Deformation of Crustal Rocks

Mt. Buffalo, Victoria, Australia, 2 - 6 February 1987

One hundred and thirty structural geologists met recently at Mt. Buffalo in the high country of Victoria to discuss aspects of crustal rock deformation. The international conference was hosted by the Specialist Group in Tectonics and Structural Geology (SGTSG) of the Geological Society of Australia. The conferences are held approximately every three years and provide a forum for the discussion of research results within Australia. Unfortunately there were only eleven foreign participants (from Switzerland, Italy, Austria, Canada, U.S.A. and Malaysia). However, a pleasing aspect was the sixty students who attended, highlighting a keen interest in the subject and ensuring a bright future for structural geology and tectonics in Australasia.

Topics covered at the conference under the theme of deformation of rocks included the nature and sequence of events in areas of crustal shortening and extension, rock strength and factors affecting it, and the interrelations between deformation and metamorphism. The first three days dealt with the geological evolution of three crustal provinces within the Australian continent: the Proterozoic belts of Mount Isa (north Queensland), the Arunta block (central Australia), and the Palaeozoic Lachlan fold-belt of southeastern Australia.

V.J. Morand and D.R. Gray (all speakers from Australia unless otherwise noted in this report) argued that the Wagga-Omeo metamorphic belt constitutes a region of localized high heat flow similar to that described for the Pyrenees. This belt shows no evidence of flat-lying, high-strain zones typical of metamorphic core complexes, and it is bounded by a system of steep wrench faults. Other talks by C.L. Fergusson, D.R. Gray, M.P. Stubley, C.McA. Powell, T.J. Fowler and others described the structures within the Ordovician, quartz-rich turbidites (continental margin, back-arc and fore-arc sediments), which characterize the Lachlan Fold belt, and the recognition of the toe of an accretionary prism on the south coast of New South Wales with prism build-up as early as the Late Cambrian Period (E.I. Prendergast).

The other regional sessions dealt with evolution through time of the belts of Proterozoic rocks at Mount Isa and central Australia. Evidence was presented for north and northwest-directed, thin-skinned thrusting at Mount Isa (D.E. Bettess and R.J.H. Looseveld) in contrast to previously published interpretations (Bell, T.H., 1983; *Nature*, 304, p. 493-497), and for extension involving mid-crustal detachments during upper amphibolite facies metamorphism in the eastern half of the inlier (R.J. Holcombe et al., P.J. Pearson et al.). G.S. Lister and his colleagues discussed the effects of transpressional strike-slip faulting (D_3) upon the early structures; D_2 structures were rotated from N-S into E-W orientations with the production of pop-out structures associated with D_3 thrusts.

Talks on the Arunta complex of central Australia highlighted the intraplate extensional-collisional nature of the orogen. This was based on structural relations in the eastern Arunta (P.R. James and P. Ding) and on analysis of the sedimentary succession in the Amadeus Basin (R.J. Korsch and J.F. Lindsay, R.D. Shaw). Basin analysis indicated an initial period of extension in the Late Proterozoic, another period of extension at about the Proterozoic/Cambrian boundary, and finally shortening in Late Devonian-Early Carboniferous time.

In the Harts Range area P.R. James and P. Ding have re-interpreted infrastructural basement and supracrustal cover to represent two related orogenic belts separated by a thick, complex, mid-crustal detachment zone characterized by early N-S crustal extension. In the southern Arunta, C. Amri and others have recognized a sub-horizontal shear zone in Proterozoic gneisses with a NE directed shear and have suggested opposed thrusting during the Proterozoic and Palaeozoic orogenies. Thrusting associated with the Late Devonian-Early Carboniferous event has determined the present outcrop relations of the Arunta complex (A.J. Stewart, R.Q. Oaks, W.J. Collins and C. Tessier).

Several papers dealt with more thematic topics related to crustal extension and shortening. G.S. Lister and others presented detachment models for the formation of passive continental margins, whereas M.A. Etheridge discussed the role of transfer faults (analogous to oceanic transform faults) in areas of continental extension. N.B. Woodward and E. Rutherford (U.S.A.) introduced the concept of structural lithic units and demonstrated how these control ramps in thrust-belts, while R.H. Groshong and D.J. Patterson (U.S.A.) used fault-bend folding geometries to model the Birmingham anticlinorium.

Another major theme at the conference was the strength of crustal rocks. Talks were related to mineral deformation, fluid-rock interaction effects and crustal modelling. Aspects of mineral behaviour included experimental deformation results on quartz (A. Ord and B.E. Hobbs, J. Gerretsen, J.D. Fitzgerald et al.), quartz aggregates (F.C. Luan and M.S. Patterson), quartz mylonites (S. Ralser et al.), galena (S.F. Cox) and zinc sulphide (J.L. Davidson et al.). Microstructural relations for naturally deformed plagioclase (J.H. Kruhl, Austria) and amphibole (Y. Lui and P.R. James) were also presented. The major questions raised were the nature of water weakening in quartz and the role of microcracking in quartz deformation.

The role of fluids in controlling rock-strength in the crust has been long recognized. Experimental studies on dilatancy above the brittle-ductile transition (G.J. Fischer) showed that compaction and dilatation increase with increasing pore

Figure 1: Conference participants distracted by hang-gliders from examining a granite on Mount Buffalo. Victorian high country in the background.

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fluid pressure and that dilatation decreases with increasing temperature. Fischer also described a new method for measuring permeability in tight rocks at elevated temperatures (up to 1200°C). Field studies on this aspect led to a description of structurally controlled infiltration-metasomatism involving saline fluids and high fluid-to-rock ratios in north Queensland (N.H.S. Oliver et al.), structurally controlled Ag-Pb-Zn mineralization at Elura, N.S.W. (J.A. de Roo), and the effects of fluid-to-rock ratios in the evolution of shear zones at Hilton, north Queensland (R.K. Valenta and B.E. Hobbs).

Computer modelling of the crust (B.E. Hobbs and A. Ord) provided a model to explain the driving forces in plate tectonics that does not invoke "ridge pushing" and/or "trench pulling." Variations in rock rheology with depth, coupled with thermal variations due to hot spots, generates a "convective motion" capable of driving plates.

An additional topic of the conference was illustrated by papers on porphyroblast growth relative to progressive deformation during prograde metamorphism (J. Reinhardt and M.T. Rubenach) and porphyroblast-matrix microstructural relations during syn-deformational contact metamorphism (R.H. Vernon). T.H. Bell presented a controversial

talk on reactivation of earlier foliations and de-crenulation due to shifting patterns of deformation partitioning. His work was also based on studies of porphyroblast-matrix relations.

