from semi-arid regions of South India, the synthesis of geo-archaeological records to identify gaps in the record and to examine the man-environment relationships. Climatologically, a
major part of the Southern Indian peninsula is semi-arid to arid, with seasonality of rainfall and high potential evapo-transpiration. Construction of ponds during the fifteenth century reflects enhanced aridity in the region that needed massive rainwater harvesting. The sediment characteristics of the pond fill sequences such as the magnetic susceptibility, granulometry and pollen assemblage changes along with the chronology are being examined to understand both the climate and human dimension of these sediments. Results so far indicate a progressive desiccation of the region for over 500 years. On a longer time scale, the alluvial sequences of the River Pennar indicate arid–ephemeral regimes 2400-2000 years ago, a more humid regime 1800-1000 years ago and drier conditions for the past 400 years. Given that the hydrology of these rivers depends primarily on the south-west monsoon, these inferences provide a surrogate for the south-west monsoon performance in the region. Studies so far reflect that the records though accord with global signatures of aridity, exact timing of the geomorphic process response differ. This implies that land use planning strategies in dry lands should take due cognisance of the response times of geomorphic processes and as a consequence the global climatic events are likely to be manifested somewhat asynchronously in the geomorphic settings. This is an aspect crucial also for the geological correlations.

A synthesis of the geoarchaeological record from the Thar Desert and its margins is enabling reconstructions of socio-environmental relationships such as the artefacts and their host strata that could be used to reconstruct environmental changes during the Quaternary. The presence of Acheulian artefacts in a playa shore context and of middle Palaeolithic artefacts in fluvial contexts reflects a relatively humid environment during early to late-mid Pleistocene. Isotopic stages 4 and 2 present sparse evidence of human occupation and of geomorphic processes and stage 3 witnessed relative abundance of flake industry. Surprisingly, evidence of human occupation during early Holocene is also sparse indicating that the contemporary climate was not conducive for human occupation. Overall, it is seen that, in this region, the human occupation thrived only during the humid phases. Work on the reconstruction of the limits of the Thar Desert at the Holocene optimum (6 Ka) and at 14 Ka (when the monsoon was established) was completed in 2001. Clear signatures of the progressive northward stabilisation of the dune activity was seen such that dune accretion ceased at 10 Ka at the southern margins, at 6 Ka north of Ahmedabad and 600 years in the present core Thar. This reflects a progressive northward shift in the dune accretion climate (i.e. monsoon) and provides a data set that can be used to validate GCMs.

Southern Africa
Research in Southern Africa continues on three fronts and includes researchers from the countries concerned and from Germany and the United Kingdom. In the Kalahari, investigations on the timing and nature of major Late Quaternary environmental changes continue to focus on developing a better understanding of the timing and controls on major Late Quaternary events. In this respect, new work dating deep sediment exposures at Matamatan mine are proving most promising since they appear to identify two major phases when aeolian activity was prevalent, with a hiatus from ca 120-60 Ka.

Elsewhere, there are promising correlations in the OSL dated records of dune construction in Northern Cape, South Africa, and Southern Namibia, respectively developed at United Kingdom and German laboratories.

In the semi-arid Karoo region of South Africa, researchers from three United Kingdom institutions are collaborating with investigators of the University of Cape Town (UCT), examining the timing of valley fill and localised dune development, from the Late Quaternary to the present. This work reflects an interest in understanding the respective roles of climatic and human agencies of change. On the semi-arid winter rainfall area of the Cape West Coast UCT workers are commencing investigations of land degradation with the University of California.

Namibia
In Namibia, German researchers continue to investigate the timing and palaeoenvironmental controls on soil development in northern and central areas of the country, including the incorporation of wind blown dust derived from eastern locations. Dutch researchers are investigating the timing of dust inputs from dry lake systems into offshore sediments, while the records of Late Quaternary changes recorded in fluvial sediments in upland areas are receiving attention on a number of fronts.

United States
Two research highlights are noted in particular for 2001:
1. Landscape evolution and ecosystem dynamics in the Colorado Plateau. New results show gradients in soil geochemistry and texture along with subtle changes in geomorphic setting that influence plant community distribution. Changing silt contents reflect different amounts of aeolian dust and control the zonation of nutrients. Modern dust inputs are monitored and are compared to estimates of past dust flux. Several geology/vegetation transects are now instrumented for monthly monitoring of plant and microbial dynamics along these gradients in nutrient and moisture availability. These measurements will provide the experimental basis for the development of a new generation of linked ecological-geochemical models, which will then be used to predict factors that influence biologic invasions.
2. Wind erosion and dust emission monitoring. Instrumentation has been developed to image dust emission events in the Mojave Desert. Digital cameras are mounted on a mountaintop overlooking three geomorphically distinct settings of dust generation, each setting having a meteorological station.
The cameras are triggered by high winds measured at one of the stations. The frequency of dust events appears to be linked closely to changes in vegetation. Vegetation conditions are monitored at the dust-emission sites using ground-based surveys and at a regional scale using remote sensing from satellites.

Some other new developments

IGCP 413 has only been directly involved in a limited amount of research in East Africa. This may change with planned investigations by German researchers into modern lake level fluctuations in Southern Ethiopia. Innovative German-Canadian collaboration is also developing work on lava-flow-dammed colluvially-modified loess accumulations in Lanzarote, which may yield important data on dust flux variations out of North-West Africa.

‘CHANGES’

A major achievement of the IGCP 413 group has been the enhanced tempo of activities towards producing more refined and robust reconstructions of environmental changes affecting drylands. This is being achieved through the use of a range of more precise chronometric techniques and of process-based studies to inform the interpretation of palaeo-features and their climatic significance. To appraise outputs from these studies, IGCP 413 is one of four IGCP Projects (the others being 448 – karst, 464 – continental shelves and 459 – terrestrial carbon) that has initiated the co-IGCP CHANGES programme.

The CHANGES (Carbon, Hydrology ANd Global Environmental Systems) Programme was formally launched in 2001. CHANGES is in receipt of financial support from the International Council of Scientific Unions (ICSU) and the Union of Geological Sciences (IUGS), and represents the merging of research activity between four IGCP projects (with others expected to join) and other IUSU-supported bodies (e.g. the Land Degradation and Karst commissions of the IGU). Amongst its activities, CHANGES allows for the time-slice outputs of late Quaternary environmental change derived from the work of these IGCP projects to be databased, compared and critically evaluated... with a view to better understanding the forcing mechanisms of global change, identifying data gaps, and making outputs widely available in the general domain. In this way, and through the activities of other participating bodies, CHANGES intends to complement existing collaborative bodies in environmental change research, but with a focus on less-investigated environments and ecosystems. CHANGES will in the first instance run for three years, and is supported by IUGS, ICSU and the University of Sheffield, where IGCP 413 is based.

Meetings

Main IGCP 413 meetings

2. National IGCP meetings in India, Germany, Canada and the United Kingdom, attended by 35-80 scientists

Other meetings where IGCP 413 scientists presented their results included

1. Long-range weather and crop forecasting in North America, 4th Workshop, Regina, Canada, March.
2. International Symposium on Land Degradation and Desertification, Mexico City, April.
3. ‘Windy day’ aeolian specialist meeting, Luton, United Kingdom, May.
4. Annual Meeting, Canadian Association of Geographers, Montreal, May-June
5. IGBP Science meeting in Amsterdam July.
10. 7th International Conference on Fluvial Sedimentology, Nebraska, United States, August.
11. 5th International Conference on Geomorphology, Tokyo, Japan, August.
12. British Geomorphological Research Group Annual Conference, Nottingham, United Kingdom, September.
13. American Geophysical Union Fall Meeting, San Francisco, United States, December.

Publications

Journal Special Issues


Selected papers, giving a flavour of IGCP 413 output

climate during the Last Interglacial (Eemian) indicated by palaeosol S1 in the western part of the Chinese Loess Plateau. *Global and Planetary Changes.*


- Thomas, D. S. G.; Holmes, P. J.; Bateman, M. D.; Marker, M. E. 2001. Geomorphic evidence for Late Quaternary environmental change from the eastern Great Karoo margin, South Africa. *Quaternary International* (In press.)


**Proposed activities for 2002**

**General goals**

1. To intensify research under the environment-society links theme, building on successful progress made at the Dryland Change 2001 meeting. Further collaborative efforts with IGU-COMLAND will be considered, while archaeologists are now taking a larger role in the overall project.

2. Data-base key information on dryland environmental responses to global changes at key late Quaternary time slices, in pursuit of the goals of the CHANGES programme.

3. To continue enhanced activities on understanding the interrelationships between people, climate and geomorphic processes with better chronological controls of identified past interactions.
4. To continue the development of the activities of ‘hydrological dynamics’ and ‘aeriel styles’ themes and completion of a first order synthesis of the aeriel sand records.
5. To develop new links in less-researched dryland areas.

Meetings and fieldtrips

The IGCP 413 business meeting, held at Upington, South Africa, August 2001, accepted the following two major meetings for 2002 (the focus is on holding meetings in key dryland areas that are relatively less researched in IGCP 413).
- (Title to be confirmed) Major meeting at Yazd, Iran, organized by the University of Yazd, August-September 2002.

It is probable that IGCP 413 will also contribute to the 5th International conference on Aeolian Research (ICAR-5) being held in Lubbock, Texas, July 2002. Regional meetings are planned in Germany, India and the United Kingdom.


G. F. Panza, Dipartimento di Scienze della Terra, Università di Trieste, 34127 Trieste, Italy, e-mail: panza@dst.univ.trieste.it

Description: The project addressed the problem of pre-disaster hazard prediction and risk assessment mapping in megacities and large urban areas. The postulate is that lives can be saved and property damage reduced by highly detailed, specific seismic predictions, based on geotechnical, lithological, geophysical, topographical, palaeoseismic and seismotectonic data, coupled with sophisticated computer modelling of wave propagation. The modelling is to be carried out for 15 large cities in Europe (especially Eastern Europe), Madagascar, China, and America. The benefits of the project for society – to prevent loss of life and property by realistic prediction of the effects of earthquakes that can be used in building codes and urban planning – are clear, and the project has direct implications in those large urban areas.

Website of the project
http://www.ictp.trieste.it/www_users/sand/
http://www.ictp.trieste.it/www_users/sand/project3.html

Participating countries

Algeria, Bulgaria, Chili, China, Croatia, Cuba, Egypt, Greece, India, Italy, Madagascar, Morocco, Romania, Russia, Slovenia, Syria.

Summary of major past achievements of the project

The project has reached significant results, worth publication in international journals, about the realistic modelling of the seismic input in many megacities and large urban areas, like Algiers, Beijing Area, Bucharest, Cairo Area, Catania Area, Naples, Rome, Ruse, Santiago de Cuba, Sofia, Thessaloniki, Zagreb. Special attention has been paid to the study of Vrancea intermediate-depth earthquakes that control the most severe seismic input in central Europe. Partners in the project have participated in the third European Union-Japan workshop on seismic risk. Our results have encountered a great interest from Japanese colleagues, since they are dealing with intermediate-depth sources affecting many Japanese urban areas. Most of the results will have an impact on the existing building codes, especially the European Building Code (EC 8).

Compilation of the database for 3-D structures, 3-D sources, and computations of synthetic seismograms along selected profiles have been carried out. An experimental study of the propagation of the seismic waves, in selected areas, and comparison to in situ measurements have taken place. Acquisition of detailed information about geotechnical, lithological, geophysical parameters, and tectonic, historical, palaeoseismological, seismotectonic models relevant for microzoning was undertaken. Determination of regional velocity models of the Earth’s crust representative of the paths from the seismogenic sources to the considered towns was realized. Contribution to the launching and strengthening of the Mediterranean cluster of Cities of the Earthquake and Megacities Initiative (EMI) was effected. Participation in the new IGCP Project 457 ‘Seismic hazard and risk assessment in North Africa’ was carried out.

The intermediate-term prediction of earthquakes can be fundamental in the exploitation of the scenarios developed by the project for preparedness. The association of deterministic hazard and pattern recognition of earthquake prone areas appears especially useful in areas where historical and instrumental information is scarce. Under such conditions, it represents an effective way to estimate the seismic hazard, more realistic than that based on the unavoidably incomplete observations. The advantage of the proposed integrated deterministic hazard procedure consists mainly in the time information provided by predictions, useful to increase preparedness of safety measures and to indicate the priority for detailed seismic risk studies to be performed on a more detailed scale. Deterministic hazard and recognition of earthquake prone zones procedures are especially useful as a means of prevention in areas that
have not yet been struck, but are potentially prone to earthquakes. In fact, in such a case the seismic input is defined on the basis of a wide geophysical and geological data set, as well as on the current knowledge of the physical process of earthquake generation and wave propagation in realistic anelastic media, and not only on the available macroseismic observations. The procedure for seismic hazard assessment based on the realistic modelling of seismic input (computation of synthetic seismograms) provides a realistic modelling of ground motion instead of a less specific upper bound for the maximum possible ground shaking.

Achievements of the project this year

General scientific achievements

The main achievements of the project, including the series of maps foreseen to integrate the results of the project, will be published in a topical volume of the internationally well established, peer reviewed journal Pure and Applied Geophysics. This volume is complementary to the one published in 2000 (PAGEOPH, 157).

As a follow-up to the activity developed under IGCP 414, several bilateral agreements have been signed at governmental level (China–Italy; Romania–Italy; Bulgaria–Italy; India–Italy; Russia–Italy), and IGCP 457 has been started.

Meetings

Open meeting for 2001 in Trieste from 9 April to 8 October 2001 (20 scientists from 12 countries):

1. Validation and homogenization of the input data to be used in the modelling, following the standard format defined by the International Lithosphere Programme, Task Group II-4.
2. Intensive use of the specialized software, developed at ICTP and DTS of University of Trieste, for the computation of ground motion, for researchers coming from the centres where the project is most advanced.
3. Systematic runs, including networking.
4. Mapping of the results of ground motion modelling.

6th Workshop on non-linear dynamics and earthquake prediction, at the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, 15-27 October 2001. Financial support for the workshop from ICTP was supplemented by contributions from the European Union within the framework of the TMR programme, which allowed the participation of 11 students from 8 European countries. More than 30 participants are from developing countries. For more details see http://www.ictp.trieste.it/cgi-bin/ICTPsmr/mklinks/mklist?smr1330


Workshop on Deterministic Approach of Seismic Zonation of some Balkan Countries, Tirana, Albania, 26-27 April 2001 with participation of IGCP 414.

Second Workshop on Seismic Risk in North Africa, Tetouan, Morocco, 14-16 May 2001. On behalf of the North Africa Seismic Group (NASG) funded by the Third World Academy of Sciences, the Department of Geology of the Faculty of Sciences at Abdelmalek Essaadi University has organized the second workshop on seismic risk in North Africa.

IASPEI/IAGA joint Assembly in Hanoi (August 2001): Co-convened S3 Theme Strong Ground Motion, Earthquake Hazard and Risk Symposium. Partners of IGCP 414 have presented several papers. At IASPEI-Hanoi the IASPEI/IAGA joint Assembly has established the Commission on earthquake hazard and risk, that involves partners of the IGCP 414. The main outcome of the meetings will be published in a special volume. A Proposal for PEPI/Tectonophysics Special Volume on Strong Ground Motion, Earthquake Hazard and Risk in Alpine-Himalayan and Pacific Regions has been formulated.

Euro-Mediterranean Seminar on Natural and Technological Disaster Management (Algiers, October 2001); paper presented: Deterministic seismic hazard assessment and ground motion modelling, by Aoudia, K.; Panza, G. F.; Vaccari, F. Discussion of the transfer of the experience gained with IGCP 414 to IGCP 457 ‘Seismic Hazard and Risk Assessment in North Africa (SHRANA) (2001-2005)’.

List of most important publications

Book


Peer reviewed scientific papers

Activities planned

General goals

Completion of the PAGEOPH topical volume ‘Seismic Ground Motion in Large Urban Areas’.


R. M. Key MBE, British Geological Survey, Murchison House, West Mains Road, Edinburgh EH45 9ER, Scotland, United Kingdom, e-mail: rmk@bgs.ac.uk

R. Mapeo, University of Botswana, Department of Geology, Private Bag 0022, Gaborone, Botswana, e-mail: mapeorbm@mopipi.ub.bw

Description: In order to produce a well-defined reconstruction of the global distribution of continental crust (notably the Rodinia Supercontinent) at the end of the Mesoproterozoic, it is important to properly understand the geological evolution of the Mesoproterozoic orogenic belts (or plate Boundary Zones, PBZs). The principal objectives of IGCP 418 were to:

1. Trace and study the south-western extension and evolution of the Mesoproterozoic Kibaran belts s.s. of Central Africa into South-Western Africa.
2. Investigate the geological evolution of other contemporaneous geological terranes and rock units in South-Western Africa.
3. Synthesise the Mesoproterozoic geological evolution of Africa.
4. Integrate the new knowledge concerning the Mesoproterozoic geological evolution of Africa into models for the creation and later destruction of Rodinia.
5. Evaluate the mineral potential of the Mesoproterozoic orogenic belts of South-Western Africa.

The south-western parts of the Kibaran Belt and contemporaneous Irumide belt of Central Africa are concealed by younger rocks and sediments. However, new regional, detailed geophysical surveys, notably in Botswana and Namibia, are enabling to delineate the full extent of these and other Mesoproterozoic terranes in South-Western and Central Africa. New geological mapping in conjunction with geochronology and other laboratory work on the Mesoproterozoic terranes is affording a fuller understanding of their evolution.

Participating countries
(*indicates the countries active this year)


General scientific achievements

The field meeting in South Africa allowed delegates the opportunity to examine the geology of the eastern part of the Namaqua Belt as well as the whole of the Natal Belt. Discussions in the field on the geology of these
two belts provided a much clearer picture of their geological histories.

The annual meeting in Durban gave national representatives an opportunity to present their latest research and this work is summarized in the attached abstract volume. New isotopic geochronology has provided a better understanding of the Irumide Belt. Fieldwork has also provided a better definition of its spatial relationship with the Zambezi and Mozambique belts.

Meetings

The 2001 meeting of IGCP 418 was held in South Africa between 8 and 21 July (about 50 participants from 11 countries). It was a very successful meeting that ended tragically on a very sad note with the untimely death of Professor Chris Powell on the flight out of South Africa. Chris’s knowledge, enthusiasm and active participation in all aspects of the meeting were major factors in its success. Letters of condolence were sent to Chris’s family and Steve McCourt sent a wreath to the funeral on behalf of IGCP 418.

The Namaqua belt

The ~400 km wide Namaqua-Natal belt of Southern Africa outcrops as a series of high grade tectono-metamorphic terranes which stretch from Southern Namibia, south-eastwards through the Northern Cape Province of South Africa to KwaZulu-Natal on the eastern seaboard. Although the Namaqua and Natal sectors of this belt are separated by thick Phanerozoic cover sequences, published models argue for a single continuous Namaqua-Natal orogen. Similar isotopic data and a comparable tectonic history support the continuity of the western (Namaqua) and eastern (Natal) sectors. There is however an important difference between the two sectors. The rocks of the Namaqua Metamorphic Province were deposited largely on Palaeoproterozoic basement whereas those of the Natal belt are entirely juvenile.

The Namaqua leg of the excursion concentrated on the eastern part of the orogen. The first day was spent in the Kheis Sub-Province interpreted as accommodating the transition between the Mesoproterozoic (Kibaran) Namaqua orogen and the Palaeoproterozoic (Eburnian) Kheis Belt. The geology of this complex and controversial area is dominated by quartzites and associated metasediments of the Nkomo, Madidima, Mandleni and Tulga respectively. The rock types in these nappes have been grouped into tectonostratigraphical packages comprising variable amounts of feldspathic, mafic and metapelitic schist and gneiss. These packages are intruded and tectonically interleaved with layered mafic intrusions and serpentinitised ultramafic rocks (the latter with podiform chromite). Dismembered ultramafic lenses and talc-schists help to define tectonic contacts between the various packages. Tectonic models suggest that the Mzumbe and Margate magmatic arcs developed in response to the closure of a Mesoproterozoic (Tugela) ocean basin that lay south of the Kaapvaal craton by subduction away from the craton. The ultramafic components of the Tugela terrane and its intermediate position between the craton and the magmatic arcs suggest that it may be, at least in part, a relic of oceanic crust from the basin.

The oldest rocks in the Margate and Mzumbe terranes comprise arc-related, felsic to mafic, volcanic supracrustal gneisses with subordinate metasedimentary rocks. The early juvenile gneisses which are probably no older than ~1.3 Ga were intruded at ~1.2 Ga by arc-related, calc-alkaline tonalitic orthogneiss and by syn-, late- and post-kineam granitoids between ~1.1 and 1.0 Ga. The youngest of these rocks include a rapakivi granite-charnockite suite (Oribi Gorge Suite) intruded at ~1.05 Ga. Magmatism ceased in Natal at ~1025 Ma but prolonged isobaric cooling of the entire complex is reflected in Rb-Sr whole rock and mineral ages as young as 850 Ma. Alternatively, these younger dates may reflect a widespread post-tectonic thermal of K-metasomatic event.
The accretion of the three Natal terranes onto the Kaapvaal craton by north-east-directed thrusting and nappe emplacement during collision led to inverse metamorphic stacking across the Natal belt, with the highest (granulite) grade rocks in the southern Margate terrane. The Mzumbe and Margate terranes were subsequently cut by numerous south-east to south-south-east-trending sinistral shears and mylonite belts. The boundary between the Mzumbe and Margate terranes is defined by a major oblique wrench structure, the Lilani-Matigulu Shear Zone, which coincides with the geophysically determined southern edge of the Kaapvaal craton. The Lilani-Matigulu Shear Zone may represent a re-activated transform boundary between the Kaapvaal craton and the Tugela Ocean. As a result, it has been argued that the extensive preservation of the early thrust-nappe structures in the Tugela terrane is a consequence of underlying cold, and thus more rigid Archaean crust. During the excursion, participants visited representative rocks and structures from each of the three terranes.

Technical session
Fifteen papers were read during the five sessions of the technical conference. Three papers presented in the first session provided overviews of Mesoproterozoic geology. Richard Hanson provided an introductory paper that comprehensively reviewed the history of the main Mesoproterozoic orogenic provinces of Southern Africa. Chris Powell reviewed existing palaeomagnetic information and provided new data on the position of the Kalahari craton in Rodinia. He noted that the Kalahari craton was at the equator at ~1100 Ma and joined with Australia at ~1080 Ma. The Congo and Kalahari cratons were joined at ~610 Ma. Toby Rivers examined the metamorphic signatures of various parts of the Grenville Province as an aid to their correlation. The high-pressure assemblages mostly formed between 1080 and 1060 Ma. During a second session, Henri Kampunzu and co-authors provided an overview of Kibaran belts in Central and Eastern Africa. An early orogenic event at ca. 1400-1250 Ma is associated with clockwise PT paths with I-type granite magmatism. A period of erosion and rift-related sedimentation followed before a second period of tectonothermal activity with S-type granite magmatism and tin mineralization between ca. 1200 and 960 Ma. Wulf Gose read a paper on behalf of his co-authors (Pancake and others) that presented new palaeomagnetic data from Botswana on the Umkondo Igneous Province. The new work supports the conclusion that the emplacement of large parts of this enormous igneous province took place in a limited time frame at ca. 1100 Ma (consistent with a plume origin). Peter Hall and his co-authors presented the results of detailed geochemical studies of different parts of the Umkondo Igneous Province. Their work records complex geochemical patterns within apparently coherent dyke swarms and sheets that need to be explained before the origin of the Province can be fully understood.

The third session was devoted to Mesoproterozoic rocks in Zambia. New work on the Irumide Belt presented by both Mapani and his co-authors, as well as by De Waele and his co-authors indicates that we are at last starting to unravel the complex history of this belt. A series of north-east-trending internal terranes are recognized in the southern part of the Irumide Belt in South-Eastern Zambia; these terranes are truncated to the south by the Zambezi and Mozambique Belts. The internal Irumide terranes are all bounded by major structural features and they may represent a telescoped progression from a cratonic setting on the Congo Craton (Serenje terrane), through a continental margin setting (Luangwa and Nyimba terranes), to an accreted arc (Petauke-Sinda terrane). The HT-LP granulite facies metamorphic signature of the Chipata terrane is not compatible with formation in the root zone of the orogen, so it may be an exotic terrane accreted during the assembly of Rodinia. New isotopic dates from the Irumide belt provide no evidence for tectonothermal activity at 1400-1350 Ma, in contrast to previous interpretations. At ca. 1800 Ma there was bimodal magmatism associated with the opening of the Irumide basin that was infilled by up to 10,000 m of sediment (although this may be a grossly misleading figure if the sediments were not deposited in a continuous layer-cake manner). Closure of the orogen took place at ca. 1180-1100 Ma with late to post-tectonic granite magmatism at 1040-960 Ma. Tembo and Katongo provided new information on the controls on emerald mineralization in the Ndola Rural area of North-Western Zambia.

The fourth session was devoted to the geology of the Namaqua belt. Van Niekerk and his co-authors proposed that the Lucknow Formation should be taken out of the Olifantshoek Group and reassigned to the Transvaal Supergroup (equivalent to the Magaliesburg Formation of the main Transvaal Basin). They recognize three groups in the Kheis Supergroup: a basal Olifantshoek Group (with a basal Nylonyon conglomerate and the overlying Hartley lavas), overlain by the Groblershoop Group and an upper Wigenhoutsdrift Group. Fluvial and shallow marine Kheis sediments were deposited on a passive continental margin. They place the western edge of the Kaapvaal Craton further to the west than previous authors. Knooper and his co-authors discussed the ‘late’ tectonothermal history of the Namaqua belt between ca. 1080 and 1020 Ma. They relate this history to protracted deformation associated with dextral transpression associated with the convergence (after collision) of the Kalahari Craton and another craton. Chris Powell observed that the deformation could be extensional, as it was associated with a very high thermal gradient. The absence of TTGs also supports an extensional setting. Rapid exhumation between ca. 1018 and 1013 Ma followed the metamorphic peak. The final paper by Grantham and his co-authors described and discussed new isotopic dates from the Leliefontein area. An emplacement age of ca. 1086 Ma for an equigranular orthopyroxene-granite is based on U-Pb ages from
zircon cores with a metamorphic overprint at ca. 1042 Ma. A concordant age of ca. 1033 Ma for gneissic granite is close to the ca. 1060 Ma age for the Spektakel Suite with which it has been correlated. Early (ca. 1200 Ma) granites are dominant. Detrital zircons from a paragneiss range in age from ca. 1300 to ca. 1650 Ma, suggesting that these supracrustals are younger than previously thought.

The final session focused attention on the Natal belt (or Natal Metamorphic Province). Thomas and Jacobs presented a definitive overview of the geology of this belt, which is known to comprise three juvenile high-grade Mesoproterozoic terranes separated by major shear zones. 1235±9 Ma is the oldest isotopic age obtained from the Natal belt. An initial collisional (thrust tectonics) event took place at about 1130 Ma with the formation of charnockites. Rapakivi granites were extensively emplaced between ca. 1070 and 1020 Ma, notably in the Margate and Mzumbe terranes. Emplacement of dykes at about 1020 Ma marked the end of magmatism. Sinistral shearing followed at about 1000 Ma (cooling below 500°C). The northern Tugela terrane was thrust over the Kaapvaal craton during the initial thrusting and was not affected by the later magmatism. A similar sequence of events was noted from Mesoproterozoic terranes (Falkland Islands, West Antarctica, older parts of the Mozambique belt) thought to have been next to the Natal belt in Rodinia. Bisnath and McCourt then provided a detailed account of three tectonostratigraphical packages in the Tugela terrane. Three major deformation events can be recognized in all three units including a final event associated with the thrusting of the Tugela terrane onto the Kaapvaal craton.

Activities planned

The general goal of IGCP 418 is to produce a book on the Kibaran events in southern and central Africa. In 2002 IGCP 418 plans to hold its final meeting in Namibia that will comprise a field meeting to examine Mesoproterozoic rocks in Namibia, as well as a conference in Windhoek. The purpose of the final meeting in Namibia will be to allow the authors of this book an opportunity to present their work for general discussion.
Description: The project is focused on regional and interregional correlation of foreland basins of the Neoproterozoic-Lower Palaeozoic Belts in Africa and South America. In relevant cases, the inner regions of the Neoproterozoic belts are researched as well as new data reflecting the foreland evolution are required. One of the focal problems is regional and intercontinental correlation of the ‘tillite’/glaciogenic markers and the underlying and overlying sedimentary sequences in Africa south of the Equator and in South America. This work is based upon the criteria provided by lithostratigraphy, sequence stratigraphy, basin analysis, palaeontology, palaeoclimatic and palaeomagnetic reconstructions, geochronology and studies of stable isotopes. Structural geology and geophysics are applied to elucidate the tectonic framework of the correlated units and provide additional correlation criteria.

Investigations of the Precambrian/Lower Palaeozoic boundary in the studied provinces of the Western Gondwana, identification and definition of the boundary in the localities crucial to the stratigraphy of the identified regions/basins is another aspect fostered by the project. The investigated basins and belts are sites of important economic resources. Therefore, research into the economic aspects of the targeted Proterozoic and Lower Palaeozoic units, especially the context of Cu-Co mineralisation, the origins of the carbonate-hosted Pb-Zn deposits and the sources and potential reservoirs of hydrocarbons are part of the project’s programme.

Website of the project
A website under the University of Botswana Homepage is now being established and should be operational in February 2002.

Participating countries
(*indicates countries active this year)


Achievements of the project this year

General scientific achievements

A comparative study of and correlation between the West Congolian Belt (Africa) and Aracuai (Brasiliano) was completed. Results are published. This was one of the most important aims of the project set in the original proposal for 2001.

A geological map of the Western part of the Katangan belt (Lufilian Arc in Zambia) was completed. The map is published, the paper in press.

The first regional version of a new stratigraphy of the Katangan foreland basins and incorporated in it new stratigraphic and sedimentological criteria for exploration of mineralized allochthonous megablocks was worked out. A book chapter was published and a keynote lecture delivered.

A sampling campaign and laboratory work on geochemical stratigraphic criteria in selected sections of the Katangan, West Congolian and Gariep Belts were completed.

Lithological characteristics of the Luapula Beds (North-East Zambia) were revised and updated, and a sampling campaign completed. This is related to the study of age relationships between this unit (Zambia) and the Plateau Kundelungu in the Democratic Republic of Congo (where follow-up work is planned for 2002).

Work on the stratigraphy and structure of the Zambezi belt to test the hypothesis of possible genetic links between this region and the Katangan has advanced.

Data collection, preliminary sedimentological and sequence stratigraphy interpretation of the Tsodilo Hills Fm. (NW Botswana) were completed. Papers and map are in preparation. The results were incorporated in the Botswana Government submission to UNESCO for consideration of the area as World Heritage Site.

A new study of the Naukluft Nappe Complex (Damara Belt, Namibia) has been completed.

Geochemical mapping of the Damara correlative region in North-West Botswana has been achieved.

Involvement of geoscientists working on East Gondwana, through a thematic session during ISRGA Conference, Osaka (see below) was established.

Meetings

A field workshop – project meeting with talks and discussion (six countries, 30 participants) was held in Zambia, 3-8 December 2001.

Participation of project 419 members in the Conference on geology of Minas Gerais, Belo Horizonte, Brazil and in IGCP 450 session.

In addition, IGCP 419 was represented at three major international conferences:
- the European Meeting of Sedimentology, Davos, 2-5 September: mainly as a preparation for the forthcoming 2002 Sedimentological Congress Thematic Session of IGCP 419 on Foreland Basins
- 6th Biennial SGA-SEG Conference, Krakow, 26-29 August: invited keynote lecture (meetings conducted on this occasion were aiming at a broader involvement of scientists specializing in economic sedimentology of sediment-hosted deposits (18 participants from 9 countries)
- Earth System Processes, a Global Meeting, Edinburgh, 24-28 June: UNESCO-invited presentation, several discussion meetings related to project research.

List of most important publications (including maps)


Activities planned

General goals

Comparison of lithostratigraphic development and assessment of genetic and temporal relationships between the Plateau Kundelungu (in the Dem. Rep. of Congo) and the Luapula Beds (Zambia). Detailed stratigraphic work on these two units. This problem is crucial for unravelling the Neoproterozoic-Lower Palaeozoic history of this part of the region.

Refinement of the new model of interplay between tectonics and sedimentation in the Katangan belt and evolution of the foreland basins through detailed sedimentological work in several parts of the belt.

Geochemical stratigraphic criteria: analytical work on the suites of samples from the Katangan, Gariep and West Congolian belts, and their comparison with the data from the Brasiliano orogenic system.

Meetings

- Sedimentological Congress, Johannesburg, 6-12 July 2002. Thematic session of Project 419: ‘Foreland Basins – 3 billion years of evolution’. The session is designed entirely in agreement with the originally

Bor-ming Jahn, Géosciences Rennes, Université de Rennes 1, 35042 Rennes Cedex, France, e-mail: jahn@univ-rennes1.fr

N. L. Dobretsov, Institute of Geology, UIGGM, Siberian Branch, RAS, Novosibirsk, 630090, Russia, e-mail: vladimir@uiggm.nsc.ru

Description: The problem of the growth and evolution of the continental crust has always been an important subject of research in earth sciences. The issue of the rate and nature of continental growth has not yet been resolved satisfactorily. All growth models predict that the formation of the continental crust was essentially completed by late Archean to Early Proterozoic, and the amount of new crust produced in the Phanerozoic is minor or insignificant. This idea of negligible crustal growth in the Phanerozoic is challenged by the discovery of voluminous juvenile crust produced in the Canadian Cordillera, Western United States, and most notably, the Central Asian Orogenic Belt (CAOB, or the Altai Tectonic Collage) during the period of Palaeozoic to Mesozoic (about 500 to 100 Ma). Central Asia or the CAOB is immense in size and its geology is poorly known outside the former USSR and China. It is rich in mineral resources, which have been subject to numerous studies in the last forty years. Its generally ‘juvenile’ crustal characteristics have invited many recent investigations of terrane accretion and geodynamic evolution as well as intense isotope studies aimed at quantifying the proportion of juvenile crust to old Precambrian basement in the CAOB.

The main purpose of this project is to investigate the processes of juvenile crustal formation in this gigantic orogenic belt. This includes: (a) genesis of the Phanerozoic crust, (b) origin of alkaline and peralkaline granitoids, (c) mineralisation associated with the granitic intrusions, and (d) structural analyses and tectonic modelling. Multidisciplinary methodology including field analyses, petrology, geochemistry, geochronology, and palaeomagnetism will be employed to study the generation of the immense volumes of granitic rocks intruded in this region and to constrain models of tectonic evolution of the accretionary orogenic belt. The data acquired for the CAOB will be used in conjunction with those obtained for other Phanerozoic juvenile crusts, such as the Canadian Cordillera, the Appalachians in North America and Eastern Australia, to reassess the growth of the continental crust. Collaboration between scientists from all countries, particularly from Russia, Mongolia, China, and other former USSR member countries, is necessary.

Website of the project
http://www.geosciences.univ-rennes1.fr/igcp420/

Participating countries (* indicates countries active this year)


Summary of major past achievements of the project

IGCP 420 has made a distinction between the two terms used in the growth of Asia:

1. (a) amalgamation of dispersed micro-continental fragments from the break-up of Gondwana. This process enlarged the size of Asia, but might not have added substantial amount of newly formed (juvenile) crust to the continent. (b) growth of the continental crust. This implies a net transfer of mantle-derived material to the continental crust. IGCP 420 emphasizes the latter.

2. Further confirmation of significant mantle contribution in the generation of the continental crust in Central Asia. This was achieved by continued Sr-Nd isotope studies, coupled with multi-methodological dating, of granitoids from many parts of the CAOB – Transbaikalia, Mongolia, Kazakhstan, Southern Siberia (Sayan and Altai), Northern Xinjiang, Inner Mongolia, and North-East China. This is certainly the most important achievement of this project. Our conceptual models of crustal growth are being redefined.

3. The CAOB appears to have formed by assemblage of Precambrian micro-continental fragments and a lot more of Phanerozoic juvenile crust produced by both lateral accretion of arc complexes and vertical accretion of underplated material of mantle derivation. Arc accretion appears to be the dominant process in the CAOB. On the other hand, the
abundant Permo-Triassic granitoids in Transbaikalia and the Altai Mountains and the vast Siberian Trap basalt could have been generated by a super-plume activity.

4. Recognition of **voluminous juvenile granitoids** in the Altai-Sayan region emplaced in post-collisional and intra-continental settings. This is thought to be related to old shear zones and granitic magmas formed by melting of mantle-lower crust mixture. In Transbaikalia, mingling of basic and acid magmas can be demonstrated in the field (Russian groups in Novosibirsk and Ulan Ude).

5. **Precise geochronology** is critical for tectonic interpretation and for estimation of crustal growth rate. Recent dating using advanced and more vigorous techniques have generated many more new results that completely changed the traditional views on the ages of many granitic massifs in the CAOB. The best examples are found in Xinjiang, Inner Mongolia and North-East China.

6. The role of **Precambrian basement gneisses** in the generation of granitic magmas has been evaluated using isotope techniques. An excellent example is given by the granitoids emplaced in the Baydrag terrane in Mongolia, the Altai and Tianshan mountains in Xinjiang, as well as those emplaced in the Jiamusi Massif of North-East China. In these cases, the Nd isotope data indicate that the presence of ‘old’ rocks was non-negligible. Thus, the accretion of the CAOB or Altai Collage involved Precambrian microcontinents, though their proportion in the entire CAOB may be small.

7. **Metalloceny**. Geochemical studies of granitoids and ore mineralization in Central Asia suggest juvenile sources for all ore elements. Ore mineralizations are mainly related to subalkaline and highly evolved granites. Moreover, intracontinental rifting resulted in the formation of carbonatite related magnetite-apatite mineralization, and REE mineralization is controlled by the deep faults of the Main Mongolian Lineament.

8. **Tectonic evolution of Mongolia**. The model of Sengor et al. (1993) for the Altaiids (= CAOB) was built essentially on the accretion of arc complexes. Detailed fieldwork during the last few years in Mongolia revealed that many interpretations in the Sengor model were based on erroneous or insufficient data published in the old Russian literature. The tectonic evolution was much more complicated than the Sengor model implies. Consequently, a new ‘terrane model’ was proposed by project participants in which the geology of Mongolia is divided into blocks of island arcs, continental margin arcs, accretionary prisms, ophiolites, passive continental margins, old Precambrian cratons, and late overlap basins. The paper of this model is being published in *J. Asian Earth Sci.*

**Achievements of the project this year**

**General scientific achievement**

The most important achievement of the project is that, through the numerous publications in the last two years the Central Asian Orogenic Belt became well known for its role in the continental growth and the enlargement of Asia during the Phanerozoic. Due to the importance of the project, renewed interest is taking place in more detailed field mapping, structural analyses, petrogenetic study and geochronology.

The highlights from different parts of the CAOB are summarized below.

**North-East China** – A large number of new ages and Sr-Nd isotope data were obtained. The results have considerably changed the views of geological evolution in North-East China and hence a new tectonic model is being constructed. At present, the ‘Caledonian’ granites seem to have disappeared as the result of better geochronology. Massive granitic rocks were emplaced since the Late Palaeozoic but culminated in Middle Mesozoic. They are mainly of I-type granites and characterized by positive ÂNd(T) values (+1 to +3). The Nd isotope data clearly suggest a significant mantle contribution to the magma genesis. However, in the area of the Jiamusi Block, the role of Precambrian rocks becomes significant in the generation of Mesozoic granitic magmas. Os isotopes of mantle xenoliths in Cenozoic basalts from North-East China were studied. The data suggest that part of the subcontinental lithospheric mantle was newly formed, and most of the old lithospheric mantle had been delaminated. This resulted in the thinning of the lithosphere from 200 to <100 km. In other words, more than 100 km of old lithosphere got lost in the Phanerozoic.

**Xinjiang, North-West China** – The Nd isotopic work on Northern Xinjiang (Altai, Junggar, Tianshan and Northern Tarim) shows that a substantial amount of granitoids was derived from mantle sources and the proportion of old crust to mantle contribution in granite petrogenesis increases from Junggar to Altai to Tianshan. The basement rocks (granitic gneisses, amphibolites and metasediments) in Northern Tarim are of middle Archean to early Proterozoic (3.2-2.2 Ga), in Tianshan early to middle Proterozoic (2.0-1.7 Ga), in Altai Mountains middle Proterozoic (1.4-1.0 Ga), and in Junggar loosely defined late Proterozoic ages (ca. 600 Ma). The ages and isotopic characteristics of the basement rocks appear to have a direct influence to the Nd isotopic compositions of the above young granitic intrusions. In a study of the sediments and granitoids from the Altai Mountains of China, it was demonstrated a secular variation of Nd isotope ratios in Palaeozoic passive margin sediments. An abrupt increase of initial ÂNd values in the Carboniferous-Permian sequence indicates a significant addition of juvenile materials in the sedimentary source.
regions, which may represent the uplifted Devonian back-arc oceanic crust and the newly formed Irtysb arcs.

**Mongolia** – A new interpretation of the tectonic evolution of Mongolia based on the terrane concept is being published by Badarch et al. (2001). According to this model, the geology of Mongolia is divided into blocks of island arcs, continental margin arcs, accretionary prisms, ophiolites, passive continental margins, old Precambrian cratons, and late overlap basins. This model is very different from that proposed by Sengör et al. (1993). Better geochronology and isotope investigations through international cooperation have contributed to a much clearer picture of the geological evolution in Mongolia. Furthermore, project collaborators discovered in the summer of 2000 an immense formation of acid volcanic rocks in Northern Mongolia. Two belts, which were previously described as silicic schists or quartzites of either Proterozoic or Devonian Age, consist of rhyolites, rhyolitic tuffs and a few conformable sheets of granite, but no intermediate or basic rocks. The rocks have been folded, but not recrystallized. The aggregate width of the two belts is about 150 km and the strike-length is about 650 km, making this the largest rhyolite field in Asia. New zircon ages suggest their emplacement in the Ordovician to Silurian, but the petrogenesis of these rocks (juvenile or re-melting of ancient continental crust?) remains to be worked out. In any case, the paucity at present of reliable structural-isotopic-geochemical data prevents the formulation of a single viable plate tectonic model.

**Transbaikalia** – This area is most celebrated for the immense volume of peralkaline granitoids and related volcanic rocks. New age data established that the granitoid belt of Transbaikalia was formed in several discrete episodes: 285-280 Ma, about 250 Ma, 225-220 Ma and about 210 Ma. In each one, large volcanic-plutonic structures, up to 2000 km² in area, were formed. The data point to multiple effect of large mantle plume on high-K basic and silicic magma generation process. Our studies on petrogeneses of some representative intrusive complexes have resulted in a few publications.

**Tuva-Sayan North Mongolia** – The Agadagh-Tes-Chem (ATC) Ophiolite in Southern Tuva is found to have the same age (ca. 570 Ma) as the Bayankhongor Ophiolite in West-Central Mongolia. Sr-Nd-Pb isotope data suggest that the ATC ophiolite and associated Tannuola arc complex have witnessed crustal contamination during their formation. Trace element geochemistry of the volcanic rocks and gabbros indicate a process of assimilation and fractional crystallisation to be responsible for their magma compositions. Consequently, the presence of an older continental crust is required for the tectonic model of the ophiolite emplacement. This work is part of the joint research between Kröner, Windley, and the Russian groups from Moscow and St. Petersburg on the late Precambrian to early Palaeozoic evolution of Central Asia.

