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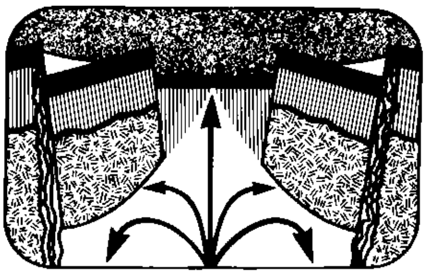

The Continental Crust and Its Mineral Deposits "The Wilson Symposium"

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This symposium, held at the University of Toronto, May 14-16, 1979, was organized with two main objectives: to honour J. Tuzo Wilson upon his recent elevation to Professor Emeritus, and to present the tangible results of research at the University supported by a five-year Negotiated Development Grant awarded by the National Research Council. The programme was arranged by a committee under the chairmanship of Professor D. W. Strangway and was designed to feature the latest ideas on the development of the earth, from its earliest stages through the evolution of the Precabrian crust to recent movements, and, within this framework, to stress the tectonic and geochemical influences on ore body formation. Of the 59 authors, 40 were invited from outside the University of Toronto, while the remainder were participants in the development grant, whose theme had been identical to that of the symposium. Approximately 300 geoscientists, many of them former students and colleagues of Tuzo Wilson, attended.

The opening paper, by Papanastassiou (California Institute of Technology) introduced changing concepts on nucleogenesis. As a result of new studies on extinct radioactivities, such as ^{26}A1, whose decay products have been found in inclusions in meteorites, the estimate of time required for nucleogenesis and the assemblage and fractionation of primeval material has been shortened to 10^{6} years. The same isotope, ^{26}A1, may well have been the heat source for the rapid melting and differentiation of meteorites. Ideas on the formation of the earth itself have not greatly changed from the hypothesis of cold accumulation of planetesimals, in favour for the past few years. Wetherill (Carnegie Institution, Washington) discussed the mechanics of planetesimal accumulation, pointing out that in spite of progress in these calculations, there remained difficulties in explaining the size distribution of the planets. In any theory of cold origin of the earth, much of the heat for initial melting and core separation must be assumed to come from impact energy. Kaula (UCLA) showed that the latter could probably provide the requisite heat, but the analysis is complicated by the action of impacts and cratering itself; for example, material thrown up by impacts will lose a portion of its heat by radiation before fallback. Jacobs (University of Cambridge) described some of the outstanding problems in the separation of the core, which is believed to have been accomplished within 20 m.y. after accretion of the earth. It is now believed that the solid inner core, of purer iron than the liquid outer core, is continuing to grow at the expense of the liquid region, and the currents set up by gravitational settling may provide motions required for the geomagnetic dynamo.

There are still differences of opinion on the formation of continental crust in Precambrian time, and its persistence to the present. Fyfe (University of Western Ontario) emphasized seawater reactions in juvenile crust, and argued for the subduction of new oceanic crust and continent-derived sediments. Very different emphasis was placed by Moorbath (Oxford), who drew on the isotopic evidence from the ancient gneisses of Greenland, and elsewhere, to argue for the significant addition of crustal material from the mantle through geological time and the resistance of continental crust, once formed, to subduction. He gave evidence that the thickness of continental crust in the Archaean was similar to that today. A point mentioned by a number of speakers was that estimates from geothermometry and geobarometry suggest a crustal temperature gradient similar to that of the present time. At first this appears paradoxical, since much greater amounts of heat from the radioactive mantle must have been escaping to the surface; the escape, according to Moorbath was not "through the thick, stabilized, geochemically differentiated, continental crust". West (University of Toronto) presented a model of Precambrian tectonics by which these early sections of thick crust may have been formed, through thermal weakening of an earlier crust, primitive subduction and eventual cratonization by horizontal compression. The present geometry of the crust is detailed geophysically by seismic reflection profiling and, in a more general way, by deep electromagnetic sounding. Oliver (Cornell) presented reflection profiles of the crust, obtained with mechanical vibrator sources, which suggest the presence of a thick wedge of sedimentary rocks underthrust beneath the Piedmont of the Appalachians. A number of Canadian groups are involved in electromagnetic sounding: measurements described by Gough (University of Alberta), Edwards, Bailey and Garland (University of Toronto) and Strangway (University of Toronto), for many parts of the continent agreed in indicating a higher electrical conductivity of the lower crust than is suggested by conventional laboratory measurements on possible rock types. However, in the course of discussion, it developed that there are additional laboratory measurements on hydrated minerals, which could possibly reconcile the field observations, if a high degree of hydration is a general feature of the lower continental crust.