One of the interesting outcomes of the conference was an increased awareness about the role of extensional tectonics during orogenesis, and about the oscillations between compressional and extensional events during crustal deformation. This was exemplified in talks by G.S. Lister on Miocene ductile stretching of over-thickened continental crust in the Aegean Sea, and by N. Mancktelow (Switzerland) on the Simplon fault zone in the Pennine Alps of Switzerland and northern Italy.

Conference abstracts have been published by the Geological Society of Australia (10 Martin Place, Sydney, N.S.W. Australia 2000). A selection of the conference papers will be published in a special issue of *Tectonophysics*. □

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LANDPLAN III: Geology in Urban Development

Hong Kong, 15 - 20 December 1986

Hong Kong provided a dramatic backdrop and a practical laboratory for Landplan III, organized by the Geological Society of Hong Kong, and supported by IUGS, AGID and Unesco. There were 60 participants from Hong Kong, 18 from the People's Republic of China, and some 35 from 11 other countries.

The Landplan series of meetings began in 1982 with an international conference - Landplan I - held in Bangkok on the impact of soil, geology and land-forms on land use planning in developing countries. In the aftermath of this meeting, a proposal was formulated by AGID for a program of activities aimed at promoting awareness of the role of geoscience in urban land-use planning in Southeast Asia, increasing its effective application to urban problems and initiating inter-disciplinary research applied to problems common to many cities.

Landplan II (Kuala Lumpur, April 1984) was a workshop on the role of geology in planning and development of urban centres in Southeast Asia. The present meeting continued and developed this theme, in a city where the influence of topography, climate and geology on many aspects of urban development is seen at its most striking. It has been said that Hong Kong can boast of a greater concentration of geotechnical engineering activity than anywhere else in the world. According to E.W. Brand, Head of Hong Kong's renowned Geotechnical Control Office, the range of problems and difficulties encountered here means that professional experience and judgement are even more paramount than usual in geotechnical engineering, with the geological aspects of many projects as important as the engineering ones.

Most of the eight pre-conference seminars featured Hong Kong. Among speakers from the host city was P.J. Strange who compared early maps and photographs that were used to reconstruct the original shorelines and contours of Kowloon and Hong Kong Island. R.L. Langford (Hong Kong) demonstrated the geologic mapping of a new town area (Tuen Mun, Western New Territories), where there are many problems concerned with terrain evaluation and environmental protection. T.Y. Irfan (Hong Kong) discussed the recurring hazards of landslides in Hong Kong, and a prime example of a heavily engineered, stabilized slope was available outside the seminar room at the University of Hong Kong (cf. Fig. 1).

J.L. Neilson (Australia) presented many examples of special purpose derivative maps that were critical to efficient urban planning. Additional seminars covered weathering profiles and subsurface excavations in tropical areas, site investigation and laboratory testing, marine studies for harbours, reclamations and foundations and the educational needs of geologists who wish to pursue careers in civil engineering.

In the technical sessions that followed, E.J.A. Lohman (The Netherlands), speaking as an urban planner, stressed the need for lucid information dissemination and communication between geoscientists, environmentalists and planners. It was encouraging to learn that M.R. Khawlie (Lebanon) was mapping land suitability for the development of the greater Beirut area.

Reviews were presented of the engineering geology of Manila and Kuala Lumpur as well as the complex problems of human habitation on tin and coal mine sites. A session on ground instability featured examples of landslides that occurred in India and Malaysia, earth movement monitoring

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Figure 1: Stabilizing a steep slope above a new high-rise housing block, Hong Kong. Photo courtesy of Geotechnical Control Office, Hong Kong.

in France, and slope stability assessment in Hong Kong. Problems associated with waste management and disposal within the physical environment were also discussed, with examples from Australia, Hong Kong and India. Six papers detailed the role of geohydrology in urban areas of China and its importance in the planning process, and a session on seismic risk cited studies from China, the Philippines, and France. Among other topics covered were tunnelling and the potential use of underground space in Hong Kong, use of karst caves in China, volcanic hazards at Mount Pelée, Martinique, and the preservation of geological monuments and surficial materials in and around cities.

Landplan III was undoubtedly a success, measured by the quality and the coverage, both technical and geographic, of the papers presented. However, reservations were expressed about the way the Landplan concept had evolved since 1982. First, the hoped-for emphasis on training of young geoscientists and interchange between geoscientists and planners did not materialize for Landplan III. Apart from some young local participants, those able to attend were all established in middle to senior professional positions. Second, the interest shown in Landplan III by government agencies in the region could only be described as minimal. Nearly all the participants from outside Hong Kong were academics, and there was only one government scientist from SE Asia. Third, no planners or representatives of planning agencies from Southeast Asia attended.

There are, however, some signs of improvements in regional interchange and cooperation. Several relevant IGCP projects are active in the region, dealing with Quaternary geology and aspects of natural hazards. The United Nations has the potential, if resources are available, to expand greatly its programs in this area. A significant recent event in this connection was a seminar on Geological Mapping in the Urban Environment, held at the United Nations Economic and Social Commission for Asia and the Pacific in Bangkok in October 1986. This might lead to increased governmental activity in the engineering geology field. However, efforts are needed to ensure that international meetings bring together those working in government, industry and academic research more effectively than at present.

In an open forum at the end of the conference, it was clear that participants new to Hong Kong were favourably impressed by the degree of communication and interaction there between geoscientists, engineers, environmentalists and planners, exemplified by the Geotechnical Control Office. Some expressed a need for comparable organizations in their own countries in order to more effectively bring geoscientists into the decision-making process.

A series of recommendations were pulled together by Dr. Yudhbir (India) and E.J.A. Lohman (The Netherlands) and approved by the participants. These stressed the "need for more effective communication and interaction between geoscientists, engineers and physical planners at all levels." These require coordinated regional, national and urban actions in the form of workshops, training programs, seminars and exchange programs and missions to promote the role of the geo- and environmental sciences in urban development.

Figure 2: In the exhibition hall at Landplan III.

"While AGID by its very nature should take initiatives in promoting the role of geosciences in these fields at the middle (professional) and lower (public) level . . . it should also, if needed, help various international organizations like Unesco in implementing these ideas at governmental level." The recommendations also pointed to the need for specific short courses to encourage training in engineering geology, including fieldwork.