**Altai-Sayan Fold Region** – This is the principal domain of research by the Novosibirsk group. The most significant achievement is summarized in the guidebook of IGCP-420 Workshop III. The guidebook was crystallized through many years of collective work effected by this group and its associates from St. Petersburg, Novokuznezk and other geologists from local Geological Surveys.

**Meetings**

- IGCP-420 Workshop III (6-16 August), in Novosibirsk and the Altai Mountains, Russia. 80 participants from 10 countries attended the conference meeting in Novosibirsk.
- A few members of IGCP 420 attended the International Symposium and Field Workshop on the Assembly and Break-up of Rodinia and Gondwana, and Growth of Asia (ISRGSA) in Osaka, Japan. This meeting was organized by Osaka City University and IGCP projects 368, 411, 440, and was sponsored by two other IGCP projects 419 and 420. Many discussions on the growth of Asia were particularly significant.

**List of most important publications**

The members of IGCP 420 were very productive in 2000-2001. In addition to the Workshop III abstract volume and field excursion guidebook, about 100 papers (exclusively articles) have been published or are in press.


**Refereed Journal Articles**

- Arakawa, Y.; Kouta, T.; Kanda, Y.; Amakawa, H.


Titov, A. V.; Vladimirov, A. G.; Vystavnoy, S. A.; Pospelova, L. N. Unusual high-temperature felsites
in post-granitic dyke complex of Kalguty rare-metal-bearing granite massive (Gorny Altai). Geokhimiya. (In press.)
- Wu Fuyuan; Jahn Bor-ming; Lo Ching-hua; Yui Tzen-Fu; Lin Qiang; Ge Wenchun; Sun Deyou. 2001. Highly fractionated I-type granites in NE China (I): Geochronology and petrogenesis. Lithos. (In revision.)
- Wu Fuyuan; Jahn Bor-ming; Lo Ching-hua; Yui Tzen-Fu; Lin Qiang; Ge Wenchun; Sun Deyou. 2001. Highly fractionated I-type granites in NE China (II): Isotopic geochemistry and implications for crustal growth in the Phanerozoic. Lithos. (In revision.)
- Wu Fuyuan; Sun Deyou; Li, Huimin; Jahn; Borming; Wilde, S. A. 2001. A-type granites in Northeastern China: Age and geochemical constraints on their petrogenesis. Chem. Geol. (In revision.)

Activities planned

General goals

IGCP 420 plans to hold its 4th and last Workshop and Field Excursion next summer in Changchun, North-East China. This is the project’s concluding meeting, of which the principal goal is to summarize achievements made during the 5-year period. Besides, discussions will proceed on a potential successor project to carry on studies in Central Asia. The accompanying field excursion will include visits to a variety of terranes including an Archean terrane, a Neoproterozoic massif (Jiamusi), a huge mass of Phanerozoic granitoids of the Zhangguangcai Range, and a spectacular Cenozoic volcanic province (Changbai Mountains). Thus, the project participants will have an opportunity to understand a complete crustal evolution in North-East China, from the Archean to the Recent. Evidently, the aspect of Phanerozoic crustal growth will be particularly underlined as North-East China provides one of the best areas for such manifestation.


R. Feist, Institut des Sciences de l’évolution, Université de Montpellier II, Place E. Bataillon, Cc 062, 34095 Montpellier Cedex 05, France, e-mail: rfeist@isem.univ-montp2.fr

J. A. Talent, Centre for Ecostratigraphy and Palaeobiology, School of Earth Sciences, Macquarie University, NSW 2109, Australia, e-mail: jtalent@laurel.ocs.mq.edu.au

Description: Although regional and national stratigraphic scales within the broad swath of North Gondwana crustal blocks/terrains are often out of alignment with each other, emergence of globally accepted criteria for defining series and stage boundaries within the Silurian to Early Carboniferous suggested that the time was ripe for a broad-scale exercise in re-correlation of the stratigraphic sequences throughout the North Gondwana regions. It was anticipated that such an exercise might
provide a sufficiently rigorous basis from which to investigate not only transgression-regression patterns, but also bioevent and biogeographic patterns. A fundamental aim of IGCP project 421 is to test to what extent biogeographic data may illuminate the dispositions and motions of the various North Gondwana crustal blocks/terranes.

Much of the taxonomic database for the North Gondwana region may be described as unruly and thus often of questionable value as a basis for tectonic inferences. Precise information on biogeographic patterns and how these may have changed over time depends on an accurate taxonomic database; it is necessary for a North Gondwana-wide exercise to be conducted to evaluate the quality of previous work (specifically for meaningful computer analysis) and for this evaluation to be undertaken with the best possible time frame at hand.

The revised and annotated faunal lists (the basic data for computer modelling) should be arranged according to the pattern of major lithospheric blocks. The stratigraphic framework needs therefore to be critically evaluated, crustal block by crustal block, using the most recent zonal schemes based on pelagic taxa. One of the objectives of IGCP 421 was to seek data that may indicate variation (or not) in impress/impact of specific global events. Special attention was being given to short-term changes in the diversity and dispersal patterns that may be linked to sea level changes and to ascertaining the extent to which these events can be deciphered throughout the North Gondwana regions.

Website of the project

Participating countries
(*indicates countries active this year)

Achievements of the project this year

Meetings

The ninth international meeting of IGCP 421 was held in the Senckenberg Museum, Frankfurt, 11–21 May. The meeting was held under the auspices of the Senckenbergische Naturforschende Gesellschaft as their 15th International Senckenberg Conference: “Mid-Palaeozoic Bio- and Geodynamics: the North Gondwana–Laurussia Interaction.” Conjoined with the conference was a meeting of the Subcommission on Devonian Stratigraphy. The conference attracted 135 participants from 18 countries; 43 papers and 45 posters were presented. An interesting aspect was seven presentations questioning current geodynamic models for Ordovician–Carboniferous times, globally as well as for southern and western Europe. A general consensus has been reached in favour for an approached position of plate boundaries between N-Gondwana, Avalonia and intervening microplates since the Early Devonian that permits exchanges of faunal and floral communities across the remnants of a narrow mid-European ocean. Associated with the conference were well-attended pre-and post-conference excursions examining recent developments in understanding of the mid-Palaeozoics of the Ardennes (Belgium), the Rheinisches and Thüringisches Schiefergebirge (Germany) and the Barrandian area of the Czech Republic. The first two regions have long been accepted as having been marginal to Baltica, the latter two as having been formerly part of the northern Gondwana margin.

Joint field meetings of IGCP 410 and IGCP 421 – North Gondwana mid-Palaeozoic bioevent/biogeography in relation to crustal dynamics, 4–21 August 2001, SW Siberia, Russia; and 21 August – 6 September 2001, Mongolia (45 participants from 10 countries). The field meeting focused on:
1. Ordovician–Devonian and Early Carboniferous sequences displaying major transgression/regression events (many conceivably global eustatic events), having faunas forming the basis of major monographic works (published and unpublished), and sequences displaying major extinction events during that time-interval;
2. Reef/clastic facial development and faunal associations/palaeocommunities within the shelf belt of the Siberian Continent during the Ordovician–Devonian and Early Carboniferous; and
3. Most recent views on large-scale translation of crustal blocks earlier hypothesized for some of the 10 or more major sutures in the Altai-Sayan Folded Area (ASFA). The last, though not a prime focus of the meeting, was of interest because of the suspicion that the ASFA collage may include a suspect terrane or two perhaps derived from the North Gondwana margin. Part of the AFSA extending from the Rudniy Altai through the South Mongolia Folded System (or, more specifically, the Inner Mongolian Fold System) includes various ophiolite slivers as well as terranes believed with high probability to have been derived from the North Gondwana continental margin.

The field excursion enabled about 40 participants to examine key Late Cambrian to Early Carboniferous sequences in the Gorniy Altai (extending into the Altai Republic), Salair and Kuznetsk Basin regions of South-West Siberia. These regions constitute the western part of the Altai-Sayan Folded Area (ASFA) where a mosaic of structures was generated by several periods of tectonic activity (Early Caledonian to Variscan orogenic cycles). Gradual decrease in age of accretional and collisional
geological complexes from east to west (with distance from the Siberian Craton) is apparent, related to successive accretion of terranes to the Siberian Craton, coupled with substantial, and some major strike-slip displacement during collisional and post-collisional stages. Outer and inner shelf zones are clearly defined. The former is characterized by extensive development of carbonate platforms including build-ups, the outer shelf zone by mainly clastic sedimentation. The Ordovician-Silurian sequences include graptolitic as well as shallow-water sequences with high diversity of benthic fossils. The Devonian and Early Carboniferous sequences are characterized mainly by benthic associations, though with occurrences of conodonts and ammonoids. It is believed that collisions of Mongolian terranes with the Siberian Continent at the beginning of the Devonian caused narrowing and eventually closure of seaways along which exchange of benthic faunas had been taken place between South-West Siberia, Mongolia, the Heilungjiang region of China, and the Russian Far East.

The excursion started with the examination of Ordovician-Silurian sequences near Bugryshykha with Llanvirn-Ashgill-middle Wenlock shelly faunas, and Kur’ya with Early Ludlow, Pragian and Early Carboniferous shelly faunas including conodonts. Sequences near Ust’ Chagyrka, Rossypnaya Mount, Charyshskoe and Tigerek provided insights into clastic, reef and deep water facies during Tremadoc-Wenlock times as well as, for the Devonian-Eifelian sequence along Kuvash Ck and the Tom’ River (including reference sections for the Rokshykh complex of the Uralian Stage and Sayan Dei and Arvaiher, WSW of Ulaanbaatar, and Shine Jinst, SSW and SW respectively of Ulaanbaatar, and Ulaanbataar. 11 conferences were presented; topics related to IGCP 421 concerned: trilobite affinity trends in N Gondwana (specially in the mid-Asian part), Devonian charophytes in Asia, Lower and Middle Devonian tabulate corals in Mongolia, Late Devonian brachiopod extinction ans recovery in South China and a progress report on computer model based biogeographic reconstructions. The main excursion areas were in the vicinity of Mushgai and Shine Jinst, SSW and SW respectively of Ulaanbaatar, and Saganai Dei and Arvaikheer, WSW of Ulaanbaatar. In all areas excellent sequences of often highly fossiliferous Ordovician, Silurian, Devonian and Early Carboniferous sediments were presented. Continuing work on these sequences is resulting in an increasingly intricate stratigraphic nomenclature and much new and important biostratigraphic data.

The excursion concluded with the examination of isolated Late Cambrian to Late Ordovician outcrops and superbly exposed Lochkovian–Pragian, Givetian and Lower Carboniferous sequences (with abundant shelly faunas) in the vicinity of Gur’evsk, and examination of Late Givetian to Early Famennian sequences along the Tom’ River (including reference sections for the Kuznetsk Basin), again with many intervals characterized by abundant brachiopods, corals, fish and microfaunas. Sequences demonstrated included one that is arguably the most elegant sequence globally through the Lochkovian–Pragian, Givetian and Lower Carboniferous, with abundant shelly faunas. The sequence extended with examination of the Early Devonian-Eifelian sequence along Kuvash Ck and the shallow-water Tremadoc (brachiopods, trilobites, conodonts) at Kamt’ak Ck.

The sequence at Bayan Khoshuu about 30 km east of Mushgai displays interesting fossiliferous intervals of Late Ordovician (Ashgill) to Early Carboniferous, with noteworthy highly fossiliferous carbonate intervals in the Lochkovian and Famennian-Tournaisian, the latter with conodont data from above and below the D/C boundary. The sequence, as so often in southern Mongolia, is thick (>3000 m). Shorter sections were visited at Hanii Doloon (Early Silurian with diverse fauna of brachiopods, rugosans and tabulate corals) and Havtsal (Early Silurian and Lochkovian). The region about Shine Jinst, the focus of intensive investigation by Soviet workers in the 1970s and 1980s, has excellent and picturesque outcrops of Ordovician to Devonian sequences. The Caradoc-Wenlock sequence at Shar Chulutt has several interesting and highly fossiliferous carbonate intervals, including build-ups in the Ashgill and late Wenlock. The succession continues at Ulaan Shand through the Ludlow and Lochkovian with intermittent carbonate intervals (and diverse but unpublished faunas), passing into clastics before the end of the Lochkovian. An especially interesting sequence at

It is planned to publish refereed papers from the Novosibisk meeting as a special issue of Russian Geology and Geophysics.

**Mongolian Segment** (21 August–6 September 2001), 35 participants from 10 countries:

The field component of the Mongolian segment of the joint IGCP 410/421 expedition (23 August to 5 September) followed a day (22 August) of technical presentations at the Mongolian Technical University and visits to the National History Museum and Geological Museum in Ulaanbataar. 11 conferences were presented; topics related to IGCP 421 concerned: trilobite affinity trends in N Gondwana (specially in the mid-Asian part), Devonian charophytes in Asia, Lower and Middle Devonian tabulate corals in Mongolia, Late Devonian brachiopod extinction ans recovery in South China and a progress report on computer model based biogeographic reconstructions. The main excursion areas were in the vicinity of Mushgai and Shine Jinst, SSW and SW respectively of Ulaanbaatar, and Saganai Dei and Arvaikheer, WSW of Ulaanbaatar. In all areas excellent sequences of often highly fossiliferous Ordovician, Silurian, Devonian and Early Carboniferous sediments were presented. Continuing work on these sequences is resulting in an increasingly intricate stratigraphic nomenclature and much new and important biostratigraphic data.
Tsakhir extends from Pragian to Givetian with carbonates and conodont data from Emsian, Eifelian and Early Givetian horizons. Sections at Yamaan Us display richly fossiliferous Ashgill, Late Llandovery-Wenlock and Late Famennian-Tournaisian, the latter with conodont data from either side of the D/C boundary. Other sections visited in the Shine Jinst region were at Daravgai (Caradoc) and Gashuun Ovoo (richly fossiliferous Ashgill-Llandovery).

The Caradoc-Ashgill sequence at Tsagaan Del in the Bayankhongor area, elaborated by Rozman and Minjin and others in the 1980s, and noteworthy for its brachiopod faunas (possibly spanning the Ordovician-Silurian boundary) was visited on the way back to Ulaanbaatar from Shine Jinst. Detailed lists of the faunas from all sections visited are given in the excellent field guide compiled by Chuulin Minjin from contributions from seven Mongolian workers (reference below).

List of most important publications

- Daniell, J. J. Sedimentology and biostratigraphy of a mid-Devonian carbonate platform margin, Broken River Province, North Queensland. Courier Forschungsinstitut Senckenberg (pagination not to hand).
- Kemp, A. 2001. Chirodipiterus potteri, a new Devonian lungfish from New South Wales, Australia;


Activities planned

General goals

The prime focus for 2002 is to move IGCP 421 colleagues towards quantitative evaluation of data on biota documented from the broad region covered by the project. IGCP 421 has published already exhaustive exemplification of compilation of a taxonomically consistent database for brachiopods for much of the North Gondwana regions and a long paper on application of expert systems to biogeographic analysis, using this database. The impact of these data so analysed (covering the broad spectrum of taxonomic groups), is being progressively evaluated, time-slice by time-slice, with regard to the pattern and relative motions of the 45 or so crustal blocks in the “North Gondwana” regions during Late Silurian to Early Carboniferous times. The impact of these analyses on geophysical/palaeogeographic models has been addressed in all three meetings of IGCP 421 during 2001, and is the principal focus of the two conferences scheduled for 2002.

Anticipated objectives in 2002 and coming years:

1. **Interaction of quantitative palaeobiogeographic and tectonic/geophysical modelling.** Because provincial patterns have a pronounced longitudinally constraining aspect, palaeomagnetic data is latitudinally constraining, we are bringing together a broad spectrum of people with expertise in palaeomagnetic modelling and/or tectonics (especially for the regions covered by IGCP 421) for interaction with colleagues who have undertaken palaeobiogeographic modelling. This will take place in Montpellier at the end of the post-conference excursion for the ECOS-VIII/IGCP 421 meeting in June 2002, and in a dedicated section of the International Palaeontological Congress in Sydney in July 2002.

2. **Synthesis of a volume setting out the extent to which palaeobiogeographic data (quantitatively probed) impinges on geodynamic models for the North Gondwana region.** This can get under way seriously only after the two conferences specified in the previous paragraph.

3. **Generation of an annotated correlation chart for central and south Asia.** This was set in train at the Esfahan, Iran, meeting of IGCP 421 in December 1998, and is continuing.

Critical milestones for 2002 will be:

1. **Publication of scientific papers arising from the 2001 meetings in Frankfurt (as a volume of Courier Forschungsinstitut Senckenberg – manuscripts presently being refereed) and the meetings in SW Siberia and Mongolia (as a special supplement of Russian Geology and Geophysics).**

2. **Acceleration of data compilation for various groups – so that exercises in computer biogeography can be undertaken in time for the two meetings we wish to have in 2002 in association with ECOS VIII and the First International Palaeontological Congress (IPC-2002). This is presently being actively undertaken for tentaculitids (E. Schindler, Forschungsinstitut Senckenberg), Silurian-Middle Devonian conodonts (R. Mawson and A. Simpson, Macquarie University), Late Devonian-Early Carboniferous conodonts (M. C. Perri and C. Spalletta, University of Bologna), Silurian-Early Carboniferous bivalves (M. Bradshaw, University of Christchurch, possibly with J. Kriz, Czech Geological Survey), trilobites (R. Feist and G. Schraut, Université de Montpellier). Expert systems analyses of brachiopod data n relation to crustal blocks continue to be undertaken by V. Yolkina et al. (Russian Academy of Science, Novosibirsk) and P. Cockle (Macquarie University).**
3. Generating a draft of the Correlation chart for mid-Palaeozoics of central and south Asia, hopefully in time for discussion during the dedicated IGCP 421 meeting associated with the International Palaeontological Congress in Sydney in July 2002.

Meetings

1. The Eighth International Conodont Symposium in Europe (ECOS VIII). Joint Meeting of IGCP 421 and SDS/ICS/IUGS. The excursions associated with this meeting (June 2002) are to mid-Palaeozoic sequences in northern Spain and SW France (Asturias/Pyrenees/Montagne Noire) of primary significance for IGCP 421, and include global stratotypes for the Middle-Late Devonian, Frasnian-Famennian and Devonian-Carboniferous boundaries. We have been invited to make this a joint venture between ECOS VIII, SDS (IUGS) and IGCP 421. The scientific session in Albi (in vicinity of Montagne Noire) will include a dedicated symposium on interaction of quantitative palaeobiogeographic and tectonic/geophysical modelling, i.e. the impact of palaeobiogeographic models on global tectonic models.

2. The First International Palaeontological Congress (IPC-2002; 6-10 July 2002, Sydney, Australia) under the auspices of the International Palaeontological Association. Associated with this will be three excursions of relevance to activities of IGCP 421 (in fact to be mounted for it): (a) Devonian fish and marine–non-marine correlations in eastern Australia; (b) Post-conference excursion: NE Australia: Burdekin, Broken River and Hodgkinson Basins Ordovician–Early Carboniferous biostratigraphy and event-stratigraphy; (c) Post-conference excursion: Canning Basin (North-West Australia) Devonian-Early Carboniferous biostratigraphy and event-stratigraphy. This conference will showcase the activities of IGCP 421. A special symposium (focused on IGCP 421 and its results) will be mounted on the theme of quantitative palaeobiogeography.


K. Sassa, Landslide Section, Disaster Prevention Research Institute (DPRI), Kyoto University, Uji, Kyoto, 611-0011, Japan, e-mail: sassa@ scl.kyoto-u.ac.jp

P. Canuti, Dipartimento Scienze della Terra, Università di Firenze, Via G. La Pira, 4-50121, Florence, Italy, e-mail: canuti@geo.unifi.it

R. Carreno, Consultant, Apartado postal 638, Cusco, Peru, e-mail: raulraulcarreno@hotmail.com

Description: This project highlights the scientific basis of landslide management where risk exists near cultural heritage sites of high value in areas of relatively dense population. An important goal is to develop techniques of rational hazard assessment by primary, high resolution monitoring of slope instability at such sites. This follows the current thinking on risk-based approaches of land sliding. The aims of the project include a higher than usual precision in hazard characterisation, zoning and risk evaluation, as well as the development of a strategy designed to serve the specific needs of heritage sites. The project will adopt a deliberately interdisciplinary and cross-sectoral approach to natural hazard and preservation of cultural heritage. Thus, it is expected to involve tangible collaborative work between these two sub-sectors.

Recent rapid urbanisation and regional development are increasing landslide risks in areas of rapidly growing population and at cultural heritage sites, particularly in developing countries throughout the world. Special attention will be given to historical areas, densely populated urban areas and cultural heritage sites of universal value, which generate considerable income through active cultural tourism throughout the world.

Website of the project http://landslide.dpri.kyoto-u.ac.jp/igcp/
http://landslide.dpri.kyoto-u.ac.jp/ICL.htm

Participating countries

Australia, Austria, Bulgaria, Canada, China, Czech Republic, Egypt, Ethiopia, France, Germany, Greece, Iran, Italy, Japan, Nepal, Peru, Slovakia, Republic of Korea, Romania, Russia, United Kingdom, United States.

Summary of major past achievements of the Projects

List of IGCP 425 Sub-Projects

1. Research on the Slope Stability of Block II of the Lishan Landslide, Lintong County, Xian, China
2. The Archaeological Site of Delphi, Greece – A Site Vulnerable to Earthquakes and Landslides
3. Slope Stability Conditions of the Rock mass at the Foundation Areas of the Monasteries of Mount Athos, in Northern Greece
4. Conservation from Rock fall of the Engraved Wall in the Fugoppe Cave, Hokkaido, Japan
5. Slope Deformation and Other Geohazards Endangering the Stability of Historic Sites in the Western Carpathians
6. Landslide Hazard and Risk Assessment in Archaeological Sites
7. The evaluation of the risk of deep-seated mass movements to the cultural heritage sites of Hallstatt-Dachstein, Upper Austria
8. Geotechnical Landslide Risk Analysis around and inside some Egyptian Historical Monuments
9. Landslide Hazard Assessment for the Places of Historical Heritage in the North-Eastern Azov Sea coastal region (Taganrog city and the area of the
Achievements of the project this year

The most eminent outcome of the IGCP 425 came from Sub-project No.15 ‘Protection of Inca Cultural Heritage on Landslide Zones at Cusco, Peru’. Preliminary investigations were conducted three times at the well-known UNESCO World Heritage ‘Machu Picchu’ Inca monument in Peru, located on the head scarp of a potential large-scale rock slide. Records by ten sets of simplified extensometers and two sets of pen-recording type ones revealed that the slope is creeping and a probability that the monument may be at landslide risk. This evaluation was reported all over the world through mass media such as BBC, CNN, Reuters, and Associated Press which contributed to the wide recognition of the societal importance of progress in landslide risk evaluation.

Two other IGCP 425 sub-projects developed portable Synthetic Aperture Radar (SAR) technique and Real-time Kinematic GPS for landslide monitoring.

Meetings

- UNESCO-IGCP Symposium ‘Landslide Risk Mitigation and Protection of Cultural and Natural Heritage’ and the third general meeting of IGCP 425, held at the Science Council of Japan, Tokyo, 15-19 January 2001 (57 participants from 18 countries). Seven new sub-project proposals for IGCP 425 were approved at the third general meeting.

- IGCP 425 Japanese National Committee and ISSMGE (International Society for Soil Mechanics and Geotechnical Engineering) ATC-9 as well as TC-11 (landslides) committee jointly held the ISSMGE ATC-9 Field Workshop on Cultural and Natural Heritage in Trabzon, Turkey, 23-24 August 2001. About 20 members from 8 countries joined this meeting and six technical papers were presented. CD-R and hardcopy proceedings are published for the participants.

- UNESCO-Kyoto University International Symposium ‘Landslide Risk Mitigation and Protection of Cultural and Natural Heritage’, Kyoto, 21–25 January 2002 (84 members from 21 countries participated, including 3 UN organizations, UNESCO, WMO, and ISDR). Proceedings of 750 pages were published as CD-R containing files of all papers. IGCP 425 Business Meeting was held on 23 January. One of the most outstanding outcome of this symposium was the round table discussion and the establishment of an International Consortium on Landslides (ICL) where Statutes and Membership were approved. A media conference was held to release the ‘2002 Kyoto Declaration’ which especially puts emphasis on how to promote an international programme on landslides (IPL) and a UNESCO Research Centre on Landslides (RCL/UNESCO).
'2002 Kyoto Declaration'
Establishment of an International Consortium on Landslides

'We, international experts in the fields of landslide research, disaster reduction, in particular landslide risk mitigation and protection of cultural and natural heritage, who are gathering in the ICL Foundation Meeting held in the International Symposium on Landslide Risk Mitigation and Protection of Cultural and Natural Heritage organized in January 2002 in Kyoto, discussed the foundation of an international non-governmental and non-profit making scientific organization named as an International Consortium on Landslides (ICL) to promote and coordinate landslide research for the benefit of society and the environment in the global scale, and agreed on the following principal objectives of ICL:

(a) To promote landslide research and capacity-building including education for the benefit of society and the environment;
(b) To integrate geosciences and technology within the appropriate cultural and social contexts with an aim to evaluate landslide risk in urban, rural and developing areas and cultural and natural heritage sites, as well as to contribute to the protection of the natural environment and sites of high societal value;
(c) To combine and coordinate international expertise in landslide risk assessment and mitigation studies, thereby resulting in a renowned international organization, which will act as a partner in various international and national projects; and
(d) To promote a global multidisciplinary programme on landslides.

Members of ICL shall include, inter alia, (a) intergovernmental entities, (b) non-governmental organizations (c) governmental agencies and departments, universities, research institutes and other public institutions and (d) other organizations that support the objectives of ICL, both intellectually and financially. The United Nations system Organizations, entities and programmes will be invited to provide special support.

Accordingly, we have unanimously agreed and declared to found the International Consortium on Landslides under the Statutes attached.'

Date: 21 January 2002
Place: Kyoto, Japan

Background and objectives of the Tokyo International Symposium

In 1999, UNESCO and the Disaster Prevention Research Institute, Kyoto University, exchanged a Memorandum of Understanding (UNESCO/DPRI Memorandum of Understanding) ‘Concerning cooperation in research for landslide risk mitigation and protection of the cultural and natural heritage as a key contribution to environmental protection and sustainable development in the first quarter of the twenty-first century’, to promote a global effort in the field of landslides. Based on the UNESCO/DPRI-KU MoU and IGCP 425, the first International Symposium on Landslide Risk Mitigation and Protection of Cultural and Natural Heritage was organized on 15-19 January 2001 in Tokyo. Participants of the symposium released the 2001 Tokyo Declaration ‘Geoscientists tame landslides’ proposing to set up a new International Consortium on Landslides (ICL).

The International Consortium on Landslides shall consist of intergovernmental member units, non-governmental units, governmental units and the public, and other types of member units, which support the following principal objectives of ICL:

• To promote landslide research for the benefit of society and the environment.
• To integrate geosciences and technology with cultural and social sciences with an aim to predict landslides and prevent them from affecting urbanized areas and cultural or natural heritage sites, as well as to contribute to the protection and remediation of such sites of high societal value.
• To combine and coordinate international expertise in landslide risk assessment and mitigation studies, thereby resulting in a renowned international profile as partner in various international and national projects.

The activities of ICL under examination are:

• Research Programme: UNESCO/ICL International Programme on Landslides (IPL) in consultation with IGCP or IHP.
• International Journal Landslide News presenting new results of landslide research and related information with colour photographs and figures jointly published by ICL, the Japan Landslide Society and an international publication company.
• General Assembly and Conference, once every 3 years, Meeting of the Board of Representatives, once a year.
• Symposia and Field Workshop, usually once a year.

• To create landslide databases
• Dispatch of landslide experts upon request
• Information transfer on landslides through seminars or schools
• Coordinating of global efforts and expertise in landslide studies and risk mitigation and promoting other objectives of ICL
• Supporting the activities of ISSMGE TC-11 (Landslides), IAEG Commission No. 2 (Landslides and Other Mass Movements) and other landslide research groups.

The objectives of this Second Symposium on Landslide Risk Mitigation and Protection of Cultural and Natural Heritage were: (1) presentation and discussion of selected research topics in the frontier of landslide research; (2) examination of the structure, activities and
the further procedure of ICL foundation within participants, especially among participants from potential ICL member units during the symposium.

Symposium topics are focused on currently important three selected topics.

1. **Earthquake and Rainfall Induced Rapid Long-Traveling Flow Phenomena**
   
   The mobility of landslides is expressed by the apparent friction angle ($\phi_a$) or average apparent friction (H/L) mobilized during the motion. The apparent friction angle in most landslides is around more than 30 degrees (equal to around the friction angle in loose sands). In Japan, slopes steeper than 30 degrees are designated to be dangerous and those are protected by remedial measures. However, recent catastrophic landslides disasters are mostly caused by rapid long-travelling flow phenomena showing the apparent friction angle around 10 degrees in Japan and in the world. Those landslide disasters occurred in urbanization areas or relatively recent developed areas as typically shown by the Las Colinas landslide triggered by the 2001 El-Salvador earthquake which killed around 600 persons.

   The mechanism of such rapid long-travelling flow phenomena is not yet known and is in the initial stage of investigation. The mechanism and its prediction is one of the most important research topics in the field of landslide risk mitigation. The Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) has selected the study on the Mechanism and Areal Prediction of Earthquake and Rainfall Induced rapid and long-travelling Flow phenomena (APERIF project) as a project of the Special Coordination Fund for Promoting Science and Technology (300 million Japanese Yen in 2001-2003). This project was proposed by the joint research group of the Landslide Research Council of Japan and the Japan Landslide Society as one of the main research activities cooperating with the planning of the International Consortium on Landslides. During this project, cooperation and joint research with foreign researchers and members of the units of ICL are planned and welcomed. The ISSMGE Technical Committee on Landslides (TC-11) has also organized a Conference on Transition from Slide to Flow: Mechanism and Remedial Measures on 25-26 August 2001 in Trabzon, Turkey, on this topic.

2. **Cultural Heritage at Landslide Risk**

   Landslide monitoring and development of the new technology is very important for landslide risk mitigation and protection of cultural and natural heritage. The Integrated Global Observing Strategy (IGOS) is planning to develop the system to monitor landslides as well as earthquakes and volcanic activities using space technology. This will be one of the most promising fields of ICL research. Landslide mapping, landslide inventory and database, and their technologies are basic tools for landslide risk mitigation. Those topics were presented and discussed in this symposium.

3. **Landslide Monitoring and Technology, Landslide Mapping and Database**

   IGCP 425 studies landslide hazard assessment at cultural and natural heritage sites. This was the main target in the first symposium in Tokyo, 15-19 January 2001. And further progress and new research were presented at the symposium beginning of 2002.

### List of most important publications


### Activities planned

#### Meetings

- ICL and IGCP 425 joint symposium is planned to be held in September/October 2002 at UNESCO, Paris. It will be organized as the 5th general meeting of IGCP 425 and the inaugural meeting of ICL.
- ICL and IGCP 425 joint field workshop on landslide risk evaluation of the World Heritage Site Machu Picchu, Peru, is planned to be held in Cusco, 2002.
- Joint meeting of IGCP 425 Japanese National Committee and ISSMGE ATC-9 Japanese National Committee will be held in FY2002.


W. R. Van Schmus, Department of Geology, University of Kansas, Lawrence, Kansas 66045, United States, e-mail: rvschmus@ku.edu

J. S. Bettencourt, Instituto de Geociências-USP, Caixa Postal 11348, CEP 05422-970 São Paulo – SP, Brazil, e-mail: jsbetten@usp.br
Description: The scientific aim of this project is to investigate the petrology and geochemistry of Proterozoic granite systems in relation to their metallogeny and tectonic environments. The principal result will be correlation of Proterozoic granite systems with the tectonic environments in which they formed, together with the development of models designed to explain these correlations. These results will, in turn, be a source of improved general understanding of granitoid petrogenesis in the context of global tectonics through time. Better understanding of the correlation between granite petrogenesis and certain types of metallogenic provinces will also improve prospection and exploration strategies. The principal societal benefits will be twofold. First, the applied results will help certain countries to find and develop better economic deposits. Secondly, involvement of participants from less developed countries as active partners with participants from more developed countries will enable the former to enhance their geological research capabilities and background.

Participating countries (all active this year)

Argentina, Australia, Belgium, Brazil, Cameroon; Canada; England; Finland; Germany, Ireland, Italy, Norway, Poland; Russia, Sweden; United States, Venezuela.

Achievements of the project this year

General scientific achievements

During the first years of IGCP 426 most of the emphasis has been on data acquisition, with preliminary results presented at conferences in 1998, 1999, 2000, and 2001. In some cases scientific publications arising from the work were published or accepted for publication this year. Discussions and meetings this year have not only brought certain aspects of the scientific themes of IGCP 426 into focus, but have also resulted in uniting some of them into topics for more detailed discussion in 2002.

One of the major goals for IGCP 426 relates to ‘societal benefits’. The project has defined these benefits in terms of providing opportunities for advanced education and research opportunities for graduate students and post-graduate students from less developed countries. During the past first three years major steps were made forward in this regard, as detailed in the preceding year report. For the most part these collaborations remain active. This year efforts were made to involve delegates from Cameroon, particularly with regard to correlation between granite systems in the Pan African fold belt of West Africa and the Brasiliano fold belt of North-East Brazil.

Meetings


– Special Session 14: ‘Proterozoic granitoids and anorthosites’, Geological Association of Canada Annual Meeting, St. John’s, Newfoundland, Canada, 28-30 May 2001. A full-day special session was organized on Proterozoic Granitoids and Anorthosites at the GAC-MAC annual meeting in May. A total of 24 papers were presented in oral and poster sessions covering a wide variety of topics ranging from Proterozoic tectonic processes to magma generation, as well as representing a wide geographic distribution of research areas including North America, South America, Scandinavia, Russia and India.

– Workshop on Geology of South-West Amazonian Craton: State-of-the-Art. Instituto de Geociencias, Universidade de São Paulo, São Paulo, Brazil, 10-12 August 2001. During the last 10 years a substantial amount of geologic data has been produced and this workshop brought together Brazilian scientists and selected international participants from a variety of disciplines to discuss the mutual themes of interest and mutual efforts to unify approaches and thoughts. It focused on: lithospheric processes and tectonic environments; platform sedimentary sequences; granitoid magma generation; basement rocks; metallogenesis; palaeocontinental reconstruction. A total of 36 papers were presented, with a total participation of about 60 geoscientists from four countries interested in the geologic evolution of the Amazonian Craton. Two of IGCP 426 themes that were important for this conference were: (a) origin of A-type (rapakivi) magmas, and (b) palaeocontinental correlations of Amazonia with Laurentia and Baltica.

– A topical session T3: ‘Focus on IGCP, Modern and Ancient Plate Boundaries and Orogens’, Geological Society of America Annual Meeting, Boston, Massachusetts, 6-7 November 2001. The meeting was co-sponsored by IGCP projects 426, 433, 436, 440, and 453. A total of 32 oral papers were presented in morning and afternoon sessions on 6 November, and 13 poster papers were presented on 7 November. IGCP 426 participants represented Brazil, Cameroon, and the United States. During their participation at the GSA meeting, Dr Toteu and Mr Tchouankoue of Cameroon and Dr da Silva Filho of Brazil spent substantial amounts of time discussing the geology of Cameroon and North-East Brazil, two Precambrian (Gondwana) terrains that were adjacent to each other prior to the opening of the Atlantic Ocean. These
discussions will hopefully lead to collaboration among geoscientists in West Africa and North-East Brazil relative to better understanding of the pre-collisional, collisional, and post-collisional history of the Pan African-Brasiliano orogenic belt that traverses both regions. Dr Toteu has already prepared a proposal and recruited participants for a new IGCP project that will examine these problems in more detail (see IGCP 470 – The 600 Ma Pan-African Belt of Central Africa, accepted at the IGCP Scientific Board meeting, February 2002).

Other activities

- In 2000, the Venezuela Working Group of IGCP-426 (Prof. Simon Rodriguez, coordinator) initiated a study of the relationship between regional tectonism and metallogenic districts of Northern Venezuela and the Southern Brazilian Shield.
- 12th International Conference of the Geological Society of Africa, Yaoundé, Cameroon, 27 March-2 April 2001. No formal IGCP 426 technical session was planned for this meeting, since its principal focus was on environmental catastrophes. However, there was an open session on Precambrian geology, and IGCP 426 members Dr Felix Toteu, CRGM, Garoua, and Mr Jean-Pierre Tchouankoue, University of Yaoundé, held an informal workshop for potential IGCP participants from other countries in Central Africa. Dr Toteu developed a new project proposal on the theme ‘The Pan-African belt of Central Africa: Deformation history, magmatism, metamorphism and geotectonic evolution’, with potential participants from several countries in Central Africa plus others from Europe, United States, and Brazil.

List of most important publications for 2001

Precambrian Research Special Issue. The project co-leaders are in the final stages of editing 14 contributions from IGCP-426 participants to a special issue of Precambrian Research special issue under the theme of IGCP Project 426 ‘Granite Systems and Proterozoic Lithospheric Processes’. A final review of manuscripts will be submitted to Elsevier Geoscience at the end of 2001 and, accordingly, an early to middle 2002 publication date is foreseen.

List of publications in which IGCP 426 is acknowledged


Activities planned

General Goals

The general goals will continue to be the major ones outlined in the original proposal, with emphasis focusing on (a) use of granite systems for intercontinental geodynamic studies of palaeocontinent reconstructions, (b) origin of A-type granite systems (rapakivi; AMCG suites, etc.); (c) metallogenesis associated with granite systems, and (d) geotechnical education and outreach for less developed countries through visitations and collaborations at laboratories in more developed countries. This year IGCP 426 proposes to concentrate on developing integration among these goals to examine some topics in more detail; these themes have developed from conferences sponsored this year and discussions held among participants. The main themes include trying to define better the tectonic regime in which A-type granites form. For example, whether some are truly ‘anorogenic’; whether some are related to convergent plate boundaries (subduction systems under the craton); whether some are related to recognized extensional events. A second theme that will continue to be pursued is the link between A-type (or, more broadly, post-tectonic) magmatism and certain types of metallogenesis. The examination of the validity of certain types of elemental ‘tectonic discrimination diagrams’ to Proterozoic systems will also be continued.

Meetings

Because of logistic problems of bringing together a large group of scientists from several continents to address some of the IGCP 426 goals during 2002, the co-leaders of the project again propose participating in several meetings in various countries which have technical sessions or symposia related to one or more of the project’s main themes. IGCP 426 would also like to organize one or two field trips in the United States, if finances, logistics, and weather permit. This approach will optimise participation of members from less developed countries, while still maintaining an integrated project.

International Basement Tectonics Conference, Rolla, Missouri (19-23 May 2002). The next International Basement Tectonics Conference (IBTC) will be held at the University of Missouri-Rolla, Rolla Missouri from 19 May to 24 May, with a pre-meeting field trip on 17-19 May and mid-meeting field trips. The themes of the conference will include (a) metallogenesis associated with A-type magmatism and (b) advances in understanding the United States midcontinent basement and...
its economic potential. Proterozoic granite systems are an essential component of these themes, and IGCP 426 will work with organizers of the conference to co-sponsor one or more technical sessions. The pre-meeting field trip for the IBTC will be held in the Mesoproterozoic granite-ryholite system in the St Francois Mountains of South-East Missouri and should be attractive to many IGCP 426 participants. In addition, the option of also holding a post-meeting field trip that will go from Rolla to Southern Okalhoma (Arbuckle Mountains), Colorado and Wyoming (Front Range) will be explored. This trip would examine relationships of Mesoproterozoic A-type magmatism to their Palaeoproterozoic host terranes and potential tectonic correlations of midcontinent-South-West United States A-type magmatism to continental margin orogenesis along Southern and Eastern Laurentia.

Note: The themes of the IBTC conference will be directly related to activities of the Venezuela Working Group, and IGCP 426 will make a strong effort to support their participation in either the IBTC (preferred) or the GSA meeting in Denver.

- Geological Society of America Annual Meeting, Denver, Colorado, 27-30 October 2001. IGCP 426b is preparing a proposal to the GSA for a special topical session at the next annual meeting. The provisional title is ‘Correlation of A-type Plutons to Convergent Margins: Orogenic Links to Anorogenic Magmatism’? The purpose of the session will be to invite speakers or accept general contributions, which will address the origin of the magma systems responsible for the Mesoproterozoic anorogenic magmatism throughout Southern Laurentia. In recent years, there have been many suggestions that this magmatism was, in fact, linked to convergent margin tectonic activity along Southern and Eastern Laurentia. Recent papers have also proposed similar links for Mesoproterozoic to late Palaeoproterozoic A-type magmatism in Baltica and Amazonia. It is believed the time is right for focusing on this topic, which will bring together IGCP 426 participants who have been focusing on these problems separately (A-type magmatism; Proterozoic tectonics). The original plan was to develop a GSA pre-meeting field trip in the Front Range of Colorado-Wyoming in association with this session, but in view of possible weather problems, that may be done earlier.

- Second Symposium on Volcanism and Associated Tectonic Settings, Belém, Brazil, Nov. 2002. This meeting is being coordinated by Dr Roberto Dall’Agnol and will include extensive discussion of Proterozoic volcanism in the Amazonian Craton, one of the themes developed within the IGCP 426 Workshop on the Amazon Craton held in August 2001. IGCP 426 will offer to co-sponsor one or more topical sessions at this symposium.


C. M. Lesher, Mineral Exploration Research Centre, Willet Green Miller Mines and Mineral Research Centre, Laurentian University, 933 Ramsey Lake Road, Sudbury, ON P3E 6B5 Canada, e-mail: lesher@sympatico.ca

S.-J. Barnes, Sciences de la Terre, Université du Québec à Chicoutimi, 555 boulevard de l’Université, Chicoutimi, QC G7H 2B1 Canada, e-mail: sjbarnes@uqac.uquebec.ca

Description: The basic and applied scientific goals of this project deal with relevant topics in fluid dynamics and thermomechanical erosion in magmatic systems with an emphasis on sulphide, PGE, oxide precipitation mechanism and controls of the composition of magmatic ores. A better understanding of the origin of ore deposits of Ni-Cu-Co, Cr-V-Ti and PGE should contribute to the efficient prospecting of ore deposits. Although not a major aim, it is expected that a contribution will be made to current understanding of how the geochemistry of sulphur may contribute to the handling of mining waste. The project will involve an international, interdisciplinary group of researchers with expertise in field geology, experimental, igneous and metamorphic petrology, volcanology, mineralogy, geochemistry, isotope geochemistry, fluid dynamics and thermodynamics. The project will meet short- and long-term world-wide needs by aiding in the transfer of research methodologies to colleagues in less developed countries and by aiding in the development of exploration tools that can be used to discover and optimally develop sustainable resources of PGE, Ni, Cu, Co, Cr, V, and Ti.

Website of the project http://www.laurentian.ca/www/geology/IGCP/IGCP.htm

Participating countries

Australia, Austria, Belgium, Brazil, Britain, Canada, China, Czech Republic, Denmark, Egypt, Finland, France, Germany, India, Italy, Japan, Morocco, Namibia, Norway, Portugal, Russia, South Africa, Spain, Ukraine, USA, Venezuela, Zimbabwe.

