Trace Fossils, Small Shelly Fossils and the Precambrian-Cambrian Boundary

St. John's, Newfoundland, Canada, 8 - 18 August 1987

The Precambrian-Cambrian boundary marks a fundamental change in Earth history, the first development of abundant skeletal and bioturbating organisms. Although there is general agreement with the principle of placing the boundary "as close as practical to the first appearance of abundant shelly fossils," marked provincialism of the earliest skeletal fossils and their virtual restriction to carbonate facies have hampered global correlation in the boundary interval (Cowie, 1985, *Episodes* v. 8, p. 93-98).

In August of 1987, fifty geologists from ten countries met to consider a possible stratotype site in eastern Newfoundland. The overall theme of the conference was correlation, and dialogue between specialists in different disciplines was encouraged by poster sessions and thematic discussions.

Small shelly fossils are critical in zoning the Precambrian-Cambrian boundary interval, particularly in the carbonate facies of central Asia. In his keynote address, J. Cowie (U.K.) pointed out the need for greater knowledge of the taxonomy and correlation of these fossils. S. Bengtson (Sweden) and S. Conway Morris (U.K.) discussed the taxonomic problems presented by the morphologic variability and multi-element nature of many small shelly fossils and showed how careful analysis of large numbers of specimens can significantly reduce the number of synonymous forms.

M.D. Brasier (U.K.) discussed the correlation of the Tethyan carbonates of Asia (including Meischucun), showing several potential horizons for correlation based on first appearance of various small shelly fossil taxa. Inter-continental correlation of small shelly fossils was more controversial, with presentations of several distinct correlations of the three candidate stratotypes. Detailed descriptions of these key sections in Siberia (N. Esakova, U.S.S.R.), Meischucun, China (Xing Yusheng, China), and Fortune Head, Newfoundland (G.M. Narbonne, Canada and E. Landing, U.S.A.) also provided lively discussions and a great deal of new information.

One major new theme of the meeting was the prospect for global correlation using trace fossils, which are especially common in siliciclastic facies where shelly fossils typically are rare and poorly preserved. Correlation in siliciclastic facies is critical, as these deposits comprise nearly 70% of exposed rocks in the boundary interval. In his keynote address, T.P. Crimes (U.K.) outlined three globally correlatable trace fossil zones that occur below the lowest trilobites. In talks on the Wernecke Mountains of north-western Canada and the Chapel Island Formation of eastern Newfoundland, Narbonne and his co-workers emphasized the fact that trace fossils are cosmopolitan, and the same genera and species can be used to zone siliciclastic strata worldwide.

J. Paczesna (Poland), G. Kumar (India) and Jiang Zhiwen (China) also pointed out the biostratigraphic potential of trace fossils. However, careful morphologic analysis, rigorous taxonomy and detailed documentation of the

stratigraphic ranges of ichnotaxa are needed for more sections, particularly in Australia and the Russian Platform, to further test the correlations. Acritarchs have not been as widely studied, but presentations by G. Vidal (Sweden), M. Moczydowski (Poland) and Xing Yusheng emphasized their potential biostratigraphic utility in the boundary interval.

In the past, paleontologic studies in the Precambrian-Cambrian boundary interval have focused upon the evolution of the biota. A major theme of the conference was the need to reconsider the effects of environmental and preservational factors on the stratigraphic distribution of these predominantly benthic fossils. E. Landing and J. Mount (U.S.A.) showed how first appearances of small shelly fossils taxa in any section are very strongly influenced by these factors, and J.P.A. Magwood (Canada) and T.P. Crimes made similar observations concerning trace fossils. All organisms are environmentally controlled to some degree, and only by carrying out detailed sedimentologic analyses in conjunction with the paleontologic studies can we assess the relative importance of evolution, ecology and preservation in controlling the stratigraphic distribution of the fossils.

Figure 1: Some members of the Precambrian-Cambrian Boundary Working Group examining the basal part of the section at Fortune Head. The arrow points to the candidate boundary stratotype point.

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Recently, there has been some concern about the possible presence of disconformities in candidate stratotype sections. P.H. Signor (U.S.A.) applied J.M. Sadler's statistical analyses of stratigraphic completeness to the three candidate stratotypes and concluded that the Newfoundland section had a much higher statistical likelihood of stratigraphic completeness in the boundary interval than the other two candidate stratotypes, but even it is not unduly thick for the length of time available for deposition.