A three member working group, consisting of a geoscientist, an engineer and a physical planner, is being set up to work out the details of these proposals and to initiate contacts at various levels. Further information may be obtained from Dr. Yudhbir, Dept. of Civil Engineering, Indian Institute of Technology, I.I.T. Post Office, Kanpur 208 016, India. □

After report by D.B. Krinsley (Reston, U.S.A.)
and D.R. Workman (Hong Kong)

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GAC Special Paper 31

The Grenville Province

Edited by J.M. Moore, A. Davidson and A.J. Baer

A synthesis of the Grenville Province of the Canadian Shield containing much new information. Examines the application of modern tectonic concepts to the solution of problems in the deeply eroded Proterozoic orogen. Tectonic modellers propose pre-Grenvillian extensional tectonics, geosutures and an island arc complex within the Province, thrust tectonics at the Grenville Front and comparison with the Himalayas. Of interest to those who work on Precambrian rocks, geochronology, geophysics, geochemistry, and economic geology.

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GEOLOGICAL ASSOCIATION OF CANADA

Geological Kinematics and Dynamics: Molecules to the Mantle

Uppsala, Sweden, 22 - 24 April 1987

European structural geologists hold an international meeting every two years to review recent progress and current problems, and the 70th birthday of Hans Ramberg was an ideal excuse to hold the 1987 meeting in Uppsala, Sweden. This conference attracted a stimulating mixture of theoreticians, experimentalists and field workers interested in the dynamics (driving forces) behind geological kinematics (movements) on all scales.

The opening theme considered geological movements on the scale where they are regarded as chemical. The lattices of single grains are sufficiently small that intracrystalline diffusion can usually be treated in terms of homogeneous equilibria (F. Seifert, F.R.G.). However, on larger scales, intracrystalline diffusion rarely reaches equilibrium in solid rocks, and Hans Ramberg suggested the principle of extreme rate of dissipation of energy to deal with this problem: strain or chemical reactions on small scales will exploit the available energy as efficiently as possible. An exciting picture began to emerge of the geometry of intercrystalline diffusion: just as there may be orientations of no finite strain, so there may be directions of no chemical potential - and identifying them in nature would offer a means of quantifying the anisotropy of diffusion (B. Bayly, and S. Gerard, U.S.A.).

The scale of the discussion increased when W. Fyfe (Canada) emphasized that the continental crust appears to incorporate as much water, CO₂ and salt as are free in the hydrosphere. Any change in this ratio would have considerable consequences for the biosphere. New light was also shed on such classical problems as ocean formation in Iceland (W. Jacoby, W. Germany) and the stability of the Baltic Shield (O. Stephansson, Sweden). The latter long thought of as the old, stable kernel of Europe, appears to be far more tectonically active than supposed and still jostles as a collection of loose fault blocks. We used to blame the stresses active in the Shield to post-glacial uplift, but their apparent similarity to those in the rest of Europe now points to a rather uniform plate-wide stress field.

Spectacularly illustrated analyses were presented of strains in different parts of the world, interspersed with theoretical developments of new techniques that might prove useful in the future (A. Fernandez and B. Ildefonce, France). Deep seismic profiles across the Swiss Alps (P. Heitzman, Switzerland) were remarkable as much for their apparent confirmation of the geological picture extrapolated from the surface down to the middle crust, as for the disappearance of the Moho beneath the suture zone. Superb pictures of deformed anhydrite in the Canadian Arctic (W. Schwerdtner, Canada), and newly recognized shear zones in Greenland (J. Grocott, U.K.) and the Pyrenees (B. van den Eeckhout, Netherlands) reminded us all of the complexities of real geology and how difficult it can be to decide whether old subhorizontal shear zones involved shortening, extension or both processes in turn.

Every geological photograph needs a scale because so many geological structures are scale invariant, that is their shapes are similar whatever their scale. Analyses of the number of rock fragments bounded by brittle fractures with others

their size find that they obey power laws. D. Turcotte (U.S.A.) argued that the three spatial dimensions of Euclidean geometry may be inadequate for structural geology and that Mandelbrot's geometry of partial (fractal) dimensions is more appropriate. Structures due to a particular mechanism (such as buckling or faulting) may only use, say 1.4 of a 2D section, leaving 0.6 of the deformation in the same section to another mechanism, such as uniform thickening or ductile shear. Structural geology, formerly based on linear relationships between stress and strain with time, is already adjusting to dealing with rocks as power law materials in time. Now it seems that we may also have to start thinking of rocks as power law materials in space.

Fracturing is so rapid, and intracrystalline diffusion occurs on such a small scale, that both processes can be studied in real space-time. Modelling larger or slower tectonic processes depends on exploiting the concept of self-similarity

Figure 1: A close-up of part of the Cap de Creus shear zone in northeastern Spain. The result of "geological kinematics" well displayed.

and on shrinking time and space to fit the laboratory. The tectonic laboratory Hans Ramberg built in the 1960s around a centrifuge and a computer in Uppsala has now been emulated by others in Europe and North America. Recently, computer-generated numerical modelling threatened to completely eclipse physical modelling. However, a new generation of physical models has appeared, sufficiently sophisticated to complement numerical models. Many of the model materials currently used are better known than the rocks they simulate (e.g. N. Mancktelow, Switzerland). Furthermore, the strains they undergo can now be quantified as readily as in computed models and more systematically than is usual in nature.

Workers from Uppsala illustrated how the complex strains suggested by 2D numerical models (e.g. H. Schmeling, Sweden) can be checked and complemented by 3D physical models produced in centrifuges equipped with either a heater or a squeeze box (G. Mulugeta, Sweden). Complex

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cycles of regressive strain are superimposed on a general progressive strain as initially horizontal layers coil ever tighter inside both convection cells sealed to the mantle (R. Weijermars, Sweden) or within rising plutons (A. Cruden, Sweden). Such models begin to explain the large range of deformation fabrics found in natural diapirs and the few specimens we have direct from the mantle.

