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ISSUES IN CANADIAN GEOSCIENCE

Global Geoscience - Canada's Link with the World

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SUMMARY

Geoscience is a global discipline, and geoscientists are typically world travellers who recognize the need for effective international collaboration. Canadian geoscientists, in particular, have a long history of active participation in international geoscience organizations and efforts. A notable example is the Association of Geoscientists for International Development (AGID), which was founded in Canada in 1974. Canadians are credited in establishing AGID, and have been prominent throughout its history. Other examples include the International Geological Congress, the International Union of Geological Sciences, and the International Geoscience Program (IGCP). The global nature of geoscience is demonstrated in research, the mineral and petroleum industries, and natural hazards prediction and mitigation. In spite of this global awareness within the geosciences, the importance of geoscience to the well-being of Earth and its inhabitants is not widely appreciated. International efforts to address this issue include activities such as the International Year of Planet Earth, but more must be done by granting agencies, societies such as the Geological Association of Canada, and individual geoscientists.

SUMMAIRE

Comme le mot l'indique, les disciplines des géosciences ont une portée planétaire, et les géologues sont généralement de grands voyageurs qui sont conscient de la nécessité d'une collaboration internationale efficace. Les géoscientifiques canadiens en particulier sont reconnus pour leur tradition de participation active et leurs efforts au sein d'organismes géoscientifiques internationaux. Fondée au Canada en 1974, l'Association of Geoscientists for International Development (AGID), en est un exemple remarquable. Ce sont les Canadiens qui ont fondé l'AGID et qui y ont tenu des rôles de premier plan depuis. L'International Geological Congress, l'International Union of Geological Sciences, et l'International Geoscience Program (IGCP) en sont d'autres exemples. On trouvera des indices de la nature planétaire des géosciences dans la portée de ses projets recherches, la structure organisationnelle des industries minérales et pétrolières, ainsi que dans les programmes planétaires de prévision et d'atténuation des risques naturels. En dépit du fort niveau de conscientisation qui existe au sein de la communauté géoscientifique, l'importance des géosciences sur le bien-être des habitants de la planète n'est pas très connu. L'Année internationale de la planète, est un des exemples d'activités qui vise à rehausser cette conscientisation; mais on doit faire plus, en soutenant financièrement des initiatives en ce sens de géoscientifiques et d'organismes et sociétés comme l'Association géologique du Canada.

INTRODUCTION

Geoscience is a global discipline, and many geoscientists travel widely and have worked in more than one part of the world. The purpose of this paper is to present an overview of international geoscience and the role of Canadians in this realm. It is not intended to be all embracing or to cover every aspect of the topic, and the perspective is mainly personal. Many readers could write on a similar theme but from their own perspectives. My main purpose here is to stress, through examples, the importance of global geoscience from a variety of perspectives.

Thirty-one years ago, in May 1974, two entirely unrelated events were to have a major impact on my life. First, a group of international geoscientists met in St. John's, Newfoundland, during the GAC-MAC annual meeting. One result was the establishment of an organization that eventually became known as AGID, the Association of Geoscientists for International Development, in which I later became a life member and served as Treasurer and Vice-President for Developed Countries. Second, in the same month, I began a posting with CUSO, teaching in the Department of Geological Sciences at Chiang Mai University in northern Thailand. I will begin by sharing with you some of the latter personal story of international experience, and then return to AGID and other related topics.

CUSO – FORMERLY CANADIAN UNIVERSITY SERVICE OVERSEAS

CUSO is a volunteer organization founded in 1961. It was originally university based, and recruited its volunteers from university campuses. That philosophy has evolved, and now the organization is known just by its acronym "CUSO", it has no university connection, and it places volunteers with a wide range of life experience (http://www.cuso.org/english_home.htm).

In contrast, at the time when I joined CUSO, many volunteers were new university graduates who were placed in schools or teacher-training colleges to teach English. However, I was posted to Chiang Mai University, where my job was to teach geology in the recently established Department of Geological Sciences. This experience turned out to be exceptionally rewarding, especially for a newly minted Ph.D. with a background mainly in marine geology and almost no teaching experience. I suddenly found myself teaching courses ranging from the second-year through to graduate-level; the department at that time was in the midst of establishing the first graduate program in geology in Thailand. In addition to teaching, I was able to conduct research that ultimately led to a number of publications (e.g., Barr and Macdonald, 1978, 1981; Barr et al., 1978, 1979) and a university job in Canada.