In another keynote address, S. Bengtson pointed out that his collections of the three small shelly fossils assemblages at Meishucun have few if any species in common, and he hypothesized that marked facies shifts or stratigraphic breaks may account for this. Several participants suggested that detailed sedimentologic analyses be carried out on all candidate stratotypes to help ascertain the degree of environmental fluctuation and stratigraphic completeness in the boundary interval.

Another new development on the Precambrian-Cambrian boundary concerns the absolute age of this boundary, traditionally regarded as approximately 570-600 Ma. In a contribution to the guidebook, S. Conway Morris argued that lithostratigraphic relationships and available dates from the Avalon zone strongly suggest a younger age, perhaps around 530 Ma. His arguments received strong support from A. Benus (U.S.A.) who reported a date of 565 ± 3 Ma (based on U-Pb in zircons) for an ash bed here at Mistaken Point containing Precambrian metazoans. The stratigraphic position of this bed is more than 7 km below the Precambrian-Cambrian boundary horizon.

The conference was followed by a seven-day field trip led by E. Landing, P. Myrow, G.M. Narbonne, A. Benus and M.M. Anderson to examine the Upper Proterozoic-Lower Cambrian strata of eastern Newfoundland (Fig. 1). Interest was focused on the newly proposed Precambrian-Cambrian boundary stratotype candidate (Narbonne et al., 1987, *Canadian Journal of Earth Sciences* v. 24: p. 1277-1293). The boundary is placed at the abrupt appearance of complex

Phanerozoic-type trace fossils (*Phycodes pedum* Zone), which approximately corresponds with the first appearance of simple small shelly fossils (*Sabellidites cambriensis* interval) in the section.

Some concerns were expressed about the relative scarcity of small shelly fossils in the immediate vicinity of the boundary, and the distinct possibility that the Acadian orogeny may have reset the paleomagnetic and geochronometric signatures of the section. These considerations were offset by the extreme accessibility of the section, the apparent absence of disconformities or marked facies changes in the boundary interval, the presence of the distinctly Precambrian fossil assemblage in the underlying strata (*Harlaniella podolica* Zone), and the excellent prospects for global correlation.

At the end of the field trip, seven of the ten voting members of the Precambrian-Cambrian Boundary Working Group (of the IUGS International Commission on Stratigraphy) present voted that the section and horizon were suitable for a boundary stratotype. Further deliberations will be held in Bristol in May of 1988 before a postal ballot of the full thirty-one voting members is held.

The conference and field trip were sponsored by the Working Group, and partly supported by the Natural Sciences and Engineering Research Council of Canada and the Canadian National Committee for IGCP (Project 29). Special thanks are due to Dr. Chris Barnes for making the spacious campus and resources of Memorial University of Newfoundland available for the conference. Abstracts of the meeting and the field trip guidebook will be published in 1988 as New York State Museum Bulletin 463. □

G.M. Narbonne
Department of Geological Sciences
Queen's University
Kingston, Ontario K7L 3N6
Canada

Hutton Bicentenary: The Origin of Granites

Edinburgh, U.K., 14 - 16 September 1987

Two hundred years ago James Hutton had just spent two years searching for field evidence to support his view published in 1785 that granite formed by the crystallization of hot magma injected into cold host rocks. While travelling Scotland seeking the essential evidence, he correctly deduced the significance of unconformities and collected the basic data which satisfied him that his *Theory of the Earth* was correct. The Royal Society of Edinburgh and the Royal Society of London jointly celebrated this bicentenary recently with an international meeting in Hutton's city of Edinburgh on the topical problem of the origin of granites.

More than 300 scientists from 21 countries attended the meeting and enjoyed G.Y. Craig (U.K.) dramatic reconstruction of Hutton's presentation of his novel idea for the origin of granite in 1785. The historical context was set by W.S. Pitcher (U.K.) who reminded us of the chequered history of granite research; he gave prominence to little-known scientists whose principal failing was to be decades ahead of their time. Indeed he showed that most current ideas have long histories, though only now are they capable of being tested rigorously.

Among the main themes discussed were material and heat sources of granite magmas and their transport and emplacement mechanisms. Also dealt with were the causes of compositional diversity on all scales, including the relationships between granitoids and their volcanic products, and the role of water in magmatism and metallogensis.