The French school of tectonicians responded with a range of physical models scaled to the continental lithosphere, with (G. Peltzer) or without (P. Cobbold) the aid of a centrifuge. It is debateable which is more impressive, to see the ductile

lobes in the top of the lower crust in a model orogen after its brittle lid of sand has been removed - or the bottom of the lithosphere photographed from below through a transparent model asthenosphere. After this exhibition of finesses, perhaps the next meeting in this series should be held in France? □

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Urban Hydrology and Aquifer Contamination: A New Latin American Organization is Born

Cochabamba, Bolivia, 23-26 February 1987

A new Latin American groundwater association was founded recently at a regional meeting sponsored by the Association of Geoscientists for International Development (AGID). The conference was held to exchange information and experiences and to review the results of programs on groundwater pollution in Latin America. More than 80 geoscientists attended the conference from Argentina, Bolivia, Brazil, Canada, Colombia, Chile, Ecuador, Guatemala, Mexico, Paraguay, Peru, Uruguay, Venezuela and Senegal. Financial support was provided by the International Development Research Centre (IDRC).

The topics addressed included hydrodynamics, hydrochemistry, and the planning, use, management and legislation of water resources, particularly groundwater. From the papers given, it was clear that few water research projects in the region had obtained final results. Some are in an intermediate stage of development, but most water projects are only in their initial stages. Little information is available on the characteristics and behaviour of groundwater where

wells are being used to meet the ever-increasing demands for water supply. The situation is made worse by the difficulty of disseminating project results to a regional geoscientific community lacking means of regular communication.

The major problems in the region were identified as concerning groundwater contamination via industrial, domestic, agricultural and mining activities; over-exploitation of groundwater, causing serious problems in urban areas; and under-exploitation of groundwater in other places because of poor management. It was noted that some countries in the region have the facilities and infrastructure that would enable them to assist others in specific projects at lower costs than by using technical assistance from industrialized countries. However, Latin American governments seem reluctant to provide the financial support necessary to monitor and control the pollution of groundwater.

To begin to address these problems, a number of proposals were made at the Cochabamba conference. These included the promotion of joint research programs among Latin American countries, communication among geoscientists of the region, regional cooperation on projects of social and economical interest. Also needed are efforts to stimulate exchange of experience and information among Latin American countries, and ways to improve human resources in the region. To carry out these proposals the conference decided to establish a Latin American network of programs and projects on groundwater research, and to form a new association to pursue this network concept.

This Asociacion Latinoamericana de Hidrologia Subterranea para el Desarrollo (ALHSUD) has already set up an organizing committee under President Dr. Ismael Herrera, Director of the Instituto de Geofisica de la Universidad Nacional Autonoma de Mexico, and Secretary-General Ing. Victor Ricaldi, Vice President of AGID for Latin America. The Secretariat of ALHSUD is located at the AGID office in Bolivia, (address below).

Following the conference, a two day training course on groundwater pollution was held, with the assistance of J. Greenhouse, R. Farvolden and R. Gillham of the Groundwater Research Institute, University of Waterloo, Ontario, Canada. □

V. Ricaldi
Casilla 183
Cochabamba, Bolivia

Figure 1: The organizing committee for ALHSUD. L-R Nelson Ellert (Brazil), Cesar Rodriguez (Colombia), Alfredo Tineo (Argentina), Ismael Herrera (Mexico), Victor Ricaldi (Bolivia), Jorge Alvarado (Venezuela), Felix Perez (Chile) and Danilo Anton (Canada).

ISGAM: A Brazilian Review of Granites and Associated Mineralizations

Salvador de Bahia, Brazil, 21 - 31 January 1987

An international symposium on granites and their associated mineralizations was held recently in Brazil under the sponsorship of the Brazilian Geological and Geochemical societies, IUGS, and other Brazilian, French and international organizations. Prof. F.R.M. de Almeida, the "President of Honour" of the symposium and a former IUGS Vice-President, pointed out that the symposium marked two decades of progress since a Unesco-sponsored meeting in Recife was attended by a few specialists interested in comparing granites of similar ages on both sides of the Atlantic.

Regional reviews of granitic rocks in Brazil highlighted the symposium, and the published proceedings should provide an excellent reference to a region that has much to offer to the general understanding of granitic genesis and crustal evolution. For example, Brazil provides particularly good evidence of granite genesis during reworking of older crust by the Early Proterozoic Transamazonian orogeny, and it also displays very extensive suites of anorogenic (A-type) granites.

In a general review of I, S, M and A-type granites J. Lameyre (France) emphasized granites generated in oceanic crust, and the use of granites as chronological milestones. He also pointed to their potential as geodynamic index formations in the context of the evolution of Kerguelen Islands and of the continental crust of France.

The importance to crustal melting models of fluids derived from crustal and mantle sources was stressed by J. Whitney (U.S.A.), who showed how the nature of the hydrous minerals in the source can influence the composition of the melts. He noted that volatiles could be critical for metallogensis and discussed reasons for variations in fluorine, chlorine and sulphur contents. For example, he believes that volatiles from the primitive mantle were high in fluorine, whereas those from the oceanic crust were more oxidized and more chlorine-rich.

Several papers demonstrated that where abundant geochemical data are available, whether for Cordilleran (subduction-related) granites or for certain Archaean and Proterozoic suites, there are consistent geochemical signatures that evidently reflect consistent genetic patterns. The detailed relations between granites and their tectonic setting remains a matter for debate, even in the younger Phanerozoic where the tectonic setting is well established. Consequently the interpretation of secular variations in terms of tectonic setting is even more contentious.

For example, J. Tarney and others (U.K.) and H. Martin (France) used geochemical evidence to support the view that Archaean tonalites are subduction related, in broad analogy with Cordilleran plutons. Martin argued for subduction of hot, young crust on the basis of interpretation of Yb anomalies and comparison with the Southern Andes. Tarney focussed on the negative Nb anomaly of the tonalites, inferring a sub-continental mantle source, which suffered a complementary enrichment in Nb and Ta and which could subsequently be tapped by A-type magmas.

In contrast, R.W.R. Rutland and others (Australia) pointed out that tonalites form a very small proportion of Archaean granitoids in Australia. They argued that granitoids there were derived from a felsic basement to the greenstone belts. Thus, the plutons themselves were not regarded as subduction-related, although the felsic basement, from which they were derived, may have been the result of only slightly older subduction-related magmatism, as postulated by Tarney and Martin.

Substantial progress in the understanding of crustal evolution in Brazil was outlined by U.G. Cordani (Brazil), who traced successive Precambrian orogenic belts around Archaean nuclei, indicating the sources of granites. The long and well-known history of Brazil is marked by critical periods, notably the Transamazonian (2200-1800 Ma) and Brazilian cycles (900-500 Ma), the effects of which are widespread. Cordani argued that all the Brazilian continental crust, which represents 50% of the South American continent, was constituted before 500 Ma ago. He favoured a model in which some 70% of crustal growth had occurred since the end of the Archaean, though this depends on the assumption that the isotopic data from granites defined the time of primary crustal growth rather than additions to pre-existing older crust. Other authors provided compelling evidence of crustal reworking, especially during the Transamazonian event.