My positive experience is apparently typical of geoscience volunteers. Hastings (2004) cited several similar examples of volunteers for whom the experience became part of their life-long work. He concluded that volunteer geoscientists provided great benefits to the host and provider countries, to the scientists themselves, and to their profession.

AGID - ASSOCIATION OF GEOSCIENTISTS FOR INTERNATIONAL DEVELOPMENT

The founders of AGID believed that geoscience, and geoscientists, should play a more active role in international development. They established AGID in 1974 to provide a continuing forum for the exchange of ideas, experience, and information amongst all persons concerned with the role of the geosciences in international development. At its peak, AGID had over 2500 members from 120 countries.

To develop the history of AGID, we need to go back to August, 1972. During that month, a symposium on "Earth Science Aid to Developing Countries" was held in conjunction with the 24th International Geological Congress in Montreal. The symposium was chaired by Ward Neale (then of Memorial University of Newfoundland) and Mousseau Tremblay (Special Advisor to CIDA). The session discussed problems related to earth science aid and ways to improve its effectiveness. De Vletter and Berger (1980) summed up the discussion using a quotation from Leo Heindl of the US Geological Survey, "*The question raised at the symposium was really - how do geoscientists get the ear of those who make the decisions to give them the benefit of our professional expertise and experience?"* This question remains prominent in the minds of many geoscientists in 2005 (e.g., http://www.iugs.org/iugs/news/iugs_hazards_statement.htm).

During 1973, Ward Neale and Tony Berger (with support from GAC president W.W. Hutchison) convinced the Canadian Geoscience Council to sponsor another international workshop on Earth Science aid to developing countries during the 1974 GAC-MAC meeting in St. John's, Newfoundland. At this workshop, the formation of AGID was endorsed, and an organizing committee (including Canadians Roger Blais and Tony Berger) was established. The work of this group led to the First AGID General Assembly, held at the 25th International Geological Congress (IGC) in Sydney, Australia in 1976.

The first headquarters for AGID was in St. John's. It subsequently moved to Venezuela, Thailand, Brazil, and now Bangladesh. For most of the first twenty years of its existence, AGID received an annual grant of $100,000 from the Canadian International Development Administration (CIDA) but since 1996 the only sources of income have been membership fees, a small annual grant from the International Union of Geological Sciences, and occasional grants for specific projects. AGID has found it difficult to sustain many of its core activities and as a result membership declined and membership income fell. The voluntary efforts of AGID supporters, as well as "in kind" contributions, have allowed AGID to maintain some of its operations.

No organization is perfect, but AGID did many things right. Membership dues were kept low, especially for those in developing countries. AGID was mainly concerned with communication, which was facilitated by publication of a widely distributed international newsletter known as AGID News; 76 issues were published before the title changed in 1994 to Geoscience and Development, after which 8 issues were published (most recently in 2003; the next issue will be electronic). AGID continues to publish the "South and West Asian Geoscience Newsletter" (Issue # 48 appeared in December, 2004). AGID also published 21 books on diverse topics such as geoscience education, geohazards, groundwater, industrial minerals, urban geoscience, mineral exploration techniques, small-scale mining, sustainable mineral development policy, and environmental geology, all with special reference to developing countries.

AGID was also concerned with training and education. It sponsored and organized or co-organized over 200 separate workshops, training courses, and conferences in almost 40 countries, 90% in developing countries. Particularly valuable were the 50 "geoscience writing and editing workshops", held between 1986 and 1996 and run by a former AGID president, the late P.G. (Jerri) Cooray. AGID also established the William Greenwood Scholarships, named in appreciation of a former member, in 1990. These small grants were used to assist individual geoscience students in developing countries to carry out fieldwork in connection with their postgraduate studies. Over 50 students have been helped, and many would not have been able to complete their training without AGID support. It was one of my pleasant tasks as AGID Treasurer (1993-96), to mail out the modest funds to the scholarship recipients, and their letters of acknowledgement and gratitude were memorable.