The sources of granite magma have been vigorously debated in recent years. It was clear from the meeting that crustal melting is now widely accepted and that many subduction-related magmas involve the complex interplay of several processes. Recent work on the Peninsular Ranges Batholith, described by L.T. Silver (U.S.A.), reveals remarkably regular geographic variations in most isotopic and geochemical parameters, yet in detail the structure is complex and not amenable to simple mixing models. R.J. Pankhurst (U.K.) considered Andean magmatism to be closely controlled by subduction processes with occasional contributions from the deep crust. A.N. Halliday (U.S.A.) emphasised the difficulties in distinguishing the various sources involved and stated that the coexistence of mantle and crust-derived

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magmas may be common. B.W. Chappell (Australia) proposed "remagmatization" for the remobilization in the crust of earlier mantle-derived magmas. His evidence for this process comes from ion microprobe studies of U-Pb in zircons from the Bega Batholith that were presented by I.S. Williams (Australia).

Relationships between volcanism and cogenetic plutonics in New Mexico were discussed by P.W. Lipman (U.S.A.) who demonstrated that the volcanic rocks were intermittently quenched samples from the upper part of the magma chamber, whereas the plutonics preserved the integrated record of protracted crystallization. R. MacDonald (U.K.) described extreme trace element enrichments in silicic volcanics also in New Mexico, and he suggested that liquid-state processes were probably responsible. In contrast, T.H. Druitt (U.K.) described more modest variations in a calc-alkaline sequence from Oregon that are explicable in terms of crystal-liquid processes.

Anatectic processes were examined in migmatitic terrains by C. Weber (France) who showed disequilibrium processes to be common, and by S.L. Harley (U.K.) who argued for the generation of tonalitic magmas in the crust by infiltration of water into mafic granulites to generate tonalitic magmas. The various forms of S-type granite in the classical Lachlan fold belt were described by A.J.R. White (Australia), and spectacular examples of this type in the Himalayas were clearly demonstrated by P. Le Fort (France) to have their sources in gneisses of the Tibetan slab in a collision environment. Eruptive equivalents of S-type granites are known, though they are relatively rare, but a most important example of extreme S-type compositions was described in ash flow tuffs and volcanic glasses from Macusani in Peru by M. Pichavant (France). Taking a statistical overview, J.A. Pearce (U.K.) described means of discriminating different plate environments using trace elements.

A nagging problem throughout the meeting was the supply of heat for the crustal melting required by so many speakers. Whereas isotopic and geochemical parameters of granitoids are inherited directly from their parents, the heat source leaves no such convenient signature. Some answers were provided by two distinct modelling approaches. H.E. Hupert (U.K.) used fluid dynamic models to show that the advection of heat into the crust through the emplacement of basaltic sills would promote the generation of large volumes of crustal melt. E. Zen (U.S.A.) described numerical models of stacked thrust sheets to create thermal conditions suitable for melting in a greatly thickened crust.

The inverted tear-drop diapiric magma body and pluton so familiar in cartoons and cross sections was subject to some critical examination at this meeting. T.M. Harrison (U.S.A.)

used numerical models to limit to considerable depths the level above which diapirs can barely deform their enclosing rocks and continue rising. D.H.W. Hutton (U.K.) described various plutons he has analysed structurally and convincingly demonstrated the importance of local structures on emplacement.

The role of water in granitoids from hydrothermal systems to batholiths based on stable isotopes was presented in a tour de force by H.P. Taylor (U.S.A.) who highlighted the problems of low ^{18}O magma sources. The important role of water in pegmatites was demonstrated at Tanco, where A.V. Thomas (Canada) used fluid inclusion determinations to speculate that magmas existed as low as 265°C .

The Edinburgh meeting provided not only a review of current thinking, but also a forum for the discussion of some novel ideas. It is to be hoped that the spirit of James Hutton will inspire these granite researchers now to visit the field in search of the evidence! The papers presented at the Hutton meeting will be published in 1988 in the *Transactions of the Royal Society of Edinburgh: Earth Sciences*. □

W.E. Stephens
Department of Geology
University of St. Andrews
St. Andrews, Fife KY16 9ST
U.K.