Achievements of the project this year

General scientific achievements

IGCP 427 was very active this year, holding six major and two minor activities. The field, laboratory, analytical, experimental, mathematical, and theoretical studies reported at these meetings and published in the international geological literature have advanced our understanding of ore-forming processes (e.g. lava/magma emplacement, thermomechanical erosion and devolatilization, wall-rock modification, magma contamination and
mixing, base metal and PGE partitioning, fractional crystallization, ore segregation, and hydrothermal mobilization) in volcanic and subvolcanic systems all over the world. These advances have benefited society by transferring research methodologies to colleagues in developing countries and by aiding in the development of better exploration tools that can be used to discover and optimally develop sustainable resources of PGE, Ni, Cu, Co, Cr, V, and Ti.

Major scientific achievements of the project include: (1) quantification of the processes by which trace elements and S-Nd-Sr-Os isotopes decouple during processing in dynamic magmatic systems, (2) modelling of sulphide fractionation processes involving liquid immiscibility, partial fractional crystallization, gravity filtration, and zone refining, (3) modelling of the transport of dense, fluid sulphides (and hydro-dynamically-equivalent large blocks of country rocks) in less dense, fluid magmas, (4) development of frameworks for the localization of PGEs in multiple settings within layered intrusions, and (5) modelling of the behaviour of volatiles in modifying the crystallization behaviour of the host magmas, in modifying the partitioning of metals between sulphide phases (solids and liquids) and in mobilizing metals during the late stages of crystallization to produce a broader range of mineralization styles, (6) further understanding of the behaviour of S, Rb-Sr, Sm-Nd-Re-Os, and Pb-Pb isotopes in dynamic magmatic systems and their value in constraining ore-forming processes, and (7) the continual discovery of many new styles of mineralization in ore deposits worldwide.

Meetings

1. **20-24 May 2001, 11th Annual Goldschmidt Conference, Roanoke, Virginia, USA.** IGCP 427 co-sponsored a Symposium on the Mafic Magna-Ore Deposit Link with the Geochemical Society. The symposium included 18 talks and 3 posters by 20 presenters on various aspects of the geology, geochemistry, experimental petrology, and genesis of mafic Ni-Cu-(PGE) and PGE-(Cu)-(Ni) deposits associated with mafic magmas. It was attended by about 50 participants from 8 countries.

2. **26-29 August 2001, 6th Biennial SGA-SEG Meeting** (Mineral Deposits at the Beginning of the 21st Century), Krakow, Poland. IGCP 427 jointly-sponsored Session 6.1 on the Genesis of PGE Deposits with SGA and SEG. The session was dedicated to Professor E.F. Stumpff in appreciation for his 4 decades of research in PGE deposits and included 10 talks and 2 posters on various aspects of the geology, geochemistry, experimental petrology, and genesis of mafic Ni-Cu (PGE), and Cr deposits. It was attended by about 100 participants from 17 countries.

3. **17-21 September 2001, XXI Spanish Mineralogical Society Meeting, Malaga, Spain.** The Spanish Working Group of IGCP 427 sponsored a special session (Organizer: F. Gervilla) that included about 12 presentations and was attended by about 25 participants from five countries. The meeting was preceded by a 2-day field excursion to the Ronda Massif.

4. **1-10 September 2001, 4th International Archean Symposium, Perth, Western Australia.** IGCP 427 participants contributed to several theme sessions, including Theme 5: Mineralization, Theme 2: Magmatic Processes, and the David L. Groves Symposium. There were 205 papers (94 oral, 111 posters) presented, the Symposium was attended by almost 500 participants from 20 countries.

5. **1-13 September 2001, Field Excursion to the Skaergaard Complex and Platinova Reefs, Kangerdlugssuaq, East Greenland.** The excursion departed from and ended in Keflavik, Iceland, and was attended by 32 participants from 11 countries. An IGCP 427 Business Meeting was held during the voyage. A conference report has been submitted to Episodes.

6. **1-5 October 2001, Annual European Short Course in Metallogeny, Brest, France.** This short course was supported by the French CNRS, GEODE (the European Science Foundation metallogeny network), and the Universities and City of Brest. It was delivered in two parts, the second of which included sessions on Ni, Cr and Pt deposits in komatiites, the Bushveld complex, and ophiolites that were relevant to this project. The twelve lecturers came from France, Germany, Portugal, Canada, and United States, and the 45 students came from 12 countries.

7. **26-27 October 2001, Workshop on PGE Exploration, Sudbury, Ontario, Canada.** This workshop was jointly-sponsored with the Laurentian University SEG Student Chapter and the Mineral Exploration Research Centre. It included a 2-day symposium with 15 talks and a 2-hour open discussion on various aspects of the geology, geochemistry, experimental petrology, and genesis of mafic Ni-Cu-(PGE) and PGE-(Cu)-(Ni) deposits, two 1-day field trips to the East Bull Lake and River Valley PGE prospects near Sudbury, and surface/underground tours of several Ni-Cu-PGE deposits in the Sudbury Basin. It was attended by about 110 participants from 3 provinces (Ontario, Québec, British Colombia) and 3 countries.

Publications

Books and Special Issues

Journal Papers and Book Chapters


Activities planned

25-29 July 2002, IGCP 427 Business Meeting and Sponsorship of the 9th International Platinum Symposium, Billings, Montana (United States), which will include one pre-meeting field excursion to Ni-Cu-PGE deposits in the Lake Superior Region (Duluth, Lac des Iles, Colwell Complex) and several pre- and post-meeting field trips to the Stillwater Complex, which is one of the highest grade and most spectacularly-exposed PGE deposits in the world
http://www.platinumsymposium.org/

No. 428 – Past Climate Change Inferred from the Analysis of the Underground Temperature Field (1998-2002)

V. Čermák, Geophysical Institute, Czech Academy of Sciences, 141-31 Praha 4, Czech Republic, e-mail: cermak@ig.cas.cz

H. N. Pollack, Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan 48109, United States of America, e-mail: hpollack@umich.edu

C. Clauser, Applied Geophysics, RWTH, D-52056 Aachen, Germany, e-mail: c.clauser@geophysik.rwth-aachen.de

Description: Temperature changes at the earth’s surface propagate downwards with an amplitude attenuation and a time delay that increase with depth. The earth’s subsurface has a certain capability to ‘remember’ what has happened at the surface many years ago. This project aims at reconstructing the climate pattern of several past centuries by an integrated analysis of borehole temperature data together with other proxy information. The key method used is an inversion technique that allows extraction of the past climate ‘signature’ still existing today in the form of small excursions detectable by precise measurements of the present subsurface temperature field when logging the holes. The general objectives include:

1. Exploitation of temperature-depth profiles to assess the ground surface temperature history (GSTH) in various locations
2. Study of temporal and spatial scales and regional trends of inverted GSTHs and correlating them with meteorological and proxy data
3. Extraction of a possible manmade component of recent climate warming from the natural climate variability

Website addresses related to the project
http://www.ig.cas.cz.html, for general information and reports
http://www.geo.lsa.umich.edu/IHFC/heatflow.html, database and additional information

Participating countries

Practically all European countries plus Brazil, Canada, China, Egypt, India, Japan, Morocco, United States, Vietnam.

Achievements of the project in 2001

General scientific achievements

(a) The existence of a fully operational database of boreholes with temperature logs and corresponding climate reconstructions,
(b) A special issue of the journal Global and Planetary Change
(c) Considerable progress was achieved in the following countries:

Russia and Ukraine: Borehole temperature data have been used to infer ground surface temperature change in the Southern Urals. Temperature profiles ranging from 300 to 1000 m were used to get information on the climate of the last approximate thousand years; a very deep borehole temperature profile (2000 m) was used to reconstruct the climate history of the Late Glacial/Postglacial Period. The ground surface temperature history exhibits a cold period, identified as Little Ice Age, with a minimum in 1700-1850 A.D., followed by a period of warming. This
fact is in agreement with meteorological data for the recent one and half century. Reliable temperature data and the absence of disturbing effects together with a good knowledge of thermophysical properties enabled to estimate the Holocene optimum of 5 to 6 Ka B.P. with a peak exceeding modern temperature by about 1.3 degrees C. Six high-quality temperature logs located in the Ukrainian Shield and on the southern slope of the East European Platform well confirmed cold climate conditions in this area between 1700-1900 A.D. with gradual changing conditions in the 20th century and warming amplitudes of 0.5 to 2.0 K.

Estonia and Finland: A major result here is that geothermal HFD data sets can be applied for palaeoclimatic reconstructions in the time scale of 100,000 years which provide a direct, although noisy, source of palaeotemperature information. The vertical variation in HFD in the Fennoscandian Shield and East European Platform can be attributed to the major climate change at the Pleistocene-Holocene boundary, and the result suggests an average warming of 8.0 ± 4.5 K from the Last Glacial Maximum time. They indicate further that the palaeoclimatic correction of HFD data for the Weichselian effects may have been underestimated in the study area. Therefore, an average correction of +1.5 mW m⁻² at 500 m depth, and +5 mW m⁻² at 1000 m respectively is proposed. The inversion yields a value of the steady-state surface HFD for the study area as being of 50.8 ± 0.3 mW m⁻².

Romania: In 2001, investigations on the palaeoclimatic effects in the crustal temperature field continued for the Transylvanian Basin and were initiated for the foreland of the Eastern Carpathians bend, based on temperature measurements in boreholes in a depth range of 100-1500 m (Transylvanian Basin) and 100-2400 m (Focsani Depression) respectively, taken with a mK range sensitive thermometer in the continuous logging mode. Measurements and interpretation were performed within the framework of a cooperation with the Geophysical Laboratory, University of Aarhus (Denmark) and the Geophysical Institute, Karlsruhe University (Germany). Temperature data are consistent with the warming following the Weichselian glaciation, 10,000 years ago. Furthermore, a method for treating data at several temporal scales has been worked out. A climate correction of 7-8 mWm⁻² to the measured surface heat flux was estimated for the Transylvanian Basin, from simultaneous inversion of temperature data from nine boreholes.

Italy: The Italian working group (previously formed by the University of Genoa is now also including the National Research Council, Pisa) has collected and inverted a series of temperature-depth data, recorded from 1981 to 2000 in geothermal boreholes scattered in Central Northern Italy, for the reconstruction of the climatic signal. Even if the results, compared to previous tests from a selected borehole located in the Western Alps, confirm a recent warming since 1960, the climatic change pattern for Italy is rather complex, showing discernible spatial and temporal variability. This seems mainly due to geographical factors such as the complex topography surrounded by the Mediterranean Sea.

Meetings

2. Fifth International Conference ‘Terrestrial Heat Flow and the Lithosphere Structure’, Kosteletc, Czech Republic, 6-10 June 2001, full week programme with two days reserved for the IGCP 428 project and a total of 65 attendees from 20 countries.
3. Special symposium ‘Temperatures within the Earth’ as part of the Joint IASPEI-IAGA Assembly at Hanoi, 25 August 2001 (25 attendees from 10 countries).

List of most important publications

Major result

Inference of Climate Change from Geothermal Data, H.Beltrami and R. N. Harris (Guest Editors), special issue of Global and Planetary Change, 29 (2001), 145-360. (IGCP 428 volume)

Other publications addressing IGCP 428 programme results

– Pasquale, P.; Verdoya, M.; Chiozzi, P.; Safanda, J. 2000. Evidence of climate variability from under-


**Activities planned**

No definite dates have been settled so far, but two meetings are envisaged for the year 2002, namely:

1. ‘Climate and borehole’ session sponsored by IGCP 428 within the Second International Conference ‘The Earth’s Thermal Field’, Moscow, May 2002 with an expected dominant participation from Russia and all CIS countries.

2. Small scale symposium ‘Borehole and Climate’ proposed by Prof. Serban Veliciu (Romania). This meeting is planned in the first half of October in the Carpathians (Sinaia) and will focus on problems of this region addressing climate reconstruction and long-term temperature monitoring in shallow holes to assess the regional magnitude of the present day warming and the assessment of the potential anthropogenic component.


IGCP co-leader: J. Pašava, Czech Geological Survey, Klárov 131/3, 118 21 Praha 1, Czech Republic, e-mail: pasava@cgu.cz

MAB co-leader: J. Jeník, Faculty of Science, Charles University, Department of Botany, Benátská 2, 128 01 Praha 2, Czech Republic, e-mail: jenik@natur.cuni.cz

**Description:** Organic matter and its derivates are essential components of the natural environment, and increasing awareness has developed recently on the varied behaviour and roles of organics in environmental issues. The scientific aim of this project is to correlate existing and new data from biospheric, geospheric and atmospheric studies in order to evaluate the different roles of organic matter in the environment. Direct evidence of natural processing of organic matter and geochemical models will be used to suggest how society may minimise the negative effects of mining activities and improve remedies. Studies will include radioactive waste depository sites, the formation of human carcinogens and the fate of organic pollutants in surface and groundwater.

Website of the project http://www.min.tu-clausthal.de/www/sga/news6/art6.html

**Participating countries** (* indicates countries active this year)


Around 70 scientists from 33 countries participated in the project activities.

**Achievements of the project this year**

**WG1: Organic Matter – Metals Interaction (A.P. Gize, United Kingdom)**

Scientists conducted potentiometric titrations and Cd-bacteria adsorption experiments using the gram-negative bacteria (Escherichia coli and Pseudomonas aeruginosa), and the gram-positive bacteria (Bacillus megaterium, Streptococcus faecalis, Staphylococcus aureus, Sporosarcina ureae and Bacillus cereus). They found that a wide range of bacterial species exhibit nearly identical Cd adsorption behaviour as a function of pH. It was concluded that metal-bacteria adsorption is not dependent on the bacterial species involved. A generalized adsorption model which greatly simplifies the task of quantifying the effects of bacterial adsorption on dissolved mass transport in realistic geologic system was also developed.

A new analytical technique for in situ observation of the binding of dissolved organics on mineral surfaces, Infrared Attenuated Total Reflectance (IR-ATR) method has been tested by Japanese scientists with the aim to develop the IR-ATR method into a new analytical tool for detecting dissolved organic pollutants in water, such as chlorinated hydrocarbons.

Jordanian scientists studied the adsorption of Cu and Zn by oil shale. They noted that an increase in the adsorbent concentration with constant Cu or Zn concentrations resulted in greater metal removal from solution. They concluded that oil shale could be used for the adsorption of the Cu^{2+} and Zn^{2+} with higher affinity toward Zn^{2+} ions. Addition of sodium salt to the metal solution influenced Cu-removal positively, but inhibited zinc removal. These results document that oil shale containing organic matter can be considered as suitable biosorbent.

Copper accumulation by Polygonum microcephalum and Rumex hastatus from copper mining waste dumps in
Yunnan Province was studied by Chinese scientists. It was found that both plant species can grow well on mining waste sites rich in Cu but with medium nutrient supply. *P. microcephalum* accumulated more Cu than *R. hastatus*. It was concluded that both species may have some potential for phytostabilization of metal-contaminated soils and also for biogeochemical prospecting.

In order to control the actual amount of pollutants formed in the environment, another group of Chinese scientist studied the loading capacity of agricultural soils for heavy metals and its applications throughout China. This loading capacity was defined as the maximum permitted amount of heavy metals in agricultural soil which preserves the benign cycle of materials in the pedosphere and limits the adverse effects of heavy metals on the biosphere, hydrosphere, atmosphere and lithosphere. It was suggested that the acceptable range in China is 23-37 g/ha/a for Cd, 6750-10125 g/ha/a for Pb, 687-2812 g/ha/a for Cu and 450-675 g/ha/a for As, respectively.

A significant correlation between Cr, Ni, Zn and Cu and organic carbon and sulphur was reported by Indian scientists from heavy metal polluted, freshly deposited sediments of the Yamuna river (Delhi and Agra urban centers, India). It was concluded that mostly anthropogenic input was responsible for such intensive pollution.

Heavy metal contamination of urban soils and street dust in Hong Kong was studied by Chinese scientist. It was documented that urban soils contain elevated concentrations of Cd, Cu, Pb and Zn which resulted from traffic emissions and industrial activities while street dust contains high Zn values (most likely a result of contamination by car tires). The geochemistry showed that Pb and Zn are mainly bound to carbonate/adsorbed and Mn/Fe oxide phases, while Cu is largely associated with the organic and sulphide fractions.

Nigerian scientists investigated the distribution of heavy metals in fish and plant species (especially *Egeria radiata* and *Tympanotomus ruscatus*) in the Cross River Estuary in South Eastern Nigeria. They found that seasonal and spatial variations of heavy metals in sediments, fish and plant species did not conform to a definite pattern as heavy metal values are generally low and concluded that this site could be considered as safe regarding its metal pollution.

Experimental pyritization of plants was carried out by British scientists. The results demonstrated that initial pyritization (precipitation on and within plant cell walls) can be an extremely rapid process (within 80 days) which is driven by anaerobic bacterial-mediated decay. Further decay and infilling at all scales preserves broad cellular anatomy. The results have implications for fossilization in general and the fidelity of the taxonomic and biomolecular information preserved in fossils.

**WG 2: Microbial Leaching in Environmental Clean Up (K. Bosecker, Germany)**

Bacteria are present in a wide range of geologic and aquatic environments. The adsorption of aqueous metal cations onto bacterial surfaces can affect the global cycling of elements, biomineralization, heavy metal contaminant mobility in soil and groundwater systems and the effectiveness of bioremediation techniques.

Considerable progress in the field of remediation of anthropogenically polluted soils by heavy metals was achieved by German scientists in the Leipzig Lowlands region (Saxony, Germany). The leaching of heavy metals was observed in suspension and in the soil bed. Acidic conditions were produced by adding either H$_2$SO$_4$ or S$\delta$O. It was found that the kinetics of leaching was largely influenced by both the procedure and the leaching agent used. In leaching with elemental sulphur, the kinetics of metal solubilization was determined by the microbial oxidation rate of sulphur to sulphuric acid (20 and more days in both environments). Leaching with H$_2$SO$_4$ proceeded very fast in suspension but needed much longer in solid bed. It was concluded that large-scale remediation of heavy metal polluted sediments seems only possible through solid-bed leaching of sediment supplemented with elemental sulphur. To enhance the effect of biodegrading process, the optimum temperature between 30 and 40°C as well as a dosage of 2% S$\delta$O was recommended based on all experiments. These achievements are very important as heavy metals in soils are still a challenging problem all over the world.

Another important problem studied by Danish scientists was Cd and Cu release kinetics in relation to afforestation of cultivated soils which causes soil acidification and elevated concentrations of dissolved organic matter in the soil solution, and hence, aggravate the risk of heavy metal leaching. The soil solution isolated from Norway spruce and soil samples from an arable Ap horizon were studied in detail. It was documented that Cd release rates are very low at pH>5 and increase exponentially as pH decreased to <5. No significant effect of dissolved organic matter was observed. The kinetics of Cu was more complicated with effects of both pH and dissolved organic matter. It was concluded that changes in soil chemical conditions after afforestation can lead to the dramatic release of Cd at soil solution pH<4.5 and that inhibition of Cu-release by dissolved organic matter (observed at pH 3.8 to 5.0), indicates that Cu is retained in the soil by interactions with adsorbed organic matter. These results are very important as afforestation process results not only in increased erosion, drainage and the change of ecosystem but also aggravates a high risk of heavy metal leaching.

The discovery of diverse microbial communities in the terrestrial subsurface has important ramifications for bioremediation and sediment diagenesis. Further important scientific results in this field were achieved by
United States scientists. They provided geochemical and microbiological evidence that viable microorganisms produce and consume volatile organic acids in the Yengua formation (east-central Texas). It was found that slow mineralization rate of \textit{in situ} organic matter in mudstones is within range for deep aquifers, and probably accounts for the long-term survival of microorganisms in oligotrophic environments.

Interesting results have been reported by scientists from Denmark who studied conditions for biological precipitation of iron by bacterium \textit{Gallionella ferruginea} in slightly polluted ground water. The rate of Fe oxidation/precipitation was found to be about 100 times faster than formerly found for abiotic physico-chemical oxidation/precipitation processes. The reason for the poor adsorption of the hydrophobic pesticides and trichloroethylene was due to the pronounced hydrophylic property of the exopolymers of Galionella and the precipitated ferrihydrite. These results are very important as biosorption is attracting wide attention as an alternate wastewater treatment technology.

\textbf{WG 3: Weathering of Organic Matter (B. Kríbek, Czech Republic)}

Further for society very useful applied scientific results have been reached by Czech scientists on the weathering of fossil organic matter in waste dumps of coal mines of various age from the Sokolov Basin (Tertiary), Pilsen Basin (Carboniferous) and Barrandian Basin (Devonian). Oxidation of fossil organic matter in relation to the coalification degree was experimentally studied. The result showed that the rate of weathering of fossil organic matter depends on the organic matter type and degree of coalification. Related to low degrees of coalification, weathering of organic matter yields a great amount of humic substances, whereas no humic substances are produced during weathering of black coals. The formation of humic substances increases adsorption capacity of anthropogenic soils. In contrast to soil humic acids, humic acids formed in a course of weathering are low of nitrogen. The gradual increase in their nitrogen contents during weathering is probably due to the interaction of weathering products of fossil organic matter with nitrogen-rich products of microbial activity. A part of weathered fossil algal-type organic matter in a low maturation degree may be directly metabolized by soil biota. These results can be very important for finding a remediation strategy of dumpsite after coal mining worldwide.

Further studies of United States scientists on kerogen degradation during black shale weathering brought very interesting results. It was shown, using a solid state $^{13}$C nuclear magnetic resonance spectroscopy for examination of kerogen composition in weathered profiles of the Montgomery, Green River, Woodford and New Albany black shale formations, that during weathering, the highly aliphatic component remains largely unaltered, while the mixed component loses aliphatic carbon and accumulates carbonyl oxidation products. It was suggested that kerogen weathering is dominated by two separate processes. Linear alkyl fragments are cleaved without oxidation, and aromatic/branched alkyl fragments are oxidized while attached to the kerogen macro-molecule and then cleaved.

Notable results were reached on the study of vegetation control of soil organic matter dynamics by United States and French scientists. The formation of Soil organic matter is one of the least understood steps of the global carbon cycle. The role of plant communities in regulating soil organic matter dynamics formation was studied through quantifying the influence of oak and pine vegetation on soil organic matter dynamics at the highly controlled conditions of the San Dimas lysimeter installation. It was documented that soil organic matter turnover rates were faster under oak than under pine. In contrast to the rapid turnover for the oak litter (<2 years), the delay in litter incorporation into the mineral soil under pine was a controlling factor of soil organic matter dynamics fluxes. These results indicate that the global mosaic of vegetation exerts significant influence on the accumulation and turnover of soil organic matter directly by determining the palatability of plant material and indirectly by conditioning the pathways of biomass incorporation into soil.

French scientists have studied experimentally oxide weathering and trace metal release by bacterial reduction on the example of a New Caledonia Ferralsol (rich in Ni, Co, Fe and Mn). Two treatments were imposed containing different sources of organic matter (soil organic matter with or without glucose addition) to link the biodegradation of organic matter with reduction process. The results showed that anaerobic Fe- and Mn-reducing bacterial activity was responsible for Fe- and Mn – oxide solubilization by anaerobic respiration and fermentation. It was concluded that the bioavailability of heavy metals in this soil was increased by biological reduction but was limited by adsorption or precipitation phenomena.

\textbf{WG 4: Acid Mine Drainage (E. Puura, Estonia)}

Organic fossil fuels often contain pyrite, as the sedimentation under anaerobic conditions leads to the reduction of both Fe(III) and sulphate, with pyrite becoming oversaturated. During mining activities, pyritic material is brought into the connection with atmosphere. This causes active oxidation of pyrite and formation of acid leachate, commonly known as acid mine drainage (AMD) or acid rock drainage (ARD). The leachate often contains high concentrations of heavy metals, originating from the sulphides, or which were adsorbed to the other solid phases of the source rock (or bound to organic matter). The deterioration of the surrounding environment depends mainly on the buffering capacity of the rocks and sediments the leachate is flowing.
through. If the buffering capacity is low, it becomes depleted and the leachate needs to be treated in order not to cause major problems on a regional scale.

Major progress in this field was achieved by Korean scientists. The first group of scientists focused on the study of dilution and removal of dissolved metals from acid mine drainage on the example of the Imgok creek, Korea. The dilution factor and removal fractions were quantitatively estimated using two different methods, the conservative component method (assuming that SO\(_4^2\) is a perfectly conservative component) and a mass balance method (relating the concentrations of dissolved components to their precipitation stoichiometries). It was suggested that the SO\(_4^2\) concentration is a good indicator of the dilution – as the calculated dilution factors of pollutants quickly decrease from the site of AMD input to the site a few kilometres downstream, and then remain more or less constant. The calculated removal fractions showed that almost all original Fe input was removed from the stream-water due to the precipitation of schwertmannite or ferrihydrite and Al due to amorphous Al\(_4\)(OH)\(_{10}\)SO\(_4\). The other metals were removed not by precipitation but by adsorption on and/or co-precipitation with Fe/Al compounds. It was concluded that the relatively abundant freshwater supply might raise the pH of the stream above the adsorption edge and consequently, contribute to rapid metal attenuation by forcing not only more precipitation but also more adsorption of the dissolved metals.

Another group of Korean scientists has completed a geochemical study of AMD in the water system in the vicinity of the Dogye coal mines in Korea which represents the main source of AMD in this region. The authors reported a pH value of 3.0 and concentrations of 2148 mg SO\(_4^2\) / 1L, 229 mg Fe / 1L, 71 mg Al / 1L and 11 mg Mn / 1L and suggested that the reduction of some metal concentrations downstream from the discharge point could be explained on the basis of dilution and precipitation. They found that the order of removal of metal ions downstream from the discharge point was Fe>Al, Cu>Zn, Mn and that acidity could be used as a good determining factor offering comprehensive and quantitative values for the pollution extent of AMD. Predominant species of dissolved Fe and Al were also identified.

**WG 5: Environmental Models of Black Shale Hosted Mineral Deposits (W. Mayer, Poland)**

Sulphidic black shale can cause serious environmental harm by (1) generation of acids; (2) release of toxic metals contained in sulphides and other ore minerals and (3) leaching of metals from other minerals such as silicates, due to the acid. Further progress in the study of sulphidic – environmentally hazardous facies of the Upper Proterozoic black shales in the Bohemian Massif was achieved by Czech scientists and similar studies were continuing on metalliferous black shales in Estonia, Poland, Slovakia, South Korea and United States.

The environmental impact assessment of heavy metal distribution in soil and streams sediments around the Southern Benue black shale hosted Abakaliki Pb-Zn deposit (Eastern Nigeria) was carried out by Nigerian scientists. They concluded that anomalous Pb (up to 0.9 wt.%) and Zn (up to 0.05 wt.%) values detected in stream sediments and soils around the mine centers are generally above phyto-toxic levels and that they resulted from the rapid decay, decomposition and transport of metals in a humid tropical environment.

**WG 6: Organic Atmospheric Particulates (K. Hall, United Kingdom)**

Atmospheric pollution from fossil fuel combustion has increased dramatically during this century. Beside the principal gaseous pollutants (CO\(_2\), CO, SO\(_2\) and a number of N-oxides), fossil fuel burning also delivers a variety of particulate matter, such as smoke particles and fly ashes, to the atmosphere. A range of experiments led to the result that atmospheric particles were classified into two categories according to their features. Organic atmospheric particulates are usually of spherical shape with the size of 0.1 mm and produced by the combustion of fossil fuel and petrochemical products. Understanding of the chemical and physical behaviour of atmospheric particles is very much in its infancy.

Important progress in the study of organic atmospheric particulates was reported by Estonian scientist. They studied spherically fly-ash particles which were emitted to the atmosphere during the high-temperature combustion process of fossil fuels and found in considerable amounts in snow samples of North-East Estonia. Close to the power plants both black coloured inorganic ash spheres and carbonaceous particles were identified and higher deposition values were reported. It was concluded that due to prevailing wind directions, the deposition of atmospheric particulates from oil shale combusting power plants is very restricted to the north-easternmost part of the country and decreases significantly towards the west and south-west.

Interesting scientific results have been reached by Nigerian scientists who studied metal contamination of soils around petroleum storage facilities and soils plus drill hole waters adjacent to densely populated heavy metal constructions works (e.g. bridges). The results of the study focused on heavy metal occurrences in roadside soils of an urban population in Ibadan (South-West Nigeria), indicated a link between traffic density, flow of traffic and the presence of some heavy metals (e.g. Pb, Zn, Cd and As) in roadside soils within the metropolis. A general concentration trend in the order of As>Pb>Zn>Cd was established based on the comparison of soil contamination with the distribution of heavy metals in the motor vehicle fuels.
The majority of other studies focused on tracking the distribution of natural and anthropogenic Pb in soils. For example, scientists from Israel sampled Mediterranean soils from soil profiles adjacent to major highway (8-23 m) and soil profiles away from the same highway (500 m). A detailed study of different soil components (soil carbonate, organic matter, Fe-oxides and hydroxides, aluminosilicates) revealed that natural Pb is associated mainly with aluminosilicates and only a small fraction with soil carbonate and organic matter (up to 10%). Conversely, anthropogenic Pb, which accumulates mainly in the upper part of the soil profile, is mostly bound to soil carbonate, organic matter and Fe-oxides. The results of isotopic composition of lead from deeper horizon of soil sampled in the vicinity of the highway and also Pb determined in the upper part of the soil profile far from the highway evidenced that this Pb is also anthropogenic, providing a unique evidence of the penetration of petrol-Pb into the soil.

Swedish scientists focused, through the study of stable lead isotopes, on the assessment of the role of airborne pollution and natural geological sources for Pb enrichment in lake sediments and in surface soils of boreal forests. They concluded that the lead that is enriched in surface soil of boreal forests (the organic moor layer of Swedish soils is totally dominated by pollution lead) and in recent lake sediments and peat was derived from atmospheric deposition and not from natural local geological sources.

Considerable results have been achieved by Venezuelan scientists who studied the distribution of lead and the composition of organic compounds in settled particles in road tunnels in the Caracas region, Venezuela. Relatively low Pb concentrations (1260-5500 ppm) indicate fractionation of Pb between settled and suspended particles. Organic geochemical study resulted in the identification of n-alkane and aromatic compounds similar to those in the diesel fuel used by heavy truck vehicles.

**WG 7: Organic Matter in Nuclear Waste Issue**

(D. Mossman, Canada)

Safe disposal of radioactive wastes is one of the most urgent political and scientific problems society is facing today. Over the long term, geological properties of specific sites together with various engineered barriers to contain nuclear waste, are the chief determinants of the total system. According to the IAEA the most critical aspect of a natural analogue study is the manner in which it tests repository effects. For various reasons the Oklo natural reactors in Gabon provide ideal subjects to study safe disposal of nuclear waste, including the role of organic matter in the origin of natural fission reactors in Gabon which successfully continued within several collaborative projects. A joint Danish-United States collaborative research project focused on the study of geology, mineralogy and retardation of nuclear-reaction products. It was concluded that organic matter in both reactor zones of the Oklo-Okélobondo reactor and near-field surroundings played an important role in the enhancement of porosity and stabilization of U during formation and operation of the Okélobondo reactor zone.

Complexation of heavy metals such as Eu with humic substances were studied experimentally by Japanese scientists in order to evaluate its relevance to the radioactive waste disposal and toxic heavy metal pollution. Using 3D fluorescence spectroscopy, the possible complexation sites have been considered to be related to 430 and 475 nm emission bands. The complexation of humic substances with Eu$^{3+}$ is also proceeded by proton release to water. However, the degree of proton release was different for different humic substances. Several possible sites and different mechanisms of complexation have therefore been suggested.

French scientist found important results on the weathering part of the Bangomé natural nuclear reactor. They found that the original natural reactor zone at Bangomé was about 10 cm thick, 2-3 m wide and 4-6 m long. Recent weathering has led to migration of REE and fission-genic REE have not been detected at a larger distance (3 m) from the reactor zone. It was concluded that trapping by organic matter and dilution were responsible for this situation. These results are very important for safe development of HLWRS in similar geological and hydrogeological situations worldwide.

**WG 8: Organics in Aquifers and Water Systems** (L. de Souza and R. Melo, Brazil; J. Spangenberg, Switzerland)

Thermal stability of dissolved humic substances in water has been studied experimentally by Japanese scientists. Aqueous solutions of humic acids (Aldrich) having an initial concentration of 50 ppm have been heated in stainless steel-lined Teflon vessels from 50 to 180°C for several days. UV-visible absorption spectra and pH of the product solution were measured after the filtration. Precipitates were measured for infrared spectra. The results showed that dissolved humic substances rapidly decomposed at 180°C. The half-life period of this humic decomposition in water was evaluated to be about 8.4 years at 40°C and 13.6 years at 20°C. These short half lives have important bearings on the fate of humic substances possibly carrying some pollutants, which can be decomposed and release pollutants into the environment.

French scientists used infrared spectroscopy and in situ pyrolysis/methylation-gas chromatography-mass spectrometry for characterization of humic acids extracted from highly polluted river sediments sampled close to the city of Deule, northern France and close oxbow-lake. The results allowed to differentiate compounds having a natural origin (terrestrial inputs, such as lignin-derived compounds) from anthropogenic compounds (sterols...
and to lesser extent fatty acids). The presence of \( \beta \)-stanols in extracted lipids from river sediments was used to evidence accumulation of sewage from the nearest oxbow-lake. It was concluded that these sterols can be used as molecular markers of a specific pollutants (sewage) to organic matter in the sediments and allow to define the extent of this input to the sediments at different depths in the oxbow-lake and in the connected system (Deule river). These results showed the importance of characterizing the lipid fraction that can provide crucial information on the nature and origin of pollutants, as well as showing that humic acids can incorporate some of the contaminants into their structure.

Anthropogenic organic contamination in bottom sediments from the hypereutropic tropical Lake Valencia (Venezuela) was reported by Venezuelan scientists only based on the comparison of total aromatic concentrations to the \( C_{\text{org}} \)– normalized total aromatic concentrations. Subsequent IRTF spectra and GC chromatograms indicated pollution through the presence of branched and cyclic hydrocarbons which were most likely produced by the incomplete combustion of oil products and also by other potentially toxic organic compounds such as antracene, phenanthrene and chrysene. The main access paths of organic pollutants to the lake are the rivers which cross the two urban and industrial areas (Maracay and Valencia cities). It was concluded that the mixture of polluted sediments with bottom natural sediments and the autochtonous contribution of organic matter mitigate the pollution levels progressively towards the center of the lake.

A very important and extremely useful critical review on the biogeochemistry of landfill leachate plumes was carried out by Danish scientists. It was shown that most leachate contamination plumes are relatively narrow and do not in terms of width exceed the width of the landfill. Diverse microbial communities have been identified in leachate plumes and are believed to be responsible for the redox processes. Dissolved organic carbon in the leachate, although it appears to be only slowly degradable when the volatile organic acids are gone, apparently acts as substrate for the microbial redox processes. Several xenobiotic organic compounds have been found to be degradable in leachate contaminated groundwater, but degradation rates under anaerobic conditions have only been determined in a few cases. Although complexation of heavy metals with dissolved organic matter is evident and acts as substrate for the microbial redox processes, the role of organic contamination in the formation of mineral deposits and related environmental issues is a subject of ongoing research.

Anthropogenic organic contamination was reported by Nigerian scientists in ground water near the Petroleum Storage facilities in the Calabar area (SE Nigeria). The results of detailed studies have confirmed that elevated levels of hydrocarbons were found in the roadside mechanic workshops compared to relatively lower concentrations around gas stations and water boreholes.

Meetings

- Annual International Meeting ‘The role of organic matter in the formation of mineral deposits and related environmental issues’, session S1 in the joint SGA-SEG Meeting, organized within the 6th Biennial SGA-SEG Meeting in Cracow, Poland (26-29 August 2001), 50-60 scientists from 11 countries attended the symposium.

Publications

More than 90 scientific papers resulted from the IGCP 429 activities and were published in the form of monographs, articles in various scientific journals and abstracts to the IGCP 429 meetings. Selected publications for 2001 are as follows:

- Ding, Z.; Zheng, B.; Long, J.; Belkin, H. E.; Finkelman, R. B.; Chen, Ch.; Zhou, D. and Zhou, Y.


Shirong, T. and Yihua, F. 2001. Copper accumulation by Polygonum microchelum D.Don and Rumex hastatus D.Don from copper mining spoils in Yunnan Province, P.R.China. Environmental Geochemistry 40, 902-907.


Activities planned

General goals

Finishing of ongoing transdisciplinary research projects covering the eight major topics of the Project with possible involvement of MAB specialists on both national and international levels. Organization and active participation in the GEOCHIM 2002 – a postgraduate certificated training course on the geochemical exploration methods and their environmental applications. Preparation of the final report.

Meetings


M. F. J. Flower, Department of Earth and Environmental Sciences, University of Illinois at Chicago (m/c 186), 845 W. Taylor St., Chicago, IL 60607, United States, e-mail: flower@uic.edu

V. I. Mocanu, Faculty of Geology and Geophysics, University of Bucharest, 6, Traian Vuia St., Bucharest 1, RO – 70139, Romania, e-mail: mocanu@gg.unibuc.ro

R. M. Russo, Department of Geological Sciences, Locy Hall, Northwestern University, Sheridan Road, Evanston, IL 60201, United States, e-mail: ray@earth.nwu.edu

Ma Zongjin, Institute of Geology, State Seismological Bureau, P.O. Box 9803, Beijing, 100029, P.R. China, e-mail: jszhang@public3.bta.net.cn

Description: IGCP 430 is addressing mantle-lithosphere interactions associated with Tethyan plate collisions. As a start to a better understanding of seismic and volcanic hazards associated with colliding plate margins, IGCP 430 is coordinating research in Tethyan ‘natural laboratories’ with a view to evaluating the role of collision-related mantle flow fields in determining geologic hazard scenarios. Factors linking collision-related mantle flow with earthquake and volcano behaviour may include processes such as asthenosphere perturbation associated with the detachment of subducting lithospheric slabs, lateral squeezing or extrusion of the asthenosphere, post-orogenic collapse, mantle delamination and exhumation, and the lateral escape of lithosphere. It is also likely that melting associated with plate convergence or collision is largely decoupled from subducting slabs and triggered by dehydration reactions within the convecting supra-subduction mantle. Two regions – referred to as ‘PANCARDI’ (the Pannonian basin and Carpathian and Dinaride orogens, in Eastern and South-Eastern Europe) and ‘SEAWPAC’ (including South-East Asia and Western Pacific marginal basins) – are already subjects of strongly funded, multidisciplinary studies. By integrating results from, and initiating new research in these and other natural laboratories, IGCP 430 will build a basis for assessing the implications of mantle dynamic collision responses.

Websites of the project
http://ns.gg.unibuc.ro/igcp430/
http://tigger.uic.edu/~flower/igcp430.htm

Participating countries

Austria, Bosnia, Bulgaria, Cambodia, Canada, China, Croatia, Germany, Hungary, India, Indonesia, Israel, Italy, Japan, Laos, Netherlands, Papua New Guinea, Pakistan, Poland, Romania, Slovakia, Russia, Taiwan, Thailand, United Kingdom, Ukraine, United States, Viet Nam, Yugoslavia.
Project achievements this year

(a) PANCARDI (Pannonia-Carpathian-Dinaride)
A seismic tomographic study of the southeastern Carpathians ‘bend zone’ (CALIXTO) conducted by a consortium from Germany, Romania, France, and Switzerland, was supplemented by studies of seismic attenuation (Q) in the Pannonian Basin and Moesian block, by scientists from the University of Bucharest and Northwestern University (Evanson, IL). The tomographic experiment was planned and carried out as an international programme under the umbrella of the CALIXTO working group. One specific aim of the project was to study the structure of the Vrancea subduction zone. Combining tomographic methods using local and tele-seismic events, receiver function analysis and 3D FD-modelling provide important constraints for understanding the tectonic setting of intermediate depth seismicity, for quantifying strong earthquake parameters such as maximum moment release, and for understanding wave propagation from the source site to Bucharest.

Preliminary seismic attenuation data suggest that seismic hazard is significantly greater for urban populations (Bucharest) south of the Carpathians. The techniques and experimental designs developed in this project provide a basis for future investigations planned for the Tethyan region, as part of our purview for delimiting seismic and volcanic hazards.

Geochemical studies of Carpathian volcanics involve collaboration between the Romanian Academy of Sciences (Geodynamics Institute) and Universities of London, Florence, Miami (Oxford, Ohio), and Illinois (Chicago) and are closely integrated with the CALIXTO programme. Seismic tomographic ‘snap shots’ of post-collision slab breakoff and mantle flow field effects provide a critical framework for interpreting geochemical data, an important interim result being that late-stage potassic activity probably reflects asthenosphere contamination by post-collision delamination and/or subduction of continental crust.

Additional studies include a seismic refraction profile of the Carpathian Bend zone (DACIA PLAN – Universitäten of Amsterdam and Bucharest) and mobile and permanent GPS investigations in the Romanian Carpathians.

(b) SEAWPAC (SE Asia and Western Pacific)
Funded research in South-East Asia, complementing projects in the PANCARDI region, involves colleagues in the United States, Taiwan, Belgium, and Japan in collaboration with institutions in Viet Nam, China, Laos, and Cambodia. Geochronologic and chemical studies of basaltic and potassic eruptives from Yunnan (China), northern Viet Nam, and Thailand are adding to the Tethyan database for post-collision magmatic activity. New Ar-Ar age data confirm that the ‘escape’ of Indochina along regional strike-slip faults post-dates the initiation of crustal extension that eventually led to the South China Sea opening. This important observation suggests that the initiation of western Pacific basin opening preceded continental lithosphere escape, and indeed, the India-Eurasia ‘hard’ collision, providing strong support for asthenospheric mantle extrusion as a likely mechanism in contrast to the conventional ‘lithosphere extrusion’ model. In collaboration with colleagues in Viet Nam, China, Taiwan, Thailand, and Laos, we are awaiting response from the NSF ‘Continental Dynamics Program’ for funding a five year project to document post-Mesozoic lithosphere kinematics, asthenospheric mantle anisotropy and mantle thermal structure in South-East Asia as a means of testing the mantle extrusion hypothesis.

(c) Tethyan ophiolites
Ophiolite studies are an important component of IGCP 430, given that these enigmatic rock bodies offer fundamental insights to continental accretion. Assuming ophiolites represent accreted forearcs generated during subduction initiation-rollback cycles, Covasna delegates agreed that a hypothesis linking subduction rollback to collision-induced asthenosphere flow could be tested by synthesizing the existing data and conducting additional studies to establish: (a) temporal correlations with plate collision, ridge subduction, and seafloor spreading adjustment events, (b) age relations of oceanic, ‘proto-arc’, arc, and backarc ophiolite components, and (c) regional continuity of ophiolite outcrops. In any case, the Covasna meeting provided an opportunity for Tethyan ophiolite specialists from Russia and newly-independent states, East and South-East Asia, the Mediterranean, and Europe to compare data and ideas, from which several exciting opportunities emerged. For example, ophiolite studies in the eastern Mediterranean and Caucasus regions are now coordinated with those in the Dinarides (Albania and Yugoslavia), Himalayas (Tibet, India, Pakistan), and South-East Asia (Viet Nam, Philippines, Indonesia, Papua-New Guinea), and South-West Pacific, emphasizing chronologic, geochemical, and stratigraphic relations to Gondwana splitting, Tethyan collisions, and seafloor spreading kinematic responses. This year’s achievements include completion of a comparative study of paleo-oceanic sutures in northern Turkey, Lesser Caucasus and northwestern Iran, with allochthonous sequences in Eastern Mediterranean Neotethyan sutures. Meanwhile, colleagues in Beijing, Hong Kong, and Halifax (NS) continuing joint work on the ophiolite in Tibet, discovered the first terrestrial occurrence of Ringwoodite, and other ultra-high pressure phases, clearly signifying UHP provenance for at least some Tethyan ophiolites.