One of the first activities of AGID was the donation of books and journals to developing country libraries. Many people were involved, especially John Moore in Ottawa and John Carman in Toronto (A. Berger, written communication, 2005). This activity was formalized in 1985 as the AGID Canada Book and Journal Donation Program, through which donated geoscience books and journals have been sent to libraries in developing countries up to the present time. In 1994, the operation became a registered charity and well over 8,000 books and 2,000 complete volumes of journals have been shipped to libraries in a wide variety of developing countries since then. The leader in these activities since the early 1990s was Owen White in Toronto. In 2004, AGID Canada decided to wind down the scheme for a variety of reasons, including the difficulty of recruiting volunteers to undertake the arduous task of packing and dispatching consignments and lack of funds for shipping the books overseas, as well as the loss of donated warehousing space. Generous donations from the mineral industry and PDAC helped in the final months of the program.

Over the years, AGID has been an effective voice for global geoscience at the grass-roots level and also on the international stage. At the 32nd International Geological Congress in Florence, Italy, in August 2004, AGID sponsored sessions on "Geoscience education for sustainable development" and "Groundwater development for poverty mitigation in low-income countries". Also, it held its regular general meeting, where a motion to disband AGID was overwhelming defeated by the members in attendance and also by postal ballot. In the light of the new global geoscience, enhanced by the ease of communication afforded by the Internet, perhaps AGID is an organization whose time has come again? Watch for the launch of the new website at www.agid-web.org.

IGC - INTERNATIONAL GEOLOGICAL CONGRESS

The IGC is a nonprofit scientific and educational organization which meets every 4 years in collaboration with, and under sponsorship of, the International Union of Geological Sciences (IUGS). The main purpose of the Congress is to encourage the advancement of fundamental and applied research in the Earth Sciences.

During the mid 19th century, the necessity of holding an international congress was strongly felt among the community of geologists in Europe and North America. In 1875, during a meeting of the American Association for the Advancement of Science in Buffalo, New York, a committee was formed to consider the organization of an international congress on geology. This committee was composed of leading geoscientists of the time, including two from Canada (T. Sterry Hunt and J. William Dawson). The Founding Committee asked the Geological Society of France to organize an international geological convention on the occasion of the Paris Exposition in 1878. The result was the First International Geological Congress, with 310 members from 23 countries in attendance. Since then, 31 additional congresses have been hosted by 21 countries throughout the world. The 32nd IGC was held in Florence, Italy, in August 2004, and was attended by over 7400 participants from 120 countries. The Congress included some 3000 oral presentations in 354 sessions, and another 3500 poster displays (S. Limaye, written communication, 2005). Through the Geohost Program, the IGC Secretariat provided financial assistance to 595 delegates from developing countries, including many AGID members. The 33rd Session will be held 5th–14th August, 2008, in Oslo, Norway, and the 34th Session is planned for Brisbane, Australia, in August, 2012.

The IGC has been held twice in Canada: 1913 (Toronto) and 1972 (Montreal). The important role of the Montreal IGC in the founding of AGID has already been mentioned, and will be again with respect to the International Geoscience Program.

IUGS - INTERNATIONAL UNION OF GEOLOGICAL SCIENCES

The IUGS was founded in 1961, with Canadian J. M. Harrison as its president. Today, with 118 national members, it is one of the largest and most active non-governmental scientific organizations in the world, and is estimated to represent about 250,000 to 500,000 earth scientists worldwide (http://www.iugs.org). The IUGS promotes the study of geological problems (especially those of world-wide significance), and supports and facilitates international and interdisciplinary cooperation in the Earth Sciences. It was founded in response to a growing need to coordinate geoscientific international research programs on a continuing basis. Geoscientists felt that a mechanism was required to take action on global geological problems between the International Geological Congresses, which are traditionally held every four years.