Very appropriately, almost every paper on past and present-day horizontal motions emphasized the "Wilson cycle" (Table I) of ocean opening and closing, Hoffman (GSC) extending this into the Precambrian. Williams (Memorial) unravelled the complex folding and over-thrusting of eastern North America to provide an estimate of 600 km as the minimum width of the forerunner of the Atlantic Ocean ("Iapetus"). Contributions from palaeomagnetism focussed on microplates. In the Cordillera of Oregon, Cox (Stanford) identified a block a few hundreds of km in horizontal-dimension which had suffered a clockwise rotation of at least 40° relative to the surrounding crust. One explanation is that where the aesthenosphere is in a state of laminar shear, as near a transform fault, blocks of lithosphere above may be torn free and set in rotation, acting as the physical concept of a "curl metre". Irving and Monger (EMR) and Yole (Carleton) described the evidence for horizontally transported terrains or microplates in the Canadian Cordillera. Wrangellia, including Vancouver and the Queen Charlotte Islands and parts of Alaska, shifted 25° north relative to the rest of the continent, and Stikinia, comprising central and north-western British Columbia, suffering a similar 13° displacement. The unravelling of Precambrian polar wander paths was discussed by York, Dunlop and Berger (University of Toronto). Through a combination of $^{40}Ar/^{39}Ar$ dating and rock magnetic measurements of Grenville rocks, the authors established time-temperature curves for the rock units, and from the known magnetic blocking temperatures, were able to assign a date for the acquisition of magnetization of the samples. The magnetic results from Haliburton do not "see through" the Grenville orogeny, dating from 0.8 to 1.0 Ga, but they suggest correspondence with the rest of the Shield rather than a Grenville collision, unless the collision zone is southeast of the sampling sites.

In connection with the oceanic floor magnetc lineation pattern, Vine (East Anglia) discussed the progress in interpretation since the Vine-Matthews paper of 1965. He was emphatic that this pioneer work did not constitute his Ph.D. thesis, since "there wouldn't have been a snowball's chance in hell of obtaining a Ph.D. for the V. M. hypothesis in 1965". Some puzzling problems remain, including the fact that ocean-floor samples from corresponding points on either side of a mid-ocean ridge, which should have been once together, can sometimes indicate very different paleolatitudes.

The final sessions of the symposium were devoted to ore deposits. For North American participants, some of the most novel ideas came from Uyeda and Nishiwaki (Tokyo) who discussed the origin of porphyry coppers in relation to back-arc stresses. Where the stress regime behind an arc is compressive, porphyry copper development is favoured, in contrast to those arcs where minor spreading centres and normal faulting indicate a tensile regime. Processes behind the arcs were also discussed in detail by Dewey (SUNY, Albany) who correlated compressive stresses with shallow subduction, and backarc spreading and collapse with steep subduction, usually of older lithosphere. In a rather analoguous approach to that of Uyeda and Nishiwaki, Strong (Memorial) showed that North Atlantic granitoid rocks could be classified as tin-tungsten bearing or barren, depending upon whether they were Hercynian (especially two-mica granites) or Caledonian respectively. Derry reviewed the record of uranium deposits in space and time, pointing out that only 12 uranium areas account for 90 per cent of the world's known deposits. The time relationship is less clear, because many Precambrian deposits may have been grouped together into times which are very long when compared to Phanerozoic intervals. Hutchinson (University of Western Ontario) presented a classification of base metal deposits according to tectonic setting, and traced this through geologic time. University of Toronto contributions included Naldrett and MacDonald on nickel, Spooner on the role of sea-water convection in ore formation, and Scott on sulphide ores in island arcs. Naldrett and MacDonald pointed out that nickel deposits owe their locations not to unusual concentrations of nickel, which is amply abundant, but to tectonic conditions which make sulphur available. Tuzo Wilson entered actively into a discussion of this paper, specifically on the role of infall material in the Sudbury structure, assuming the latter to be an impact feature. In contrast to the authors' suggestion that the Onaping formation was formed from the fall-back, Wilson proposed that the micropegmatite of the irruptive represented assimilated infall fragments, stating that he had prepared evidence on this hypothesis for publication some years ago (one of his very few unpublished ideas!).