Figure 1: The Conference logo illustrating in the Streckeisen-IUGS triangle the major magmatic series converging toward the ideal granite composition, each arrow being related to a stage in the Wilson cycle.

In some regions, geochemical contrasts between orogenic and anorogenic granites are becoming well established. B. Bonin (France) emphasized the abrupt change from orogenic to anorogenic characteristics during crustal evolution and showed that many anorogenic granite suites appear to require a younger more primitive source than the earlier orogenic granites. The isotopic character of other anorogenic granites indicates clearly that they result from anatexis of older continental crust. The development of these magmas was illustrated by M. Pichavant (France) who compared the main characteristics of lithophile-rich leucogranite plutons with their volcanic equivalents. He employed experimental data, especially in relation to albite enrichment, controlled by high F contents in the magma, and also showed how B, Li, Sn, W and U could be enriched by magmatic processes.

The importance of fluids in the post-crystallization changes to the more evolved granite types was also discussed. D.B. Wenner (U.S.A.) reviewed the evidence on crustal and

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mantle stable isotope signatures. He demonstrated how stable isotope data reveal exchange processes in the sub-solidus state and indicate the likely location of major mineral deposits. He also showed how the data can constrain tectonic models of granite genesis, as in the Appalachians and southeast Australia. In reviewing REE distributions, B.J. Fryer (Canada) also emphasized the importance of the fugitive components, in contrast to some closed system approaches, especially in rocks associated with mineralization. In addition he stressed the major role of REE-rich accessory minerals.

Ph. Vidal (France) discussed the use and misuse of radiogenic isotopes, pointing out the possibility of changes in isotopic ratios, especially in the interval between genesis and final cooling. He illustrated radiogenic isotopic characteristics of examples of granites produced from crustal, mantle, and mixed sources (including new data from the Proterozoic of Bahia, Brazil), and he emphasized the importance of combining a number of isotopic methods and of developing new isotopic methods involving, for example, Lu and Hf.

A comprehensive review of Brazilian granitoids was opened by R.A. Fuck and others who gave a precise description of the greenstone belts of the critical area of west-central Brazil with their tonalitic orthogneisses and peraluminous granites. Among the many interesting contributions from Brazilian workers was a review of the Rondonian tin province and the famous younger anorogenic Precambrian granites (1 Ga), presented in the framework of the Amazonian craton with its different magmatic series superimposed since the Archaean (R. Dall'Agnol). N. Sial described the granitic rocks of northeast Brazil, judging their origin by precise and sophisticated data in REE and isotopes.

The interpretation of the main characteristics of the granitoids and related mineralizations in Bahia (I. McReath and P. Sabate) led to a reconstruction with oceanic episodes, active margins and collisions in a complex system involving Archaean nuclei and Transamazonian belts with important nappes. Sabate and colleagues also presented a thematic map of granulogenesis of Bahia State, integrating compositional and structural data, and utilizing the IUGS classification of plutonic rocks to show real progress in the mapping of plutonic regions. The geology of southern Brazil was covered by E. Wernick and others, who described the regional magmatic zoning of the granitoids in the late Precambrian Feliciano belt, making effective use of detailed data on zircon typology. P.T.F. Kaul stressed the geodynamic changes that occurred in south Brazil with the extensional emplacement of the large alkaline over-saturated province during late Precambrian and early Palaeozoic times. New U/Pb data on zircons and monazites from granitoids were reviewed by G. Gaal and others as reflecting Early Proterozoic crustal evolution in Bahia.

There were also many Brazilian contributions to sessions on petrology and geochemistry. J. McMurtry and colleagues concluded from petrographic and isotopic studies that the association of porphyritic granitoids with basic rocks in northeast Brazil cannot be interpreted either as the result

Figure 2: Participants on one of the ISGAM excursions examining a swarm of mafic enclaves in the Transamazonian Cansanção Monzonite, 280 km NNW of Salvador. Photo by T. Frisch.

of magmatic differentiation, or as a product of partial melting giving basic residues. From the Sr-Pb isotope evolution of Proterozoic granites in the Sao Paulo region C.G.G. Tassinari and P.N. Taylor, proposed a multi-level model of generation by partial melting of mantle, lower and upper crust. L.V.S. Nardi and E.F. Lima presented a well documented mineralogical and geochemical study of a granitic association with shoshonitic affinities from Rio Grande do Sul and its associated Cu-Sn mineralization, showing the contrast with the calc-alkaline suites. Jumping to the Patagonian Massif, C.W. Rapela and R. Caminos reviewed the upper Palaeozoic evolution of this portion of crust intruded by granitoids, which range from calcalkaline types with volcanic arc signatures to high K series and to leucogranitic intrusions. Several interesting papers on Brazilian mineral deposits were also given.

The numerous papers on Brazilian geology were supplemented by significant contributions relating to other Precambrian shields from Australia, Canada, South Africa and Sweden. A group of papers from South Africa was particularly noteworthy in relating alteration and mineralization of Archaean granitoids north of the Witwatersrand Basin to the nature of the gold and uranium in the Basin itself.

In a country where deep weathering is widespread, the participants on the conference field trips to east and northeast Brazil were impressed by the remarkable quality of many of the outcrops and by the very careful preparations that had been made, not least through the preparation of an excellent set of field guides. These and the extended Abstract Volume are published by the conference organizers, who deserve credit for an efficiently run meeting. Complete papers will be published later this year by the Brazilian Geological Society. Further details may be had from ISGAM General Secretary, Av. Paulo VI, 400-Pituba, 40 000 Salvador BA, Brazil. □

After reports by J. Lameyre, University of Paris, and R.W.R. Rutland, Canberra, Australia

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THE MEASURE OF EXCELLENCE

Inversion Tectonics

London, England, 3 - 4 March 1987

In recent years interest has been increasing in the characteristics and origins of basin inversion. The oil industry has used the term for many years to describe basins that have undergone uplift due to compression, transpression or thermal and isostatic processes. The processes of basin inversion have, however, been poorly understood in detail, and the current widening of the use and application of the term led to a meeting held recently in London. The aim of the meeting was to allow discussion of the characteristics and origins of inversion structures based on diverse studies selected to illustrate the broad current usage of the term. We sought to develop a consensus view on what was understood by inversion.