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Observing the Continental Crust Through Drilling

Mora, Sweden, 7 - 10 September 1987

The third international symposium on this topic was held recently at the small town of Mora within the Siljan impact structure in Sweden and close to the site of the controversial deep gas drilling project in crystalline rock. This project and deep drilling of the continental crust for scientific purposes were the main themes of the symposium, which was attended by some 300 participants from 20 nations.

Deep drilling refers to the penetration to depths greater than 4.5 km. Such depths can be reached by slim line, wire coring techniques, but at greater depths, in so-called ultra-deep holes greater than 7 km, there are difficulties with conventional drilling and coring techniques. It was made clear that, although technically feasible, such deep drilling projects require the close and early cooperation of scientists and drilling engineers. The costs and technical problems, such as penetration rate, bit life and the effects of temperature, are considerable and increase as the fourth power of the depth.

Among the national programs reviewed was that of the U.S.S.R., the only nation so far to have drilled an ultra-deep hole. At Kola, a 12 km vertical section of Proterozoic and Archean continental crust has been sampled. There are plans to deepen Kola to 15 km and to drill 12 more deep holes in the U.S.S.R., seven in crystalline rocks.

At the time of the symposium, a fully cored, 3-5 km pilot hole was set to begin at the West German site for deep drilling in Bavaria. The main hole is planned for 12-14 km and is scheduled to be drilled in 1989-90. Considerable pre-drilling geological and geophysical investigations over a period of three years were necessary before selecting the drilling site, for the choice is not simply a scientific one but must also include technical considerations. In the case of West Germany, the other potential site at Schwarzwald was considered technically more difficult, because the pre-investigations indicated a geothermal gradient which suggested temperatures of 300°C at 7-8 km.

Other national programs reviewed included the program "Géologie Profonde de la France," which has drilled three holes, the deepest to 3.5 km, in crystalline basement. Also discussed was the U.S. drilling of the 2 km hole at Cajon Pass to study the San Andreas fault and plans for a 10 km hole in the Appalachians. Less advanced plans in the U.K. and Canada were also reviewed. It is evident that, although much can be learnt about the crust at depth, these deep holes are massive multi-disciplinary projects involving considerable monetary, technical and time investment.

A number of scientific projects that have utilized drilling, but not necessarily to great depths, were also reviewed. Among them were the highly successful Ocean Drilling Program and various projects in geothermal areas such as the Valles Caldera and Salton Sea in the U.S.A. Also noted was the scientific gains that may be made through using "holes of opportunity" drilled for commercial purposes. One such project called Upper Crust uses holes drilled to the buried Precambrian basement in the central U.S.A. This allows geologists to obtain samples for geochronologic, petrologic and geochemical studies in order to correlate

sub-surface geology with exposed terranes and geophysical data and to interpret the results in terms of models of the lithospheric evolution of North America.

As expected, there was considerable interest in the results of the hole at Siljan, which has been drilled to explore the potential of crystalline rock for methane gas. The occurrence of such gas is predicted by the controversial hypothesis of Thomas Gold (U.S.A.) that the mantle contains primordial abiogenic methane, which can leak upwards into the crust. The drill hole at Siljan is sited at Gravberg, 14 km from the center of this 52 km diameter impact structure. Earlier work had indicated a number of geochemical anomalies in the area and the hole was located over a -20 mgal gravity anomaly, with indications of seismic reflectors at depth. The hole is in Precambrian granite and has reached a depth of 6.3 km. Drilling is currently suspended.

Figure 1: Examining drill bits at Gravberg.

The hole has been extensively studied by down-hole wire logging instruments, including a geochemical logging tool and fracturing imaging with a microelectric scanner. There have been problems due to breakouts from differential stress in the fractured granite, and unlike logs in sedimentary rocks, there is no complementary data bank for correlating and evaluating the logs with changes in the properties of crystalline rocks. Unfortunately, core recovery at Gravberg has been very poor. Only 7 out of 14 coring runs contained core and they had recoveries of only 1 to 40%.