(d) Post-collision igneous activity
Following the Covasna meeting, several integrated multi-isotope studies of post-collision volcanic rocks are in progress with a view to developing and evaluating geochemical tracers of mantle flow. These include
coordinated studies of Sr, Nd, Pb, O, Os, and Hf isotopic ratios in samples from Turkey, Spain, Pakistan, and South-East Asia, interpreted on the basis of their decay systematics to record enrichment (contamination) and depletion histories in asthenospheric and lithospheric mantle, and crustal reservoirs. These studies can be divided into two groups: (1) post-collision potassic magmas in Anatolia and Yunnan (China), collaborations involving the Universities of Isparta (Turkey), Leuven (Belgium), Illinois (Chicago), California (Los Angeles), and the China University of Geosciences (Beijing), (2) postcollision intraplate magmas including basalts and olivine-leucitites in Central Spain – Universities of Illinois (Chicago) and Madrid, and (3) Pre-, syn-, and syn-collision volcanics in Ladakh-Kohistan, Pakistan – University of Peshawar, Roosevelt University (Chicago), and the Argonne National Laboratory.

(e) Numerical modelling
Development of finite element numerical modelling of Tethys closure and attendant tectonic processes has progressed apace with development of new 3-D models replacing older 2-D versions constrained by geodetic rate data showing surface motions, deep geophysical data delimiting lithosphere and underlying asthenosphere, and new petrologic data which place bounds on the ambient temperature variability in deforming regions.

(f) Geographic Information System (GIS)
Data and results accruing under the auspices of IGCP 430 will be amenable to dissemination to the community at large via the internet. Our first workshop led to the establishment of a GIS working group for IGCP 430. We anticipate that as results become available they will be incorporated into a Tethyan belt geographic information system accessible through the IGCP 430 website. The GIS will include raw data as well as interpretive maps and figures resulting from the project displaying our evolving picture of geologic hazard factors. The most advanced pilot project is the GIS database for Tethyan ophiolites.

(g) China (PRC) projects
Chinese participation in IGCP 430 involves: (1) petrologic tests of a 3-phase post-collision model to explain Tibetan Plateau lithosphere heterogeneity and evolution during South China Sea spreading, (2) tomographic definition of ancient lithospheric mantle roots beneath China and thinning of Chinese lithosphere, and (3) a broadband digital seismic study of the palaeo-Tethyan orogen in western Yunnan. Each of these provides input to numerical modelling studies.

Projects complete this year are: (1) tectonics and seismicity of the Qinghai-Tibet Plateau and Taiwan, (2) analysis of west, central and eastern parts of the Qinghai-Tibet Plateau, (3) the effect of north-south segmentation in Taiwan on earthquake activity, (4) inhomogeneity of Qinghai-Tibet Plateau lithosphere and 3-stage tectonic evolution, (5) lithosphere evolution during South China Sea opening, (6) a comparison of India-Asia collision effects and South China Sea opening, (7) continental subduction dynamics of the Pamir and westernmost China.

Continuing research on mantle dynamics beneath China will involve tomographic studies of cratonic roots and potential effect on mantle flow. Most recently, broadband digital seismic studies of western Yunnan, the most earthquake-prone region of China, were begun with a view to defining lithospheric configuration and motions. Future Chinese IGCP 430 contributions will include collaborative ventures focusing on mantle anisotropy, cratonic roots, and global-scale significance of Tethyan syntaxes. Planned projects include: (1) studies of large earthquake distribution, (2) dynamics of the Taiwan syntaxis, (3) magmatism in relation to the eastern Qinghai-Tibet syntaxis, (4) continental subduction beneath the Pamir and western China, and (5) preparation for the fourth IGCP 430 workshop in China, 2003.

Meetings
1. December 2000: IGCP 430 session on Tectonics and magmatism in southeast Asia at the American Geophysical Union Fall meeting, San Francisco,
2. April 2001: EUG, Strasbourg, Special Session on Lithosphere-asthenosphere coupling,
4. May 2001: Workshop on the Geodynamics of the western part of Eurasia-Africa plate boundary, San Fernando, Spain
5. September 2001: IGCP 430-sponsored iSEAT Meeting, Taipei, Taiwan
6. December 2000: IGCP 430 Ophiolites session at the American Geophysical Union Fall meeting, San Francisco,

IGCP 430 Steering Committee meetings
1. January 2001: Institute of Geological Sciences (NCNST) Hanoi, representatives from United States, Viet Nam, Germany, China, Hong Kong, and Romania. Plans for the 2nd workshop were finalized and field trip planned for Song Da ophiolite and Song Ma flood basal field
2. December 2000: American Geophysical Union Fall meeting, San Francisco,
3. February 2001, Chicago/Evanston

Publications
– Benedek, K.; Nagy Z.R.; Dunkl, I.; et al. Petrographical, geochemical and geochronological constraints on igneous clasts and sediments hosted


Zhang, Z. C.; Zhou, M. F.; Robinson, P. T.; et al. SHRIMP dating of the Aoyougou ophiolite in the west sector of the north Qilian Mountains and its

In press
- Wenzel, F.; Sperner, B.; Lorenz, F. and Mocanu, V. Geodynamics and Seismicity of the Vrancea Region (SE Carpathians, Romania), Annalae Geophysicae, in press.


A. M. Lezine, URA 1761, Centre national de la recherche scientifique (CNRS), Paléontologie et stratigraphie, UPMC Jussieu, B.P. 106, 75252 Paris Cedex 5, France, e-mail: lezine@ccr.jussieu.fr
B. Sowunmi, Nigeria, e-mail: sowunmi@skannet.com
M. Hoepffner, e-mail: Michel.Hoepffner@medias.cnes.fr

Description: The African Pollen Database is a network grouping together all scientists involved in African palynology. Its objective is to provide a tool independent of particular research programmes to carry out research concerned with biodiversity and global change. This project fills a gap in what is otherwise a global endeavour to provide tools with which to assess vegetation changes linked to recent climate changes. Its premises are that present-day ecosystems are largely dependent on their history, and that their present-day state cannot be considered initial or stationary. While the project proposal builds on northern hemisphere traditions of pollen analysis, there are problems peculiar to the topics that will be addressed, i.e. the greater diversity of tropical ecosystems, and the frequently lower pollen production of many species. Results will facilitate consideration of the effects of human activity and its relation to the process of desertification. The project has good links with others established under the INQUA umbrella, such as the European Pollen Database, and regional associations of palynologists. There is an important link with the World Data Center for Palaeoclimatology in Denver, Colorado, United States, which is the official data centre for the IGBP PAGES programme. Applications of societal relevance include the assessments of controls on land cover changes and lessons learnt for land management.

Website of the project
http://medias.meteo.fr/apd/

Participating countries (all active)
Belgium, Congo (DR), Ethiopia, France, Germany, Kenya, Morocco, Netherlands, Nigeria, Spain, South Africa, Tanzania, Togo, Uganda, United Kingdom, United States.

Introduction

Vegetation plays an important role in stabilising soil and in increasing water infiltration capacity, thus maintaining subsurface water reservoirs. Studying the history of vegetation change, such as in the pollen records, is useful in analysing the trends of changes in land cover – and the amplitude through which soil and water resources would have been affected through time. In particular, it will be possible to investigate the timing and nature of the shift from the natural state of land cover to that brought about by human impact. This will show how long and how intensively a given land surface has been affected by erosive agents, providing information that is essential for the rehabilitation of degraded lands at the local level. Modifications in the local environment could also contribute to changes at the global scale as illustrated for example by the replacement of tropical forests by rice cultivation that increase the release of methane to the atmosphere from the flooded rice fields.

Particularly Africa is facing a major challenge due to the ever-increasing human population forced to live on marginal lands which are rapidly degrading. Added to this, recurrent droughts are causing food shortages and depletion of water resources. Land degradation following human impact is a widespread phenomenon. For example, deforestation of the Ethiopian highlands has reduced the vegetation cover from about 16% of
the land area in 1950 to 3% by the end of the 1980s. Estimates from test plot measurements show that soil erosion on the Ethiopian highlands can reach about 70 tons/ha/yr. Consequently, water loss through runoff is increasingly depletion the subsurface water on the highlands, and leads to drought when rainfall is scarce, and to flooding when it rains. The risks associated with such hazards are enormous, as shown by extensive international media coverage in recent years. The objectives of the PMIP (Paleoclimate Modelling Intercomparison Project) project in 1994. The goal of PMIP was to evaluate whether climate models can be reliable on to predict future climate change. If the climate models can simulate past climatic conditions then they can be used with success to predict future climates. In order to evaluate climate models, close cooperation has been built between climate modellers and “palaeodata” experts who are using environmental data from terrestrial and marine sediments and from ice cores to reconstruct palaeoclimates. The first results of PMIP have demonstrated that it was possible to accurately simulate past variations in the Atlantic Monsoon system in West Africa using simple “atmosphere” nor coupled “atmosphere-ocean” models and that it was absolutely necessary to add information on continental land masses: hydrology and land cover (vegetation distribution and composition). The “Biome 6000” project initiated by C. Prentice in 1994 tested the importance of the geophysical feedbacks in the climate system: land surface conditions and regional water budgets were estimated from pollen and lake level data using the Pollen and Lake Status databases. Then, TEMPO was initiated by Kutzbach and collaborators to construct fully coupled 3D earth system models including simulation of the atmosphere, ocean, sea-ice, vegetation and terrestrial hydrology. All these international initiatives require that pollen, hydrological and land-cover data are gathered and validated by the scientists who provide data. International efforts to build regional and global pollen databases started in 1994 during a Biome 6000 meeting in Lund, Sweden. Then a special APD meeting in 1996 was organized near Paris to discuss and adopt protocols and administrative structures. These include an executive committee, an advisory board, a committee for nomenclature and botanists in charge of botanical validation of pollen taxa. Thanks to the financial support of the European Union in the frame of a three years INCO-DC concerted action (INCO-DC IC18-CT98-0274) and of UNESCO/IUGS in the frame of IGCP 431, the network has been built, including at this stage (1998-2001), 8 partners from Europe and Africa (France, United Kingdom, Sweden, South Africa, Ethiopia, Uganda, Togo, Congo).

The first task of the African Pollen Database was to ensure the compilation and the accessibility of data. The compilation of data was the task of the data manager, Hilaire Elenga in Congo with the help of Dominique Jolly, now Professor at Montpellier University and Roberto Magioncalda in France: 150 fossil pollen sites and 1192 modern data have been gathered. Data are stored at Medias-France, Toulouse. It is accessible from Medias-France (http://medias.obs-mip.fr:8000/apd/) and the National Geophysical Data Center (NGDC) of Boulder, Colorado (http://www.ngdc.noaa.gov/paleo/pollen.html) through the web as tifia files or paradox tables. To ensure the accessibility of data and use them to reconstruct past vegetation at a given time, two problems have to be solved by palynologists: the taxonomy has to be discussed and homogenized and standardized age-models have to be provided. This work has to be steadily up-dated as soon as the data are collected. A default age model is constructed for each data time-series using radiocarbon dates. This task is in progress. After discussions during the Nanjing meeting held in China in 2000, APD has provided a by default chronology for some 100 fossil pollen sites and offers the possibility for alternative ones in providing accurate software tools. The taxonomy of pollen grains has been discussed and homogenized to allow easy extraction of data at any taxonomic level: species, genus or family, pollen types etc. Misspelling, synonyms, and wrong nomenclature have been corrected. This was done by Annie Vincens and colleagues from Cerege, France. A list of more than 3000 pollen types has been elaborated. In the future, taxonomic hierarchy has to be adopted in close collaboration with the other regional initiatives within the Global Pollen Database. The hierarchy will permit the database to retain the maximum taxonomic resolution provided by the original investigators.

Modern data useful for pollen calibration and studies of pollen-vegetation-climate relations have been collated and made accessible through the web both as individual data files and using an applet recently developed by
Medias-France. The pollen-vegetation-climate relation in Africa, Madagascar and Arabia have been investigated using this modern pollen database. Maps and response surface depicting the distribution in geographic and climate space of the main pollen types distinguishes the major regions. In addition, the study of individual pollen types allows to characterize and quantify the landscape conditions at a continental scale.

Another task was to provide tools for pollen determination. This was done by Leila Ben Khalifa-Jacobsen, Annick le Thomas and the project leader. Photos of more than 1000 species belonging to 653 genera and 164 families have been entered from a dataset of 8,235 images. Access to these images, determination, references and remarks is also possible via a specific tool which will be soon distributed to APD members. Tools for statistical analyses, drawing and modelling were provided by Medias-France and Joel Guiot from CEREGE (France): land surface and climate data are available for each pollen site; free access to software tools such as Tilia and Tilia-Graph were provided thanks to E. Grimm from the Global Pollen Database. Specific programs for calibration and age model calculation are also directly available.

Another task was to develop long-lasting partnerships among scientists at an international level. Regular training courses and symposia were organized to develop the use of software tools for pollen entry, diagram drawing and statistical analyses and scientific discussions. The African Pollen Database was represented during several international manifestations: KEW 1998, INQUA-Durban 1999, ICP-NANJING 2000, International Geological Congress-Rio 2000, PEP III conference, Aix 2001 and Nairobi 2001, where results were discussed and disseminated to a wider scientific community. Business meetings allowing for the executive committee or the advisory board of APD to discuss were organized at these occasions. As a partner of the SEARCH action of ENRICH, APD is also involved in the realization and maintenance of the Pan African Database for environmental studies at Nairobi (Kenya). This database centre is co-financed by the IGBP-START and the University of Nairobi (Kenya). It gathers regional initiatives and provides an easy access to data stored at Medias-France and Boulder. This centre allows African scientists to increase their exchanges.

The final objective of APD was to ensure scientific cooperation at an international level: Strong relationships exist between APD and other regional databases, mainly the European one (European Pollen Database (EPD)). APD and EPD use the same protocols and infrastructure to compile and store their data. North African pollen data are now stored in EPD since they have been gathered along with data from other Mediterranean countries. They will first be duplicated in APD. And then, the two pollen databases, which are both stored at Medias-France, would form a single database thus providing an excellent opportunity for improved research networking and capacity building between European scientists and their homologues from the rest of the world, especially in Africa: in addition a joint Euro-African pollen database will respond to the recommendations of IGBP by increasing relations along the PEP III Europe-Africa transect. APD belongs to the Global Pollen Database and was represented during the two meetings held in 1999 in Boulder (United States) and in 2000 in Aarhus (Denmark) to organize the pollen database at the international level. It takes part of other, integrated initiatives developed in the frame of PAGES.

APD also encourages the participation of African scientists to international research programs dealing with past environments and climates such as IDEAL (An International Decade for East African Lakes), which plans to recover long cores in lake Malawi in 2002, then in Lake Bosumtwi in 2003.

The African Pollen Database has demonstrated its ability to mobilize the strengths, expertise and resources of the European scientific community jointly with the African research teams involved in land-cover change studies. It can only survive with the active cooperation of all palynologists involved in Africa. New proposals, including additional partners have to been written to ensure the permanency of the network, the compilation and accessibility of data and to coordinate research activities concerned with the assessment and conservation of natural resources, while developing long-lasting partnerships among scientists from Europe and Africa.

**No.433 – Caribbean Plate Tectonics (2000-2004)**

M. A. Iturralde-Vinent, Museo Nacional de Historia Natural, Obispo no. 61, Plaza de Armas, La Habana 10100, Cuba, Tel.: (+537) 63 25 89, Fax: (537) 62 0353, e-mail: iturralde@mnhnc.inf.cu

E. G. Lidiak, Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, Pa., United States, e-mail: egl+@pitt.edu

**Description:** The scope of this project is to construct a concise, multi-disciplinary geotectonic model for the Caribbean realm. The Caribbean is a tectonically complex region of interaction between several plates (continental and oceanic) and is important for global understanding of active tectonic settings in narrow zones between major continent-bearing plates. The present contradiction between existing plate tectonic models and palaeogeographic reconstructions of the Caribbean motivated the proposal to launch this project. Contradictions that raise questions are, for example: Is the Caribbean plate allochthonous or autochthonous? Has the subduction in the volcanic arcs changed its polarity? When would the alleged jump in polarity have occurred? First of all, an evaluation of the existing Plate Tectonic Models and palaeogeographic
reconstruction of the Caribbean realm will be made in order to encourage a critical review of the models and reach agreement on the basic facts. This should serve as a framework for the formulation of a properly substantiated model of the origin and evolution of the Caribbean Plate, as well as the palaeogeography of the area. The project gives the authors of those models the opportunity to exchange ideas and visit key areas of the region.

Website of the project
http://www.ig.utexas.edu/CaribPlate/CaribPlate.html

Countries involved in the project
(* indicates the countries active this year)

Summary of past achievements of the project

The project work is organized through the following working groups:

WG-1. Coordination Group. Leaders of the project and leaders of the working groups integrate and coordinate the efforts of the membership of the project, organize meetings and workshops, keep the website updated, and promote the accomplishments and goals of the project.

WG-2. Positioning of major plates: Jurassic to Recent. This group will evaluate existing models for the break-up of Pangaea and the evolution of the major plates surrounding the Caribbean (NOAM, SOAM, FARALLON, NAZCA, COCOS, etc.) from Jurassic to Recent. As a result they will provide the other working groups with a modern framework for the reconstruction of the Caribbean area.

WG-3. Positioning of terranes of Northern South America. This group will define plates, blocks and terranes, will identify the palinspastic evolution, historic position and relationships, and produce sets of time-framed reconstructions of the tectonic position of these terranes.

WG-4. Positioning of terranes of Southern North America. This group will define plates, blocks and terranes, will identify the palinspastic evolution, historic position and relationships, and produce sets of time-framed reconstructions of the tectonic position of these terranes.

WG-5. Positioning of terranes of the Greater Antilles. This group will define plates, blocks and Palaeomagnetic control of the historic position of terranes, plates and subduction zones. This group will evaluate the tectonic positions of Caribbean terranes, plates and subduction zones taking into account geochronology, geochemistry and palaeomagnetics.

WG-7. Palaeontological support of Caribbean Palaeogeography. The purpose of this group is to study the fossil assemblages – marine and terrestrial – of different ages in distinct terranes, and identify the biogeographic and palaeogeographic implications of its occurrences, with special focus on their input toward understanding the positioning of the terranes in selected time-frames.

WG-8. Geochronological, Geochemical and Palaeomagnetic control of the historic position of terranes, plates and subduction zones. This group will evaluate the tectonic positions of Caribbean terranes, plates and subduction zones taking into account geochronology, geochemistry and palaeomagnetics.

WG-9. Origin, composition and age of the Caribbean oceanic lithosphere. This group will investigate the occurrence of oceanic crust of different ages within the Caribbean, both in the present marine basins and regions of obducted lithosphere.

During the first two years activities have focused on discussion and selected presentations during the workshops and meetings. This approach has highlighted many problems that are currently among topics of research:

Origin of the Present-day Caribbean Plate. The concept that the present-day Caribbean Plate is allochthonous from the Pacific produce models that explain many aspects of the evolution of the Caribbean. Some advocates of the autochthonous models have reconsidered their points during the meetings in Stuttgart and Leicester. However, the allochthonous models still present major problems pending adequate solution.

The Galapagos hotspot and Caribbean plateau. There are two fundamental points of view regarding the role of the Galapagos hotspot in the geology of the Caribbean, which were the subject of extensive debate in Stuttgart and Leicester. One group holds that the Galapagos hotspot has nothing to do with the ProtoCaribbean crust or the Caribbean Plateau basalts, because the hot spot was always positioned west of both of them, and, consequently, was not the source of the so-called Caribbean plateau basalts. The other interpretation holds that the Galapagos hotspot actually produced the Caribbean plateau basalts and the ridges within the Nazca and Cocos plates. Pindell’s new unpublished palinspastic reconstructions say that it is impossible that the Galapagos hotspot produced the Caribbean plateau basalts. Trace element and isotopic geochemistry, however, do not rule it out.

Subduction reversal in the Caribbean. The polarity of subduction of the Caribbean plate in Cretaceous time has been an intriguing topic since Mattson (1979)
proposed that a reversal in subduction direction occurred during plate development. A summary of the evidence relevant to a reversal and the possible timing of the event is given by Jolly et al. (1998). Most models seemingly require a change in subduction direction. For example, Pindell (1994, 2001) proposed a flip in the polarity of the arc at about 120 Ma. However, several researchers consider that the arc’s subduction flip required by Pindell’s model about 120 Ma ago is problematic for several reasons. Those investigating the origin of the plateau basalts disagree because a thick buoyant oceanic plateau would be very difficult to subduct, and would therefore significantly affect the subduction polarity reversal. They cite the arrival of the buoyant and thick Caribbean plateau at the eastward dipping subduction zone as a mechanism for the flip, in a situation analogous to that seen in the Solomon Islands with the attempted subduction of the Ontong Java oceanic plateau. However, Pindell’s latest unpublished model suggests that the 120 Ma polarity reversal occurred before the bulk of the plateau was formed, on the basis of the following pieces of evidence:

(a) Abundant evidence for a large tectonic event around that time.
(b) Unconformities in many arc-related sequences at ca. 120 Ma.
(c) P-T paths from high-pressure metamorphic rocks.
(d) Change in geochemical character from PIA to CA in many circum-Caribbean arcs.
(e) The earlier the flip occurred, the easier would occur tectonically.

At 120 Ma, the arc would have been short and straight and there was a powerful potential mechanism available (the acceleration of the opening of the Atlantic. At 75 Ma, the arc was about 2000 km in length, and may have been very highly accurate in shape, which would require huge internal deformation as the convex side changes from the South-West to the South-East. However, in the discussion at Leicester it was conceded that there is growing evidence for an earlier, and possibly more voluminous, pulse of plateau magmatism around 130-120 Ma. If that is the case, an earlier plateau could have formed and caused the postulated subduction flip, and the later plateau building events (78, 90 Ma) could have represented the last pulses of magmatism. Other authors also disagree with the subduction reversal because this flip does not explain the geochemical evolution of the Cretaceous arc magmatism in Cuba, neither the tectonics of north central Cuba. The project leader postulated a major change in the geometry of the convergent plate boundary between latest Campanian and Palaeocene, involving deformation and almost complete extinction of arc volcanism, modification of the trend of the arc axis, and a major change in the orientation and geochemistry of the arc.

The alleged Albian-Campanian arc in Central America. Another subject that did not find agreement is the existence of an active Albian-Campanian island arc in Central America, and its evidence in the Nicoya Complex. According to a paper by Calvo and Bolt (1994), there is an arc-derived volcanoclastic, stated that their geochemical and geological investigations in the Nicoya Complex do not confirm its presence. An Albian-Campanian island arc as part of present-day southern Central America is a major issue concerning the geology of the Caribbean plate because the presence of a Central American mid-Cretaceous arc will reduce the rate of relative eastward movement of the Caribbean plate respect to North and South America, and would have a strong bearing on the palinspastic reconstruction of the circum-Caribbean fold-belts.

Tectonic position of the Cuban Southwestern terrains (CSWT). Many early plate tectonic models of the Caribbean ignored the CSWT, but fortunately, they have been taken into account in more recent versions. However, as demonstrated by the lively discussion at the Havana meeting in March 2001, the geology of the CSWT is still too poorly known to be interpreted without ambiguity. More field and laboratory research focused on the petrology and internal structure of the Socorro (Grenvile), Escambray, Purial and Pinos metamorphic terrains, as well as on the stratigraphy and tectonic position of the Placetas and Rosario belts (terrains) are urgently required before a fair interpretation of the origin of these geologic units can be reached. Available P-t path studies, isotopic dating and geochemical data for the Escambray and Purial are still insufficient.

The Great Arc vs Multiple Arc concept. Pindell’s Caribbean models show a single “Great Arc” evolving from Cretaceous to recent as the leading edge of the Caribbean plate progressively occupy the space created by the separation of North and South America. Another concept is that there were multiple arcs that evolved step by step from Cretaceous to Recent. The Multi Arc concept evolves from the following ideas:

(a) The occurrence of several magmatic and stratigraphic gaps within the Greater Antilles- Lesser Antilles volcano-sedimentary sections and the presence of unconformities at different time intervals on the various islands.
(b) Modification of the geochemistry of the arc magmatism after some of these gaps, especially in Cuba. However this does not apply to all of the tectonic breaks in Puerto Rico.
(c) Modification of the orientation and geographic distribution of the arc magmatic axis after each gap, but specially after the earliest Cretaceous boninite and IAT arc, and after the Cretaceous arc.

The Geometry of the Arcs. During the meetings in Rio de Janeiro, Stuttgart, and Cuba the geometry of the arc was the subject of consideration. A debate arose concerning the characteristics of the Greater Antilles-Aves Ridge- Lesser Antilles Cretaceous-Palaeogene volcano-sedimentary complexes and the fact that the components of the original arcs (backarc, axial arc, front
arc, subduction suture) are not evident in any cross-section of the present-day islands. The issue is that the arcs have been deformed by combined thrusting, extension along the axis, and were subsequently subdivided into distinct terrains that were the subject of rotation and eastward transportation. Consequently, the original geometry of the arcs are no longer represented by today’s outcrops and their elements can only be found along specific islands of the chain.

**Polarity of the Palaeogene Sierra Maestra-Cayman arc.** Caribbean plate tectonic modellers hold the position that the subduction zone of the Palaeogene arc was located north of the arc and with a dip to the south. Another group presented evidence that the Palaeogene subduction zone dipped north and was located south of arc. Recent geochemical, geochronological and palaeontological research in the area favours the subduction from the south model and the fact that the Palaeogene arc developed after a Maastrichtian gap in the magmatic activity and with a distinct orientation with respect to Cretaceous volcanism.

**Meetings**

*First meeting* of the project in Río de Janeiro during the 31st International Geological Congress, General Symposium 17.6: Caribbean Plate Tectonics, Origin and Evolution (7-8 August 2000). It was attended by project members from Cuba, USA, Canada, Italy, Germany, United Kingdom, France, Venezuela, Argentina, and others. Four special oral presentations and 12 posters were the subject of interesting debates and active exchange of data and interpretations. The oral session was attended by 50 persons.

The *second meeting* in Stuttgart (11-13 October 2000) was organized as part of the 17 Colloquium on Latin American Geology, attended by nearly 300 scientists from countries in South America (Argentina, Brazil, Chile, Venezuela, Colombia), Central America (Costa Rica, Mexico), North America (United States), Europe (Italy, France, Germany, United Kingdom, etc.) and Cuba. Presented were 12 talks and 13 posters about the geology, palaeontology and plate tectonics of the Caribbean, and a round table was organized to discuss important issues concerning the origin and evolution of the Caribbean Plate.

The *third meeting* was a field workshop on the Northern Caribbean Plate Boundary organized as part of the 4th Cuban Geological and Mining Congress (Havana, 19-23 March 2001). The workshop included both oral and poster presentations, focused mainly on the northern margin of the Caribbean plate in Cuba and its early geologic evolution. Participants came from Argentina, Canada, Chile, Colombia, Cuba, France, Great Britain, Italy, Mexico, New Zealand, Spain, and United States. A field trip to Central Cuba was held immediately after the Congress, 24 to 27 March, in order to visit critical areas in the vicinity of Camagüey, central Cuba, where the northern Caribbean plate boundary is well exposed.

The *fourth meeting* was organized in Leicester, United Kingdom (23-24 April) as a Workshop on the Geochemistry of the Caribbean plateau and Cretaceous island arc terranes, and their implications for the geodynamics of the Caribbean. The Workshop hosted 35 participants from six countries (Colombia, United States, Italy, France, Germany and the United Kingdom). In addition, more than 30 researchers from 5 other countries registered interest in the proceedings, but were not able to attend.

The *fifth meeting* was celebrated as part of the 4th North American Palaeontological Convention (Berkeley 26 June–2 July). Several papers were presented concerning the palaeontological data as a counter part to plate tectonic interpretation of the evolution of the Caribbean. The meeting was attended by about 15 persons, mostly from the United States.

**Activities planned**

**Meetings**

*Geological Society of America Annual Meeting*. 1-10 November 2001. Upon the request of the IGCP and the GSA, IGCP 433 shall participate in the Annual Geological Society of America Meeting in Boston, Massachusetts. The project has been invited to present papers at the GSA Topical Session “Focus on IGCP: Modern and Ancient Plate Boundaries and Orogens”. Participants from Cuban, American, and other delegates will be partially supported by the project.

*Motagua Fault Zone, Guatemala*. 28-31 January 2002. The project will hold a Workshop and Field Trip to the Motagua Suture Zone of Guatemala. This event is being organized by the Italian-Caribbean Group, with the kind cooperation of the Sociedad Geologica de Guatemala and other Guatemalan institutions. Motagua suture zone in Guatemala is part of the northwestern boundary of the Caribbean plate and an important on-shore segment of the Caribbean plate boundary. The project will partially support the field transportation and the participation of delegates from Cuba, Guatemala, Costa Rica, Venezuela and United States.

*16th Caribbean Geological Conference*. 16-21 June 2002. The project will hold a Workshop and Field Trip during the 16th Caribbean Geological Conference, in Barbados, BWI. The purpose of this Workshop and Field Trip is to study and evaluate further the Lesser Antilles island arc, the easternmost boundary of the Caribbean plate. The project will support the field trip by covering the transportation expenses, and will support participants to the meeting from Cuba, Jamaica, Dominican Republic, Venezuela, Costa Rica, Guatemala, Mexico, United States, and other countries.

H. Hirano, Department of Earth Sciences, School of Education, Waseda University, Nishiwaseda 1-6-1, Shinjuku, Tokyo 169-8050, Japan, e-mail: hhirano@mn.waseda.ac.jp

Description: This project builds on and continues IGCP project 350, Cretaceous Environmental Change in East and South Asia. It intends to construct a new scale for the correlation between the Cretaceous marine and non-marine deposits by establishing a stable carbon isotope stratigraphy for the Cretaceous, taking notice of the global carbon cycle as a new point of view. The non-marine Cretaceous is widely distributed in Asia, but the age-determination is still not so well fixed. IGCP 434 aims to study the Cretaceous plume activities and the associated tectonic movements in East and South Asia on the one hand, with the background of daily developing, higher resolution and more reliable correlation. On the other hand, the project encompasses the genesis of metallic, non-metallic ore deposits, and fossil fuels, sea-level changes, carbon cycle, changes of partial pressure of carbondioxydes, climatic changes, floral changes including the appearance and flourish of angiosperms, turnover of oceanic layered structure including the occurrence of up welling and anoxic events, and the response of biotope, elucidating their relation of cause and effect in more detail. At present, the project comprises 200 scientists from fourteen countries.

Special attention is paid to:
2. Environmental analyses by various chemical analyses.
3. Collecting and evaluation of various geological information that affects the global carbon cycle.
4. Study of the cause and effect between environmental changes and changes of bio-diversity.

Participating countries
(* indicates countries active this year)


Achievements in 2001

China
In the past year the Chinese working group concentrated on the study of marine diversity changes during Late Cretaceous. Marine Cretaceous mainly developed in the Himalayan area where mass extinctions and their aftermath have been recognized. In the project's research, upper Cretaceous marine red beds and their response to ocean/climate global change are emphasized for the first time. Cretaceous bituminous facies are relatively common in the southern Tethys-Himalayan belt. The Cenomanian – Early Turonian dark shale and marl sediments has been recovered in southern Tibet. Fossils are well preserved in the strata and are dominated by planktonic taxa. Studies of abundance and diversity suggested that increasing oxygen depletion caused stepped extinction or temporary disappearance at the top of the Cenomanian. It is indicated that the onset of oxygen-depleted conditions began in the upper part of the R. cushmani Zone, followed by the acme of the Oceanic Anoxic Event in the lower part of the W. archaeocretacea Zone. The dysaerobic conditions were recovered stepwards in the Turonian. Bio-recovery happened in the upper W. archaeocretacea and H. helvetica Zones of the base Turonian, where the abundance of fauna fluctuates in 11 rhythms, which represent stressful environmental conditions. Contraction and weakening of the oxygen-minimum zone from Early Turonian allowed the recolonisation of new fauna. The characteristics of the geochemistry of those strata show that tremendous changes occurred in the mid-Cretaceous ocean. The carbon, oxygen, strontium and U, Th, K isotope composition of marine rocks are mainly controlled by global events, such as relative amount of organic accumulation, changes in seafloor spreading rate and palaeoclimate variation. \( \delta^{13}C \) curves are characterized by low-high-low cycle change. The positive excursion of \( \delta^{13}C \) coincides with sea-level rises, accumulation of organic carbon and oceanic anoxic event. The curves of U, Th, and K indicate that their contents are higher during the oceanic anoxic period because of an increase of organic materials and clay minerals. Low \( ^{87}Sr/^{86}Sr \) ratio in the mid-Cretaceous coincides with the tectonic activity. Mid-Cretaceous in southern Tibet is a period of short time expansion of the Tethyan Ocean, and related to the global sea level rising. Consequently, a large amount of organic carbon was accumulated in an oxygen depleted environment. After the accumulation of organic matter, a group of red beds rested on top of dark sediments. IGCP 434 results suggest that this kind of reddish sediments in deep marine facies could be the aftermath of the anoxic conditions. Upper Cretaceous deep marine red beds are well exposed in southern Tibet in the eastern part of the Neo-Tethys. This oceanic phase is proposed as the “Cretaceous Marine Red-Bed Event” (CMRE). Indeed, strata representing the CMRE crop out in many regions of the western Tethys such as the Alps in Austria, France, Spain and Italy, and in the Carpathian Mountains of the Czech Republic, Poland, Slovakia, and Romania. Deep marine, red Upper Cretaceous deposits have also been cored in the North Atlantic and the northern Indian Ocean by the DSDP/ODP drilling programme.

Japan
Recent development on carbon-isotope stratigraphy and its applications in Japan: Hasegawa and Hatsugai (2000), which was selected as the Article of the Year of the Palaeontological Society of Japan, applied the carbon isotope ratio (\( \delta^{13}C \)) stratigraphy
to designate the Cenomanian/Turonian boundary in the Kotanbetsu area, Japan showing an example as the practical tool for correlation. Shimizu et al. (2001) published the carbon isotope stratigraphy and some data characterizing the organic matter from Barremian through Cenomanian in the Nakagawa area, Japan. Ando et al. (2000) reported terrestrial carbon-isotope profile for Aptian and Albian from Ashibetsu, Japan at the IGCP symposium in Tokyo. The story is very impressive because of the similarity of the total shape of the curve to the $\delta^{13}C$ curve from marine carbonate carbon suggesting carbon-isotopic coupling between the ocean-atmospheric $\text{CO}_2$ reservoir during this period. The study by Ando et al. (2000) is now in preparation for publication.

Detailed megafossil biostratigraphy and lithostratigraphy from Santonian through Maastrichtian, in the Chikubetsu area, Japan was published by Moriya and Hirano (2001). These are one of the fundamental data for the Late Cretaceous stratigraphy in this area which requires the establishment of $\delta^{13}C$ stratigraphy. After a preliminary report by Hasegawa (2000) in Japanese, Hasegawa (in press, (a)) compared the stratigraphic profiles of $\delta^{13}C$ between Japanese terrestrial organic carbon and European marine carbonate. He discussed a long-term discoupling of the terrestrial curve from the marine curve in the middle Cenomanian through lower Turonian. Long-term fluctuation of humidity and forest canopy effect over the provenance of terrestrial organic carbon, namely East Asian continent, is proposed as possible mechanisms of the discrepancy. Palaeoclimatology of continental Asia was first demonstrated by carbon-isotope data by this paper. It also suggests that a time-stratigraphic profile of $\delta^{13}C$ based on terrestrial organic carbon potentially contains some climatic signals that should be separated from the original global signal for interregional correlation. Hasegawa (in press, (b)) characterized organic matter preserved in mudstone from Hokkaido Island, Japan and Sakhalin Island, Russia. He applied organic petrology to identify each kerogen and exhibits exclusive predominance of terrestrial organic carbon in marine mudstone. The composition of the kerogen containing serious amounts of semifusinite and vitrinites show various reflectance, suggest wider provenance of these kerogens. This result allows to use kerogens preserved in marine Cretaceous sediments in Hokkaido and Sakhalin for reconstruction of terrestrial palaeoenvironments.

Establishment of Sequence Stratigraphy of the Cretaceous Forearc Basins
In IGCP 434, the establishment of the Cretaceous sequence stratigraphy and regional correlation are a matter of urgency. The present understanding of global sea-level fluctuation is based mostly on the rift-generated basins in passive margin of Northern Atlantic-North Sea regions and on the foreland basins in Western Interior of North America. There has been, however, no data from the forearc and intra-continental basins, which are the predominant basin type in Asia. Cretaceous sedimentary basins in Asian region possess a wide variety of basin type with hybrid nature. Among them, most of the marine basins are dominant in the forearc setting. These were an obstacle to the analysis of sequence stratigraphy. To establish the sequence-stratigraphic framework with high-age resolution, some Cretaceous deep-sea fan and shelf successions in Japanese Islands were examined in detail. Recent advance in the knowledge of deep-marine sequence stratigraphy will provide a new scale for the regional correlation of different depositional environments in the same tectonic setting. In addition, IGCP 434 collaborators could recognize the occurrence of some major sequence boundaries both in forearc and continental basins. These are also important as regional correlative surfaces, representing a contemporaneous large-scale phisiographic change during the Cretaceous. IGCP 434 is now examining the sequence-stratigraphic correlation of the Cretaceous forearc basins in Far East Russian, West Sarawak, Myanmar and other regions in cooperation with regional coordinators.

Korea
During the past year the Korean working group studied several aspects of Cretaceous geology and published about 30 papers in international and local journals. In the present report, only works on biotic events and sedimentary evolution are summarized below. New ichnogenus Protovirgularia McCoy, 1850 was reported from the Jinju Formation, a lacustrine deposit, in southwestern Gyeongsang Basin. This occurrence represents the first formal recording of the ichnotaxon from Korea and the first one, on a global basis, from a nonmarine depositional environment. The oldest known tracks of web-footed birds were reported from Early Cretaceous deposits. The discovery of web-footed tracks with abundant non-web-footed tracks indicates that there was a considerable diversification of shore birds as early as the Early Cretaceous. A curious Cretaceous mushroom fossil was reported in the Gongju Basin, an isolated small basin in the western central Korea. Palaeodepositional history of the Middle Cretaceous Hampyeong Basin, SW Korea, was studied based on sedimentary sequence and plant fossils. Also, Cretaceous plant fossils were reported from a new locality in Goeheung area, central southern coast. Provenance of Hayang Group sediments in the Gyeongsang Basin was studied using sedimentary petrology and zircon morphology. The former study suggests the onset of continental arc volcanism in the eastern margin of the Asian continent during the Early to Middle Cretaceous. Provenance of Cretaceous Gilwangri Conglomerates of the Muju Basin in central Korea was studied. Late Jurassic radiolarians were recovered from chert pebbles of Lower Cretaceous conglomerates of the Hayang Group, in the Yeongyang subbasin. Dinosaur bone-chip burrows, and taphonomic process and depositional conditions of dinosaur track-bearing sediments were studied. Also, Cretaceous vertebrate faunas from the Gyeongsang Supergroup were reviewed. The facies analysis of the uppermost strata of
the Gyeongsang Supergroup, the Jindong Formation, which was regarded as monotonous lacustrine sediments, was studied in detail.

**Myanmar**

Participation in IGCP is not approved by the government yet, but the project was permitted to hold its Second International Symposium and Field excursion in the Union of Myanmar. With many Myanmar geologists from most of the universities and institutes of this country, successful discussion took place on Late Mesozoic evolution of the eastern part of Asian Continent, which has developed as an active margin facing the Tethys Ocean. This gave a great opportunity to understand the geological and palaeontological relationship between the meso-Tethys and proto-Pacific regions. Among the results, it is noteworthy, especially, that the Late Jurassic to Early Cretaceous elements exposed along the west of Shan Plateau show strong similarity with those in Cretaceous tectonic zones of the eastern margin of the Asian Continent, where they have been regarded as a suspect terrane. The similar nature of the accreted land masses, stratigraphic records of the overlying clastic sediments, fauna and flora, and deformation phases will provide an important clue to solve the origin of the suspect terranes and the tectonic evolution of the eastern margin of the Asian Continent.

**Philippines**

The work of the Philippine group from last year up to the middle of this year concentrated on the study of different ophiolite complexes. For the Southeast Bohol Ophiolite Complex, collaborators have finished mapping the whole complex. Corresponding geochemical analyses using XRF, ICP-MS and EPMA have been conducted. Geophysical surveys, involving magnetics and gravity, were also done. Studies on the associated metamorphic units were completed. Papers on the geophysical signature of the Cretaceous ophiolite, field characteristics of the associated melange and the underlying metamorphic rocks have been published in *The Island Arc*. Papers have been submitted to the *International Geology Review, Journal of Asian Earth Sciences* and *Australian Journal of Earth Sciences*. With regards to the Cretaceous crust-mantle sequences located east of the Philippine archipelago, field mapping was done in the Aurora-Isabela area. Located in northeastern Thailand, the Aurora-Isabela ophiolite was sampled and appropriate geochemical analyses started which involved whole rock ICP-AES and ICP-MS analyses of the volcanic and peridotitic rocks. Additional ICP-MS analysis was done for volcanic rocks collected from the Cretaceous Rapu-Rapu ophiolite. All data, involving field and geochemical data, are being collated and correlated to determine the manner of evolution of these different ophiolite complexes. This is being done to determine if the ultramafic-mafic complexes originated from a single marginal basin and whether they are good exploration targets for ophiolite-hosted mineral deposits. All these facts are believed to contribute to our understanding on how the Philippine island arc system had evolved since and through the Cretaceous period.

**Russia**

The research group of Y. D. Zakharov continued to investigate palaeotemperatures based on the stable oxygen isotope of Lower and Upper Cretaceous brachiopod, bivalve including inoceramid scaphopod and ammonite shells from the Penzhin Guba area and Tavolka river basin, Western Koryak Upland, and also Southern Alaska. Warming maxima have been recognized in the Early Barremian (24.5°C), Aptian-Early Albian (18.4-25.9°C) marked by an anomalously high δ13C values (up to 6.6‰ for the Lower Albian of the Koryak Upland), Late Cenomanian (20.8-23.3°C), and Late Campanian (20.6-16.1°C). The Early Maastrichtian shallow-water cooling (10.2-16.9°C) was also discovered there. The strongly negative δ18O values ranging from -4.3 to -5.9‰ have been found in aragonite of well preserved Middle and Late Turonian inoceramid bivalves. This is associated with the freshening of the Penzhin Guba basin and is evidently a result of the distribution of the humid climate during the Turonian in the northwestern circum-Pacific.