Wilson did not himself present a scientific paper, but he attended the entire symposium and spoke in appreciation of it at the close. Certainly almost all of his ideas, from Precambrian tectonics through continental accretion

Stage	Examples	Dominant Motions
Embryonic	E. African Rift Valleys	Uplifts
Young	Red Sea	Spreading
Mature	Atlantic Ocean	Spreading
Declining	Pacific Ocean	Shrinking
Terminal	Mediterranean Sea	Shrinking and Uplift
Relic Scar	Indus Line (Himalayas)	Shrinking and Uplift

Table I
The Wilson Cycle of Oceans (after Wilson, J.T. 1968. Static or mobile earth. The current scientific revolution: Proc. Amer. Phil. Soc., v. 112, p. 309.)

to the Wilson cycle of oceans, transform faults and hot spots, were referred to by one or more of the speakers. At the banquet which formed part of the event, Tuzo received the Albatross of the American Miscellaneous Society from the previous holder, Sir Edward Bullard. The Albatross is awarded for "unusual contributions to oceanography"; Tuzo's citation states that his was "making the faults run backwards".

The quality of the papers and the useful discussions contributed to making this symposium a most successful tribute to Wilson. Many persons remarked on the unusual cross-section of interests which this single assemblage of moderate size represented, from those concerned with the earliest times of the globe to those related to economic aspects of mineral exploration.

The papers presented will be published in a volume to be produced by the Geological Association of Canada under the Editorship of D. W. Strangway and with the support of the Geological Survey of Canada.

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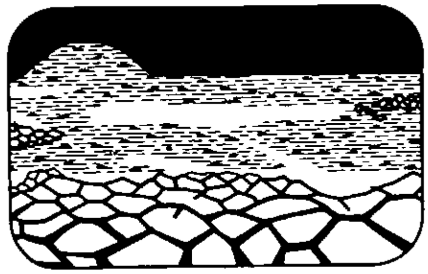

Third International Conference on Permafrost

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The Third International Conference on Permafrost, sponsored by the National Research Council of Canada through its Associate Committee on Geotechnical Research, was held in Edmonton July 10-13, 1978 attracting nearly 500 scientists and engineers from 13 countries, mainly Canada, the United States and the Soviet Union. Delegates from the People's Republic of China attended for the first time. Several countries in Western Europe were represented: Denmark, France, Netherlands, Norway, Sweden, United Kingdom and West Germany. Japan and Argentina completed the list.

The technical program, during the four days of meetings, consisted of eight invited special review papers in plenary sessions covering the state-of-the-art in various high interest aspects of permafrost science and engineering and nearly 150 submitted papers in concurrent sessions. Simultaneous translation facilities were provided in the three official languages of the Conference - English, French and Russian. Poster sessions, films and exhibits by government agencies and private firms were also part of the program. The banquet address was given by Robert F. Legget, first Director of the Division of Building Research, National Research Council of Canada in which he traced the history of permafrost observations and investigations and made a plea for increased concern of environmental considerations in future northern development. Immediately after the Conference some delegates went on conducted field trips to various regions in northern Canada.

Special Review Papers

Each half day of the technical program began with the presentation of a review paper at a plenary session followed by submitted papers in three concurrent sessions. The first of the eight presentations, by J.R. Mackay (University of British Columbia) was concerned with ground ice, which is a vital factor in cryolithogenesis (the formation of permafrost earth materials containing ice). This in turn has important considerations in permafrost engineering. The hydrogeology of permafrost terrain by P.J. Mel'nikov (Soviet Union) pointed out the need for improved methods, especially remote sensing, in mapping groundwater geology. Groundwater occurrences greatly influence the distribution of permafrost and are extremely important in future resource development. The role of vegetation in the permafrost environment and results of revegetation in disturbed areas was presented by L.C. Bliss (University of Washington). He reported that northern varieties of agronomic species are well adapted for use in revegetating northern boreal forest lands but not the High Arctic. Jerry Brown (U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)) and N.A. Grave (Soviet Union) discussed physical and thermal disturbances and protection of permafrost. Recommendations included continued observations on the past distribution of permafrost, terrain sensitivity mapping, stability of permafrost, computer modeling, long-term monitoring and development of environmental protection guidelines. The paper by W.J. Scott, J.A. Hunter (Geological Survey of Canada) and P.V. Sellmann (U.S. Army CRREL) on terrain analysis and remote sensing described the recent large advances in the use of geophysical methods to map the distribution of permafrost and identify bodies of ground ice.

Three engineering papers completed this part of the program. S.S. Vyalov (Soviet Union) presented a basic treatise on the interaction of foundations and permafrost. The two main approaches are to preserve the permafrost, or allow the permafrost to thaw during construc-