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There are five sub-horizontal, high-amplitude seismic reflectors in the area of Gravberg. Drilling results indicate that the upper three are dolerites with an associated increase in fracturing of the surrounding granite. In these areas the highest concentrations (approximately 100 ppm) of methane have been found. This is enriched in ^{13}C and gives isotopic values similar to abiogenic methane (16-26‰ $\delta^{13}\text{C}$). In the granites much lower concentrations of methane occur and are isotopically lighter than those in the dolerites. The granite methane appears to be associated with the magnetic fraction, where it may have been produced by the reaction of carbon monoxide and hydrogen with magnetite acting as a catalyst - the so-called Fischer-Tropsch reaction.

Hydrogen and helium, are also present. The latter appears to be crustal in origin, but that of the hydrogen is not known at present. It could be indigenous or produced from water by the thermal action of drilling. This so-called bit metamorphism and contamination from mud and other materials used in drilling is clearly a problem in identifying the sources of the various gases.

Although open to some interpretation, it appears that abiogenic methane gas is restricted to the dolerites. This is consistent with the isotopic data from calcite vein fillings in the granite. These were originally used as an argument for abiogenic methane in the granite, but it now appears that their isotopic trend is consistent with the simple precipitation of calcite from meteoric water.

While most participants felt there was little or no case to be made for mantle-derived methane in the granite, they were in general agreement that the hole should continue to 7.5 km, where it will penetrate the third major seismic reflector, cited as having the best potential for gas. The feeling was that unless this target was reached, there would always be some lingering doubt as to the potential of Siljan for methane gas.

The symposium emphasized what can be learnt from drilling into crystalline basement. It also stressed the large investment required for deep drilling. This means that the potential number of deep drill holes will be limited and requires that site selection must lead to solving geological problems beyond those at the particular site and must promote understanding of the continental crust elsewhere. At the same time, work must be undertaken to select areas where the deep targets of interest are at abnormally shallow depths. Given the high costs of such projects and the limited number of potential deep holes it would seem appropriate that the community give consideration to some form of international cooperation, perhaps similar to that which has been so successful in the drilling program to explore the oceanic crust. □

Richard A.F. Grieve
Geological Survey of Canada
1 Observatory Crescent, Ottawa
Canada K1A 0Y3

African Geology Reviewed

Berlin, Germany 18 - 22 August 1987

In a week when tropical thunderstorms gave way to glorious sunshine, 300 people from 41 countries converged on Berlin for the fourteenth Colloquium of African Geology. The Colloquia date back 23 years to the first meeting in Leeds, which was convened by W.Q. Kennedy in 1964, the year in which he defined the West African, Congo and Kalahari cratons and the Pan-African thermotectonic event. Alternating at regular intervals since then between the United Kingdom and continental Europe, the colloquia have grown from small gatherings, into large international meetings with parallel sessions and an international audience.

The meetings provide a forum for scientists studying all aspects of African geology, and they offer the opportunity both for European geologists working in isolation in different regions of Africa and for Africans, restricted by national boundaries, to meet and discuss their results before an international audience including eminent scientists not directly involved in Africa. The colloquia have also provided a break-through in communications between English and French-speaking geologists and between researchers working in west Africa and those operating in north, central, east and southern Africa.

Although many continents were mobile throughout the Phanerozoic, the main part of Africa was then cratonic, with fold belts only along the north-west and southern margins. In the study of ancient cratons that have been involved in more than one period of continental accretion and fragmentation, major scientific contributions have come from Africa in a wide variety of fields. These include Archaean greenstone belts and granulite terranes, Pan-African continental accretion and plate tectonics, evolution

of intracratonic basins as a function of thermal age and structure of the underlying basement, ancient glaciations, and intraplate deformations. Evidence from Africa is also important in the study of rifting and continental fragmentation, anorogenic magmatism (alkaline ring complexes, carbonatites and kimberlites), and of course in the investigation of evolution of life forms, including man, and of Quaternary climatic evolution.

Each of the previous colloquia were characterized by a particular theme often reflecting the expertise of the hosting institution. According to Russell Black (France), the 1966 and 1983 meetings in Brussels were much concerned with the interpretation of geochronological data, Sheffield (1967) and Leicester (1971) by geochemistry and the relationship between vulcanism and tectonic setting, Clermont Ferrand (1969) by the Mauritanides, Pan-African orogeny and geophysics. The 1973 colloquium in Florence focussed on the Afar triangle, Gottingen (1977) and Montpellier (1979) on the Pan-African of West Africa and the Damara; Milton Keynes (1981) on the Pan-African of northeast Africa and the Mozambique Belt and St. Andrews (1985) on alkaline anorogenic ring complexes.