The research group of P.V. Markevich continued to study sedimentary environments of Lower Cretaceous formations in the Sikhote-Alin. Fragments of the Moneron-Samarga island-arc system have been studied in the Kema river basin as well as the filling of the backarc basin along the Kema, Samarga, Tumnin and Koppi rivers. Studies suggest that during the Barremian-Albian fragments of the continental crust existed in the Pacific Ocean that served as a source for island-arc basins. The research group of G.L. Kirillova continued to study different types of the Cretaceous sedimentary basins in southeastern Russia (Amur-Zeya, Uda, Upper Bureya, Partizansk, Sangjiang-Middle Amur, and Alchan). The following supersequences have been distinguished: Berriasian-Lower Valanginian, Valanginian, Hauterivian-Barremian, Aptian-Middle Albian, and Upper Albian-Cenomanian.

**Thailand**

Research results of the Thai Cretaceous rocks are still focused on palaeontological, stratigraphic and sedimentological aspects. These results have been carried out by both Thai and overseas researchers. Details are as follows:

1. Early March 2001: There have been a joint working team (Prof. Yong Il Lee and his student, and Dr. Assanee Meesook and his colleagues) for detailed work on palaeosols found particularly in the Cretaceous Sao Khua Formation of the Khorat Group in northeastern Thailand. Preliminary results from this work explain palaeoenvironment and palaeoclimate of deposition and formation in which the meandering river system and semi-arid palaeoclimate are prevailed respectively.
2. Mid March 2001: The excursion with Japanese geologists along Thai-Myanmar has been carried out with particular respect to palaeontology. Preliminary results based on bivalves reveal that the Mesozoic rocks in this region are confined to marine Jurassic of Tethyan affinities and possibly non-marine Cretaceous red beds.

3. June 2001: The brackish water Jurassic bivalves of the Khlong Min Formation are found in Surat Thani Province of southern peninsular Thailand, overlain by the Lamthap Formation. This discovery extends knowledge on the formation in which its distribution is far larger than previously thought.

4. July 2001: The Khlong Min Formation in Surat Thani Province was also found further north to Chumphon Province approximately 500 km South-West of Bangkok. The stratigraphic succession and faunas are similar to those found in June 2001.

5. August 2001: Theropod footprints were recently found in the Khok Krut Formation of the Khorat Group in the outcrops exposed near the Mekhong River.

**Viet Nam**

This year, members of the Vietnamese working group have achieved following works.

1. In the framework of the project “Lithology and paleogeography of Jurassic-Cretaceous red beds of North Viet Nam” some field trips were realized in Dinh Lap (NE Viet Nam), Song Da Depression (NW Viet Nam) and Quang Binh (Central Viet Nam). Many sections were studied, samples were collected for stratigraphic and lithologic studies. The similarity between sections of Jurassic-Cretaceous from Quang Binh and Nam Theun Basin (Central Laos) was discovered, leading to a new stratigraphic division of Jurassic-Cretaceous in Quang Binh. In the Song Da Depression, gypsum was found in some boreholes in Yen Chau and Nong Heo areas, drilled in Upper Cretaceous red beds of the Yen Chau formation. However, fossils are very rare and the dating of sediments has been meeting many difficulties.

2. The study on the Jurassic-Cretaceous Nam Theun Basin (Central Laos). For the first time, a basin of the Khorat type has been studied and described from this region. Similar to the Khorat Group, the Nam Theun Group contains thick members of rock salt and gypsum in its upper part (Nong Boua Fm), but there is a small difference between them: basal members of the Nam Theun Group consist of shallow-sea sediments bearing marine bivalves of Early Jurassic age (pliensbachian).

3. The origin of dispersed carbon matter in volcanicogenic sediments of Jurassic-Cretaceous age in NW Viet Nam (Tu Le Depression) is a study object of a Vietnamese-Russian group. Under the influence of hydrothermal activities and geodynamic metamorphism humic material in the rock was altered to form a black quartz-mica schist rich in dispersed carbon, which has the composition and structure close to lean shungite.

4. Palaeomagnetic studies have been carried out on Jurassic-Cretaceous continental red beds in North and South Viet Nam. The palaeomagnetic directions of Cretaceous red beds show that the Indochina Block was relatively stable with respect to Eurasia since Cretaceous, while those of Jurassic-Cretaceous red beds in North Viet Nam a pattern of 9-150 counter clockwise rotation that may be related to the 9-150 motion of NW-SE trending strike-slip system and has been interpreted as a local tectonic rotation around a vertical axis.

**Meetings**


2. Field trip and discussion of working group for Tectonic evolution in Far East Russia and the Island arc: Eight scientists of two countries, July to August 2001.


**Most important publications**


Activities planned

General goals

1. To establish the stable carbon isotope stratigraphy in some reference sections of the marine Cretaceous in Asia. Research is ongoing in China, Japan, and Russia, but the whole Cretaceous is not included yet.

2. To obtain the stable carbon isotope stratigraphy for the non-marine Cretaceous in Asia. Research was tried in China, Japan, and Korea, but the material is mostly weathered, or altered in the sections of China and Korea. Much better section must be found by members.

3. To obtain as much information as possible on the Cretaceous faunas, floras, and bio-diversity changes as the total, including the interesting studies on the phylogeny of birds from feathered dinosaurs, and the origin and evolution of gymnosperms in Asia.

4. To support the development of mining in Indonesia, Malaysia, Myanmar, Thailand, and Viet Nam by using the knowledge obtained in the joint works of members.

5. Exchanges of faculty members to support developmental technology.

Meetings

1. Field trip and discussion to complete the correlation chart of Indo-China. December 2001 and January 2002 in Viet Nam, and March, 2002 in Thailand. Participation of scientists from Viet Nam, Myanmar, Thailand, Malaysia, and Indonesia is planned.

2. Field trip and discussion to study the stratigraphy and tectonics of Far East Russia. July 2002. Participation of scientists from Thailand and Russia is planned.


4. Field trip and discussion to synthesize the information on sequence stratigraphy, biostratigraphy, magnetostratigraphy, and stable carbon isotope stratigraphy of the marine Cretaceous, in Hokkaido, Japan. July 2002. Participation of scientists from China, Viet Nam, and Russia is planned.

5. Fourth International Symposium and Field trip. September 2002. Symposium in Khabarovsk, and field trip along the Amur River. Participation of scientists from China, India, Indonesia, Malaysia, Mongoliga, Myanmar, Philippines, Russia, Thailand and Viet Nam is planned.


R. J. Pankhurst, British Antarctic Survey, c/o Kingsley Dunham Centre, Keyworth, Nottingham NG12 5GG, United Kingdom, e-mail: r.pankhurst@bas.ac.uk

L. Spalletti, Director, Centro de Investigaciones Geológicas, Universidad Nacional de La Plata, 644 Calle nº. 1, 1900 La Plata, Argentina, e-mail: spalle@cig.museo.unlp.edu.ar

J. D. Bradshaw, Department of Geological Sciences, University of Canterbury, Private Bag 4800, Christchurch, New Zealand, e-mail: j.bradshaw@geol.canterbury.ac.nz

Description: The main goal of the project is to explore and correlate the geological development of the Gondwanan continental masses that now form the southern boundary of the Pacific Ocean, South America, West Antarctica, Australia and New Zealand. Although now widely dispersed, these regions were once continuous parts of the Gondwana supercontinent margin. Activities will concentrate on investigating: (i) the continental basement inherited from Gondwana, (ii) the age and provenance of the accretionary metasediments of this margin and their relationship to subduction-related magmatic arcs, and (iii) the development of economically important sedimentary basins as part of the break-up process. The Pacific margin of Gondwana is a long-lived Andean-type active margin, although there has been a great deal of strike-slip motion and opening of marginal basins in some provinces. This region is therefore of global significance for understanding long-term subduction related geologic problems. The data from the project will play a key role in the understanding of several long-lived Phanerozoic orogenic systems. The societal benefits of the project are seen in the investigation of hydrocarbon-prone sedimentary basins and assessment of natural hazards.

Participating countries

(* indicates countries active this year)

Achievements of the project this year

General scientific achievements

The project symposium in Montevideo was divided into four themes:
(a) Parentage and birth of the Pacific Gondwana margin,
(b) Upper Palaeozoic modifications of the Pacific Gondwana margin,
(c) Patagonia in the Pacific Gondwana margin, and
(d) Maturity, late history and break-up.

These reflect the range of the main topics current being addressed in Gondwana margin research, this time with a focus on South America and the Antarctic Peninsula. Papers were presented by various groups, on topics such as palaeomagnetism, structure and metamorphism of different blocks, aspects of different basins, volcanism and granites. A large number of papers, in addition, reported the results of international collaborative projects. Examples include the Argentine Precordillera as a rifted-off piece of Laurentia (Thomas and Astini), the geochemical identification of terranes (Bahlburg and collaborators), geochronology and structural studies, thermochronology and terrane recognition (Casquet and others), and work the British Antarctic Survey on the Antarctic Peninsula (Pankhurst, Millar, Vaughan). Glen gave a paper attempting to correlate the Neoproterozoic developments of the South American proto-Pacific margin with the developments of the Tasmanides in the Delamerian and Lachlan orogens.

In the wider context of this year’s work, a major focus is still the Early Palaeozoic history of the margin in North-West Argentina, where the hypothesis of a collision between Gondwana and a smaller crustal fragment (the Precordillera) is being subjected to intense examination; stratigraphical evidence clearly favours an Early Ordovician collision. The origin of the Precordillera (Laurentia? or the Antarctic/Australian margin of Gondwana?), and hence the mechanism by which it reached its final position, is not yet unambiguously established. The controversy is generating renewed efforts to solve this problem, with numerous project members concentrating on the lithology, stratigraphy, isotope geology and metamorphism of basement rocks now lying to the east of the Precordillera – which of these can be thought of as ‘Gondwanan’ in origin and which, if any, ‘Laurentian’? Geochronological data, especially relating to the timing of metamorphism and the provenance of detrital zircon, are being acquired to address these questions further. Since Australia is the country best equipped to carry out important aspects of this analytical work, the project has been invaluable in encouraging collaboration between Australian and South American researchers.

A further major tectonic problem being investigated in a similar way within the project is the relationship of Patagonia to the Gondwana margin: For how long has it been an integral part of Gondwana? Some evidence is now emerging that at least the northern part of Patagonia was attached to cratonic South America by Cambrian times, and that the Antarctic Peninsula was also in place by the Late Palaeozoic. Project members are actively applying structural, palaeomagnetic, isotopic and geochronological analysis to these problems.

Work continues on the nature of the metamorphic rocks of the Chilean accretionary complexes, where pressure-temperature conditions are being defined and the history of provenance, metamorphism and exhumation are being addressed using mineralogical and geochronological techniques.

Research groups from South America, France and United Kingdom have made significant advances in understanding the palaeogeographic evolution and the Mesozoic palaeo-environment of Gondwana. This work encompasses studies of the general palaeogeography of Gondwana and Pangea, the analysis of palaeolatitude variations on the basis of palaeomagnetic information, and conclusions concerning secular and global climatic changes. New conceptual models have been proposed for the development and evolution of the Mesozoic sedimentary basins in western Gondwana. The geometry of the basins and the main sedimentary systems have been related to tectonic processes at the continental margin and have led to the definition of the following separate developmental stages: pre-breakup (Triassic – Early Jurassic), breakup (Early–Mid Jurassic), full development of the Andean magmatic arc (Late Jurassic – Early Cretaceous) and Andean compression (Late Cretaceous).

In New Zealand, the provenance history of the Torlesse complex is being studied using geochemistry, isotope geology and fission track methods – the latter have shown that sedimentation of the complex extends back to Jurassic times. Other work is being carried out on the Precambrian and Cambrian rocks of New Zealand and Victoria Land, Antarctica, some of which has demonstrated Late Cambrian oceanic-arc accretion to the Gondwana margin. Results were presented at a Geological Society of New Zealand Conference.

Meetings

A single project symposium was held this year: Structure and Development of the Pacific Margin of Gondwana. The vehicle chosen was the joint meeting XI Congreso Latinoamericano/III Congreso Uruguayo de Geología, 12-16 November, in Montevideo, Uruguay. The attendance at the symposium varied between 50 and 85, from all the active countries listed above except Bulgaria. The scientific products of this meeting were significant. Twenty-one oral presentations of a consistently high standard were delivered over one and a half days. Abstracts of 27 contributions are assigned to the project in the Abstract volume and the accompanying CD-ROM handed out at the congress.
Reviewed papers in international publications:

- Casquet, C.; Baldo, E.; Pankhurst, R.J.; Rapela, C.W.; Galindo, C.; Fanning, C.M.; Saavedra, J. 2001. Involvement of the Argentine Precordillera Terrane in the Famatinian Mobile Belt: Geochronological (U-Pb SHRIMP) and Metamorphic Evidence from the Sierra de Píé de Palo. Geology, 29 (8), pp. 703-706.


- Hervé, F.; Fanning, C.M. 2001. Late Triassic detrital zircons in meta-turbidites of the Chonos Metamorphic Complex, southern Chile. Revista Geológica de Chile, 28 (1), pp. 91-104


Book chapter


Activities planned

General goals

There are three main aims to the project’s work next year: to reinforce the collaboration between members in South America and Australasia, to incorporate research based in South Africa (as was requested by the IGCP Board as a modification to the initial proposal), and to make concrete progress with the map project. Real scientific progress is now being made and it is hoped that next year’s meetings will provide a stimulus for project members to reveal their latest findings and to begin to draw the different lines of investigation together in preparation for the final year’s synthesis.

Meetings

16th International Sedimentological Congress ‘3.5 billion years of sedimentation’, 8-12 July, Rand Afrikaans University, Johannesburg, South Africa. As well as linking into South African research and collaboration, this will be used to develop the third main objective of the project: the development of economically
important sedimentary basins as part of the Gondwana break-up process.

*Gondwana 11 ‘Correlations and Connections’, 25-30 August 2002, University of Canterbury, Christchurch, New Zealand.* This will bring our Australasian members back into full play and will be a special opportunity to advance the map project significantly.

In addition, there are two other major international meetings next year that will present clear opportunities for IGCP 436 presentations and discussion:

*V Congress Geológico Argentino, 24-26 April, Villa El Calafate, Argentina.* The geological evolution of Patagonia will be a central theme of this meeting.

*Fifth International Symposium on Andean Geodynamics, 16-18 September, Université P. Sabatier, Toulouse, France.* This will be a main forum for project members unable to travel to New Zealand or South Africa.

**No. 437 – Coastal Environmental Change during Sea Level Highstands (1999-2003)**

C. V. Murray-Wallace, School of Geosciences, University of Wollongong, New South Wales, 2522, Australia; e-mail: colin_murray-wallace@uow.edu.au

**Description:** The principal objective of this project is to examine the evolution of coastlines during sea level highstands, and compare and contrast the products and nature of different Quaternary highstands. In particular, the objectives include:

1. To compare and contrast the evolution of coasts during the present Holocene sea-level highstand with earlier highstands (e.g. particularly the last interglacial maximum; Oxygen Isotope Substage 5e; 125 ka), and to explain the geological and geophysical basis for any morphostratigraphic similarities or differences in these records.

2. To document through geological mapping and detailed stratigraphic analysis, the global distribution of highstand shoreline successions from the Holocene and last interglacial, and where possible, earlier highstands, with the aim of elucidating the geological and geophysical basis for similarities and differences.

3. To quantify the magnitude of sea-level variation evident during highstands and document their basis (e.g. the contributions of glacio-hydro-isostatic processes, climate change, as well as relative sea-level changes associated with neotectonism).

4. To develop new and refine existing technologies for the assessment of the age of coastal sedimentary successions and landforms through the critical application of a range of Quaternary dating methods; and

5. To evaluate the impact of human-induced environmental changes in coastal environments in the context of natural environmental changes.

The results from these studies will provide the necessary data and scientific interpretations permitting the subsequent management of present and future coastal change. The varying nature of the world’s coastline naturally implies that not all of the stated research objectives documented above, can necessarily be resolved on every country’s coastline. In particular, it is acknowledged that in regions formerly glaciated during the Quaternary, that the coastal stratigraphical record for the last interglacial is particularly fragmentary. Despite this, recent mapping has extended the known distribution of last interglacial deposits in these regions.

**Website of the project**

http://imina.soest.hawaii.edu/Coastal_Conf


**Countries involved in the project**

(*indicates countries active in 2001)


**Achievements of the project for the year 2001**

**General scientific achievements**

The following activities were reported from the national working groups:

**Argentina**

Detailed studies continue of coastal interglacial deposits for the past three interglaciations represented along the Argentine coastline, particularly in terms of the molluscan fossil record and evidence of climate change.

**Australia**

Further mapping in South Australia of coastal deposits of the last interglacial has been undertaken in this temperate carbonate province. The results reveal that although Australia may be regarded in a global context as tectonically stable, in detail subtle variations in the elevation of last interglacial shoreline deposits can be confidently discerned. Further research has also been undertaken in refining the method of whole-rock amino acid racemisation dating as a geochronological framework for demonstrating the correlation of these deposits over broad distances of coastline. Geophysical modeling of Late Quaternary sea surface variations and mantle rheology continue. In addition, intertidal fixed biological indicators such as calcareous remains of the tube worm *Galeolaria caespitosa* have been used in studies of Holocene sea-level change in eastern Australia. Studies of Late Quaternary estuarine valley fill successions in eastern Australia continue.
Belgium
Research focused on sea-level highstands during the last interglacial and Holocene in the western part of the Belgian Coastal Plain. The last interglacial highstand was investigated in a palaeovalley incised in the Tertiary substratum indicating multiple cycles of incision and deposition resulting from fluctuations in base level during the Quaternary. Remnants of deposits from the last interglacial were found in deep boreholes and were investigated on the basis of stratigraphy and palynology revealing preliminary results for a paleogeographical reconstruction of the coastal environments during the last interglacial.

The role of human occupation in relation to the renewed marine flooding since 3000 cal BP was investigated in detail at a site with archaeological remains from the Roman Period. The investigation revealed that lowering the land surface by human activity was most likely largely responsible for the marine flooding. The case study provides an interesting model of anthropogenic influence in landscape modification that may be compared with processes affecting the Belgian Coastal Plain today.

Canada
Research continued on modelling post-glacial sea-level changes and mantle rheology and studies of foraminifera as proxy indicators of sea-level change. Marsh foraminifera are being examined to assess whether northern Vancouver Island experiences land level changes during earthquakes associated with movements of the Nootka Fault which separates the Juan de Fuca plate from a zone of complex crustal deformation, located between the Pacific and North American plates.

Estonia
The reconstruction and distant correlation of palaeoclimatic events and deposits of palaeoshelf, glacial, periglacial and extraglacial zones of northern Eurasia within the Brunhes epoch have been undertaken. Electron spin resonance dating has been particularly important in discriminating the ages of these coastal successions. The dating frequency curve of the whole collection of shells taken from northern Eurasia displays peaks that possibly correlate with the climate amelioration and transgressive phases during Oxygen Isotope Stage 5 sensu lato at c.135, 125-120, 110-105, 95-80 and 70 ka.

Finland
A new research programme has been initiated comparing Holocene and Eemian sea-level histories in the eastern Baltic region.

France
On the western coast of France between Dinard and Cap Fréhel, previously undescribed coastal deposits of Eemian age have been identified. The features are represented by abrasion platforms covered by raised gravel beach deposits. The raised beach deposits are in turn buried beneath slope deposits in which periglacial features are preserved (ice wedges, etc). Precise surveying of these features reveals that they occur between 5 to 8 m above present sea level. Fieldwork has also been undertaken by French scientists in Lebanon, Sardinia and Sicily. In Lebanon, samples have been collected on locations where the early byzantine paroxism is expected to be identified. Dating of samples is in progress. In Sardinia and Sicily, fieldwork concentrated on areas characterised by neotectonic uplift. The rates and nature of neotectonic changes are being examined in the context of a comparison of the Last interglacial and Holocene shoreline successions.

Germany
A new coastal research project was initiated in Turkey. Extensive morphodynamic studies of a series of submerged beach ridges were examined using an integrated approach based on aerial photographs, observations by scuba divers, particle size analyses, seismostratigraphy and vibracoring. The relict beach deposits occur between 12 and 1 m below present sea level and reflect different evolutionary stages of the Baltic Sea. The main sedimentary component of the ridges is sand and gravel and it is remarkable that these features have been preserved in the stratigraphic record especially in view of the obvious effects of wave attack.

Italy
A major report was released this year that examined the effects of wind, atmospheric pressure changes, seiches and tidal perturbations as they relate to Venice for the period 1951 to 2000. Studies of the evolution of the Fortore River coastal plain in response to neotectonics and sea-level changes in Apulia, southern Italy continued.

India
Examination of the geological attributes of coastal heavy mineral sand deposits have been further carried out in 2001.

Japan
Relative sea-level changes during the past 3,000 years along the southern Kurile Trench at the Akkeshi estuary, Hokkaido in northern Japan were examined. The study is based on fossil diatoms and radiocarbon dating of estuarine deposits and volcanic ash. Despite episodic uplift events, the overall record reveals one of submergence for the past 2,000 years. A major synthesis project is being undertaken examining Holocene sea-level changes and mangrove habitat dynamics in the Asia-Pacific region.

Portugal
Research continued examining the Holocene stratigraphy of the estuarine valley fill successions in the Guadiana, Gilão-Almargem and Arade-Boina estuaries of southern Portugal based on the analysis of 14 boreholes. The main focus of this ongoing research is to derive a record of sea-level change.
Spain
The sedimentary record of historical tsunamis in the Bay of Cádiz, Spain, has been examined. Particular attention has been given to examining the sedimentological characteristics of three wash-over fans which contain shell and gravel lenses. Marine terrace deposits of the Aguilas Basin, southeastern Spain are being examined to document the neotectonic history and palaeoclimatic record of this region.

United Kingdom
Fieldwork conducted in Maine, United States, Nova Scotia and New Brunswick, Canada and Donegal, Ireland, and western Iceland, all with the aim of reconstructing late Holocene sea-level changes. Further fieldwork was undertaken in northwest Scotland examining the post-glacial stratigraphy of isolation basins and a record of relative Holocene sea-level change. A considerable research effort is also in progress examining the application of foraminifera, testate amoebae and diatoms as a quantitative multi-proxy tool for studies of sea-level change.

United States
A newly funded 5 year, cooperative programme between the US Geological Survey, NC Geological Survey, East Carolina University and the University of Delaware has been initiated to examine millennial to decadal scale Holocene climatic and sea-level fluctuations and the associated coastal response in the US mid-Atlantic coastal system. A major programme of quantifying rates of carbonate sediment production on the shallow inner shelves of the Hawaiian Islands and shoreline morphodynamics continues.

Uruguay
Martinez and colleagues continued their research examining the age and palaeoecology of a selection of Pleistocene coastal deposits in Uruguay. Advances have been made in mapping the distribution of shoreline deposits that formed during the last interglacial.

Viet Nam
Studies of the barrier sand accumulations near Phan Thiet in southern Viet Nam continued. Samples of quartz sand from the barrier successions have yielded thermoluminescence ages that range between 108 to 85 ka indicating that a substantial portion of the coastal barriers of southern Viet Nam were deposited during the last interglacial sensu lato. Some of these deposits are of commercial interest in view of their heavy mineral content. A new project was also initiated in 2001 by the South Viet Nam Geological Mapping Division examining the Late Quaternary stratigraphy of the Mekong Delta.

Meetings
- Third Annual Meeting of IGCP Project 437 in association with the INQUA Neotectonics and Shorelines Commission, Sea-level changes and neotectonics, Durham and Fort William, United Kingdom, 4–12 September 2001 (Scotland Fieldtrip 8–12 September). Approximately 50 people attended the meeting from 16 countries.
- Belgium Working Group in association with Geologica Belgica; A one-day field meeting (2 June 2001) was organized in the Western Coastal Plain of Belgium examining the Late Quaternary geology of the Ijzer palaeovalley and modern and inland dunes, and involved 40 participants with 5 from France and 10 from The Netherlands.
- Co-sponsorship of the 5th Iberian Quaternary Meeting, Quaternary Congress of Countries of Iberian Languages, Lisboa, 23–27 July 2001 (Sociedade Geológica de Portugal, Grupo de Trabalho Portugês para o Estudo do Quaternário and Asociación Española para el Estudio del Cuaternario). 130 delegates from 14 countries were represented at the meeting.

Selected Publications
Activities planned

General goals

1. To continue to increase the participation of researchers from developing countries through increased publicity and by establishing a more pro-active approach to inviting people from developing countries to participate in international meetings.

2. To further consolidate the linkages between IGBP PAGES (Past Global Changes) and LOICZ (Land-Ocean Interaction in the Coastal Zone). A joint PAGES-LOICZ workshop accompanies the inaugural meeting of IGCP 437 in Hawaii in 1999. The workshop revealed that there are very clearly defined research linkages between these projects and it was agreed wherever possible to hold joint meetings in the future. IGCP 437 will also establish particularly strong links with the recently approved Project 464, Continental shelves during the last glacial cycle: knowledge and applications.

3. To complete the editorial activities associated with the second and third annual meetings of IGCP 437. A special issue of Sedimentary Geology arising from the inaugural meeting of the project will be published early in 2002. The special issue contains 12 papers that were presented at that meeting. Special issues of Marine Geology and Journal of Quaternary Science associated with the second and third annual meetings respectively are currently being edited.

4. To compile a global database of Holocene and Pleistocene sea-level curves. There is no other scientific research group with the depth of knowledge and collective expertise to undertake such a task.

Specific meetings and field trips

The planning the fourth annual meeting of IGCP 437 with the intention to hold the meeting and fieldtrip in Barbados in 2002 is in progress. A field study trip to examine the Quaternary geology of the Coorong Coastal Plain in South Australia will also be conducted in July 2002. This activity is part of the 16th Australian Geological Convention, an activity organized by the Geological Society of Australia and also represents an official activity of IGCP 437.


C. Powell

(Professor Powell sadly passed away in July 2001).

S. Bogdanova, Institute of Geology, Department of Mineralogy and Petrology, Sölvagatan 13, S-223 62 Lund, Sweden, e-mail: Svetlana.Bogdanova@geol.lu.se
H. Kampunzu, Faculty of Science, University of Botswana, Private Bag 0022, Gaborone, Botswana, e-mail: Kampunzu@mopipi.ub.bw

Zheng-Xiang Li, Tectonics Special Research Centre, The University of Western Australia, Crawley, WA 6009, Australia, e-mail: zli@tsrc.uwa.edu.au

Website addresses related to the project
http://www.tsrg.uwa.edu.au/
http://www.geol.lu.se

List of countries involved in the project
(*indicates countries active this year)


Achievements of the project this year

General scientific achievements

The project has made some scientific breakthroughs between late 2000 and 2001. One is the emerging evidence arguing against a coherent East Gondwana during Rodinia time. The other is new palaeomagnetic evidence indicating that the SWEAT fit could not have existed at ca. 1.07 Ga. However, there is still a lack of reliable palaeomagnetic data for the interval between ca. 1.0 Ga and ca. 0.75 Ga. Recent work from Siberia indicates that there is no evidence for active plate margin (i.e. Rodinia assembly history) around the Siberian craton between 1.4 and 1.05 Ga. Emerging data from Africa and South America indicate that some of the cratonic blocks may not have been part of the Rodinia supercontinent. These data also indicate that the early stage of Western Gondwana assembly started during the late stage of the Kibaran-Grenvillian orogeny, which implies that the assembly of Gondwanan cratons may have started before the Rodinia breakup.

Apart from a large number of individual papers in international journals, two Precambrian Research special issues and one GSA Special Paper were published in 2001 reporting latest research related to Rodinia. One Precambrian Research Special Issue was co-edited by the late C. McCa. Powell (Project co-leader) and J. Meert (Vol. 110). The volume contains 18 papers on the Early Neoproterozoic history of Rodinia and its subsequent breakup, especially in Siberia, East Greenland, the East African orogen, Seychelles and North-West India, the Congo and adjacent South America. Professor Powell spent much effort during his last year editing this volume.

The second special issue (Vol. 111) on Rodinia and the Mesoproterozoic Earth–Ocean System was edited by L. C. Kah and J. K. Bartley. They dedicated the volume to the memory of Professor Powell for his tireless efforts in uniting scientists worldwide to the cause of Rodinia. R. E. Ernst and K. L. Buchan co-edited a GSA Special Paper Series (volume No. 352) on Mantle plume: their identification through time. This is a timely volume as a number of members are currently working on the possible relationship between mantle plumes (or a superplume) and the breakup of Rodinia.

Currently, a number of journal special issues on the results of the project are in preparation. In addition, one book reviewing the latest scientific contributions to the project is also in preparation.

The project also made progress in the making of the Rodinia maps. It was decided that the project will produce continental tectonic maps, at 1:2 million scale where possible, but with the main focus on the production of the 1:10 million GIS-based Rodinia map. The legend for the map will be finalised in early 2002, and thus the compilation of the regional maps will be done during 2002.

Meetings

The sudden passing away of Co-Leader Professor Powell in July was a major moral setback to the approximately 300 members of the project. However, members were united to continue with this strong and popular project. The project sponsored or co-sponsored three successful activities during 2001.

1. Field workshop on ‘Assembly and breakup of Rodinia’, held in Irkutsk, Russia, between 23 July and 4 August 2001 was attended by about 40 geologists from nine countries. There was a two-day symposium, as well as pre- and post-symposium field trips to Early Precambrian metamorphic complexes, a Neoproterozoic mafic dike swarm in the Sharyzhalgai salient, the Neoproterozoic (Baikalian) passive margin sedimentary sequence of the Siberian craton, and zoned metamorphic complexes related to the closure of the Palaeo-Asian ocean in the central part of the Baikal area.

2. The Chris Powell Memorial Symposium on ‘From Mountains to Basins: Rodinia at the Turn of the Century’, held at the Tectonics Special Research Centre, Perth, Australia, between 30 September and 2 October 2001. The symposium was attended by over 60 scientists from 14 countries. The two-day-long, high-spirited oral sessions were made up of twenty-one invited talks on five themes: (a) Shaping Rodinia, (b) Mountain belts and the assembly of Rodinia, (c) Testing Rodinia – basins and microanalysis, (d) From Rodinia to Gondwanaland, and (e) Neoproterozoic world. About 25 posters were also presented at the symposium. All
papers were published in an extended abstract volume (Geological Society of Australia, Abstracts No. 65, 120 pp.), and can be viewed on the Geological Society of Australia website soon (http://www.gsa.org.au). Hard copies can be purchased from either the GSA or the TSRC at A$20 each).

3. International symposium on ‘The evolution of Rodinia and Gondwanaland and the formation of Asia’, held at Osaka between 26 and 30 October 2001. The meeting was co-sponsored by IGCP Projects 386, 411 and 440, and was attended by about 250 scientists from 33 countries/regions. Topics were wide-ranging, from the assembly and breakup of Rodinia and Gondwanaland and the formation of Asia to tectonic processes related to those events, and palaeoenvironmental changes. The meeting finished with a joint forum discussing all major issues raised during the five-day meeting.

Other events: In addition to the above events, IGCP 440 was involved in a chiefly IGCP 418-sponsored field symposium in Durban, South Africa, 8-21 July. Several members of IGCP 440 participated in both the meeting and pre- and post-field trips to the Namaqua and Natal belts. Since 2001 was the final year for IGCP 418 (with the possibility of a one-year OET in 2002), the leader of IGCP 418 and the participants in the meeting decided unanimously that all the members of this project should join IGCP 440.

Rodinia aspects were also discussed during the EURO-PROBE (ESF/ILP) time-slice symposium, *Archaean and Proterozoic plate tectonics: geological and geophysical records*, in Saint Petersburg, Russia (31 October-4 November). The IGCP 440 Russian Working Group and other symposium participants discussed the current state of the project and future work required, geochronological work in particular.

List of most important publications

**Book edited by members**

**Refereed journal articles**

- Bylund, G.; Pisarevsky, S. A. Remagnetisation in Mesoproterozoic dykes from the Protongrze Zone, southern Sweden and the Sveconorwegian Loop. *Geologiska foreningen i Stockholm forhandlingar (GFF)*. (In press.)
- Gladkochoub, D. P.; Sklyar, E. V.; Menshagin, Y. V.; Mazukabzov, A. M. 2001. Geochemical affinities of Early Precambrian ophiolites of the Sharizhalgay salient (Siberian craton). *Geochemistry*, 8, pp. 224-43. (Complete translation in English will be published at the beginning of 2002.)


**Activities planned**

**General goals**

– Continue to obtain and publish high-quality data (e.g. ages and kinematics of Grenvillian orogens, basement provinces, basin histories during the assembly and breakup of Rodinia, evidence for Neoproterozoic mantle plumes and their possible roles in the breakup of Rodinia, palaeomagnetism, etc.) in order to constrain the evolution of Rodinia further, and

– Drafting of 1:10 million tectonic maps for major continental blocks.

**Meetings**

The project plans to hold seven meetings for 2002 but only the first three events below will be the main IGCP 440-sponsored events in 2002:

1. The Grenville field symposium, 30 May to 7 June. This will be the first meeting of the project in the Grenville belt. The field workshop will follow the Annual GAC-MAC Meeting, to be held in Saskatoon between 26-29 May 2002. ([http://www.usask.ca/geology/sask2002/eng/index.html](http://www.usask.ca/geology/sask2002/eng/index.html)). There will be special sessions on 29-30 May at the GAC-MAC Meeting on 'Aspects of Rodinia assembly exempliﬁed in the Grenville Province’. The Grenville ﬁeld excursion/workshop (post-conference excursion No. B6) will start on May 30, leaving from Toronto, and end in Montreal on 7 June. The ﬁrst part will have one day in the Grenville Front area, one in the interior gneiss terranes, and two in the Composite Arc Belt in Ontario. The second part will be in Quebec, with one day on the Metasedimentary Belt, one on the AMCG suite and its tectonic setting, and the last day on the early arc assemblage (1400 Ma) to the east. There will be two separate ‘hole up’ days during the trip for presentations and discussions on aspects of Rodinia assembly in the world.
2. MXC2 Global metallogeny during the assembly and breakup of the Rodinia Supercontinent (incorporating IGCP 418, 419 and 440), and a related 7-9 day field trip on assembly and breakup of Congo and Kalahari margins across the Namibian segment of the Damara belt, July (http://geoconference2002.com). A special field trip related to the Mesoproterozoic of South-West Namibia is being prepared.

3. A meeting of the Rodinia Map Steering Committee towards the end of the year in Perth to report on progress made on regional maps, in order to ensure that a common standard is maintained between the different map sheets, and plan the next step of putting them together in an agreed Rodinia configuration.

4. The 16th AGC in Adelaide, 1-5 July, which has a major theme on Plate Margins and Supercontinents, a symposium dedicated to Professor Powell, and a number of relevant field trips (http://www.16thagc.gsa.org.au).

5. The Gondwana 11 meeting, 25-30 August, Christchurch, New Zealand.


D. Hovorka, Department of Mineralogy and Petrology, Faculty of Natural Sciences, Comenius University, 842 15 Bratislava, Mlynská dolina-G, Slovakia, e-mail: hovorka@fns.uniba.sk

G. Trnka, Institut für Ur- und Frühgeschichte, Universität Wien, Franz Klein Gasse 1, A-1190, Wien, Austria, e-mail: gerhard.trnka@univie.ac.at

Description: The main goal of the project is to carry out interdisciplinary studies to establish the source and characteristics of Neolithic/Aenolithic stony artefacts (tools, weapons, etc.) in order to define communication paths of raw materials used by the Neolithic/Aeneolithic populations and in the majority of cases their possible sources (geological units/bodies are discussed), (2) one raw material type is described in detail by means of topical laboratory techniques (electron microprobe, etc.).

IGCP442 is the first broadly formulated international project to deal with petroarchaeological and archaeological issues.

Website of the project http://www.ace.hu/ace-home/igcp442/igcp442.html

Participating countries (*indicates countries active this year)


Achievements of the project this year

General scientific achievements

Published research work concentrated on: (1) areas (mostly countries, or parts of them) from which raw materials used by the Neolithic/Aeneolithic populations are described and in the majority of cases their possible sources (geological units/bodies are discussed), (2) one raw material type is described in detail by means of topical laboratory techniques (electron microprobe, etc.).

Meetings

4th Workshop of the IGCP Project 442, 25–28 September 2001, Udine and Genova, Italy, 26 participants of the project in Udine and 32 participants in Genova from 10 countries (17 lectures in Udine and 12 lectures in Genova).

List of most important publications

The following publications have not been listed in previous annual reports for IGCP 442. Papers which are listed below with earlier date as 2001 have been published in the first months of 2001.

Scientific papers published “in extenso”


Informative papers:


Activities planned

Meetings

1. During the XVIITH Congress of the Carpathian-Balkan geological association (being member of IUGS) in September 2002 (Bratislava, Slovak Republic) workshop (No. 5) on the theme of IGCP 442 will be held.

2. The final plenary session of the project will be organized during the second half of October – beginning of November in Wroclaw (Poland) or in Budapest (Hungary). Date and place is not fixed yet.

General goals

The plenary session in Genova authorized the project leader to get all available information in order to publish the final results of the project in form of a monograph book, which should cover the whole of Europe issues of stone raw materials used in the Neolithic/Aeneolithic.


M. Radvanec, Geological Survey of Slovak Republic, Markušovská cesta 1, 052 01 Spišská Nová Ves, Slovak Republic, e-mail: radvanec@gsrcsnv.sk

W. Prochaska, Department of Geological Sciences University of Leoben, A-8700 Leoben, Austria; e-mail: prochask@unileoben.ac.at

A. C. Gondim, Federal University of Paraná, Rua Marechal Mallet 185/401, 80540-230 Curitiba-PR, Brazil; e-mail: gondim@geologia.ufpr.br

Cai Keqin, China University of Geosciences, 29 Xueyuan Road, Haidian District, Beijing 100083, P.R.China; e-mail: cai@mail.ngl.org.cn
**Description**: The project intends to improve knowledge about the specific genesis aspects of magnesite and talc (controversial models on the origin of magnesite accumulations still exist today), and their behaviour in geological processes, then to find new ways to minimise the negative impact on the environment of the exploitation of magnesite and talc. Specifically, the project will cover aspects related to the contamination of aquifers in the vicinity of mineral deposits, development of Karst triggered or accelerated by the exploitation of deposits hosted in carbonate rocks and geo-environmental monitoring and modelling. Indeed, magnesite and talc are raw materials which are gaining in importance in everyday life. In many countries, magnesite and talc remain the major industrially exploited raw materials. Therefore, it is essential to find new, very effective ways of pollution monitoring and environmental protection. The techniques applied will use structural geology, petrology, geochemistry, geochronology and environmental geology. Additionally, the non-traditional use of magnesite and talc (soil improvement, etc.) will be investigated.

**List of countries involved in the project**
(*indicates the countries active this year)

Argentina, Australia, Austria*, Brazil*, Canada, Chile, China*, Croatia, Cuba, Egypt*, Finland*, Germany*, Greece, India*, Italy*, Japan*, Republic of Korea, Namibia, Pakistan, Russia*, Slovakia*, Turkey, Ukraine*, United States, Yugoslavia*

**Achievements of the project in 2001**

**General scientific achievements**

1. **Geology, structure geology, geochemistry, petrology and mineralogy of magnesite and talc deposits**

IGCP 443 studied individual genetic types of deposits and carried out sampling for further petrological, isotopic and petrotectonic research. The correlation in Carinthia, Austria, (realized already in May 2000, but with ongoing research this year) was focused on the magnesite deposit Radentheim, originally interpreted to be a constituent of Middle Austro-Alpine Unit. Most of the magnesite of the Eastern Alps occurs in Palaeozoic series of the Upper Australpine units. New research related to IGCP 443 indicates an interpretation of exceptional position of Radentheim deposit being a tectonic wedge thrust into the Australpine crystalline basement. According to the special chemistry of inclusion fluids the metasomatic stocks of sparry magnesite were formed by evaporitic brines during the Permoscythian in a very shallow hydrothermal environment, where these fluids came in contact with underlying Palaeozoic carbonates percolating through brittle fractures originating in a rift environment.

First results of fluid investigations on magnesites and dolomites from the Eastern Alp show very high Br/Cl ratios of the inclusion fluids thus indicating highly evolved seawater to be the mineralizing fluid for the magnesite mineralization. During their downward flow into the brittle fractures of the crust, these fluids can be incorporated into hydrothermal systems still exhibiting their original ratios. While percolating into deeper crustal levels, water-rock reactions caused a reducing environment and leaching of Fe, resulting in the formation of siderite deposits. The immediate transition in the fluid composition between marine host rock carbonates and the minealizations characterized by evaporitic fluids is not compatible with a simple marine-sedimentary model. Generally, the formation of talc deposits in the Eastern Alps can be attributed to the Alpine orogenic cycle. One of the most striking features of this type of talc deposits is their localization in prominent thrust zones and faults transecting carbonate series of the Carboniferous Veitsch nappe of the Greywacke Zone. The Rabenwald talc mine was formed during the staking of the Austroalpine nappes in a magnesite-bearing thrust zone. The Lassing talc mine is situated in the Greywacke Zone and was formed by hydrothermal process after the peak of the Eoalpine metamorphism.

Talc formation in Austrian deposits Rabenwalad and Lassing is due to the ingress of Si-bearing hydrothermal fluids reacting with the dolomitic component of the carbonate rocks. Talc formation took place according to the reaction:

\[
3 \text{CaMg}((\text{CO}_3)_2 + 4 \text{SiO}_2(\text{aq.}) + 6\text{HCl} \rightarrow \text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2 + 3 \text{CaCl}_2 + 2 \text{H}_2\text{CO}_3 + 4\text{CO}_2
\]

As a result of this hydrothermal reaction only newly formed talc and residual (recrystallized) dolomite can be found in the talc-bearing area. Continuous availability of H$_2$O and removal of CO$_2$ from the system along fractures are basic requirements for talc formation.

Talc represents a product of metamorphic reactions that can be enriched by subsequent deformation due to the high strength contrast between talc and other rock-forming minerals. This model was deduced from structural data collected within the Lassing talc deposit where talc constitutes fault cores within the Palten fault zone. Talc likely formed by the metamorphic reaction quartz + dolomite + H$_2$O $\rightarrow$ talc + calcite + H$_2$O within greenschist facies conditions was subsequently enriched to pure talc lenses by a succession of regionally controlled deformation events because talc behaved ductile in contrast to brittle-deformed country rocks. Talc bodies progressively formed along continuous C-surfaces along which slip occurred.

To evaluate the Brazilian talc occurrences in Paraná state, there were revealed four main geological controls of deposits location. These are now used for prospecting in Paraná talc district. Late Proterozoic Itaiaica
Vein type dolomite-bearing carbonates. explained by the iron deficiency of magnesite and magnesian silicate gels) in the talc from Bahia is greenalite – being the product of diagenesis of iron-of minnesotaite (resulting from metamorphism of probably supplied by intrusive processes. The absence sary for talcification of magnesian carbonates was tectonothermal and magmatic events. The silica neces- 110 sary for talcification of magnesian carbonates was probably supplied by intrusive processes. The absence of minnesotaithe (resulting from metamorphism of greenalite – being the product of diagenesis of iron-magnesian silicate gels) in the talc from Bahia is explained by the iron deficiency of magnesite and dolomite-bearing carbonates.