IUGS Commissions, Committees, Initiatives, and Task Groups are concerned with a wide range of geologic research of direct interest to governments, industry, and academic groups within the Earth Sciences. IUGC fosters dialogue and communication among the various specialists in Earth Sciences around the world and it achieves these goals by organizing international projects and meetings, sponsoring symposia and scientific field trips, and producing publications. Topics addressed span the gamut from fundamental research to its economic and industrial applications, from scientific, environmental, and social issues to educational and developmental problems. IUGS also serves as a vital link in solving problems requiring interdisciplinary input from other international scientific unions operating under the aegis of the International Council for Science (ICSU).

The IUGS Secretariat is located in Trondheim at the Geological Survey of Norway, and is financed by the Norwegian Ministry of Trade and Industry. Three Canadians are past-presidents of IUGS: J. M. Harrison, W.W. Hutchison, and W.S. Fyffe. The current Secretary-General is Canadian, Dr. Peter T. Bobrowsky. After the Asian tsunami, it was the IUGS secretariat that was the first organization to issue a strongly worded resolution on behalf of earth scientists worldwide (http://www.iugs.org/iugs/news/iugs-hazardsstatement.htm).

IGCP - Internation Geoscience Program

To geoscientists, the most well known IUGS activity is probably IGCP, whose logo is a widely recognized symbol of global geoscience. Formerly called the International Geological Correlation Program (hence the acronym), the name was changed recently to International Geoscience Program to reflect the evolving goals of the program. IGCP is co-sponsored by IUGS and UNESCO, for the latter originally through its Division of Earth Sciences and now through its Division of Ecology and Earth Sciences, and was launched in Canada in 1972 at the Montreal IGC. IGCP is among the most successful international scientific programs ever undertaken. The Canadian National Committee of IGCP (IGCP-CNC) was founded in 1974, and established as a standing committee within the Canadian Geoscience Council in 1976.

Many Canadians have been involved in IGCP as both project participants and leaders. In 2004, for example, of about 38 projects, 11 (almost 30%) had Canadian international leaders and 75% had Canadian coordinators. Over the history of IGCP, about 50% of projects have had Canadian participation (C. Gower, written communication, 2005).

Given the success of IGCP, and its importance to Canadian and global geoscience, it was ironic that, as President of the Geological Association of Canada, I received a request at the end of January, 2005, to write letters in support of an effort by the global geoscience community to reverse recent decisions by the Director-General's office of UNESCO to abolish the Division of Earth Sciences and halve the budget for the International Geoscience Program (IGCP), beginning in 2006. The longer term impacts of this decision remain uncertain, but a new structure for IGCP is being jointly developed by IUGS and UNESCO (P. Bobrowsky, personal communication, 2005), which appears promising.

The Year - International Year of Planet Earth

On an even more promising note, a new joint IUGS and UNESCO project is nearing implementation. The International Year of Planet Earth is intended to be a vigorous international endeavour, the principal goal of which is to demonstrate the enormous potential of the Earth Sciences to lay the foundations of a safer, healthier, and wealthier society. This goal leads naturally to the YEAR subtitle: Earth Sciences for Society, which will have two major lines of action - Science and Outreach.

The Science program will endeavor to provide answers to specific scientific questions vital to addressing societal needs. It is currently divided into eight broad themes:

- Groundwater: toward sustainable use
- Hazards: minimizing risk, maximizing awareness
- Earth and Health: building a safer environment
- Climate: the 'stone tape'
- Resources: sustainable power for sustainable development
- Megacities: going deeper, building safer
- Deep Earth: from crust to core
- Ocean: the abyss of time.

The Outreach program will serve the general public and promote activities including:

- Communicating progress in, and provisional results of, the science topics (above)
- Involving the general public in the research
- Sponsoring excursions and tours to geoscientifically interesting places
- Commissioning educational tools on Earth Science's significance for society
- Supporting production of Earth Science TV documentary programs
- Supporting exhibitions and events on geoscientific/societal topics
- Promoting the Earth Sciences to a wider public.