The Berlin meeting was hosted by the "Special Research Project in Arid Areas," a group concentrating on projects in north-eastern Africa, in co-operation with counterpart institutions in Egypt, Sudan and Somalia. The major theme, new to the colloquia, was "Geology for Development." At the outset, delegates were told that only 1% of the world's geologists are African and that more encouragement should be given to co-operation both between Africans and Europeans and between Africans of different countries.

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Results from geotraverses by international teams in central, west and southern Africa were presented, and suggestions were made for simple ways of replenishing soil nutrients by applications of powdered rocks. "Geology for Survival" covered vital aspects of palaeoclimate and water resources in the Sahel and considered not only the characteristics of aquifers, but also the quality of different water, aspects of water storage, the effects of the Saharan climatic response to glaciation and geological support for agricultural production. Special sessions were devoted to the IUGS - Unesco programs on the Geological Application of Remote Sensing and on Mineral Deposit Modelling.

Many papers were presented on aspects of Archaean and Proterozoic rocks, with emphasis on crustal evolution and geochronology in specific regions and correlation between

Figure 1: Listening to a keynote paper at the Berlin colloquium. Dr. G. Matheis, a key organizer of the meeting, is front right, next to Dr. C. Kogbe, IUGS Vice-President and President of the Geological Society of Africa, a co-sponsor of the meeting.

different areas. Under the topic of basin analysis there were numerous reviews of lithologies ranging from Upper Proterozoic to Tertiary with several papers considering the resource potential of hydrocarbons, phosphates and bauxite. Papers on metallogeny covered not only specific metals such as Cu, Sn, Nb, Ta, W, REE, Au and Fe minerals but also considered exploration techniques and ore-forming processes. To balance these and other specific topics, five lectures were presented on continental sediments in Africa, Precambrian of northeast Africa and Arabia, the Archaean of West Africa, palaeobotany for stratigraphy, and Africa in Gondwanaland.

Representatives of international organizations and projects stressed the increasing need for co-operation between European and African scientists. In this respect it was encouraging that there were 112 participants from 28 African countries at the colloquium, including 31 from Egypt, 16 from Nigeria and 12 from Sudan. In addition, IGCP Project 255 was initiated for central Africa. This concerns the development and co-ordination of research programmes on the mineral deposits associated with the Kibaran orogeny.

Copies of the 215-page Abstract volume are available for 80FF from CIFEG, 103 Rue de Lille, 75007 Paris, France. (Editor's Note: Also available already is a 486-page volume "Current Research in African Earth Sciences," published by A.A. Balkema for \$48.50US (Postbus 1675, NL-3000 BR Rotterdam, The Netherlands). Edited by G. Matheis and H. Schandelmeier, this is a compilation of "extended abstracts from the Berlin meeting, each about 4 pages long with key illustrations and references, in the increasingly popular "short reports" format being encouraged by ICSU Press.)

The 15th Colloquium on African Geology is to be held in Nancy, France, in 1990. □

Judith Kinnaird
Department of Geology
University of St. Andrews
St. Andrews, Fife
UK KY16 9ST

Structure of Melts at High Pressures: Petrogenesis in the Mantle

Vancouver, Canada, 12 August 1987

During the last decade significant progress has been made in studies of the structure and physical properties of silicate melts over wide pressure and temperature ranges. Major progress has also been made in the determination of melting relations of mantle minerals and rocks to pressures of 25 GPa and their application to the melting of the Earth's mantle and the genesis of magmas. Papers on these two important topics were presented at a symposium held during the recent IUGG General Assembly and sponsored jointly by the IUGS Commission on Igneous and Metamorphic Petrogenesis and IAVCEI.

Melt structures based on Raman spectroscopic studies were summarized by B.O. Mysen (U.S.A.), who showed that silicate melts consist of several different structural units: monomer, dimer, chain, sheet and 3-dimensional networks.

The proportion of these units does not change significantly at pressures to 2.5 GPa, though T-O-T angles (where T represents tetrahedral cations) decrease by 2-4%.