The first session commenced with a keynote talk by J. Dewey (U.K.) with perceptive insights into the possible causes of inversion structures. The remainder of the first session was devoted to modelling studies and contained some remarkable results obtained by K. McClay (U.K.) from sand box modelling of the effects of inversion above a master extension fault.

A session on the Alps, with an introductory paper by P-C. de Graciansky (France), indicated a major division in the understanding and use of the term inversion. The majority of delegates from industry objected strongly to the use of the term to describe Tethyan margin extensional fault blocks now incorporated in the Alpine thrust system.

These differences recurred during reviews of inversion in the Canadian Rockies and the East African Rift. The talks all implicitly recognized re-activation of older fault systems as an important characteristic of inversion. However, there was considerable disagreement over this usage, with several delegates stating that it should only be used for deformation

in intra-cratonic settings. There was also adverse comment on the use of the term "negative inversion" for the extensional faulting of a thrust system.

The second day was focussed primarily on processes in hydrocarbon basins and was introduced by a keynote paper on inversion in the Alpine Foreland by P. Ziegler (The Netherlands). Tertiary and Mesozoic inversion in onshore Britain and the western part of the NW European continental shelf were reviewed, and D. Roberts (U.K.) presented an excellent paper on the evidence for Tertiary uplift in the region. The occurrence and origin of inversion in parts of the southern North Sea were also discussed with excellent illustrative seismic data from M. Badley (U.K.). Adventurous examples of inversion from northern Scotland and the western margin of South America were also presented.

At the end of the meeting there was a long discussion on the wide use (to some, "abuse") of the term "inversion." It was clear that there was little support for a rigid definition of an inversion structure. The traditional use of the term for an intracratonic extensional or transtensional basin that has subsequently suffered uplift during compression or transpression was strongly supported primarily by industry delegates. However, there was also support for the application of geometric criteria to characterize and recognize inversion structures. This would promote clearer understanding of the processes involved, without restricting the term to a particular plate tectonic setting. These two views were not, however, reconciled during the discussion and remained as a significant difference of opinion at the end of the meeting. The papers presented at the meeting will be published as a Special Publication of the Geological Society of London. □

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Lunar and Planetary Scientists in Annual Reviews

Houston, Texas, 16 - 20 March 1987

The 18th Lunar and Planetary Science Conference, the premier annual review of planetary science, was held recently at the NASA Johnson Space Center, co-sponsored by IUGS through its Commission on Comparative Planetology. International interest in planetary studies appears to be growing, for attendance was up almost 15% from last year, with close to 700 registrants from 18 countries.

Topics ranged from planetary accretion, through planetary differentiation and crustal genesis, to the evolution and nature of such bodies as the early Earth, the Moon, Mars, Venus and those in the outer Solar System. Research results were not limited to studies of large planetary bodies, and there were presentations on asteroids, comets and all aspects of meteoritics, including cosmic dust and meteorite impact phenomena.

With only three concurrent sessions at any one time, it is possible to gain a true flavour of the varied and multidisciplinary nature of planetary research. For example, on one afternoon one could listen to presentations on lunar mare basalt petrogenesis, isotopic anomalies and nucleosynthesis, and the nature and evolution of the outer planets, including the enigmatic and bizarre satellites of Uranus imaged last year by the Voyager spacecraft (see Rossbacher, Episodes, March 1986). Strangely, such diversity in subject matter does not scatter one's attention. Perhaps it is because planetary geoscience has always been multidisciplinary in nature, as a result of the need to use all possible tools and techniques to understand the evolution of bodies for which the costs of gathering data are so high. Yet it is difficult to select highlights from such a range of presentations, but a few that made a personal impression are summarized below.

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In March 1986, five spacecraft encountered the comet Halley. The most impressive missions were the VEGA probes launched by the U.S.S.R. and the Giotto probe launched by the European Space Agency, which passed within a mere 600 kilometres of the nucleus at a relative speed of 68 kilometres per second. An intriguing result of the comprehensive chemical and isotopic analyses of material blown-off Halley is that carbon monoxide was the second most plentiful gas; its major source is not the comet nucleus but more likely accreted interstellar dust. This tends to confirm the suggestion that Halley is the most primitive body investigated so far in the Solar System. Another interesting observation is that the deuterium to hydrogen ratio in Halley water-ice is comparable to that of terrestrial water, strengthening the hypothesis that the original source of water on the terrestrial planets is from the accretion of cometary bodies during planetary formation.

The success of the Halley mission was in part the result of international cooperation by Soviet, European and American scientists. A comet rendezvous and an asteroid flyby mission have been identified by NASA as being of the highest scientific merit. In addition, a future Japanese mission to sample a comet nucleus is being studied. This would provide information on the processes that marked the beginning of the Solar System.

Venus is another planetary body that is the focus of close international cooperation on both the scientific and technical level. As the Earth's so-called sister planet because of its similar size, both the surface geologic history and interior structure of Venus are of interest for studies of comparable planetary evolution and in constraining models of Earth evolution. As a general rule, the larger terrestrial or silicate planets have younger surfaces and more intense and long-lived internal activity, expressed at the surface as tectonism and volcanism.

Previous Soviet analyses of the 1-2 km resolution radar images of portions of the northern hemisphere of Venus, which were supplied by the highly successful Venera 15 and 16 missions, suggested an average surface age of 1 billion years. Such age determinations are based on counting the number and size of impact craters, but there are a number of uncertainties in making absolute age determinations on this basis. A new analysis of the data, using cratering rate estimates based on the terrestrial record and observations of Earth-crossing bodies suggests that the imaged portion of the surface may be as young as 100 to 200 million years old.

One complication is the effectiveness of the dense Venusian atmosphere in filtering-out relatively weak cometary material. If only the largest cometary bodies survive passage through the Venusian atmosphere, then the mean age of the northern hemisphere could be as great as 450 million years, similar to the mean age of the Earth's crust.

Another long-standing question is whether or not there is plate-tectonic activity on Venus (see McGill, Episodes, December 1983). The Venera 15 and 16 images clearly show evidence of considerable tectonism and what has been considered the equivalent of compressional mountains belt. This by itself makes Venus unique among the terrestrial planets except the Earth. The complementary component of extensional tectonics and spreading centers may have been discovered from topographic data from the Pioneer-Venus spacecraft and radar data from the Arecibo radio telescope.