Vein type magnesite was found in peridotite lenses at the western termination of the Bhavani lineament forming a part of the Moyar-Bhavani shear zone, India. The major rock types of the zone, hornblende gneiss and quartz-biotite schist are mylonitized by ductile shearling. Structural analysis revealed two folding events accompanied by pervasive plastic deformation. The genesis of magnesite veins, being not affected by these deformation events, is a matter of ongoing research.

The magnesite and talc of Slovakia was the main subject of the Field correlation in 2001 which revealed some unclear aspects of magnesite and talc genesis (e.g. different stratigraphic affiliation of corresponding deposits with corresponding lithology as well); new petrological data were presented. The Mg carbonate occurrence Dubrava, being part of the Jelsava deposit, mainly consists of magnesite, two generations of dolomite (Dol1, Dol2) and two generations of calcite (Cal1, Cal2). Fe magnesite, talc (Mg\(^+\) = 0.98), chlorite 2 (clinochlore; Mg\(^+\) = 0.96), graphite(?)-organic matter, apatite, quartz and pyrite occur in small amounts. According to the chemical composition \(X_{Fe} = \frac{Fe}{Fe+Mg+Ca+Mn}\) in dolomite1 versus \(X_{Mg} = \frac{Mg}{Fe+Mg+Ca+Mn}\) in calcite 2, the temperature of the replacement was calculated, using the carbonate geothermometry by Powell et al. (1994), with obtained essential temperature \(T = 370-400^\circ C\) representing the first metamorphic stage (peak of metamorphism) with formation of Cal2 + Dol1 \(\equiv Mg\). The second and major stage of the replacement formed mineral assemblage magnesite with reduced amount of dolomite1 at the beginning of the retrograde metamorphism. Irregular to tabular inclusions of older dolomite1, being frequently enclosed inside dominated and chemically homogeneous magnesite, are interpreted as a relict of the first stage. In the third stage (retrograde metamorphism) the idiomorphic or hypidiomorphic dolomite2 is formed, usually enclosing small and irregular grains of older magnesite. Dolomite2 with inclusions of magnesite are well recognized in the youngest talc. In the matrix, the third stage forms Fe-magnesite (FeCO\(_3\) = 9.20-13.30\%). Fe-magnesite is usually accompanied with pyrite and represents cooling during retrograde metamorphism under lower temperature (probably below 300\(^o\) C).

2. Methods of exploration, investigation of the raw materials and processing

One important result of this thematic group is cata- logging of known magnesite and talc deposits and occur- rences in the participating countries. The database of the project summarizes deposits from Brazil (110), Slovakia (10), Austria (7), Russia (11), Ukraine (4), China (7), Australia (7) and Pakistan (1).

Recent outputs of IGCP 443 in the field of economic geology are exact numbers about
- Magnesite reserves in the world (divided according the main producers China, North Korea, Russia, Brazil, Turkey, India, Slovakia, Greece, Spain, Austria, etc.)
- World production of natural magnesite (division into various countries)
- Talc reserves in the world (division into various countries)
- Talc production in the world (division into various countries)

Data about reserves and annual exploitation, as well as methods of exploitation and processing are known from Brazil, Slovakia, Russia and Ukraine. Slovakia is a type country where data of economic geology, methods of exploitation, but also about dressing methods and ways how to make magnesite and talc plants profitable, are precisely characterized and published. By this way they can serve as transfer of knowledge to the countries of the 3rd world. Reciprocity of knowledge exchange is documented by information from Brazil, that the explo- ration of talc in Paraná considers preferably structural and morphologic controls, being determined by aerial photos and satellite images, some times geophysical magnetic methods are used to detect dolerite dykes configuration. The contrast of electrical properties between talc bodies and carbonate host rocks makes possible and recommendable the application of Spectral
Induced Polarization (SIP) and Resistivity methods for geophysical prospecting of the talc deposits in Paraná district.

3. **Geoenvironmental models**

Environmental protection, inevitable during magnesite and talc production, has been characterized in the type case of Slovakia:

*Pollution of soil by magnesite dust*

The main component of emission is represented with magnesite dust (approximately 1 mm in size) with content of MgO 65-85%, where MgO is present in oxide and carbonate form. According to the weight of particles and air conditions the dust has been deposited in various distances from the polluting source mainly on agricultural and forest ground which is chemically and mineralogically changing the soil. If the content of magnesite in soil is increasing, agrochemical and pedological characteristics of contaminated soil are also changing. Contaminated soil is alkalised, the content of carbon is increasing and the pH value is increasing to 7-9 according to the level of contamination. This contamination is highest in the arable level of soil, deathward it is decreasing. Soils in more rangy terrain increasingly suffer water erosion.

*Influence of emissions on vegetation*

Forest economy is one of the most sensitive branches (qualitatively as well as quantitatively) towards impacts of air pollution. Forests dying in industrial areas are a result of this. Mostly oaks, beeches and in higher altitudes spruces and pines are growing in endangered forests. The degradation of forests and especially dying of top branches of trees causes the soil lightning and growth of new gross vegetation similarly like on forest glades. According to results from area diagnosis of negative emission impacts with regard to the influence of external factors, mainly the configuration of terrain, three zones of forest threat were established:

(a) Area of strong threat that includes area without vegetation and area of dying vegetation. In the case of Slovak magnesite industry it is totally 1,014 hectares.

(b) Area of medium threat, characterized by long-term influence of low concentration of emission compounds (mainly SO₂). This type represents chronic type of damage, mainly damage of sensitive pinewoods, and such damage can evoke severe devastation; totally 2,011 hectares.

(c) Area of weak threat (protected zone) characterized with low level of pollution; totally 3,617 ha

The impact of magnesite emissions on the substances cycle in forest ecosystems:

1. Decisive changes of soil chemist (pH value of water in surface area is 9.1-9.3 and HCl pH is 8.6-9.1).

2. They influence negatively both the decomposing of organic substance and mineralization of organic substances; they limit the effectiveness of microorganisms and biological soil activity.

3. The dust in assimilation organs damages photosynthesis, causes defoliation and decreases wood growth.

4. They attack and limit the dynamics of physical, chemical and biological processes as well as damage absorption complex of soil and nutrition of woods.

5. Mg emission influences qualitative changes in ecosystem compounds, that means retreat of economically most important woods and their replacement by more sturdier woods (e.g. birches, alders, etc.) as well as quantitative changes – mainly reduction of wood reserves, soil bonity deterioration, total wood health and resistance deterioration.

Town forests in areas of magnesite sources are abused by emissions. The main emission compound is MgO that creates secondary minerals in contact with water and CO₂. After they fall to the ground and on vegetation, mainly hydromagnesite appears in contacts with trunk, branches and leaves. In areas of high SO₂ concentration (acid rains) it is possible and proper to apply MgO for decreasing the acid content in soil. This positive feature has already been used in several areas. Second emission compound is SO₂ that can create with water low-concentrated acids. Emission compounds in synergic activity negatively influence the wood in such way, that they decrease solar income and assimilation intensity which evokes decomposition of the chlorophyll. They change the physical and chemical composition of soil, increase soil reaction and decrease its general fertility.

*Influence of emissions on animals*

The following facts result from knowledge about high content of magnesite and other compounds of magnesite waste in living organisms:

- Surplus of Mg impacts mainly juvenile animals, because these do not have developed or stabilized physiological functions.

- Mg is accumulated in organs, bones and fur even in situation, when highest possible limit 12.5 g.m⁻² / 30 day is not overcome.

- Surplus of Mg has negative impact on nervous, renal and endocrin systems, on the bones and on the gravidity of animals.

- Plan indexes for sheep and cattle stock-raising are not fulfilled due to area pollution by magnesite dust. On the contrary, pig raising is successful. Damage for cattle and sheep consisti in decreased weight, frequent diarrhoea and increased consumption of mineral substances.

Possible remedy to decrease emission consists in catching magnesite dust by fabric filter, dust chamber, electrostatic or other ways.

In the IGCP 443 Introductory Newsletter (Mineralia Slovaca 6:32, 2000) fifteen papers were published. The additional and subject matter articles were issued at the “Mineral Deposits at the Beginning of the 21st Century (section Magnesite and Talc)” edited by Adam Piestrzyński et al. (2001), SGA-SEG / Balkema, Nisse, Netherlands.
Meetings

- 1st meeting of the Slovak National Working Group of IGCP 443, Košice, Slovakia, 5 March 2001; 16 participants from Slovakia
- Annual Meeting 2001 – Krakow, Poland, 29 August; 23 participants from 12 countries
- Field Correlation 2001 – Magnesite and talc deposits in Slovakia (Jeľava, Hnúšťa, Gemerská Poloma, Košice), 30 August – 3 September; 14 participants from 7 countries

List of most important publications

Activities planned

Specific meetings and field trips


No. 448 – World Correlation on Karst Ecosystems (2000-2004)

Y. Daoxian, The Institute of Karst Geology, 40 Qixing Road, Guilin, Guangxi 541004, China, e-mail: dxyan@mailbox.gxnu.edu.cn

C. Groves, Hoffman, Environmental Research Institute, Department of Geography and Geology, Western Kentucky University, Bowling Green, KY 42101, United States, e-mail: chris.groves@wku.edu

G. Messana, C.N.R., Centro di Studio per la Faunistica ed Ecologia Tropicale, Via Romana 17, 50125 Firenze, Italy, e-mail: messana@fi.cnr.it

Description: The ecosystem in karst regions is fragile. Therefore, a better understanding of the mechanism governing their formation and of differences around the world is essential for sustainable development in those regions. The main goal of this project is to compare the karst ecological systems in tropical, subtropical, boreal, arid, semi-arid, Mediterranean, Gondwana and other regions, in order to understand how karst is formed in each case. The project will also compare the microscopic karst ecological system under different geochemical conditions and for different phases of carbonate rocks, especially the impact of this background on species selection and biodiversity. Also, methods for the rehabilitation of karstlands will be proposed. The subterrestrial ecological systems of karst will be compared from both a geographical and geological perspective as well as their influence on the evolution of troglobites, troglophiles and troglobxene species, and the relation between surface species and the karst environment. The interrelation of karst ecological systems, human health and human activities will be studied, including agriculture, urbanization, timbering and mining. The societal aspects of the project include environmental protection strategies and health aspects. Altogether, 110 scientists are participating in this project.

Website addresses related to the Project
http://www.gxnu.edu.cn/KDL (for general informations of the Project)
http://www2.wku.edu/~grovecg/ (for IGCP 448 past meeting, and future meeting in 2003, United States)
http://www.hidrogeo.uma.es (for 448 meeting in 2002, Spain)

Participating countries
(*indicates countries active this year)


Achievements of the project in 2001

General scientific achievements

The scientific achievements of the project in the second year are characterized by an international comparison of various karst ecosystems along a north-south transect in East Asia, i.e. from tropical ones to boreal ones. Concrete achievements of the project this year can be summarized according to its four objectives on the basis of presentations and discussions in symposia, field excursions and reports from National Working Groups.

World comparison of karst ecosystems

Based on the 2001 field correlation in subtropical karst of South-West China and on the semi-arid karst in Western Beijing of North China, integrating reports from Eastern Siberia (Russia), and tropical karst of Ryukyu
Island (Japan), Viet Nam, Malaysia, and Indonesia, the project comprises a whole transect of karst ecosystems in East Asia from tropical, subtropical, coastal, semi-arid to boreal karst ecosystems. This is a major step for the project towards the understanding of karst ecosystems in the world. Yuri Trizhtsinski reported on the characteristics of the boreal karst ecosystem in Eastern Siberia (50-60° North Latitude), underlain by Cambrian strata of mixed carbonate-evaporite formations. The boreal karst ecosystem used to enjoy shallow groundwater located on permafrost, which supports vegetation. But global warming and a series of reservoirs constructed on the Angara River since the 1960s has brought about the disappearance of permafrost, the draining of shallow groundwater, and damaging of the Taiga Forest. The reservoirs also activate the dissolution of the evaporite-carbonate rock formation, which results in serious karst collapse problems. In some parts of the west bank of the Bratsk Reservoir, the density of the collapse pit could be 2.5-200/km². The pollution from metallurgical and collapse problems. In some parts of the west bank of the Bratsk Reservoir, the density of the collapse pit could be 2.5-200/km². The pollution from metallurgical and coal industries along the reservoirs has endangered fish.

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But processes of rock desertification, under the impact of human activities, like those that occurred in South-West China also happened in the karst of Northwest Viet Nam. Sambudhi Sudibyo discussed the tropical ecosystem of the karst belt underlain by Tertiary limestone at the southern peripheries of Java Island (7-8° S), the Yogyakarta Province of Indonesia. It is about 1,000 km long in the east-west direction, and 20–30 km wide in the north-south. Under the prevailing climatic conditions marked with seasonal extremes of water and heat, population pressure and bad land use planning have transformed the karst ecosystem into a rocky barren landscape that is almost devoid of soil and vegetation. The remaining soils on karstland are confined in dissolutional fissures or holes distributed in patchy patterns between limestone outcrops or boulders. Local peasants cultivate their soil like growing plants in pots, the so-called ‘pot culture’. Moreover, Sambudhi Sudibyo also reported that some cash crops are calicheplant and can grow well on limestone and benefit local people, such as mango, cashew, and Gnetem gnemon (‘Mlinjo’ in the Indonesian language). Such ecological scenarios and experiences are quite comparable with those of South-West China Karst, although the plant species of Indonesia are more tropical.

In the middle of the great East Asia transect lie the broad karst areas in China. Chinese colleagues provided background data on five different karst ecosystems with different geological, topographical, climatic, vegetation conditions, and human activity: the Western Mountain in Beijing (40° N), the Jinfo Mountain Nature Preserve, Chongqing (29° N), Liupanshui City, Guizhou (26° N), the Stone Forest, Kunming (24° N), and Guilin (25° N).

The semi-arid karst in the mountainous region of the western suburb of Beijing is underlain by Cambrian-Ordovician limestone, presenting periglacial shaping and limestone peaks, the ‘Pseudo Cone Karst’ developed on Proterozoic siliceous carbonate rocks along the Juma River. The abundant well-decorated speleothem in the 2,500 m long Shihua Cave which developed in Ordovician limestone is considered to have deposited during some warm humid period of the geological history, such as the stable isotopic stage 5e 130 Ka ago. The karst vegetation is improving in the areas near Beijing city and some scenic resorts, but still shows bare rock in remote parts. Impact of human activities (limestone quarry, cement manufactory, and excess buildings in scenic areas, etc.) on karst ecosystem were discussed.

The Jinfo Mountain Nature Preserve with over 5,000 species of plants and 500 species of wild animals lies about 200 km south of Chongqing city or 100 km south of the Yangtze River. Although based on a subtropical monsoon humid climate, the high relief (500 m-2200 m asl) of the Jinfo Mountain and its wide geological coverage (from Cambrian dolomite limestone at its foot to Permian limestone on the top of its plateau) bring about various karst ecosystems. Experts experienced how karst features, soils, water chemistry, and vegetation changed in accordance with changing altitude and stratigraphy. Some particular species were examined, e.g. Cathaya argyrophylla which used to be widespread in the Northern Hemisphere during the Cretaceous and Tertiary, but declined during glaciations, and now remain only in the Jinfo Mountain because of its special geographical situation. Liriodendron Chinese, now present only in China and North America is considered as an evidence of continental drift and is found at 1,200 m to 1,800 m in Jinfo Mountain. There are ten thousand hectares of Chimonobambusa utilis, a particular species of bamboo with a rectangular cross-section spreading on the top of the Jinfo Plateau.

On the Guizhou Plateau a deteriorated karst ecosystem (the karst rocky desert) and its rehabilitation were examined. The vegetation cover between Guiyang and Liupanshi city is only 3.15% (for the Puding country) and 1.14% (for the Shuicheng country). The causes of karst rock desertification were discussed which include population pressure (135 p/km²), bad land use in cultivating slopes steeper than 25°, poor soil formation on limestone under intensive karst processes, and slow rate of vegetation growth on the plateau. On the other hand, an ecological rehabilitation area at Baihe village, 5 km west of Liupanshi city was also visited. Through years of afforestation, 8,668 mu (1 acre = 6.07mu) a secondary forest developed, including 1,000 mu of dense forest. Studies of the biodiversity in the
rehabilitation areas show that the secondary forest now includes not only local prevailing species, such as Pinus armandii, Pinus Yunnanensis, but also many other species, e.g. Coriaria Sinica, arbutus (Myrica rubra), walnut, poplar, birch. The rehabilitation has also improved the eco-hydrological system. An epikarst spring became permanent with a discharge of 20 l/s, which facilitates water supply for villagers.

The Stone Forest represents the unique karst features developed on Permian limestone on the plateau surface 1800–1900 m asl. There the most characteristic pinnacle karst of the world and its varieties were investigated. The history of the origin and evolution of such a karst landscape was discussed. In the Naigu Stone Forest area, participants examined on the spot the action of aerial blue Algae in the formation of micro karst features and their function in water detention on the surface of limestone rock. The importance of such phenomena for the rehabilitation of karst rocky desert was stressed.

Guilin is a paradise for world karst geomorphologists, especially for those who are devoted to the study of tropical karst. The tower karst in Guilin is developed on a pure, massive limestone of Upper Devonian, with altitudes from 150 m asl (on plain surface) to 200-400 m asl (on stone peak surface). It is divided into two subtypes, i.e. the peak cluster (Fengcong) and the peak forest (Fengling). The former enjoys a common stony basement, but the latter is a group of peaks separated from each other by a flat plain. The karst Hydrogeological Experimental Site established in the 1980s by a Sino-French cooperative project is continuously used by the IGCP projects. It is situated near the village of Yaji at the east of Guilin. Automatic data log was demonstrated, and the results of 16 years of monitoring the water cycle and carbon cycle at the site were noted. A relationship between the ecosystem and hydrochemistry and the microclimate was found. Since the early 1990s, the catchment area of the site has been closed for vegetation recovery. It has thus evolved positively from rocky desert to secondary grass-bush vegetation, with Vitéx negundo, Loropetalum chinensis, Phyllostachys sulphurea, and Rosa cynosa as predominant species. The monitoring data reveals that following the recovery of vegetation the $P_{CO2}$ in soil atmosphere and the Ca$^{2+}$, HCO$_3^-$ content in karst water have all increased remarkably. Moreover, the data log revealed that the conductivity in the borehole water has increased, and the pH value reduced during a storm. These phenomena are considered to result in the pushing of CO$_2$ into the borehole by storm water. Meanwhile, the microclimate in the site is worse still than in the nearby karst forest on the boundary between Guangxi and Guizhou. For example, the annual variation of temperature and humidity on the site is 33°C and 80% respectively, but in the karst forest, it is only 18.3°C and 35%. Moreover, the temperature on the surface of bare limestone in the summer can be as high as 58°C, a condition that is very unfavourable to the rehabilitation of karst rock desert.

**Geology and the Karst Ecosystem**

A lot of plant species that grow on carbonate rocks are identified as calciphile. Some of them are beneficial, such as Zenia insignis chun. Lonicer hypoglauca Muq, Camellia Kuding, Nervilia fordii (Hance) Schltr, Eucommia Ulmoides. Others are found to be harmful, such as Pteridium, Kadzu vine, Euratorium adenophorum. Zhang Weiji discussed the formation type of red soils in the Yunnan Province of China and its relation to ecology, especially to agriculture, forestry, water conservancy and environmental protection. Dora Angelova reported the ecological consequences of palaeoearthquakes in the karst terrains along the Northern Bulgaria Black Sea Coast: rearrangement of karst water basins; cave deformation or collapse; oil, gas and salt intrusions. Vyda Elena Gasuniene analysed the impact of palaeokarst and its reactivation on ecosystems in Akmene and Karpenai of Northern Lithuania: ground-water quality; geohazards; and quarrying. Hiroyasu Furukawa and others found the high permeability of Quaternary coral reef limestone at Ryukyu Island. Japan brings about severe water shortage due to rapid leakage, although the annual mean precipitation is as high as 2,300 mm. Based on the research in Nongla, Guangxi, a subtropical peak-cluster depression mountainous village, Jiang Zhongcheng discussed the relationship between element migration (K, Na, Ca, Mg, Si, Al, Fe, Mn) in rock, soil, water and karst ecosystem, especially the development of precious medicinal herbs.

**Subterranean Karst Ecosystem**

Silviu Constantin reported with a video tape the biospeleologic findings by Christian Lascu and Serban Sarbu at the Movile Cave, on the southeast coast of Romania. The cave is developed in limestone of the Upper Miocene, with a passage situated a little lower than modern sea level. Through diving in a siphon, a totally closed chamber, 24 m$^3$ in volume, was found where 1,000 cave animals from 33 species including centipedes and spiders are living in. The closed condition of the cavity with a temperature between 25° and 30°C and its high concentration in methane (1%v/v) and H$_2$S brings about the idea that the cave fauna is entirely dependent on chemohautotrophic microorganisms. Li Wei and Yu Longjiang studied the subsoil bacteria in four different karst ecosystems of South-West China. The bacteria that produce Carbonic Anhydrase (CA) which can accelerate dissolution of CO$_2$ in water and thus enhance karst processes were screened out. It was found that the activity of CA in subsoil bacteria is related to vegetation. Perrin and others reported results of investigating faecal bacteria in a karst aquifer of the Milandre Test Site, Swiss Jura. Tian Youping identified 188 species of aerial blue algae on the surface of carbonate rocks in the Stone Forest Resort, Yunnan, China, and discussed their actions on the formation of micro karst features. Based on a study at Barkly Karst, Northern Australia, Russell Drysdale reported his findings on the role of some aquatic insect larvae (Orders of Diptera, Lepidoptera, Trichoptera) in travertine building. The
results of subterranean ecosystem research on the Guizhou Plateau were demonstrated with an example at the Zhengjiadadong cave, 1315 m asl. Six classes, 11 orders and 20 families of cave animals were identified from that cave. The tendency of each Family's preference to stay in the entrance belt, twilight belt, or dark belt of the cave is studied on the basis of statistics. The availability of beetles, birds and Noctuidae, Orthomorpha sp. is compared between the caves in Guizhou and other parts of the world.

**Effects of human activities on karst ecosystems**

Tan Boon-Kong provided an overview of karst engineering geology in Malaysia, with special discussions on rockfall, sinkhole and karst foundation problems. V. V. Tolmachev reported on the karst hazards on sulphate-carbonate rocks in the European part of Russia, and suggested protective measures for civil and industrial buildings. Milena Samalikova discussed the karst formation at Moravia in the eastern part of the Czech Republic, and relevant problems such as rockfall, sinkhole foundation, quarrying, and ecological aspects of civil engineering works. Shane Fryer talked about the vulnerability of karst terrain to contamination with a dramatic incident of 3800 gallons diesel oil leakage which happened recently in the Mammoth Cave region, United States. De Beer Johannes discussed the ground deformation problems in the karst of South Africa, especially those related to gold mining.

The reciprocal changing of biodiversity in the Stone Forest area, Yunnan, China, in the past half century provides a good example of relation between human activity and biodiversity. It was noticed that in the central part of the Big Stone Forest, the evergreen broadleaf endemic flora with a nice view represented by *Physaloides*, *Pistacia Chinensis*, *Nicondra Physaloides*, and others is surrounded by a uni-species artificial forest of *Pinus yunnanensis*, and *Pinus armandii* widespread outside the Big Stone Forest region. The explanation of such phenomena was given from a historical point of view. Early last century, deforestation happened here following intensive timbering and mining activities. Since the 1950s, the planting of selective fast growing and economically beneficial species such as *Eucalyptus* and pine trees has brought about quick afforestation, on the one hand, but a reduction of the biodiversity, on the other hand. Later, the disadvantages of uni-species forests, such as frequent large scale Pine moth hazards happened. In the late 1980s, it was decided to protect the biodiversity in the central part of the Stone Forest Scenic Resort. Some planted species were cut. Under the favourable climatic conditions, biodiversity is improving in the central part but a uni-species forest still remains in the surrounding areas.

The Lionne Karst Spring at Swiss Jura is a test site of COST (European Commission: Cooperation of Science and Technology), Action 620, for Karst Hydrogeology and Vulnerability Study. Its catchment area is situated 1300-1500 m asl on the southern side of Joux Lake, and underlain by Jurassic limestone outcropped at series of North-East anticlines and synclines (from north to south: Chaumilles anticline, Grand Essert syncline, and Bucley anticline). It covers an area of about 30 km². The Jurassic limestone is gently dipped and favourable for karstification and infiltration, but becomes steep near the Lionne Spring, where the argillaceous bed of Cretaceous blocks the hydrological system and makes the spring flow out. The discharge of the spring ranges between 100 l/s and 8500 l/s. A series of research works on this typical karst system has been carried out by the Centre d’hydrogéologie de Neuchâtel, including hydrogeological survey, caving, tracing, infiltration test, hydrological, hydrochemical, bacteriological, and meteorological monitoring.

**Meetings**

1. Joint Meeting of the ‘First International Conference on Sustainable Development in Karst Region’ and IGCP 448, Beijing, China, 30-31 August 2001. (73 participants from 18 countries took part.)

2. IGCP 448 meeting in conjunction with the 7th Conference on Limestone Hydrology and Fissured Media, Besançon, France, 20-23 September 2001. (187 people from 17 countries participated.)

**Most important publications**


Activities planned

Meetings


No. 449 – Global Correlation of Late Cenozoic Fluvial Deposits (2000-2004)

D. Bridgland, Department of Geography, University of Durham, South Road, Durham DH1 3LE, United Kingdom, e-mail: D.R.Bridgland@durham.ac.uk

Description: The sedimentary deposits left by rivers represent considerable databanks of palaeoclimatic and palaeoenvironmental information concerning responses in the land domain to changes in the atmospheric, oceanic and ice-sheet domain. In recent decades, substantial progress has been made in the description and interpretation of Late Cenozoic, and especially Quaternary fluvial systems and their evolution. This project is timely in the light of these recent advances. The major aim of this research is to compile and disseminate a data collection of long fluvialite sequences. As stated, those sequences are of significant importance in that they can potentially provide frameworks for Cenozoic sequences on land. First of all, a methodology and a strategy for the study will be agreed, and fluvial sequences will be recorded. A database of well-dated Late Cenozoic fluvial sequences from all parts of the world will then be compiled. The best of these as regional fluvial strato-types will be designated with which less well-dated sequences, partial sequences and sequences from other environment can be compared. The fluvial sequences are correlated with the global marine record, by whatever means possible and with emphasis on a multi-proxy approach. This project requires a multidisciplinary approach and calls for a team of specialists dealing with a wide range of techniques such as lithostratigraphy, biostratigraphy, palaeobotany, geochronology and archaeology.

Website addresses
Main project website: http://www.qra.org.uk/FLAG/IGCP449.htm

2001 IGCP 449 international meeting: http://www.iitk.ac.in/infocell/announce/zenozoic/circular.html

2002 IGCP 449-sponsored regional meeting in Canada: http://www.usask.ca/geology/sask2002

NW Europe Palaeodrainage maps: http://www-qpg.geog.cam.ac.uk/Phil%27s%20web%20page/NWEuroRivers/NW euroindex.html

Countries involved in the project (* denotes activity in 2001)


The project started in 2000 with 104 identified participants from 33 countries. The number of countries represented has grown to 43.
Achievements of the project in 2001

General Scientific achievements

Reports from various regional and thematic groups within IGCP 448 show that project activity in and around the Phase 1 area of NW Europe has been extended satisfactorily into phase 2 areas and beyond. Active contributors have been identified in most countries of Eastern Europe and in Russia, as well as in the Middle East, North Africa, India and envisaged late-stage countries such as Uruguay.

The following reports were received from coordinators:

**Regional Reports:**
(i) IGCP 449 2001 Activity in the UK (Simon Lewis)
(ii) IGCP 449 2001 Activity in France (Pierre Antoine, Nicole Limondin-Lozouet and Jean-Francois Pastre)
(iii) IGCP 449 2001 Activity in the Czech Republic (Jaroslav Tyracek, Pavel Havlicek and Dan Nyvlt)
(iv) IGCP 449 Activity in Turkey (Tuncer Demir, Sema Yurtmen and Rob Westaway)
(v) IGCP 449 Activity in Lithuania (Algirdas Gaigalas)
(vi) IGCP 449 2001 Activity in Canada (Serge Ochietti)
(vii) IGCP 449 2001 Activity in India (Sampat Tandon)
(viii) IGCP 449 2001 Activity in Belgium (Frans Gullentops)
(ix) IGCP 449 2001 Activity in Uruguay (Martin Ubilla).

**Thematic Reports:**
(i) Report of the Subgroup on Archaeology from fluvial sequences (Mark White, Peter Beaumont and Sheila Mishra)

Database formats and protocols were discussed at the Prague meeting, particularly during Workshop 1, which was devoted to this topic. It is planned to finalize the Phase 1 database entry in time for the September 2002 regional meeting of IGCP 449 in Clermont-Ferrand, France.

A special issue of *Proceedings of the Geologists’ Association* will be produced as a proceedings volume for the Inaugural Meeting of IGCP 449. It will be edited by David Bridgland and Sampat Tandon. It is anticipated that contributions will cover the following countries (according to topic, not nationality of author): Czech Republic, Germany, Morocco, Russia, Turkey, United Kingdom, Ukraine, Uruguay, United States.

Meetings

1st International meeting, Prague, Czech Republic 21-24 April 2001.

Attended by 44 participants, representing 18 countries, this meeting was a great success (see report published in *Quaternary Newsletter*, October 2001). As well as lectures, posters and a field excursion to the Vlatava River, there were two project business meetings and a workshop on the project database. At Business Meeting 1, the project was introduced and there was discussion of methodology and strategy for the study and recording of fluvial sequences. Topics on the agenda were:

- Identification and designation of the regional fluvial stratotypes
- Approaches to Correlation
- Geochronology
- Biostratigraphy
- Archaeology.

At Business Meeting 2 the outcomes of the Inaugural Meeting were summarized and targets and strategies were established for delivery of project goals, with names of potential providers identified where possible. There was also a debriefing on the database workshop. The agenda included:

- Establish data requirements (summary of workshop questionnaires)
- Identity of data providers (names of contributors)
- Data production deadlines (important submission dates)
- Annual Report requirements and deadlines (immediate requirements)
- Targets for Year II/III.

In addition to the above, there was also IGCP 449 participation at the following meetings:

- “The Alluvial Archaeology of North-West Europe and the Mediterranean”, Leeds, UK, 18-19 December 2000. David Bridgland presented a poster at this meeting promoting IGCP 449. Flyers on the project were included in the conference pack.

- “The 7th International Conference on Fluvial Sedimentology”, (6-10 August) Nebraska (United States). This included sessions sponsored by FLAG (Fluvial Archive Group) included IGCP 449 contributions. These sessions were “Fluvial system response to climate change through time” and “Alluvial and tectonic system interactions”.

- “The 5th International Conference on Geomorphology” (International Association of Geomorphologists), Tokyo, 23-28 August 2001. Session S6 at this conference was organized by the IAG and GLOCOPH Working Group on Large Rivers. IGCP 449 was represented by several participants.
INQUA Subcommission of European Quaternary Stratigraphy (SEQS) annual meeting, Kiev, Ukraine, 11-20 September 2001. Several IGCP 449 participants were involved in the meeting, which included lectures, posters and a field excursion. Fluvial sequences and loessic overburden were important themes, particularly involving the record from the River Dnieper. Project co-leader David Bridgland attended and was invited to outline the activities and objectives of IGCP 449, as a result of which a number of new recruits were identified.

**List of most important publications (2000-1)**


Activities planned

General Goals

To build on work carried out during 2000 and presented in Prague (and to be presented in India). To see work initiated in more regions and countries, following exemplars presented at Prague and India and disseminated via publications (including special volumes) and via the website.

To consolidate the work on the Phase 1 area of NW Europe and to establish the IGCP 449 database by placing the Phase 1 data therein.

Details

It is hoped that the coming year will see publication of FLAG/IGCP 449 special issue of Geologie en Mijnbouw/Netherlands Journal of Geosciences. This arises from the FLAG meeting in Mainz, Germany, 20–23 March 2000. It will contain papers that are contributions to IGCP 449, including a brief review of the baseline position at the outset of the project.

Meetings

2nd International meeting of IGCP 449 in Kanpur, India. This meeting will consist of two days indoors, with lectures and posters, and one day’s field excursion to the Gangetic plain. Interspersed with the scientific presentations will be two business meetings and a workshop on dating fluvial deposits. Amongst the presentations, a significant contribution has been put together by the Indian community, an important aim of the meeting being to extend and promote the project in southern Asia. In addition there will be presentations on fluvial sequences in Australia, Eastern Europe, Turkey, the coastal Black Sea, Syria and the Amazon basin. It is anticipated that publication of the proceedings of this meeting will constitute a significant contribution towards the Indian component of IGCP 449.

The 3rd International meeting of IGCP 449 will take place, in July/August 2002, in Beijing, China.

Regional Meeting of IGCP 449 (NW Europe); within Fluvial Archives Group biennial meeting, Clermont-Ferrand, France, 9-14 September, 2002. There will be a day devoted to IGCP 449, plus other IGCP 449 – related material in the 3-day field excursion.

Quaternary Research Association field meeting, Thüringen and surroundings, Germany. There will be a significant IGCP 449 component to this meeting and the planned field guide will represent a publication that contributes to the project.

Global Correlation of Late Cenozoic Fluvial Deposits: present processes and past environments. This will constitute an IGCP 449 regional meeting in Canada.

It is intended that an IGCP 449 session will be organized at the 2003 INQUA symposium in Reno, Nevada, United States.

No. 450 – Proterozoic Sediment-hosted Base Metal Deposits of Western Gondwana (2000-2004)

S. S. Iyer, Department of Physics and Astronomy, University of Calgary, Calgary T2N 1N4, Canada, e-mail: iyer@ucalgary.ca
A. Misi, Centro de Pesquisa em Geofísica e Geologia, Universidade Federal da Bahia, Rua Caetano Moura, 123 (Inst. de Geociencias), 40210-340 Salvador, Bahia, Brasil, e-mail: misi@ufba.br

A. F. Kamona, Geology Department, University of Namibia, Private Bag 13301, Windhoek, Namibia, e-mail: afkamona@unam.na

J. Cailteux, Département Recherche et Développement, c/o GFI-EGMF, Entreprise Générale Malta Forrest (EGMF), Parc Industriel, 22, av. Kigoma, Lubumbashi, Democratic Republic of Congo, e-mail: jyc.egmf@forrestgroup.com

Description: The project aims to correlate the mineral deposits through large areas of South America and South Africa. Recent studies on the Proterozoic base metal deposits on either side of the Atlantic indicate many common sedimentological, structural, geochemical and isotopic characteristics, probably arising from a common geological evolution. The study will begin by preparing a database of sediment-hosted base metal deposits in Western Gondwana. The data acquired will raise the awareness of the mineral potentials of Gondwana sequences on both sides of the Atlantic and subsequently contribute to the development of genetic models for Proterozoic sediment-hosted base metal deposits of South America and Africa. The preparation of a mineral deposit map of sediment-hosted base metal deposits of Western Gondwana is planned. Specific aspects of the study are the structural and stratigraphical control of the mineralization, the timing of the mineralisation and age of host rocks, the sources of metal and sulphur and the temperatures of deposition, the palaeo-geothermal gradient during the emplacement of the deposits, the nature of the ore-forming fluids and the radiogenic and stable isotopic signature. Therefore, this project involves the application of many scientific disciplines and knowledgeable researchers.

Website of the project
A web page with relevant information on IGCP 450 has been launched with the help of the Information Technology Department of the University of Calgary, Canada. http://www.ucalgary.ca/~iyer/igcp450/unesco/catalog.htm

Participating countries (all active)
Argentina, Australia, Botswana, Brazil, Canada, Congo (DR), Germany, Namibia, South Africa, Uruguay, United States, Zambia.

Achievements of the project in 2001

General scientific achievements

1. Update the geochemical, isotopic and fluid inclusion database of the Proterozoic sediment-hosted base metal deposits on either side of Atlantic and attempt regional correlation of the deposits and their host rocks.

2. Develop metallogenic models of Neoproterozoic sediment-hosted Cu-Pb-Zn deposits of Western Gondwana.

3. Draft preliminary metallogenic maps.

4. Refine the Craton-specific Pb-isotope evolution model for São Francisco Craton and model similar curves for other cratons of Western Gondwana.

5. Organize post-graduate student seminars in the universities involved in the project.

6. Publication of the Special volume of Ore Geology Reviews on sediment-hosted base metal deposits.

The stated objective of IGCP 450 is “inter and intra continental correlation of the geological, geochemical, isotopic, geochronological and mineralizing fluid characteristics of the deposits”. In conformity with this objective the project collaborators discuss inter and intra continental (more specifically cratonic) correlation. The First Field Workshop in Brazil provided a suitable platform to discuss the initial results on intercontinental stratigraphic and metallogenic comparison between South America and Africa. Main results are presented below:

(a) The Neoproterozoic groups of Bambui (Brazil), Otavi (Namibia) and Nguba (Congo D.R.) could be equivalent taking into account:

- The occurrence of glaciogenic diamictites (e.g. the Chuos in Namibia and the “Grand Conglomérat” in the D.R. Congo) at or near the base of these Neoproterozoic successions, provides a useful correlation tool of intra and intercontinental formations. These diamictites represent the oldest Neoproterozoic glaciation (746 ± 6 Ma) in Gondwana and their ages still need to be better constrained. A second glacial deposit, the Ghaub, is recognized at the base of the Tsumeb Subgroup in Namibia.

- Strong sedimentological similarities between the various platform carbonates of Sete Lagoas (Brazil), Tsumeb (Namibia), and Kakontwe (Congo D.R.) on the one hand, and the overlying transgressive pelitic formations of Santa Helena (Brazil), the Mulden Group (Namibia) and the Ki.13 (Congo D.R.) on the other hand.

- Based on detailed studies of lithostratigraphy, sedimentology, palaeontology and carbon isotopes the Arroyo del Soldado Group of Uruguay is correlated with the Corumba Group of Brazil and possibly with the Nama Group of Namibia.

(b) Major Pb-Zn (Cu) deposits are apparently hosted in similar, possibly stratigraphically equivalent carbonate platform formations, including:

- The Morro Agudo and Vazante deposits in the Vazante Group in Brazil, which is supposed to be the stratigraphic equivalent of the Bambui Group.
– The Tsumeb and Kombat deposits in Namibia at the
top of the Tsumeb Subgroup.
– The Kipushi, Lonbe, Kengere deposits in the
Kakontwe formation of the D.R.Congo.
– The M’Passa deposit in the Schisto-calcaire Group
of the West Congolian fold belt.

(c) Most of these deposits contain germanium sulphides
(germanite, briarite and renierite) and are frequently
associated with Ga, Cd, Ag and In. The significance
of these associated metals in relation to possible
source rocks is being investigated.

(d) The stratiform/stratabound Cu – (Co) deposits or
occurrences of the Congo-Zambia Copperbelt and of
the Ghanzi (Botswana) and Klein Aub (Namibia) formaciones occur in siliciclastic, shaly to carbonate
and pelito-arkosic intercontinental successions stratigraphically below the "Grand Conglomérate" and
Chuos glacigenic diamictites. As a consequence,
these Cu-(Co) deposits cannot be correlated to the
Pb-Zn carbonate-hosted type deposits of Brazil.

Two interesting hypotheses were presented in the work-
shop and are worth elaborating.

1. Evidence of Palaeoproterozoic collage and dispersal
of some Western Gondwana components, with impli-
cations for the Neoproterozoic metallogenesis
The former perception that many differences exist
between Archean and Palaeoproterozoic basement
terranes of Africa and South America across the Atlantic
gap gave rise to a long lasting puzzle with respect to
the pre-Gondwana cratonic fragments. A new concept
concerning the formation and break up of part of
Atlantica, the first identifiable supercontinent in
Precambrian times has been put forward. The proposed
assemblage includes the São Francisco, West Africa,
Venturi-Tapajós, Central Amazonian and Borborema
provinces, which record the various steps of a fully
developed Wilson Cycle during the Palaeoproterozoic.
This concept may provide a reasonable explanation for
the non-existence of the so called ‘São Francisco-Congo
Bridge’. A newly redesigned configuration of parts of
Gondwana, especially the western part, particularly the
suggested location of the São Francisco Craton, also
reconciles the failed attempts in comparing the
Neoproterozoic base metal distribution of South America
and Western Africa.

2. The Relationship of Neoproterozoic Climate Change
and Ore Genesis
Accurate Trans-Atlantic correlation of Neoproterozoic
strata using detailed litho-, bio- and chemo-stratigraphic
comparison of sedimentary successions in South
America and southern Africa suggests:
– Rifting of the supercontinent around 750 Ma ago
created wide passive margins whose thermal subsi-
dence allowed rapid accumulation and preservation
of shallow marine carbonate sediments worldwide.

– Stratigraphic suites of carbonates from these succes-
sions – in particular those from the Otavi, Witvlei
and Nama groups of the Congo and Kalahari cratons
in southern Africa (and their regional equivalents),
and the Macaubas, Bambui, and La Tinta groups in
central South America (with their regional equivalents)
are significantly enriched in $^{13}C$, punctuated in
as many as four or more extreme negative excurs-
sions mostly in carbonates immediately above glacial
diamictites.

Based on the above observations, a new model is
proposed suggesting a strong genetic linkage between
severe climatic and environmental perturbations and
subsequent emplacement of Cu-Pb-Zn deposits in
carbonates that overly glacial strata or hiatus.

INTRA CONTINENTAL CORRELATION
AND REGIONAL STUDIES

In this section the discussion is devoted to the studies
relating to the intra-continental correlation of the
Proterozoic sediment hosted base metal deposits of
Western Gondwana.

1. South America
(a) Neoproterozoic basins of the São Francisco Craton
A significant result with important implication is the
tectono-sedimentary evolution model of sedimentary
basins from Late Palaeoproterozoic to Late Neo-
proterozoic in the Sao Francisco Craton and Aracuai fold
belt, eastern Brazil. According to this model tectonic,
magmatic, climatic and eustatic processes all combined
to control basin evolution. The Bambui megasequence
(ca. 800-650 Ma) was deposited in a foreland basin
during convergent and collisional tectonics related to
closure of the Brazilide Ocean and generation of the
Brasilia fold belt west of the Sao Francisco palaeo-
continental region. The evolution of the Bambui Basin,
whose fill is characterized by three transgressive-
progradational, shallowing-upward sequences, was
mainly controlled by tectonic processes.

Integrated investigations involving stratigraphic,
geochemical, stable (C, O, S) and radiogenic (Sr, Pb)
isotopic, fluid inclusion and geophysical methods
(Bouguer anomaly, radiogenic heat production and heat
flow) on the Pb-Zn deposits of Morro Agudo, Vazante
and other occurrences such as Januária-Itacarambi,
Montalvânia, Serra de Ramalho, Nova Redenção, Irecé,
Morro Gomes and Melancias reveal:
– The preliminary metallogenic working model suggests
that the Neoproterozoic sediment hosted Pb-Zn
deposits of the São Francisco Craton are formed
during extensional events, when the steep palaeo geot-
thermal gradient generated by the high heat producing
basement rocks helped the circulation of hot miner-
alizing fluids along the major fault zones. These solu-
tions extracted metals from the basement rocks and
sulphur from the Neoproterozoic marine. sulphates.
– The common characteristic of the enriched Pb isotopic composition of the sulphides of nearly all deposits attests to the derivation of metals from the highly radioactive basement rocks of the São Francisco Craton. Hence Craton specific Pb isotope evolution curves were developed for the upper crust of the São Francisco Craton, using whole rock Pb isotope data of geological formations spanning a time period from the Archean to Neoproterozoic. Such curves plot well above the curves found in the literature and conform with the radioactively enriched crust of the São Francisco Craton, where even the granulites are enriched in U, Th and K.