Structural changes in silicate melts with pressure were discussed by A.L. Boettcher and others (U.S.A.) on the basis of solubility of CO₂, and by P.F. McMillan (U.S.A.) based on Raman spectroscopy. Although most Al is in tetrahedral coordination in aluminosilicate melts, the average coordination of Al most likely increases gradually with increasing pressure. E. Ohtani (Japan) proposed that at pressures greater than 6 GPa, a significant amount of Al may be in six-coordination, as observed by NMR spectroscopy and in melting relations of Al-bearing silicates. The importance of understanding the influence of quenching from above the liquidus on structural studies of ΔT was emphasized during

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the discussion. It was questioned whether samples quenched from temperatures considerably above the liquidus are representative of melt structure at the liquidus.

The viscosity of silicate melts as a function of composition and volatile (CO_2) content was discussed by D.B. Dingwell (F.R.G.) and D. Virgo (U.S.A.) who demonstrated systematic viscosity changes due to the addition of alkalis and alkali earth elements. The interaction between C-O-H fluids and silicate melts and the effects of such fluids on phase relations were discussed by R.H. Luth (U.S.A.).

The density of silicate melts at high pressures is a central factor in magma transport in the mantle. To calculate this density, partial molar volumes of oxide components applicable to high pressures were obtained by R.A. Lange (U.S.A.) and I.S.E. Carmichael (U.S.A.), based on accurate measurements of the 1-atm volumes of melts as well as on ultrasonic velocity and calorimetric data. Using these partial molar volumes of oxide components, it is possible to calculate the density of magmas at high pressures. T. Fujii (Japan) tested his calculations of densities by flotation and sinking of olivine crystals in basaltic melts at pressures to 8.5 GPa. He demonstrated that olivine does not float in melts equilibrated with peridotite to pressures of at least 8.5 GPa.

The diffusivities of Si, O, Mg and Ca in melts in the system jadeite-diopside were measured by N. Shimizu (U.S.A.) and I. Kushiro (Japan) to 2 GPa using diffusion couples with different isotopic ratios. Diffusion profiles were measured with an ion-probe. They showed that the diffusivities of Si and O increase with increasing pressure in jadeite-rich melts; whereas they decrease in diopside-rich melts. The results are consistent with viscosity changes as a function of pressure. The presence of tetrahedrally coordinated Mg in the melts was also suggested.

The genesis of magmas in subduction zones was discussed by Y. Tatsumi (Japan) in relation to dehydration in the hydrated mantle just above a subducted slab. Based on phase equilibrium experiments at high pressure, D.C. Presnall (U.S.A.) proposed that whereas primary MORB magmas are olivine tholeiites that equilibrated at 0.5-1.1 GPa, the primary magmas for Hawaiian tholeiites are picritic and equilibrated at pressures greater than 1.8 GPa.

The melting relations of peridotites and chondritic materials to pressures of 25 GPa were determined by E. Ohtani, by E. Takahashi (Japan), E. Ito (Japan) and C.M. Scarfe (Canada) and by C.T. Herzberg (U.S.A.). The compositions of liquids formed by partial melting of these materials become very olivine-rich and even peridotitic at pressures above 10 GPa, suggesting that upper mantle peridotites themselves are frozen partial melts. Ohtani demonstrated that majorite garnet is the liquidus phase over a wide pressure range (14-25 GPa). There was considerable discussion concerning the fractionation of majorite garnet versus Mg-perovskite in the early history of the Earth's mantle.

The first measurements of the attenuation of compressional waves in peridotite was reported by H. Sato (U.S.A.), I.S. Sacks and others (U.S.A.) at both subsolidus and supersolidus temperatures at pressures to 0.73 GPa. It was shown that Q decreases significantly even below the solidus. The results were used to estimate the temperature of the asthenosphere near mid-ocean ridges. □

Ikuo Kushiro
Geological Institute
University of Tokyo
7-3-1 Hongo, Tokyo 113
Japan

Christopher M. Scarfe
Department of Geology
University of Alberta
Edmonton, Alberta T6G 2E3
Canada

European Sedimentologists Meet

Krakov, Poland, 23 - 26 May 1987

Two hundred and fifty sedimentologists from 26 countries met earlier this year in the ancient city of Krakov to discuss sedimentation and the origin of sedimentary formations. This 7th European conference sponsored by the International Association of Sedimentology had two major themes: carbonate and evaporite sedimentation, and terrigenous rock formation as compared to modern sedimentary environments in oceans and inland seas.

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