The analysis suggests that the elongated highlands known as Aphrodite Terra, which extends 21,000 km along the equatorial region of Venus, is divided into offset rectangular segments, not unlike what is observed at fracture zones that occur at mid-ocean ridges on Earth (Fig. 1). The straight

Figure 1: Part of the global topographic map of Venus, based on the Pioneer spacecraft data. Courtesy of L.S. Crumpler and J.W. Head.

northwest-trending lines mark the locations of topographic troughs and scarps resembling fracture zones. The east-northeast-trending lines locate the axes of bilateral symmetry which characterize Aphrodite Terra in directions parallel to the fracture-zone-like features and which suggest that crustal spreading may have occurred. Like mid-ocean spreading ridges on the Earth, the axes of symmetry are offset where they intercept the fracture-zone-like features. Topographic profiles across these regions suggest spreading rates of a few cm per year.

Definitive answers to many of the questions relating to Venus evolution must await the results of the Magellan Venus Radar Mapper, scheduled now for 1989 launch by NASA. To aid mission planning, V.L. Barsukov (Vice President of IUGS and Director of the Vernadsky Institute in Moscow) presented J.W. Head (member of the Magellan imaging team and chairman of the IUGG Commission on Comparative Planetology) with digital Venera 15 and 16 data.

This was not the only display of international exchange and cooperation in planetary exploration and study. There was an evening public panel session where plans for the future exploration of Mars, particularly the Mars Observer (U.S.A.) and Phobos (U.S.S.R.) missions, were discussed, as well as ideas for international cooperation. There was also a public exchange of lunar samples, with V.L. Barsukov (representing Interkosmos, the Soviet Space Agency) presenting G.T. Taylor (chairman of NASA's Lunar and Planetary Sample Team) with samples from the Luna 16, 20 and 24 missions. These samples will be made available to the scientific community for analysis.

Although it is more than 10 years since any nation launched a mission to the Moon, the origin of the meeting as the Lunar Science Conference was not forgotten. Lunar studies may not attract the same headlines as recent results of cometary and Uranus missions, but much remains to be learned. The accumulated knowledge and the unanswered questions about the Moon were featured in a session devoted to the planned Lunar Geoscience Orbiter (LGO) and future lunar exploration. Highlighting this discussion was a presentation by H. Schmitt (U.S.A.), the only geologist to conduct field work on the Moon.

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Potentially, the Moon is a scientific treasure house and an economic resource, but there are still no firm answers to such questions as its origin and why lunar rocks are magnetic when the Moon has no magnetic field. Another unresolved problem remains the source of the component KREEP (named for its high potassium, rare earths and phosphorous), which is critical in isotopic and petrogenetic modelling but which has never been observed as a discrete rock or in specific surface locations.

These questions are, in part, being addressed with existing data. For example, the most-favoured current hypothesis for the origin of the Moon is the massive impact of a Mars-sized body on the still-forming Earth. This radical hypothesis would satisfy some of the physical and chemical constraints of the Earth-Moon system. Simulations of such an impact and its consequences on very large computers indicate that such a hypothesis is possible and that the impact of body in an orbit similar to the Earth's, which results in a relatively low velocity impact, is most favorable for injecting material into Earth orbit to form the protomoon.

The question of magnetism on the Moon is now being discussed in the context of a transient concentration of magnetic flux occurring at the antipode of basin-forming impacts. The significance of this model is that much of the observed distribution of lunar crustal magnetization may be a natural consequence of impact processes. More detailed mapping of magnetic anomalies is required, however, and this and other working hypotheses must await the LGO for confirmation or denial.

Although NASA is beset with problems following the Challenger disaster and is questioning its goals, the Conference provided ample evidence that the planetary science community is still vigorous, enthusiastic and committed to addressing basic questions in comparative planetology. □

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Magmatism of Extensional Regions

Lubumbashi, Zaire, 10 - 15 August 1986

IGCP Project 227, concerning igneous processes in extensional regions, was launched in 1985 to bring together data on the extensional magmatism of the African Plate with the view of establishing comparisons with similar igneous provinces around the world. Last year, geoscientists from 15 countries on five continents gathered in Zaire for the first international conference organized by Project 227. Zaire was an appropriate venue, for it displays a wide range of geological situations related to extensional magmatism. Eastern Zaire contains a typical continental rift (the western branch of the East African Rift), with ultra-alkaline, highly potassic, undersaturated lavas, classical Na-alkaline volcanic suites, and transitional and tholeiitic basalts.

The fundamental mechanisms of mantle metasomatism at a regional scale can be established from the study of xenoliths and from constraints imposed by experimental geochemical

studies on tholeiitic, transitional, alkaline and ultra-alkaline lavas. Episodes of metasomatism in eastern Zaire have been dated, and there is a Late Proterozoic (800-700 Ma) magmatic province (carbonatites, underand over-saturated alkalis, tholeiites and plutonic rocks) with a distinctive mantle isotopic signature. This igneous province with its Cenozoic volcanism permits the evolution of mantle composition to be studied in space and time in terms of a possible multi-stage mantle metasomatism.

The Late Proterozoic carbonatitic complexes here contain economically interesting mineralization in places (e.g. Nb in Lueshite at Lueshe), a type generally associated with fenitized zones. A similar metasomatic process was invoked to explain the mineralization in the oversaturated anorogenic complexes of Niger and Nigeria. Participants in the conference field trips were able to observe the relationships between the structural features of this part of the African Rift and the associated magmatism, and discussions were held on the geodynamic significance of the latter in terms of regional extension.

Several speakers discussed the petrology and geochemistry of the volcanic products of the western and eastern branches of the East African Rift. The similarities between these two branches in terms of their volcanism is well known; in both segments continental tholeiites, transitional and alkaline, ultra-alkaline to carbonatitic lavas were erupted. But some differences were also reported concerning the ultra-alkaline products, which are highly potassic in the Great Rift and highly sodic in the Gregory Rift, a difference ascribed to mantle heterogeneity.

The succession of cycles (from oldest to youngest) from continental tholeiitic basalts and or transitional basalts through alkaline basalts and their differentiated products to transitional basalts differs from that predicted by classical modes (see Kampunzu et al., Episodes, December 1986 for a review), with important implications for asthenosphere/lithosphere dynamics during extension.

Reviews were presented of magmatism linked to the opening of the Atlantic Ocean. Included here were papers on the continental tholeiites of West Africa, which are similar to

Figure 1: The Nyiragongo stratovolcano as seen from Karasimbi, eastern Zaire.