– Model simulation of the palaeothermal gradient using the nature of the relationship between heat flow and the depth of circulation of fluids during metallogenic episodes reveal high palaeo-heat flow due to stretching accompanied by intracrustal magma underplating.

– Data on trace and minor elements in sulfides and other minerals (e.g. willemite, chlorite) from the Zn-Pb carbonate-hosted deposits of Vazante, Ambrósia and Fagundes (Minas Gerais, Brazil) reveal contrasting hydrothermal ore-forming processes. The inferred fluid regimes are (a) Vazante: mixing of meteoric and metasomatized fluid with low reduced sulphur content channelled into shear zones favouring $f_{O_2}/f_{S_2}$ values required for experimentally predicted willemite assemblage stability conditions (b) Ambrósia: different mineralizing fluid evolutionary stages related to temperature and $f_{S_2}$ conditions (c) Fagundes: affinity with oxidized brines derived from a carbonate – evaporite – shale dominated basin.

(b) The Sul – Riograndense Shield, Southern Brazil

Integrated investigations using stratigraphic, geochemical (microprobe), stable (S) and radiogenic (U-Pb zircon, Pb – Pb in galenas) isotopic and fluid inclusion and geophysical methods on the Camaquã Cu (Au, Ag) and Santa Maria Pb-Zn (Cu, Ag) deposits of the Precambrian Sul-Riograndense Shield, Southeastern Brazil reveal:

– The mineralization (ca. 594 Ma) is fracture-controlled and distal magmatic-hydrothermal (210 to 300°C) in origin rather than stratiform syngenetic or diagenetic. The evidence for the magmatic hydrothermal origin comes from (i) sulphur isotope data of sulphides (-2.6 to +1.1‰) and (ii) concordant SHRIMP U-Pb zircon ages (550 to 590 Ma) of Lavras, Caçapava São Sepé granitic plutons with Pb-Pb model ages of sulphides and minimum depositional ages inferred from the K-Ar ages of illites associated with the ores.

– The structural control of mineralization, the occurrence of superimposed mineralizing events, the temperature of deposition of the early-formed ore minerals (330°C to 190°C), and the sulphur isotope ratios, indicate a likely hydrothermal-epithermal origin for the Camaquã Cu deposits, more specifically low sulphur/high copper epithermal deposits.

(c) Other regions

New studies show that there are other regions, such as the Araçuai Belt in the São Francisco Craton and the Corumba Group (Mato Grosso State, Brazil) and Arroio del Soldado and Lavelleja Groups of Uruguay where detailed investigations are warranted. As mentioned earlier studies of lithostratigraphy, sedimentology, palaeontology and carbon isotopes indicate that the Arroio del Soldado Group of Uruguay is correlated with the Corumba Group of Brazil and possibly with the Nama Group of Namibia. The Arroio del Soldado Group contains thick (300–500 m) deposits of oxide facies BIF (35% magnetite/hematite) and is associated with magnetite siltstones and black shales. Studies support a strong stratification and eutrofication of the basin favouring the accumulation of base metals.

2. Africa

The studies carried out in the central African Copperbelt and the Damaran orogen involve stratigraphical, sedimentological, petrological, geochemical and geophysical methods. The main findings are:

– The geochemistry of the footwall and hanging wall rocks and the Cu-Co-Ni ore bodies within the Roan Supergroup allows further constraint on the primary source of metals. It has been shown that the primary source of metals are Palaeoproterozoic and Archaean low-grade/high tonnage deposits in the Palaeo-proterozoic Bangweulu block and related terrains and from the Zimbabwe Archaean craton.

– Petrological and radiogenic investigations on uraninite and associated minerals, which are also present in copper and cobalt ore bodies, demonstrated that their primary deposition occurred during the earliest stages of the Cu-Co-Ni mineralizing process.

– A critical review of old and recent sedimentological, petrological, geochemical, isotopic and fluid inclusion data has led to a step by step unraveling of the complex synengetic-diagenetic process which resulted in the formation of the Congo-Zambia Cu-Co stratiform ore bodies and the remobilizing events that occurred during the later Lufilian orogeny.

– Interpretative studies on recent geophysical data showing the gravity signature for the Neoproterozoic Katangan Belt suggest the subduction of a northern plate (Congo) beneath a southern plate (Zimbabwe) and then a nascent continental collision. The model is being developed and could lead to a better understanding of the distribution of deposits within the Lufilian orogen.

– Regional stratigraphic studies in Namibia have led to the redefinition of the two glacial deposits found within the Otavi Group, a lower Chuos formation in the Abenab Subgroup and an upper Ghaub formation in the Tsumeb Subgroup. Both glacial deposits are overlain by cap carbonates, which are potential exploration targets for Tsumeb-type base metal deposits.

– Local geochemical studies in the Tsongoari area of northern Namibia on SEDEX type barite occurrences
with associated base metals are revealing pathfinder elements useful in mineral exploration for such deposits.

- Ore sampling of selected deposits (Tsumeb, Kombat, Kuiseb Springs, Otjihase and the Matchless Mine from the Damaran orogen) initiated in 2001 is designed to establish the age of mineralization based on Re-Os and palaeomagnetic dating techniques.

IGCP 450 DATABASE OF SEDIMENT-HOSTED BASE METAL DEPOSITS

A map and a CD of the main ore deposits of the African continent have been produced by the Council for Geosciences (South Africa) as part of the World Map of Ore Deposits. The data in that document will be reprocessed and updated by the members of the IGCP 450 and merged with the data related to South America currently in the compilation stage.

The work under progress consists of erecting a tabular register totally related to and centered on individual deposits and built by adding all geological, structural, petrographic, geochemical, geophysical, geochronological, isotopic and economic attributes along with the relevant references. The software “IGCP450 – Sediment-hosted base metal deposits v. 1.0” is under development and has the main objectives of compiling, processing and recovering data for the information management of base metal deposits of Western Gondwana. The software, designed by Nelson Custódio da Silveira Filho (CPRM – Brazilian Geological Survey) and Teobaldo Oliveira Junior (Departamento Nacional da Produção Mineral – Bahia), uses BA-Visual Basic for Application, with a jet engine of MS Access 97 structure. The fully developed and tested software will be made available in CD-ROM and could be installed in the graphic environments of Windows 95, Windows 98, Windows NT 4.0 and Windows 2000/XP.

Available data (CD-ROM, geological maps) from the Geological Survey of Brazil (PRM) in collaboration with State Geological agencies for the different regions of Brazil will be utilized by the IGCP 450 researchers and relevant information will be incorporated into the IGCP 450 databank. A CD-ROM on the mineral province of the Bambui has been recently released as a part of “The São Francisco Project” (www.saofrancisco.gov.br and http://www.comig.com.br/ingles/menu/index.htm).

The São Francisco Project research plans to carry out geological studies at 1:100,000 and 1:250,000 scales, and the listing of the mineral and water resources in an area of approximately 220,000 km² in the central-western region of the State of Minas Gerais, corresponding to 38% of the surface area of the State. It extends from the western border of the Serra do Espinhaço to the Triângulo Mineiro region and the borders of the State of Goiás. Major base metal deposits studied under IGCP 450 lie within this region of study.

ORE GEOLOGY REVIEWS AND GONDWANA RESEARCH SPECIAL ISSUES

The first planned special issue of IGCP 450 will be published in the journal “Ore Geology Reviews” with full length papers from the General Symposium 11-1 “Pre-Atlantic Metallogeny of West Africa and Eastern South America” and other papers related to IGCP 450. This issue is taking shape under the guest editorship of Sundaram Iyer, Hartmut Beurlen, A. F. Kamona and A. B. Kampunzu. Ten manuscripts covering different aspects (geology, structure, geochemistry and isotopic study) of the deposits of Western Gondwana were received and reviewed. This special OGR issue will be published by Elsevier in 2002. A second special issue of the project will be published in Gondwana Research based on the outcome of the First Field Workshop held in Brazil in 2001. Gondwana Research has been selected for publication as the journal is devoted to studies on Gondwana.

Meetings

The theme of IGCP 450 was discussed in some of the national and international scientific meetings such as 2001 the Annual Geological Society of America convention in Boston, MA, XI Simpósio de Geologia de Minas Gerais (27-29 September 2001) and the Latin American Geological Congress. Two exclusive scientific meetings of the project in the year 2001 were organized to discuss the scientific results of IGCP 450. They are:

FIRST FIELD WORKSHOP OF IGCP 450. The workshop was held during the XI SIMPÓSIO DE GEOLOGIA DE MINAS GERAIS at Belo Horizonte, Brazil, 27 September–3 October 2001. The field workshop consisted of scientific sessions (oral and poster presentations) at Belo Horizonte and Paracatu and field trips to Sete Lagoas, Vazante and Morro Agudo. However, it should be reported that the tragic incidents of September 11 cast its dark shadow over the meeting. Many of the African delegates cancelled or were forced to cancel their trip at the last moment despite the generous financial assistance offered by the Brazilian Federal Scientific agency CNPq. Yet the delegates from Africa contributed much in the way of discussion. A brochure and a CD-ROM containing the abstracts and other details were prepared and distributed. One of the sponsors Companhia Mineira de Metais (CMM) produced an exclusive two-part video on the proceedings at Paracatu.

PROJECT SEMINAR OF IGCP 450 (SEMINÁRIO DO PROJETO) (http://www.geocities.com/shg_bahia/Semin_igcp450.pdf) The project seminar Zn-Pb deposits of the Proterozoic basin of the São Francisco Craton (Depósitos de Zn-Pb das bacias Proterozóicas do Cratô do São Francisco) (FINEP/PADCT III) took place on 11–12 December
2001 at the Instituto de Geociências, Federal University of Bahia, Brazil. The participants of the symposium were the Brazilian members of IGCP 450 to present papers on geological, structural, sedimentological, isotopic and geophysical aspects of the Neoproterozoic base metal deposits and their host rocks were presented. The estimated number of participants is fifty.

**List of most important publications**

- Gaucher, C. 2000. Sedimentology, palaeontology and stratigraphic models of the Arroyo del Soldado Group (Vendian to Cambrian, Uruguay). Beringeria, 26, pp. 120.

**Activities planned**

**General goals**

1. A data base of mineral deposits;
2. Metallogenic maps and development of new genetic models for the mineral deposits;
3. Field workshops (including field trips during the 2002 IAGOD Symposium in Namibia);
4. Post graduate research (incorporating students from various universities in developing countries);
5. Long distance internet courses.

Scientific activities envisaged are:

- Update the stratigraphic, sedimentologic, geochemical, isotopic, ore reserve and fluid inclusion database of the Proterozoic sediment hosted base metal deposits in various tectonic settings in South America and Africa (including the São Francisco Craton, the Sul-Rio-Grandense Shield, the Luflilian-Damaran fold belt, and the West Congolian fold belt);
- Modelling of the palaeogeothermal regime of the Proterozoic mineral deposits and cratons of Western Gondwana;
- Investigate the relationship of Neoproterozoic Climate Change and Ore Genesis;
- Preparation of a regional exploration database of Proterozoic base metal deposits of Western Gondwana by Geographic Information System (GIS) predictive probabilistic methods;
- Investigate the role of organic matter in the genesis of the ore shale of the Zambian Copperbelt;
- Refine Craton specific Pb isotope evolution curves for the São Francisco Craton and other related cratons of Western Godwana;
- Conduct lithostratigraphic, petrological, geochemical and isotopic studies on the Arroya del Soldado Group and the Lavalleja Group of Uruguay and correlate with Corumba (Brazil) and Nama (Namibia);
- Conduct lithostratigraphic, petrological, geochemical and isotopic studies on the Roan, Nguba and Kundelungu successions in Katanga (Congo D.R.) in order to better constrain the tectonic evolution of the basin and the origin of the base metal deposits occurring in the Nguba-Kundelungu sequences;
- Conduct isotopic studies on several carbonaceous markers of the Katangan succession in order to date the major sedimentological events, particularly the glaciogenic diamicrites. The results will constrain stratigraphic correlations with equivalent formations in Namibia, Brazil and Uruguay.

Meetings

The formal second field workshop of IGCP 450 will be held during the forthcoming 11th Quadrennial IAGOD Symposium and Geocongress 2002, 22-26 July, Windhoek, Namibia. A scientific session on stable isotopes is scheduled for IGCP 450 participants to discuss various aspects related to mineral deposits generated by diagenesis and metamorphism in compressional environments. A pre-conference field trip to the Zambian Copperbelt will be held from 14 to 20 July 2002. This field trip will include regional geological aspects and visits to the Kombat mine and Khusib Springs mine in the Otavi Mountainland of northern Namibia. Details of the field trips and the IAGOD Symposium can be obtained from the website: http://www.geoconference2002.com.


J. B. Murphy, Department of Geology; Saint Francis Xavier University, Antigonish Nova Scotia, Canada, B2G 2W5, e-mail: bmurphy@stfx.ca

J. D. Keppie, Instituto de Geología, Universidad Nacional Autónoma de México, 04510 Mexico D.F., Mexico, e-mail: duncan@servidor.unam.mx

Description: The goal of this project is to enhance the understanding of the causes and effects of modern and ancient mountain belts, and how these relationships have varied with time. Geoscientists studying ancient belts have developed different approaches from those used to help to understand modern belts. As a result, two different groups of scientists have evolved with little communication between them. Therefore, it is important to bring together these two groups of geoscientists with complementary expertise in order to provide a more comprehensive understanding of orogens and their evolution throughout the ages. In addition, the information and technology transfer will enhance understanding of the relationship between geological processes and resources in developing countries. It is planned to produce an ‘Atlas of ancient and modern orogens’, which will represent an important outcome of the project. This is indeed a typical example of geological correlation on a broad tectonic scale and of exploration of the Earth evolution in four dimensions. The project will provide the basis for comparing various geologic and geophysical expressions of orogenic belts, a summary of their dimensions, nature of their boundaries and a distillation of their tectonic histories.

Websites related to the project
http://www.sst.unil.ch/igcp453/index.html
http://www.anta.canterbury.ac.nz/gondwana/index.htm
file:///C:/igcp/igcp2001meeting/IGCP453.htm

The websites contain the project’s newsletter, list of publications, conferences, and photographs of the field workshops.

Countries involved in the project
(all active this year)

Argentina, Armenia, Australia, Cameroon, Canada, Chile, Denmark, England, France, Germany, Hungary, India, Iran, Ireland, Mexico, Norway, Poland, Russia, Spain, Switzerland, United States.
Summary of major past achievements of the project

The first annual meeting (October 2000) focused on the evolution of the modern flat-slab subduction in the Andes and attracted 45 participants from 10 countries. As a result of this conference, it was decided to solicit contributions for a Special Issue of the Journal of South American Earth Sciences FLAT SLAB SUBDUCTION IN THE ANDES with Victor A. Ramos and Brendan McNulty as guest editors. The papers in this volume will provide the characteristics of flat-slab subduction, which may be used as a template for the recognition of flat-slab subduction in ancient orogens. The following papers are now in hand for this volume with expected publication in 2002:

- Gutscher, M. A. Andean subduction styles and their effect on thermal structure and interplate coupling.
- Pardo, M.; D. Comte and T. Monfret. Seismotectonic and Stress Distribution in the Central Chile subduction zone.
- Yañez G.; J. Cembrano; M. Pardo; C. Ranero and D. Celles. The Challenger-Juan Fernandez-Maipo major tectonic transition of the Nazca-Andean subduction system at 33º-34ºS: Geodynamic evidence and implications.
- Kay, S. M. and C. Mpodozis. Magmatism as a probe to the Neogene Shallowing of the Nazca plate beneath the modern Chilean flat-slab.
- Giambiagi, L. B. and V. A. Ramos. Structural evolution of the Andes between 33º30' and 33º45'S, above the transition zone between the flat and normal subduction segment, Argentina and Chile.
- Charrrier, R.; O. Baiza; S. Elgueta; J. J. Flynn; P. Gans; S. M. Kay; N. Muñoz; A. R. Wyss and E. Zurita. Evidence for Cenozoic extensional basin development and tectonic inversion in the south flat-slab segment, southern Central Andes, Chile (33º-36ºSL).

Achievements of the project this year

General scientific achievements

(a) There is an increasing awareness of the role of flat-slab subduction in the development of orogens and the connection with hot-spots in modern and ancient orogens. Features of flat-slab subduction in the Andes and Rocky Mountains have now been applied to the Acadian and Avalonian orogenies in the Appalachians. Thus, the Acadian Orogeny, long regard as the result of collisional orogenesis between eastern Laurentia and Gondwana, has found a modern analogue in the Laramide Orogen of western Laurentia. In these two cases, flattening of the subduction zone is related to swells surrounding hotspots. As the continent approaches the swells, coupling between the down-going and over-riding slabs leads to deformation with the deformation front migrating inland with time. Shallowing of the subduction zone also leads to landward migration of the arc magmatism followed cessation of the arc. Passage of the hotspots beneath the continent leads to uplift and erosion, a period of magmatic quiescence followed by a short-lived, but voluminous burst of plume-related magmatism as the hotspot burns its way upwards into the lower crust. This is accompanied by low pressure-high temperature metamorphism and economic polymetallic mineralization of benefit to society. These features migrate as the continent moves relative to the hotspots. Given the multitude of modern hotspots, there is ample scope for the recognition of others in the geological record.

(b) In contrast, in the Avalonian orogeny, flattening of the slab is related to younging of the subducting oceanic lithosphere and collision of a mid-oceanic ridge. A modern analogue may be found in the western side of Laurentia, and a field conference in this region is currently being planned for 2003. Flattening of the slab led to landward migration of the arc, which terminated diachronously as oblique collision of the ridge progressed. The trench was replaced by a transform, and pull-apart basins formed inland accompanied by rift-related magmatism associated with polymetallic mineralization, a benefit to society. As a result, no terminal collision deformation occurred. This rifting led to the development of core complexes, which brought low pressure/high temperature metamorphic rocks into contact with low grade rocks. Application of this modern analogue explains several anomalies in the traditional accordion model for the Appalachian orogen of opening and closing Iapetus between eastern Laurentia and Africa. These anomalies include:

(1) recognition that the northwestern margin of Avalonia-Carolina-Cadomia was still an active margin during the latest Neoproterozoic at which time eastern Laurentian margin was developing a rift-passive margin; (2) realization that 170 million years of Neoproterozoic subduction in Avalonia-Carolina-Cadomia terminated not in collisional orogenesis but with a transition to an early Cambrian platform; (3) isotopic data indicating that Avalonia and Carolina are underlain by a ~1 Ga basement and contain ~1 Ga detritus in Neoproterozoic units, which may be linked with the ~1 Ga orogens that encircle the Amazon craton but are absent in the northwest African cratons; and (4) subsidence curves, Rodanian reconstructions, and palaeomagnetic data that led to the hypothesis that eastern Laurentia lay adjacent to western South...
American prior to the birth of Iapetus. Thus, ridge-trench collision provides a mechanism to explain some ancient orogens that have traditionally been attributed to arc-continent or continent-continent collision. Furthermore, Avalonia provides a region where the characteristics of such a mechanism are well preserved in an ancient orogen.

(c) On another scale, the consequences of amalgamation and breakup of supercontinents appears to be similar for Pangea and Rodinia. Thus, striking similarities between the late Mesoproterozoic-Early Paleozoic record of Avalonia and the Late Paleozoic-Cenozoic history of western North America suggest that the North American Cordillera provides a modern analogue for the evolution of Avalonia and other peri-Gondwanan terranes during the late Precambrian. Thus: (1) The evolution of primitive Avalonian arcs (proto-Avalonia) at 1.2-1.0 Ga coincides with the amalgamation of Rodinia, just as the evolution of primitive Cordilleran arcs in Panthalassa coincided with the Late Paleozoic amalgamation of Pangea. (2) The development of mature oceanic arcs at 750-650 Ma (Early Avalonian magmatism), their accretion to Gondwana at ca. 650 Ma, and continental margin arc development at 635-570 Ma (main Avalonian magmatism), followed the breakup of Rodinia at ca. 755 Ma in the same way that the accretion of mature Cordilleran arcs to western North America and the development of the main phase of Cordilleran arc magmatism followed the Early Mesozoic breakup of Pangea. (3) In the absence of evidence for continental collision, the diachronous termination of subduction and its transition to an intracontinental wrench regime at 590-540 Ma is interpreted to record ridge-trench collision in the same way that North America's collision with the East Pacific Rise in the Oligocene led to the diachronous initiation of a transform margin. (4) The separation of Avalonia from Gondwana in the Early Ordovician resembles that brought about in Baja California by the Pliocene propagation of the East Pacific Rise into the continental margin. (5) The Late Ordovician-Early Silurian sinistral accretion of Avalonia to eastern Laurentia emulates the Cenozoic dispersal of Cordilleran terranes and may mimic the paths of future terranes transferred to the Pacific plate. This close similarity in tectonothermal histories suggests that a geodynamic coupling like that linking the evolution of the Cordillera with the assembly and breakup of Pangea, may have existed between Avalonia and the late Precambrian supercontinent Rodinia. Hence, the North American Cordillera is considered to provide an actualistic model for the evolution of Avalonia and other peri-Gondwanan terranes, the histories of which afford a proxy record of supercontinent assembly and breakup in the Late Precambrian.

(d) In 2001, we examined collisional orogens in the following places:

**Mesozoic-Recent**: Alps-Carpathians, Verkhoyansk-Kolyma, western Laurentian Cordillera;

**Paleozoic**: southern Laurentian Ouachitas, European Variscan, Norwegian Caledonides, Mexican Acatecan;

**Neoproterozoic**: Avalonian, Cadomian;

**Mesoproterozoic**: Mexican Grenville;

**Paleoproterozoic**: Usagarian belt in Tanzania;

**Archean**: southern India.

It has become clear that most of the features (e.g. synchronous orogen-wide tectonothermal events, granulite facies metamorphism, post-collisional magmatism) associated with collisional orogens are also present in non-collisional orogens. Thus, the identification of collision as a genetic mechanism requires the recognition of the opposing cratons or microcontinents. Furthermore, it is emerging that while the concept of uniformitarianism appears applicable to the Phanerozoic and Neoproterozoic orogens, it may not work so well in the Archean-Mesoproterozoic orogens. This is very significant because the full title of IGCP 453 is: Uniformitarianism revisited: comparison of modern and ancient orogens. This topic needs to be further investigated in the future.

(e) A major result from our field conference is the Swiss Alps is the development of a comprehensive, Early Paleozoic to Cenozoic, plate tectonic model for the Alps and surrounding regions that has been compiled into a book (Stampfli, 2001, Geology of the western Swiss Alps, a guidebook, Memoires de Géologie (Lausanne) No. 36, 195p.). This shows that the Variscan orogeny resulted from the Silurian-Carboniferous closure of the Rheic Ocean and the collision of the Gothic and Hunic terranes with Laurussia. These terranes were rifted off northern Gondwana leading to the opening of PaleoTethys between the Gothic-Hunic terranes and Africa. This was followed by Permo-Triassic closure of PaleoTethys as another strip of peri-Gondwanan terranes rifted off northern Gondwana and drifted towards Laurussia opening the Neotethys Ocean between them and Africa. Subduction beneath Laurussia produced a series of backarc basins. There followed the Triassic-Cretaceous opening of the Alpine Tethys, a branch of the Central Atlantic, between the Helvetic domain and a narrow strip consisting of Dent Banche-AustroAlpine-West Carpathians. Subsequent closure of the Alpine Tethys produced the Alpine orogeny. Thus the main conclusion is that the Alps, the type example of a collisional orogen, is the result of several cycles of divergent and convergent (accordion) plate tectonics with the addition of superimposed lateral dispersal that led to repetition of tectonic elements.

(f) IGCP 453 is currently soliciting papers relating to collisional orogens from the Swiss international conference for a special volume of Tectonophysics edited by J. B. Murphy and J. D. Keppie. The end of January, 2002 is the deadline for submission.

(g) In May 2001, the Spanish working group examined various orogens in Iberia (Cadomian, Variscan, Pyrenean,
and Betic) in the context of modern analogues. This included a field trip to the Badajoz-Cordoba shar zone and it control on mineralization. Structural controls include domino-type faults, brecciation, thrusts, and saddle reefs, all of which have some societal benefits. Papers on this topic are to be published in a Special Issue of the journal Boletín Geológico y Minero in 2002.

**Meetings**

The 2001 annual conference/field workshop focused on collisional orogens, and was organized by Gerard Stampfl, University of Lausanne, Switzerland. In all, there were 61 contributors from 19 countries who presented 31 papers. The conference was held in Sion, Switzerland on 26-27 September. A preconference field trip (23-25 September) focused on the external nappes (classical Helvetic domain) of the Alps, including the Variscan basement. The postconference trip (28-30 September) featured the internal nappes (classical Penninic domain) and exotic nappes in the Pre-Alps.

The Spanish working group (29 participants, led by Cecilio Quesada, IGME) organized a conference and related field trips in Badajoz, Spain in May. Papers associated with this conference are published in a Special Issue of the journal Boletín Geológico y Minero.

**List of most important publications**

**BOOKS**

- Special Issue of Boletín Geológico y Minero, In press.

**PAPERS**

- Murphy, J. B. and Nance, R. D. 2002. Nd-Sm isotopic systematics as tectonic tracers: an example from West Avalonia, Canadian Appalachians Earth Science Reviews, in press.
- Murphy, J. B.; Keppie, J. D.; Stacey, J. S. and


Activities planned

Meetings

Next year’s conference will be held at the University of Canterbury, Christchurch, New Zealand, from 25 to 30 August 2002 and is being organized by Bryan Storey. The meeting will be held in conjunction with Gondwana 11 and will focus on the evolution of the Gondwanan Earth System through time. There are a wide variety of pre- and post-conference field trips planned, ranging from Neotectonics of the South Island to an examination of the collage of Gondwanan terranes. Linking the project meeting with the Gondwana conference will probably result better exposure for IGCP 453 and in more participants.

No. 454 – Medical Geology (2000-2004)

O. Selinus, Geological Survey of Sweden, P.O. Box 670, SE-75128 Uppsala, Sweden; e-mail: olle.selinus@sgu.se

P. Bobrowsky, British Columbia Geological Survey Branch, PO Box 9320, Stn Prov Govt, Victoria, BC, Canada V8W 9N3; e-mail: peter.bobrowsky@gems7.gov.bc.ca

Description: ‘Medical Geology’ is defined as the science dealing with the relationship between natural geological factors and health problems in men and animal, including the understanding of the influence of ordinary environmental factors on the geographical distribution of such health problems. Hence, ‘Medical Geology’ is a broad and complex subject, which requires interdisciplinary contributions from several different scientific fields. The main goal of the project is to bring together, at the global scale, scientists working in medical geology in developing countries with their colleagues in other parts of the world stressing the importance of geoscientific factors that affect the health of humans and animals. The proposal considers such topics as toxic elements in soil and rocks, natural occurring metals and non-metals, sources of pathways from air to water to food, examination of the environment and transport mechanisms. The project will involve joint technical meetings designed to address issues of mutual concern amongst geoscientists and other disciplines (medical doctors and veterinarians) concerned with Medical Geology.

No. 454 – Medical Geology (2000-2004)

Website related to the project
http://home.swipnet.se/medicalgeology

List of countries involved in the project (*active in 2001)


Achievements of the project

General scientific achievements

At the completion of the short course and other activities, the attendees were able to:

- Know and gain information on the type of evidence available about geological sources and processes, environmental health, toxicology, and pathological manifestations of exposures to toxic metal species.
- Know and gain information about geochemical processes, natural and anthropogenic sources, speciation, modes of occurrence, to assess the impact of trace elements and toxic metal ion species on human and environmental health.
- Have an elementary understanding of environmental toxicology, epidemiology, medical geology and issues associated with assessment, regulations and legislation as applied to the study of toxic metal species and trace elements.

Meetings

The main meeting for 2001 was held in Lusaka, Zambia (27 June–1 July). This meeting was divided into several parts:

- Short course on Metals Health and the Environment, especially for the African countries, held by IGCP 454
- Regional East and Southern Africa workshop on Medical Geology, sponsored and partly held by IGCP 454
- Special discussions with the African delegates on the IGCP 454.
- Medical Geology fieldtrip around Lusaka emphasizing health problems.

The meeting brought together more than 50 geoscientists and medical scientists from around the world. Africa was especially well represented with participants from 9 countries, as well as 12 overseas delegates. The experts comprised geoscientists, medical practitioners, veterinarians, environmental economists and engineers, and social scientists.
Metals, Health and the Environment Short Course
The most significant part of the meeting in Lusaka was a short course and seminar under the auspices of IGCP 454, entitled “Metals, health and the environment”. An extensive syllabus was produced, about 300 pages in length, covering many aspects on Medical Geology. A copy of this syllabus was provided to all 50 participants.

Scope and Purpose: Metal ions occur naturally in rocks, soils, gases, and waters in both harmless and harmful forms and concentrations. Natural concentrations of metal ions can be extraordinarily high and have been known to cause serious health problems. Metals are important in environmental health and in the study of human diseases (pathology), because of their potential toxic effects to any number of organs. Exposure to toxic metal ions may occur via three principle routes: percutaneous absorption, ingestion, or inhalation. Dermal toxicity results from local tissue responses through direct contact of the metal with skin, or alternatively, may represent a manifestation of systemic toxicity following ingestion or inhalation. Allergic contact dermatitis induced by nickel is one example of a local tissue response. The adverse cutaneous reactions resulting from chronic ingestion or inhalation of arsenical compounds exemplify systemic toxicity. A variety of toxic pathology responses in human tissues and organs (i.e. skin, liver, heart, kidney) associated with both acute and chronic exposures to metals have been described. The aim of this Seminar was to provide examples where both deficiencies of trace elements, as well as toxic exposures of metals may be involved in physiologic changes and the development of human diseases. We discussed the impacts of metal ions and trace elements on human health as illustrated with examples of arsenic poisoning from contaminated water in the Bengal Delta (India and Bangladesh) and Taiwan, as well from coal combustion in southwest China. Studies associated with lung cancer risk in an occupational cohort of chromate production workers were described. An overview of the clinical aspects of toxic metal exposures including discussions of essentiality and clinical manifestations were presented.

Themes covered included an overview of essential elements and metals, potential toxicities and known disease associations, as well as clinical features of diseases and theories on mechanisms of toxicities, followed by sources of trace elements and pathways of potential impact. Consideration of anthropogenic sources and human activities that enhance or change trace elements concentrations and availability were illustrated. Standard methods of epidemiological studies and approaches to characterizing metal exposure were also described.

Two case studies were introduced, the first As and F poisoning through food drying processes in China, activities which affect about 10,000 and 10 million people, respectively. This is a relatively recent phenomenon due to forest denudation in the early 1900s and the subsequent necessity of a new fuel source, which came in the form of fuel briquettes, composed of a mixture of As-rich coal and F-rich clay. During coal burning, food dried over an open fire is coated with As and F that is also inhaled directly. This was elaborated on with an overview of clinical features of chronic As poisoning. Calin Tatu (Country Hospital, Timisoara, Romania) spoke on the elusive etiology of Balkan endemic nephropathy (BEN) that occurs in Romania, Bulgaria, Serbia, Croatia, Bosnia, and Kosovo and currently affects over 100,000 people. Through geological and disease prevalence maps, BEN is known to occur in areas where people derive their groundwater from layers of lignite, hence current research is focusing on organic contaminants as a possible causative factor.

The second day started with the importance of specification (bio-availability, mobility, and toxicity) and the appropriate methods for their determination. Analytical methods to determine trace elements in geological material, especially for extremely low concentrations were then described, followed by methods and procedures used for the determination of trace elements in biological samples. Current topics with regard to trace elements, environmental legislation, and various approaches to regulation were also discussed.

Olle Selinus (Chairman of IGCP 454, Geological Survey of Sweden) gave an overview of the emerging discipline of medical geology, including an historic perspective. He highlighted the multidisciplinary approach in Sweden at the Centre for Metal Biology in Uppsala, consisting of members from various scientific organizations who come together monthly to discuss relevant issues, and encouraged this collaborative type of approach. He illustrated a positive outcome regarding the solution to the mysterious moose disease in Sweden, originally attributed to a virus but later diagnosed as diabetes due to molybdenosis and copper deficiency, caused by liming in acidified regions where there are high contents of natural molybdenum in bedrock and soils. In the African context, Theo Davies (Moi University, Eldoret, Kenya) presented an overview of medical geology research in east and southern Africa, in which he stressed the important role of earth scientists in helping to isolate causative factors, the need for baseline data, and correct diagnosis of diseases. He discussed a variety of issues including I, F; endomycocardial fibrosis and Ce, asbestosis, Hg exposure, geophagia, Kaposi’s sarcoma, radiation and radon gas, trace element deficiency studies on soils and plants, and the need to study health impacts of mine and waste dumps.

Imasiku Nyambe ended with an emphasis on the importance of the transfer of our geological and biochemical knowledge once acquired, especially to policy makers. He pointed out that policy is donor driven in Africa with standards often set by foreign countries.
Cooperation has started with US Armed Forces of
A new poster has been produced and distributed.
Two newsletters have been published during the last
The webpage of the group
About 600 contacts via e-mail have been made during
About 200 persons are engaged in the work of IGCP
Medical Geology: An Emerging Discipline in
Current Topics on Trace Elements and Toxic Metal
Special Topics on Environmental Toxicology and
Analytical Methods for the Study of Metal Ions in
“Speciation” of Trace Elements and Toxic Metal Ion
Analytical Toxicology: Trace Element Speciation,
Analytical Methods for the Study of Trace Elements and Toxic Metal Ions in Geological and Environmental Samples
Analytical Methods for the Study of Metal Ions in Biological and Tissue Samples
Special Topics on Environmental Toxicology and Human Health Research on Metal Ions
Current Topics on Trace Elements and Toxic Metal Ion Studies: Environmental Legislation, Management and Use of Some Waste Products Containing Toxic Metals
Medical Geology: An Emerging Discipline in Environmental and Human Health.

In summary, the following topics were covered in Lusaka:
• Exposure and Effects of Toxic Metal Ions
• The Diversity of Trace Elements and Toxic Metal Ions in Environmental Health and Human Diseases:
• Essentiality, Toxicity and Carcinogenesis
• A Process-oriented Approach to Understanding Natural and Anthropogenic Sources, Transport and Fate of Toxic Metal Ions in the Environment
• Environmental Toxicology Studies and Considerations
• Considerations for the Design of Environmental Health Studies Associated with Effects of Toxic Metal
• Environmental Pathology, Geochemical Studies and Health Effects
• Environmental and Toxicologic Pathology of Metal Ion Exposures: An Overview of Selected Toxic Lesions
• Chronic Arsenic Poisoning: An Introduction and Overview
• An Overview of Health Impacts of Coal and Coal Use: Arsenicosis and Fluorosis
• Analytical Toxicology: Trace Element Speciation, Detection and Quantification Methods
• “Speciation” of Trace Elements and Toxic Metal Ion Species
• Analytical Methods for the Study of Trace Elements and Toxic Metal Ions in Geological and Environmental Samples
• Analytical Methods for the Study of Metal Ions in Biological and Tissue Samples
• Special Topics on Environmental Toxicology and Human Health Research on Metal Ions
• Current Topics on Trace Elements and Toxic Metal Ion Studies: Environmental Legislation, Management and Use of Some Waste Products Containing Toxic Metals
• Medical Geology: An Emerging Discipline in Environmental and Human Health.

Other activities of IGCP 454 in 2001
• About 200 persons are engaged in the work of IGCP 454 from about 45 countries all over the world during 2001.
• About 600 contacts via e-mail have been made during 2001 with participants in IGCP 454.
• The webpage of the group http://home.swipnet.se/medicalgeology has been updated at least twice a month, often even more frequently. The website has now about 700 visitors every month.
• Two newsletters have been published during the last year. Another newsletter will be ready in late 2001. The newsletter is distributed to almost 300 persons.
• A new poster has been produced and distributed.
• Cooperation has started with US Armed Forces of Pathology (AFIP) and USGS. One result of this cooperation is that about 35,000 medics all around the world are regularly informed on the work going on in Medical Geology. A Medical Geology registry is also under discussion.
• The National Museum of Health and Medicine in Washington DC has unveiled an exhibit highlighting the developing science of medical geology.
• The book on Medical Geology, to be published by Academic Press, is proceeding. All authors are identified and drafts of most of the manuscripts will be ready at the end of 2001. The book has one Chief editor (O. Selinus), 6 associate editors and about 50 authors from all over the world; geoscientists and medics. The volume will be about 800-900 pages.
• There are plans for having short courses on Metals, Health and the Environment in three countries in 2002.
• As a spin off effect USGS has introduced a new programme on Medical Geology. Also AGSO in Australia is discussing a new programme or activity on Medical Geology.
• A new one year project on Medical Geology has been approved by ICSU.

An East and Southern Africa Association of Medical Geology (ESAAMG) was decided on in Lusaka at the IGCP meeting. Members of an Executive Committee were chosen to represent several countries as follows: Angola – Dr Suzanet Nunes da Costa (jacuan@netangola.com)
Kenya – Ms Monique Omulo (Monicaomulo@hotmail.com)
Tanzania – Dr Edda Vuhahula (evuhahula@muchs.ac.tz)
South Africa – Ms Portia O. Ceruti (poceruti@matties.sun.ac.za)
Zimbabwe – Dr Noma Ndiweni (ndiweni@vet.uz.ac.w)

Meetings

During the 2001 annual meeting of the Geological Society of America, Boston, MA, a Pardee Symposium entitled “Medical Geology: an emerging discipline” was held on November 5. The meeting was sponsored by IGCP 454, the GSA Institute for Earth Science and the Environment, US Armed Forces Institute of Pathology, IUGS, USGS, COGEOENVIRONMENT, Swedish Geological Survey and the Swedish Institute for Metal Biology. The organizers consisted of Dr Dennis Goldman (GSA), Dr Peter Bobrowsky (IUGS and International Co-leader of IGCP 454), Dr Jose Centeno (US AFIP) and Dr Catherine Skinner (Yale University). The meeting primarily attracted about 150 geologists from a variety of disciplines and focused on broadening the appreciation of earth sciences amongst seasoned practitioners towards direct societal issues such as human health.

An opening introduction to the session was given by Peter Bobrowsky who stressed the importance of the discipline in addressing today’s global needs, he also reviewed the history of activities associated with IGCP 454 and outlined plans for the future. Ross MacPhee (American Museum of Natural History) proposed an infectious disease...
have a series of complicating factors, of which genetics but also only occurs in areas of low soil Mg and high
known to have genetic and suspected viral components, Nasopharynx occurs in the south-east of China and is
between human disease and the environment. Trondheim, Norway) with an overview of associations
by Bjørn Bølviken (Geological Survey of Norway, geology work in eastern and southern Africa was opened
Century”, a one-day workshop presenting medical
workshop in Uppsala, Sweden in 2000. AFIPs newsletter in the
beginning of 2001 was devoted to medical geology describing this subject and the IGCP project. It was
distributed to about 35,000 medics all around the world. The November 2001 issue of Geotimes (American Geological Institute) was fully devoted to the theme Geosciences and Human Health.


Medical Geology Workshop, GEOMED 2001

Following the successful short course in Lusaka, and with the theme "The Role of Geomedicine in the 21st Century", a one-day workshop presenting medical geology work in eastern and southern Africa was opened by Bjørn Bølviken (Geological Survey of Norway, Trondheim, Norway) with an overview of associations between human disease and the environment. Nasopharynx occurs in the south-east of China and is known to have genetic and suspected viral components, but also only occurs in areas of low soil Mg and high Th. Likewise, multiple sclerosis in Norway seems to have a series of complicating factors, of which genetics is suspected to play a role, as well as viral and environmental factors. Studies have shown a positive correlation between multiple sclerosis and Rn, and he speculated on the possibility of an antagonistic synergy.

The first session of the workshop focused on fluorine and Adebayo Oladimeji (National University of Science and Technology, Bulawayo, Zimbabwe) presented a summary of F distribution in a variety of drinking water sources in populated areas of western Zimbabwe. Examination of the variation in mean concentrations over a thirty year period found the average F concentration to be within acceptable limits, although quite a few sites in the west had very high levels, which exceeded acceptable guidelines. Fluoride concentrations have been found to be inversely correlated with rainfall in this area. Edda Vuhahula (University of Dar es Salaam, Tanzania) presented work on the severe endemic dental fluorosis in Tanzania in communities exposed to low levels of F in drinking water, although some areas with dental fluorosis could not be explained by F levels in drinking water, and seem to be associated with magadi, a commonly-used salt composed of sodium carbonate or bicarbonate mined from saline lakes. Regional variations in diet with coastal people consuming mainly fish and tea, and higher altitude communities consuming more milk and magadi, were related to variations of F in urine samples.

Donnati Mosha (University of Dar es Salaam, Tanzania) described the problems of analysis of F in Tanzanian salt lakes, which are a potentially valuable local resource, subject to little research or exploitation, although the extremely high F concentrations could pose a health risk. He noted some of the complications that can arise during analysis such as etching of glass at low pH, the problem of molecular F not being detected, the fact that many of the multiple species in solution are not well known, and, lastly, the critical factor of maintaining the correct ionic strength. In another study, Patrick Hayumbu (University of Zambia, Lusaka, Zambia) reported on nuclear analytical techniques used to analyze a variety of geological, waste, and building materials to determine occupational exposure to radioactivity in Zambia, where about 30% of the underground mines were found to have very high levels of radioactivity.

Trace and major element deficiencies of soils in relation to an endemic osteoarthritis, Mseleni Joint Disease (MJD), and dwarfism in Maputaland, South Africa were explained by Portia Ceruti (University of Stellenbosch, South Africa), who is looking at the spatial pattern of nutrient heterogeneity in relation to the prevalence of MJD. This work for her doctoral studies has shown multiple soil deficiencies of P, Cu, Zn, and Se that vary across the landscape. Health implications of geophagy were illustrated by Mr Shitumbanuma (University of Zambia, Lusaka, Zambia) in a study of the textural and chemical composition of soils, as well as termite material deposited on tree bark, consumed by women in
Lusaka. The materials were found to be acidic and clayey, with high Mg and Mn concentrations in soil from the Kafue region of Zambia versus soil from the Democratic Republic of Congo, whereas in the termite material Mg and Mn levels were also quite high.

The major theme of the workshop concentrated on pollution of soil and water, and ultimately impacts on ecosystems and humans, through a common activity in east and southern Africa: mining. Small-scale mining was considered by Benjamin Mapani (University of Zimbabwe, Mount Pleasant, Zimbabwe) who spoke on the importance of social as well as economic considerations in the search for a solution for a river system of northern Zimbabwe where small-scale Au mining has led to the destruction of the river. Jason Ogola (University of Venda, Thohoyandou, South Africa) stressed the necessity of public awareness in putting pressure on pollution and waste management policy makers with respect to environmental impacts of operational and abandoned mines in South Africa, such as the use of asbestos tailings as road material and to fill school playgrounds.