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lavas of the eastern American margin, and on the petrological characteristics and geodynamic significance of the Mesozoic magmatism of the Benue Trough of Nigeria. Many other topics were also discussed including the volcanic Cameroon line and its comparison with the African rift volcanism, ultrabasic xenoliths in Cenozoic to Recent basalts, geophysical evidence for the presence of magma reservoirs beneath the Nyiragongo and Nyamuragira volcanoes, anorogenic ring complexes, carbonatites and kimberlites, and Precambrian magmatism and associated mineralizations.

During the last day of the conference, some general topics were identified for the continuation of IGCP 227. These include the evolution of rift volcanism in space and time, metasomatism and heterogeneity of the upper mantle, the origin of the potassic anorogenic magmatism and its structural control, the relationship between tectonic regime and associated volcanism, and the importance of hydrothermal fluids and mineralization processes.

Future activities now being planned include a workshop on the Katangan (rift-type sedimentary basin) and the Cu-Co deposits of Zambia and Zaire in the Lufilian arc of Central

Africa (Lubumbashi University, November 1987), and a workshop on Mesozoic to Holocene magmatism of the African Plate and its structural framework (Marseille, France, September 1988).

Abstracts of some 50 selected communications were published in a bilingual (French and English) volume of 120 pages by the International Center for Training and Exchanges in the Geosciences (CIFEG, 103, rue de Lille, Paris, France). The proceedings of the Lubumbashi meeting will be published by the IGCP 227 in a book devoted to a number of review articles on the Phanerozoic magmatism of the African Plate. □

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The Geology of Indochina

Ho Chi Minh City, Vietnam, 5-7 December 1986

One of the most important geological events in Indochina this century took place recently with the organization of the first conference on the geology of the region. The approximately 300 geoscientists from 26 countries who participated listened to 150 papers, 41 of which came from outside Indochina. Simultaneous translation in English, French, Vietnamese and Russian was provided.

At the opening session, the present state of knowledge of the geology of Vietnam was presented by Tran Duc Luong, Chairman of the Conference, who reviewed the results of geological investigation and mineral prospecting carried out in recent decades. D. Soulivong (Laos) summarized the development of geological exploration and mineral prospecting in Laos; while Ith Praing (Kampuchea) reported on the restoration of the Geology and Mines Branch of his country.

Advances in the stratigraphy of Vietnam over the past 25 years were reviewed by Tong Duy Thanh. Nguyen Dinh Hoe, and E.A. Yolkin correlated the Devonian strata of Southeast and Central Asia, Vietnam and Australia, and summaries were also presented of the late Paleozoic (Le Hung and Phan Cu Tien), the Triassic (Vu Khuc) and the Tertiary (Trinh Danh). Other speakers presented the results of their research from the Precambrian to the Quaternary.

Intrusive and volcanic rocks in Indochina, especially in Vietnam, were described and classified on the basis of petrology, geochemistry, origin and isotopic dating. Huynh Trung distinguished eight stages of magmatic activities, while Nguyen Kinh Quoc described 13 main episodes of volcanic activities; Permo-Triassic mafic and ultramafic complexes and related mineralization in the Da River rift zone were described by G.V. Poliakov and A.P. Krivenko (U.S.S.R.). Other topics included Mesozoic magmatism in the Dalat zone, (Nguyen Van Quyen), Paleozoic regional metamorphism, and the evolution of magmatism and metamorphism during Precambrian time (Tran Quoc Hai).

Nguyen Xuan Tung pointed out the relationship between magmatic emplacement and plate tectonics, with high-K granites always appearing in the final stages of continental rift series.

The geological structures and tectonic plans of Indochina and neighbouring areas were delineated by many geologists on the basis of geological mapping and photogeology. The territory of Vietnam was divided by Tran Van Tri into six main tectonic units, two belonging to the Paleozoic and four to the Mesozoic-Cenozoic age. K. Ichikawa (Japan) pointed out three types of Indosinian-Akiyoshi tectonic belts in eastern Asia. M. Hayashi (Japan) reviewed the Permian-Jurassic orogenic belt surrounding Kontum Massif, and the Red River suture and Arakan Yoma accretionary prism, which belong to Himalayan orogenic belt. Hoang Anh Khien presented a map of ring structures and lineaments in Vietnam, and Ngo Thuong San reviewed the tectonic features and hydrocarbon distribution of Tertiary basins in Southeast Asia. A three-day field excursion from Ho Chi Minh City to Dalat, demonstrated again that the Dalat structural zone, once considered as Hercynian, is in fact of Mesozoic-Cenozoic age.

The most abundant mineralizations in the region are of Mesozoic and Cenozoic age, and rift-related deposits play an important role. The metallogeny of Indochina was reviewed (Vu Ngoc Hai and Nguyen Nghiem Minh), as were the tectonic and metallogenic evolution of Kampuchea (Le Thac Xinh), and the geological features and mineral resources of Laos (V. Bosaykham). Gold mineralization and lateritic bauxite were emphasized by many speakers and J.C. Samama spoke about the metallogenic role of tropical weathering. Mineral deposits of tin, iron, lead, zinc, pagodite, barite, apatite and precious stones were also discussed.

The Red River plain, Mekong Delta and Western plateaus are the main groundwater regions in Vietnam. In the Red River plain, the basal formation of the Quaternary is the principal aquifer, while in the Mekong Delta four hydro-

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geological zones have been distinguished (Tran Hong Phu) with three main aquifers of Holocene, Pleistocene and Pliocene age. The hydrogeological setting of the Delta is very complicated because of intercalation of salty and fresh water aquifers. The highest aquifer is variable in water quality, and saline water intrusion is a threat to rational exploitation. The thermal and mineral waters of Vietnam were summarized by Vo Cong Nghiep and Vu Ngoc Phuong. A review of geothermal research in Asia and the rest of the world and usage of thermal sources for power-plants in various countries was presented by M. Fanelli.

Prior to the Conference three seminars and workshops were organized on Geochemical Exploration Methods in Tropical Rainforest Environments, (RMRDC/ESCAP and General Department of Geology, Vietnam), Small Scale Mining (General Department of Geology, Vietnam and Centre

d'Etudes des Matières Premières, France), and Hydrogeological Exploration Methods in Deltaic Areas, (Center of Geography and Natural Resources and Hydrogeological Department, Vietnam).

The Conference was organized by the General Department of Geology of Vietnam in collaboration with the Vietnamese Geological Society. Conference organizers issued a book prior to the meeting containing 217 abstracts and two volumes of the full proceedings. A third volume has yet to be released. □

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