The influence of mining on water resources was discussed by James Kahatano (University of Dar es Salaam, Tanzania) with his work on heavy metal proliferation in the environment of Mpanda mineral field in western Tanzania, where maximum allowable levels in the water and soil are often exceeded due to atmospheric fall out. Monique Omulo (Maseno University, Kenya) introduced preliminary results from her doctoral work on heavy metal contamination and health problems in western Kenya, where artisanal Au mining has polluted tributaries to Lake Victoria. Callist Tindimugaya (Directorate of Water Development, Entebbe, Uganda) reported on groundwater pollution in Uganda where reprocessing of stockpiles has caused widespread contamination by heavy metals, especially Mn, Cd, and Cr, through varied pathways.

Staying with the theme of groundwater, Samuel Mtetwa (University of Zimbabwe, Mount Pleasant, Zimbabwe) presented a spatial distribution map of nitrate, phosphates, and suspended and dissolved solids as a tool for water quality management, to control the particularly diffuse pollution sources in an agro-rural watershed in Zimbabwe. Daniel Nkuwu (University of Zambia, Lusaka, Zambia) discussed a local problem in the karst landscape of Lusaka where natural holes in the ground are used for the disposal of liquid and solid waste, and the high watertable is easily contaminated. More data are needed to determine the association of pit latrines that intersect the watertable with outbreaks of cholera, as well as the impacts of open pit waste dumps on groundwater quality.

Imasiku Nyambe gave a review of the history of mining and the impact of tailings dams on the Kafue River in Zambia, which has elevated concentrations of Ca, Mg, Cu, and Co. He highlighted problems associated with atmospheric impacts, such as the high S emissions from the Nkana smelter. Maxwell Mwase (University of Zambia, Lusaka, Zambia) then introduced the topic of bioindicators in an ongoing study looking at chemical and morphological features of tropical fish species in the Kafue River in Zambia. He has found evidence of parasite infection and liver histological abnormalities in fish, as well as extremely high Cu concentrations in fish liver. Noma Ndiweni (University of Zimbabwe, Mount Pleasant, Zimbabwe) introduced work done on Se-dependent enzymes of crocodiles as a possible new Se index for biochemical and xenobiotic metabolism, as a precursor to addressing nutritional and prophylactic remedies for skin diseases in crocodiles. Steve Mogere (Moi University, Eldoret, Kenya) presented findings of the first benthic study on Chironomous larva as an indicator of temporal changes along the River Nzoia in Kenya due to pesticide pollution. Beneah Odhiambo (Moi University, Eldoret, Kenya) discussed a study along the Rift Valley in West Pohot District, Kenya to determine background concentrations of Ni, Co, and Mn in mineralized soil, where specific plant species are used as indicators of high Cr accumulation associated with serpentine deposits. Soil concentrations of Ni and Mn were found to be elevated with respect to background levels and there is concern of toxic human and animal consumption.

An overview of medical geology was given by Theo Davies on the effects of metal and toxic ions on environmental health, with specific reference to toxicology and metal pathology.

A panel discussion of several key issues raised in both the short course and workshop led to the following statements:

Preamble:
To bring awareness of medical geology to multiple disciplines and the public, specifically the importance of environmental factors in disease causation and prevention, which will decrease health costs and increase quality of life.

Resolutions:
• To encourage improved medical diagnosis and reporting of disorders that have a geological or environmental basis. In order to achieve this, there is a need to engage the participation of medical practitioners in medical geology meetings as well as in collaborative research.
• To increase the geoscientific considerations in political decision-making, the transfer of data from the geosciences and the biomedical sciences to policy makers and the public. This will require repackaging of the scientific information for public and layperson consumption, thus effectively communicating the value of our contribution to the public, public health practitioners, and to politicians.
• To generate or acquire the best quality analytical data feasible. This may involve collaboration with experts
in analytical chemistry, and the correct use of reference standard and reference materials. There is a need to strengthen efforts on research on speciation and bioavailability of elements.

- To advocate the incorporation of medical geology into the geo-curricula of institutes of higher learning.
- To sensitize the public and policy makers on safe waste disposal practices, especially in cities and municipalities.
- To abide by the Uppsala decision to use the term “Medical Geology” rather than “Geomedicine”. This refers to the previous IGCP meeting for IGCP 454 Medical Geology in Uppsala Sweden in September 2000.
- To increase research on and strive to inform the public of the potentially harmful effects of using natural materials as dietary supplements and as cosmetics.
- To increase and improve communication and networking by posting, as well as by the effective use of, relevant web pages, and to provide material for the biannual Medical Geology Newsletter.
- To advocate for the revival of the Global Geochemical Baseline Project IGCP 259 since Africa was poorly studied. This initiative will increase the use of multi-elemental analysis for medical geology.

Plans for the next East and Southern Africa Regional Workshop on Medical Geology were also discussed. The venue of the next meeting will be Dar es Salaam, Tanzania, the convener is Dr Edda Vuhahula. The meeting will be held in 2004 so as to avoid coinciding with the 6th International Symposium on Environmental Geochemistry meeting in Edinburgh, June 2003 (where IGCP #454 also will be actively involved). Publication of workshop papers will be either in African Geoscience Reviews or the Journal of Zambian Applied Earth Sciences.

**Activities planned**

**General goals**

Planned activities during 2003 are short courses in three countries, including former Eastern Europe, continuing work with the book on medical geology, two newsletters during 2002, all in order to involve as many scientists as possible from developing countries. The book on medical geology will be almost finalized during 2002.

**Meetings**

Meetings and field trips are planned in South America, Eastern Europe and Eastern Asia.

There will also be substantial involvement in some international symposia and meetings.
Project No. 463 – Upper Cretaceous Oceanic Red Beds

Full Title: Upper Cretaceous Oceanic Red Beds: response to Ocean/Climate Global Change

Proposers: C. Wang (China), M. Sarti (Italy), R. W. Scott (United States), L. F. Jansa (Canada)

Address: Prof. Wang Chengshan, Prof. Massimo Sarti, Dr Robert W. Scott, Prof. Luba Jansa

The main objective of the project is to investigate and understand conditions which resulted in the change from anoxic to oxic sediments deposition in the world oceans during the Late Cretaceous. Such a change represents a unique event during the last 250 million years of the Earth history. It remains unknown what triggered such profound change in oceanic sedimentation, from sediments enriched in organic carbon as deposited during middle Cretaceous, to sediments devoid of any carbon as deposited during the parts of the Late Cretaceous. This could result from changes in the operating mode of various earth processes such as palaeoceanographic (e.g. changes in global ocean chemistry, palaeocirculation), tectonic (opening and closing of the seaways, migration of the continent plates), and climatic (change form greenhouse to icehouse conditions). Another possibility is that it may signal change in palaeoproductivity, which could alter the balance between carbon sources and sinks in the oceans. It has been suggested by some researchers that the increase in organic carbon in deep sea sediments during the middle Cretaceous was in part related to an increase in organic productivity in the oceans; therefore. Does this entail that the lack of organic carbon in deep ocean sediments during the Late Cretaceous represents a major change in bioproductivity in the ocean? If it does, what caused such major change? If that is a change in bioproductivity, then understanding its forcing would be of major interest and concern to society, indicating potential for sudden changes in the food chain triggered by changes in the Earth Systems. Furthermore, such a study has economic overtones because changes in the location of organic carbon reservoirs imply changes in location of potential source rocks for hydrocarbon generation, which is of primary interest and importance for hydrocarbon exploration around the world.

The first step of the project will be to develop a catalogue of occurrences of such facies around the globe. Secondly, each of the distinctive facies will be assessed through geochemical, sedimentological and high-resolution chronostratigraphic analyses. Standardized methods of geochemical and chronostratigraphic analyses of deep-sea redbed deposits are important because some are predominantly unfossiliferous, such as those in the North Atlantic, and other dating methods must be used. Thirdly, these procedures will enable the correlation and timing of redbed occurrences and the evaluation of their synchronity or diachronity. The relationships among global occurrences of red, oxidized facies, palaeoceanographic processes, palaeoclimate changes, and plate tectonic changes will be analyzed with an aim to determine causes of major changes in Earth Systems, as locked in the Upper Cretaceous sedimentary record of the world oceans.

As the result of tectonic processes such deep sea sedimentary rocks are exposed on many continents, therefore available to on-land geologic studies. Indeed, strata representing the Upper Cretaceous oceanic red bed deposits (subsequently abbreviated to CORB) crop out in many regions of the Western Tethys such as the Alps in France, Spain and Italy, and in the Carpathian Mountains of the Czech Republic, Poland, Slovakia, Romania, and Cyprus. Recently they were discovered in Southern Tibet. Deep marine, red Upper Cretaceous deposits have also been cored in the North Atlantic and the Northern Indian Ocean by the DSDP/ODP drilling programme. The widespread distribution of CORBs has the potential for reconstructing the ocean structure in the aftermath of the Cenomanian/Turonian OAE, because CORBs were not only deposited in the deep ocean below the CCD, but also extended up the continental rises and slopes, where they are represented by reddish coloured marls and pelagic limestones.
Such research requires not only an integrated multidisciplinary approach, but also coordinated international action to facilitate cooperation among different specialists from different countries. This global approach is only possible within an international project such as the IGCP.

**Project No. 467 – Triassic Time**

**Full Title:** Triassic Time and trans-Panthalassan Correlations

**Proposer:** M. J. Orchard (Canada)

**Address:** Michael J. Orchard, Geological Survey of Canada, 101-605 Robson St., Vancouver, B. C. V6B 5J3, Canada. Tel: 604-666-0409, Fax: 604-666-1124, e-mail: morchard@nrcan.gc.ca

The goals of the project are to identify correlatable data for global correlation of Triassic rocks and thereby produce a stable temporal framework based on sound palaeontological data complemented by magnetic and geochemical scales and calibrated with absolute isotopic ages. The project embraces current efforts of the IUGS Subcommission on Triassic Stratigraphy (of which the proposer is Chairperson), and of several international projects, and provides a vehicle to enhance the degree of international cooperation and collaboration between palaeontologists, stratigraphers, magnetostratigraphers, and geochemists, in both the marine and non-marine realms. Trans-Panthalassan correlations are emphasized in order to focus on the considerable Triassic data now available from the accreted terranes of the Pacific margin and to ensure that chronostratigraphic standards established in Tethys are applicable in the new world.

**Project No. 470 – The 600 Ma Pan-African Belt of Central Africa**

**Full Title:** The 600 Ma Pan-African Belt of Central Africa: Sedimentation, Deformation History, Magmatism, Metamorphism and Geotectonic Evolution

**Proposers:** S. Félix Toteu (Cameroon)

**Address:** Dr S. Félix Toteu, Centre for Geological and Mining Research, B. P. 333, Garoua, Cameroon. Tel/Fax: (237) 27.13.35/ (237) 94.83.41, e-mail: ergm@iccnet.cm; sfototeu@yahoo.fr

The Central African region (Cameroon, Chad, Central African Republic, Gabon, Congo Democratic Republic of Congo) is one of the poorly understood of the Pan-African-Brasilian belts system, despite its real mineral potential (Au, Sn, Nb, Ta, U, sulphides, etc.). The region is unequally surveyed, and works in different countries are initiated and conducted by isolated teams. As consequence, trans-national correlations of litho-structural units are difficult. The main goal of the project is to favour the constitution of a trans-national research team. Such a team will reconstruct the general framework of the evolution of the Pan-African orogeny; it will particularly concentrate on the following points: (1) the typology of granitoids, their origin and their relation with deformation processes; (2) the correlation between the Meso-to Neoproterozoic basins and volcanics involved in the Pan-African orogeny in all countries with particular reference to the early fragmentation history; (3) the tectono-metamorphic evolution with particular reference to the extent and significance of the granulitic belt north of the Congo Craton; (4) the synthesis of geophysical data. Furthermore, the project will offer opportunities (a) to each country to benefit from the experience of the others on the ground ore deposit survey; (b) to the research team to evaluate the economic potential of different rock units, which will enable the definition of exploration guidelines for geological and geochemical exploration; and (c) to graduate students to carry out research on the comparative studies on a regional basis.

**Project No. 471- Evolution of Western Gondwana during the Late Palaeozoic**

**Full Title:** Evolution of Western Gondwana During the late Palaeozoic: Tectono-sedimentary Record, Palaeoclimates and Biological Change

**Proposers:** C. O. Limarino (Argentina), L. A. Buatois (Argentina)

**Address:** Carlos O. Limarino, Departamento de Ciencias Geológicas, Pabellón II, Ciudad Universitaria, 426 Buenos Aires, Argentina. Tel: (054) 114-666.1218 e-mail: limar@advance.dcl Luis A. Buatois, Instituto Superior de Correlación, Casilla de Correo 1, Correo Central, 4000 San Miguel de Tucumán, Argentina. Tel.: (054) 381-425.3050, Fax: (054) 381-423.6395, e-mail: ichnolog@infovia.com.ar

The major objective of the project is to promote the interaction among scientists and institutions devoted to the study of the Upper Palaeozoic of Western Gondwana in different countries. Research will be focused on three main aspects: (1) tectonic activity and sedimentary evolution of the Upper Palaeozoic basins; (2) climatic history of Western Gondwana and its impact on the biota and, (3) stratotype definition and sea level changes as a tool for regional and intercontinental correlations.
Project No. 473 – GIS Metallogeny of Central Asia

Full Title: Metallogeny of Central Asia: a GIS-based Synthesis on a Modern Geodynamic Background (Young Scientist Project)

Proposers: Dr Reimar Seltmann (Coordinator for initially 5 Young Scientist Project Proposal Teams targeting the Central Asian countries, i.e. the “Stans”, and involving the neighbouring regions of Russia, Mongolia and China)

Address: Centre for Russian and Central Asian Mineral Studies, Department of Mineralogy, Natural History Museum, Cromwell Road, London, SW7 5BD, United Kingdom, Tel: (+44) 207 942 5042; Fax: (+44) 207 942 5537, e-mail: rs@nhm.ac.uk

The proposed study will integrate the currently available data with new data in order to combine the geotectonic units of Central Asia and its mineral inventory, and to see the metallogenic evolution against the background of crustal growth during accretionary orogeny aiming to develop a unified metallogenic–geodynamic model of Central Asia. The selected mineral deposit sites will be studied in the field and by modern laboratory methods to obtain data on geochemistry of ores, mineralized rocks, wallrock alteration, and country rocks for developing genetic models of major mineral deposits. Interdisciplinary research will include classification and data processing of about 1200 deposits within the hosting terrains according to their age, deposits type, and metal-lotect. The complex research and correlation will be done through complementary teams with technical-methodological skills in GIS techniques and geodynamic-metallogenic expertise. This will result in the compilation of a set of GIS-based geological, geodynamic and metallogenic maps of Central Asia, scale of 1:1 500 000 aiming to assess the mineral potential of the study area, along with a monograph on Geology of Central Asian Mineral Deposits Types. It is expected that final maps and databases will be available in a single GIS-based package for the public domain and will help in recognition of prospective exploration terrains and mineral assessment of Central Asia.
IGCP projects active in 2002

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| 413 | Understanding Future Dryland Changes from Past Dynamics  
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| 420 | Phanerozoic Crustal Growth  
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updated 6/03/02
Members of the IGCP Scientific Board in 2002

Prof. Ian W. Dalziel
Chairman IGCP Scientific Board
University of Texas at Austin
Institute for Geophysics
4412 Spicewoods – Springs Road
Building 600 – Austin Texas 78759
U.S.A.
Tel.: 1 512 471 0431 or
1 512 471 6156
Fax: 1 512 471 8844
e-mail: ian@utig.ig.utexas.edu

Prof. Dr Sospeter M. Muhongo
Department of Geology
University of Dar es Salaam
P.O. Box 35052
Dar es Salaam
Tanzania
Tel.: 255-22-2410013/2410500-8
Fax: +255-22-2410481/2410078
e-mail: muhongo@udsm.ac.tz

Dr Max Deynoux
Ecole et Observatoire des Sciences de la Terre (EOST)
1, rue Blessig
67084 Strasbourg Cedex
Tel.: 33 3 88 35 83 89
Fax: 33 3 88 36 72 35
e-mail: mdeynoux@illite.u-strasbg.fr

Dr Prabhas Pande
Director
Earthquake Geology Division
Geological Survey of India, NR.
Lucknow – 226 024
India
Tel.: 91 522 37 87 96 Ext. 462
Fax: 91 522 37 64 07
e-mail: geodatnr@sancharnet.in
prabhaspande2002@yahoo.co.uk

Prof. Maurizio Gaetani (Chair WG1)
Università di Milano
Dipartimento di Scienze della Terra
Via Mangiagalli 34
20133 Milano – Italy
Tel.: 39 02 23698229
Fax: 39 02 70638261
e-mail: maurizio.gaetani@unimi.it

Prof. Nobutaka Shimada
Dept. of Earth and Planetary Sciences
Kyushu University – Hakozaki 6-10-1
Fukuoka 812-8581
Japan
Tel.: 81 92 642 2516
Fax: 81 92 642 2684
e-mail: nshimada@geo.kyushu-u.ac.jp

Prof. Alexander Gliko
Deputy Director
Institute of Physics of the Earth
Academy of Sciences
123810 – B. Gruzinskaya str. 10
Moscow – Russia
Tel.: 7 (095) 254 30 44
Fax: 7 (095) 255 60 40
e-mail: gliko@uipe-ras.scgis.ru

Dr Victor A. Ramos (Chair WG 4)
Diaz Vélez 820 – La Lucila
1636 Buenos Aires
Argentina
Tel.: 54 (11) 4701 69 47 (off.)
4790 9873 (home)
Fax: 54 (11) 47016947
e-mail: andes@gl.fcen.uba.ar

Prof. James T. Teller (Chair WG2)
University of Manitoba
Winnipeg – Manitoba
Canada R3T 2N2
Tel.: (1-204) 474 9274
Fax: (1-204) 474 7623
e-mail: tellerjt@MS.umanitoba.ca

Prof. Sylvi Haldorsen
Agricultural University of Norway
Dept. of Soil and Water Science
Section of Geology and Water
P.O. Box 5028
N-1432 Ås – Norway
Tel.: 47 64 94 82 52
Fax: 47 64 94 82 11
e-mail: sylvi.haldorsen@ijvf.nlh.no

Dr Sylvi Haldorsen
Agricultural University of Norway
Dept. of Soil and Water Science
Section of Geology and Water
P.O. Box 5028
N-1432 Ås – Norway
Tel.: 47 64 94 82 52
Fax: 47 64 94 82 11
e-mail: sylvi.haldorsen@ijvf.nlh.no
Dr Susan Turner  
Queensland Museum  
P. O. Box 3300  
South Brisbane  
QLD 4101 Australia  
Tel.: 617 3840 7677  
(H) 617 3878 1066  
Fax: 617 3846 1918  
e-mail: SueT@qm.qld.gov.au

Prof. Marjorie Wilson  
School of Earth Sciences  
Leeds University  
Leeds LS2 9JT  
United Kingdom  
Tel./Fax: 44 (0) 113 233 5236  
e-mail: m.wilson@earth.leeds.ac.uk

Dr Gerhard Wörner  
Geochemisches Institute  
University of Göttingen  
Goldschmidstr. 1  
D-37077 Göttingen  
Germany  
Tel.: 49 551 39 39 71  
e-mail: gwoerne@gwdg.de

Prof. Zhenyu Yang  
Institute of Geomechanics  
Chinese Academy of Geological Sciences  
11 Minzuuxueyuan South Road  
Beijing 100081 P. R. of China  
Tel.: 86-(10)-6842-2365  
Fax: 86 (10)-6842-2326  
e-mail: yangzy@public3.bta.net.cn

Prof. Cari Zazo-Cardeña  
Geology Department  
Museo Nat. Cc. NAturales  
José Gutierrez Abascal 2  
28006 Madrid  
Spain  
Tel.: 34 91 41 50 077  
Fax: 34 91 41 11 328  
e-mail: mcnz65@mncn.csic.es

IUGS Representatives

Prof. Attilio C. Boriani  
Secretary General IUGS  
Dip. di Scienze della Terra  
Univ. Degli Studi di Milano  
Via Botticelli 23  
1-20133 Milan  
Italy  
Tel.: 39 2 236 98 310  
Fax: 39 2 706 38 681  
e-mail: boriani@10.terra.unimi.it

Dr Ed F. J. de Mulder  
President of IUGS  
NITG TNO and Technical University  
P. O. Box 6012 2600 JA  
Delft – The Netherlands  
Tel.: 31 23 530 0292  
Fax: 31 23 526 2709  
e-mail: emulder@wxs.nl

Dr Werner R. Janoschek  
IUGS Treasurer and Secretary-General Elect  
Geological Survey of Austria  
Rasumofškygasse 23  
POB 127  
1031 Vienna  
Austria  
Tel.: 43 1 712 56 74 180  
Fax: 43 1 712 56 74 56  
e-mail: wjanoschek@cc.geolba.ac.at
IGCP National Committees
(2 July 2002)

AFGHANISTAN
Dr Ebrahim Hamid
Secretary
Afghan National Committee of Geology
Geology and Mineral Survey Dept.
Micro-Rayon
Kabul, Afghanistan

ALBANIA
Dr Aleksander Cina
Chairman, IGCP National Committee
Blloku “Vasil Shanto”
Tirana, Albania

ALGERIA
Dr Mohammed Tefiani
Institut des Sciences de la Terre
Université des Sciences et de la Technologie
B.P. No.9
Dar El Beida, Algerie

ARGENTINA
Dr C. Cingolani
Presidente
Centro de Investigaciones Geológicas
Calle 1 n° 644
1900-La Plata, Argentina
e-mail: ccingola@cig.museo.unlp.edu.ar

AUSTRALIA
Dr Cec Murray
Chairman, IGCP National Committee
Geological Survey
Queensland Department of Mines and Energy
G.P.O. Box 194
Brisbane QLD 4001, Australia
e-mail: cmurray@dme.qld.gov.au
http://www.oeaw.ac.at/mathnat/foprog/igcp.html

AUSTRIA
Prof. Dr Franz Weber
Chairman, IGCP National Committee
Institute für Geophysik
A-8700 Leoben, Austria
e-mail: http://www.oeaw.ac.at/mathnat/foprog/igcp.html

AZERBAIJAN
Dr A.D. Ismail-Zadeh
Executive Secretary
AzNCG
Geology Institute
H. Gavid pr., 29-A
370143 Baku, Azerbaijan
e-mail: gia@azdata.net

BARBADOS
Mr Leslie Barker
Chief Geologist – Energy Division
Ministry of Finance
2nd floor – National Petroleum Corp. Building
Wildey – St. Michael, Barbados

BANGLADESH
Md. Khurshid Alam
Chairman, IGCP National Committee
Director-General, Geological Survey of Bangladesh
153 Pioneer Road – Segunbagicha
Dhaka 1000, Bangladesh

BELARUS
Academician R. Garetsky
Chairman
Belarus National Committee for IGCP
Academy of Sciences of Belarus
Kuprievich str. 7
220141-Minsk, Belarus
e-mail: garetsky@igs.ac.by
BELGIUM

Prof. L. Dejonghe
Geological Survey of Belgium
13 Jenner street
B-1000 Brussels, Belgium
e-mail: leon.dejonghe@pophost.eunet.be

BENIN

M. J.-C. Kogblevi
Président
Comité national pour le PICG
Directeur général de l’Office béninois des Recherches Géologiques et Minières
Ministère des Mines, de l’Énergie, et de l’Hydraulique
B.P. 249
Cotonou, Benin

BOLIVIA

Ing. Antonio Saavedra Muñoz
Présidente, Comité Boliviano de Correlacion Geologica
Academia Nacional de Ciencias
Av. 16 de Julio No. 1732
Casilla – 5829 La Paz, Bolivia

BRAZIL

Prof. D.A. Campos
Chairman, IGCP National Committee
DNPM/Paleontologia
Av. Pasteur 404, urca
22290-240 Rio de Janeiro R.J., Brazil
e-mail: dac@abc.org.br

BULGARIA

Prof. Dr Platon Tchoumatchenco
Président – Comité national pour le PICG
Institut géologique – Académie bulgare des sciences
Acad. Gheorghi Bonev Str.
Block 24 1113 Sofia, Bulgaria
e-mail: ptchouman@geology.bas.bg

BURKINA FASO

Monsieur Wenmenga Urbain
Maître Assistant
Département des sciences de la terre
Université de Ouagadougou
Faculté des Sciences et Techniques
03 B.P. 7021
Ouagadougou 03, Burkina Faso

CAMEROON

Prof. F. Tchoua
President, Comité national du PICG
Chef du Département des sciences de la terre
Université de Yaoundé
Yaoundé, Cameroun

CANADA

Dr N.W Rutter
Chairman
IGCP National Committee
Department of Earth and Atmospheric Sciences
University of Alberta
Edmonton – Alberta, Canada
e-mail: Nat.Rutter@ualberta.ca

CHAD

Monsieur O.A. D’Babeh
Président, Comité national du PICG
Doyen – Faculté des Sciences
Université du Tchad
B.P. 1027
N’Djamena, Tchad

CHILE

Dr E. D’Etigny Lyon
Chairman, IGCP National Committee
National Commission for Scientific and Technological Research
CONICYT
Casilla 297 V
Santiago 21, Chile

CHINA

Prof. Liu Dunyi
Chairman, IGCP National Committee
Institute of Geology
Chinese Academy of Geological Sciences (CAGS)
26 Baiwanzhuang Road
Beijing 100037, China
e-mail: igcp-china@cags.cn.net
http: www.cags.cn.net/igc-china
http:www.cags.cn.net/igcp-china

COLOMBIA

Sr. Ricardo Escobar Reyes
Présidente, Comité Nacional del PICG
INGEOMINAS
Diagonal 53 nº. 34-53
Aptdo. Aéreo 4865
Santa Fé de Bogota, Colombia
CONGO
Comité National du PICG
c/o Commission Nationale pour l’UNESCO
B.P. 14
Kinshasa/Gombe G.C.
République Démocratique du Congo

COSTA RICA
Lic. Teresita Aguilar Alvarez
Director
Presidente
Comité Nacional para el PICG
Escuela Centroamericana de Geología
San Pedro Montes de Oca
San José, Costa Rica
e-mail: aaguilar@cariari.ucr.ac.cr

CÔTE D’IVOIRE
Mr Joseph N’zi
Président
Comité national ivoirien de corrélation géologique
Directeur général – Sodemi
O1 BP 2816 – Abidjan O1
Côte d’Ivoire

CROATIA
Prof. Josip Tisljar
Chairman, IGCP National Committee
Faculty of Mining, Geology and Petroleum Engineering
Pierottijeva 6
HR-10000 Zagreb, Croatia
e-mail (secretary): gdurn@rudar.rgn.hr

CUBA
Dr Nancy Garcia Lamadrid
Chairman, IGCP National Committee
Oficina Nacional de Recursos Minerales
Ave. Salvador Allende No. 666
La Habana 10300, Cuba

CYPRUS
Dr G. Petrides
Chairman, IGCP National Committee
Director, Geological Survey Department
Ministry of Agriculture
Natural Resources and Environment
1415 Nicosia, Cyprus
e-mail: gsd@cytanet.com.cy

CZECH REPUBLIC
Dr J. Pasava
Chairman, Czech IGCP National Committee
Geological Survey of Prague
Klárov 131
11821 Praha 1, Czech Republic
e-mail: pasava@cgu.cz
http://www.gli.cas.cz/IGCP

DENMARK
Dr Agnete Steenfelt
Chairperson
Danish National Committee for Geology
c/o Geological Centre Institute
Oster Voldgade 10
DK 1350 Copenhagen K, Denmark

EGYPT
Prof. M. Lotfi Abdel-Khalek
Department of Geology
Cairo University
Giza, Egypt

FINLAND
Prof. Jorma Kangas
Chairman
IGCP National Committee
Sodankylä Geophysical Observatory
FIN-99600 Sodankylä, Finland
e-mail: Jorma.Kangas@sgo.fi

FRANCE
Dr Denis Vaslet
Président
Comité national pour le PICG
BRGM – Avenue de Concy
BP 6009-45060 Orléans, France
e-mail: d.vaslet@brgm.fr

GERMANY
Prof. Dr Fritz Steininger
Chairman
IGCP National Committee
Forschungsinstitut Senckenberg
Senckenberganlage 25
D-60325 Frankfurt-am-Main, Germay
e-mail: fsteinin@sng.uni-frankfurt.de
http://www.geokomission.de/arbgru/NCIGCP.html
GHANA

Dr G.O. Kesse
Chairman
IGCP National Committee
Geological Survey Department
Ministry Branch Post Office
P.O. Box M. 80
Accra, Ghana

GREECE

Mr G. Gekas
General Director
Institute of Geology and Mineral Exploration
70 Messoghion Street
Athens 11527, Greece

GUYANA

Mrs Karen Livan
Manager
Geological Services for Commissioner
Guyana Geology and Mines Commission
Upper Brickdam
P.O. Box 1028
Georgetown, Guyana

HUNGARY

Dr Károly Brezsnayánszky
Chairman
IGCP National Committee
Geological Institute of Hungary (MAFI)
H-1143 Budapest
P.O.B. 106
Stefánia út 14, Hungary
http://www.mafi.hu

INDIA

Shri Ravi Shanker
Chairman
IGCP National Committee
Director-General
International Division
Geological Survey of India
27 Jawaharlal Nehru Road
Calcutta 700 016, India
e-mail: gsi@gems.vsnl.net.in

ISLAMIC REPUBLIC OF IRAN

Dr Abdolazim Haghipour
President
Geological Survey of Iran
Azadi SQ – Ave Meraje
Tehran
Home 28 Ave. Miremade
15879, Tehran, Islamic Republic of Iran
e-mail: Haghipou@accit.com

IRELAND

Mr Ralph Horne
Chairman, Irish National Committee for Geology and IGCP
Geological Survey of Ireland
Beggars Bush
Haddington Road
Dublin 4, Ireland

ISRAEL

Dr Amos Bein
Chairperson, IGCP National Committee
Director, Geological Survey of Israel
30 Malkhei Yisrael Street
95501 Jerusalem
e-mail: bein@mail.gsi.gov.il

ITALY

Prof. Cavazza
Secretary, IGCP National Committee
Department of Geological Sciences
University of Basilicata
Macchia Romana
85100 Potenza, Italy
e-mail: cavazza@geomin.unibo.it

JAMAICA

Dr Larence Henry
Chairman, IGCP National Committee
Director
Geological Survey Division
P.O. Box 141
Hope Gardens
Kingston 6, Jamaica

JAPAN

Prof. R. Tsuchi
Chairman
IGCP National Committee
Shizuoka University
Miyatake 1-9-24
Shizuoka 422-8035, Japan
e-mail: rtsuchi@mvibiglobe.ne.jp

IRAQ

Dr Yahya Tawfik Al-Rawi
Chairman, IGCP National Committee
University of Babylon
P.O. Box 4 – Hilla
Babylon, Iraq
JORDAN
Mr K. Jreisat
Chairman, IGCP National Committee
Director-General
Natural Resources Authority
P.O. Box 7
Amman, Jordan

KAZAKHSTAN
Mr Khalel Abdulkhakovich Bespaev
Chairman, IGCP National Committee
Institute of Geological Sciences
Kabanbai batyr st., 69-a
480100 Almaty, Kazakhstan

KENYA
Mr D.R.O. Riaroh
Chairman, IGCP National Committee
Ministry of Energy
P.O. Box 30582
Nairobi, Kenya

KOREA
Prof. Dr Yong Ahn Park
Chairman, IGCP National Committee
Department of Oceanography
Seoul National University
Seoul 151-742, Korea

LIBERIA
Dr Beauford O. Weeks
Director
Liberian Geological Survey
Ministry of Lands and Mines
P.O. Box 10-9024
Monrovia, Liberia

LITHUANIA
Dr Gediminas Motuza
Director of the Geological Survey
Konarski 35
Vilnius 232600, Lithuania

LUXEMBOURG
Comité national du PICG
Attn: Monsieur R. Maquil
Service géoloque du Luxembourg
43 Bd. G.D. Charlotte
1331 Luxembourg

MACEDONIA
Prof. D.R. Risto Stojanov
President, IGCP National Committee
Faculty of Mining and Geology
ul. Goce Delcev 89
Stip 92000, Macedonia

MADAGASCAR
Président du Comité national malgache pour le PICG
Chef du Service des mines et de la géologie
B.P. 280
Antananarivo, Madagascar

MALAYSIA
Mr Yin Ee Heng
Chairman, IGCP National Committee
Director-General
Geological Survey of Malaysia
P.O. Box 11110
Jalan Tun Razak
50736 Kuala Lumpur, Malaysia

MEXICO
Sr. Diego Cordoba
Comité nacional del PICG
Instituto de Geología – Universidad Nacional
Apdo Postal 07296 – Delegación Coyoacán
México D.F. 04510

MONGOLIA
Dr Rinchen Barsbold
Chairman, IGCP National Committee
Geological Institute
Ulaanbaatar 51, Mongolia

MOROCCO
Monsieur M. Bensaid
Président, Comité national marocain du PICG
Ministère de l’énergie et des mines
Direction de la géologie
Rabat, Maroc

MYANMAR
Myanmar National Committee for IGCP
Myanmar Oil and Gas Enterprise
P.O. Box No. 1049
74/80 Min Ye Kyaw Swa Road
Yangon, Myanmar
NEPAL
Mr Madhab Raj Pandey
Senior Seismologist
Chief, National Seismological Centre
Department of Mines and Geology
Lainchaur – Kathmandu, India

NETHERLANDS
Prof. Dr J. Menlenkamp
Chairman, IGCP National Committee
Institute of Earth Sciences
Mail Box 80021 Enschappen
35087a Utrecht, Netherlands

NEW ZEALAND
Assoc. Prof. V.A. Neall
Chairman
IGCP National Committee
Massey University
Institute of Natural Resources
Private Bag 11222
Palmerston North, New Zealand
e-mail: V.E.Neall@massey.ac.nz

NICARAGUA
Dr Mauricio Darce Rivera
Chairman
Nicaraguan Mining Institute
Department of Geology
P.O. Box 195
Managua, Nicaragua

NIGER
Monsieur B. Ousmane
Secrétaire, Comité national pour le PICG
Ministère de l’Enseignement Supérieur de la Recherche et de la Technologie
B.P. 628
Niamey, Niger

NIGERIA
Dr O.M. Ojo
Director
Geological Survey Department
Federal Ministry of Petroleum and Mineral Resources
P.M.B. 12844
Federal Secretariat
Ikoyi
Lagos, Nigeria

NORWAY
Dr David Bruton
Secretary, IGCP National Committee
Universitetet Oslo
Paleontologisk Museum
Sars Gate
N-0562 Oslo 5, Norway

PAKISTAN
Prof. Dr Shafeeq Ahmad
The Institute of Geology
University of the Punjab
Quaid-e-Azam Campus
Lahore 54590, Pakistan

PAPUA NEW GUINEA
Dr R.H. Findlay
Chairman, IGCP National Committee
Senior Regional Geologist
Geological Survey Division
Department of Mining and Petroleum
Private Mail Bag
Port Moresby, Papua New Guinea

PARAGUAY
Dr J.H. Palmieri A.
Présidente, Comité paraguayano para el PICG
Instituto de Ciencias Basicas
Universidad Nacional del Asuncion
ciudad Universitaria
Casilla de Correo 1039
Asuncion, Paraguay

PERU
Dr J. Macharé
Soc. Geol. del Peru
P.O. Box 2559
Lima 100, Peru

POLAND
Prof. Jerzyt Fedorowski
Chairman, IGCP National Committee
Institute of Geology
Adam Mickiewicz University
ul. Maków Polnych 16
61 – 686 Poznan, Poland
e-mail: jerzy@amu.eu.pl
PORTUGAL

Executive Secretary
National Commission of Portugal for UNESCO
Coordinator – CNU Liaison Group for IGCP
Av. Infante Santo 42/5
Lisboa 1300, Portugal

REPUBLIC OF SOUTH AFRICA

Dr C. Frick
Chairman, IGCP National Committee
Chief Director, Geological Survey
Private Bag X112
Pretoria 0001, Republic of South Africa
e-mail: cfrick@geoscience.org.za
http://www.geoscience.org.za

ROMANIA

Prof. M. Sandulescu
Chairman, IGCP National Committee
Romanian Academy
Calea Victoriei 125
Bucuresti 1, Romania

RUSSIAN FEDERATION

Prof. V.A. Zharikov
Chairman, IGCP National Committee
Geological Institute of the Russian Academy of Sciences
Pyzhevsky per. 7
Moscow Zh-7 109017, Russian Federation
e-mail: igcp@geo.tv-sign.ru

SAUDI ARABIA

Dr Mohammad A. Tawfiq
Acting President
Saudi Geological Survey
P.O. Box 54141
Jeddah 21514, Saudi Arabia

SENEGAL

Professor O. Dia
Department de Géologie
Faculté des Sciences
Université Cheikh Anta Diop
Dakar-Fann, Sénégal

SIERRA LEONE

Mr Smart Kamara
Chairman, IGCP National Committee
Geological Survey Division
Ministry of Mines
New England
Freetown, Sierra Leone
SYRIA

Dr Eng. I.I. Yussef
Chairman, IGCP National Committee
The General Establishment of Geology and Mineral Resources
P.O. Box 7645
Damascus, Syria

TANZANIA

Prof. A. Mruma
Chairman IGCP National Committee
Department of Geology
University of Dar Es Salaam
P.O. Box 35052
Dar es Salaam, Tanzania
e-mail: geology@udsm.ac.tz or abdulruma@hotmail.com

THAILAND

Mr Somsak Potisat
Chairman, IGCP National Committee
Deputy Director-General
Department of Mineral Resources (DMR)
Rama 6 Rd
Bangkok 10400, Thailand

TOGO

Monsieur Père B. N’Zonou
Président, Comité national pour le PICG
Directeur général adjoint
B.P. 356
Lomé, Togo

TUNISIA

Dr H. Besbes
Président
Comité national tunisien pour le PICG
Le Métallurgique de Tunisie
9 rue Danton
1002 Tunis-Belvédère
Tunisia

TURKEY

Mrs Nükhet Karabiyikoglu
Secretary
NRC/IUGS/IGCP-Turkey
MTA Genel Müdürlügü
Jeoloji Etutleri Dairesi
06520 Ankara, Turkey
e-mail: jed@mta.gov.tr
http://www.mta.gov.tr (in Turkish language)

UGANDA

Director
Department of Geological Survey and Mines
P.O. Box 9
Entebbe 22, Uganda

UKRAINE

Academician V.N. Semenenko
Chairman, IGCP National Committee
Institute of Geological Sciences
National Academy of Sciences
Gonchara str. 55b
252601 Kiev, Ukraine

UNITED KINGDOM

Ms R. Cooper
Secretary, IGCP National Committee
The Royal Society
6 Carlton House Terrace
London SW1Y 5 AG, United Kingdom

URUGUAY

Rosario Bajo de Osuna
Chairperson, IGCP National Committee
INGEOMIN
Piso, 5, Torre Oeste, Parque Central
Caracas, 1010, Venezuela

VIET NAM

Prof. Dr Tran Van Tri
Chairperson
IGCP National Committee
Geological Survey of Viet Nam
6 Pham Ngue Lao
Hanoi, Viet Nam
e-mail: gsvbdvn.vnmail.vnd.net
e-mail: gsv@bdvn.vnmail.vnd.net

YEMEN

Dr Mohamed Fara
Chairman, IGCP National Committee
Sana’a University
Department of Geology
P.O. Box 11431
Sana’a, Yemen
YUGOSLAVIA

Prof. Dr St. Karamata
Chairman, IGCP National Committee
Rudarsko-geološki fakultet
Djusina 7
11 000 Belgrade, Yugoslavia

ZIMBABWE

Mr H. Munyanyiwa
Coordinator, IGCP National Committee
University of Zimbabwe
Geology Department
P.O. Box MP 167
Mount Pleasant
Harere, Zimbabwe
BURUNDI

Dr Audace Ntungicimpaye
Direction générale de la géologie et des Mines
Ministère de l’Energie et des mines
B.P. 745
Bujumbura

CONGO (DEMOCRATIC REPUBLIC OF)

Professor Boneza T. Rumvegeri
University of Burundi
Department of Earth Sciences
P.O. Box 2700 Bujumbura
Burundi

ETHIOPIA

Mr Amenti Abraham
Head
Regional Geology Department
Ethiopian Institute of Mines and Energy
P.O. Box 23O2
Addis Ababa

FIJI

Mr R. Rodda
for Director of Mineral Department
Mineral Resources Department
Private Mail Bag
Suva

INDONESIA

Mr P. Prijosoesilo
Indonesian Association of Geologists
Jl. Diponegoro 57
Bandung

LAO P.D.R.

Mr S. Duang Aephymani
Chief of Technical Division
Department of Geology and Mines
Vientiane

LEBANON

M. El Soufi
Conseil national de la Recherche Scientific
B.P. 11-8281
Beyrouth

LESOTHO

Dr Konka Chakela
The National University of Lesotho
P.O. Roma 180

LIBYAN ARAB JAMAHIRYA

Mr Yousef Shagrouni
Head of Geological Mapping Section
Industrial Research Centre
Geological Research and Mining Department
P.O. Box 36310

MALAWI

Mr F.R. Phiri
For: Chief Geologist
Geological Survey Deptment
P.O. Box 27
Zomba

MALI

M. Mory Kane
Ministère des Mines de l’Hydraulique et de l’Energie
Direction nationale de la géologie et des mines
B.P. 223
Bamako

MAURITANIA

Mr Mohamed Salem Ould Sabar
Chef département Géologie
I.S.S. B.P. 5026
Nouakchott
OMAN (SULTANATE OF)
M. H. Kassim
Dir. Gen. of Minerals
Ministry of Petroleum and Minerals
P.O. Box 551
Muscat

PANAMA
Sr. Julio Merida
Colegio Panameño de geólogos (COPAGE)
CÁMARA Minerq de Panamá (CAMIPA)
Apartado 10068
Panama 4

PHILIPPINES
Dr Raymundo S. Punongbayan
Chairman
National Committee on Geological Sciences
c/o Bureau of Mines and GeoSciences
Pedro Gil St.
Malate
P.O. Box 1595
Manila

QATAR
Dr I.A. El Kassas
Head
Remote Sensing Project
University of Qatar
Scientific and Applied Research Centre (SARC)
P.O. Box 2713
Doha

RWANDA
M. Marc Rugenra
Minister of Crafts
Mining and Tourism
P. O. Box 2378
Kigali

SWAZILAND
Dr Maphalala
Geological Survey and Mines Department
P.O. Box 9
Mbabane

UNITED STATES OF AMERICA
Dr Paul Hearn
U.S. Geological Survey
National Center 917
Reston, VA 20192

ZAIRE
Profesor Kanda Nkula
Directeur
Centre de Recherches Géologiques et Minières (C.R.G.M.)
Ministère de la Recherche Scientifique
B.P. 898
Kinshasa I

ZAMBIA
Mr John Tether
Director
Geological Survey Department
P.O. Box 50135
Ridgeway
Lusaka