It is planned that the YEAR, actually envisioned as a three-year event, will be proclaimed through the United Nations and will involve the active collaboration of the geoscience community worldwide. On April 28th, 2005, UNESCO's Executive Board adopted a Draft Resolution, tabled by the Permanent Delegation of the United Republic of Tanzania, which invites UNESCO's Director General to support all efforts leading to the United Nations General Assembly to declare 2008, the International Year of Planet Earth. Fourteen nations, one of which was Canada, voiced their full support for this initiative. The next step will follow soon by tabling the International Year of Planet Earth on the Agenda of UNESCO's General Conference for October 2005 and by tabling a Draft Resolution for the UN General Assembly.

GLOBALIZATION

The examples cited above demonstrate that the international geoscience community is in the forefront of the current trend of increasing globalization. The geoscience role in globalization is perhaps even greater than we realize - in research, in the global economy (e.g., mineral and petroleum industries), and in terms of social issues (hazard prediction and mitigation).

Looking first at global geoscience research, a few examples will illustrate my point.

A search in "GeoRef" for the word "China" in the titles of publications for the years 1975-1980 yielded 708 hits, whereas the period 1999-2004 gave 8191 hits. Interestingly, Canada had 1572 and 2528 hits for the same time periods. As another example, I noted that the May, 2005, issue of the Elsevier journal "Tectonophysics" contains papers on the following diverse geographic areas: Aegean Sea, Japan, Greece, Morocco, Canada, Chile, Australia, Switzerland, California, France, and Central America (the 12th paper is not region specific). The authors' addresses represent an even wider range of geographic locations. As a third example, a comparison of authors of papers in 1974 and 2004 in the journal "Geology", published by the Geological Society of America, showed that in 1974 most (88%) of the authors had addresses in the USA or Canada, whereas in 2004, less than 50% had addresses in those countries (Fig. 1). Although a large increase in that 30-year period was in authors with European addresses, the increase in the number of authors from Asia is also dramatic. Looking at the scientific topics, the number of papers dealing with topics that are not region-specific has stayed approximately constant at about 25%, but the proportion on North American topics has declined from about 46% to 26%, whereas the proportions from other parts of the world have all increased (Fig. 2).

The mineral and petroleum industries have long been global. As an example, Figure 3 shows that the exploration budgets of the world's larger companies for precious-metal, base-metal, and diamond exploration in 2003 were spent all over the world. It is interesting that a high proportion of these companies (over 40%) are based in Canada. The annual meeting of the Prospectors and Developers Association of Canada (PDAC) in Toronto in March, 2005, reached an all-time high of 12,000 registrants. In all, 85 countries were represented (http://www.pdac.ca/pdac/conv/2005/summary.html).

Turning to social issues, the IGC in Florence in August, 2004, included general and special symposia on topics such as geoscience education for sustainable development, ground-water development for poverty mitigation in low-income countries, disaster management, tsunamis, engineering geology, landslides, foundations, tunnel drilling, geoscience curricula in schools, watershed development, geo-tourism, geo-parks, eco-geology, geo-ethics, and taking geosciences to society. These diverse topics indicate a significant application of geoscience in service of global society. But we must do more. A recent thought-provoking article (Mutter, 2005) vividly pointed out that poverty and disaster vulnerability are co-dependent, and vulnerability to natural variations in Earth behaviour preferentially affects the lives of the poorest. Mutter (2005) argued for the need for research on the question "How does the condition of the Earth govern and limit human well-being"? He pointed out that earth scientists uniquely have the skills to do that research, and recommended that:

1. Granting agencies must develop programs targeted toward issues of the poor world.
2. Scholarly societies must support such work.
3. Individual earth scientists must develop research programs that will help.

LOOKING FORWARD

Global geoscience comprises numerous players, a few of which have been touched on in this article. They include international organizations, industries, international aid agencies, and professional societies. All such organizations now have websites for dissemination of information, and in recent years, the Internet has become increasingly a facilitator for Global Geoscience. The ability to educate, communicate, and network, goals toward which AGID worked so hard and at so much expense, is now at our fingertips, in Canada and Worldwide. With the new global economy, are geoscientists finally poised, in the 1972 words of Leo Heindl, "to get the ear of those who make the decisions to give them the benefit of our professional expertise and experience"?

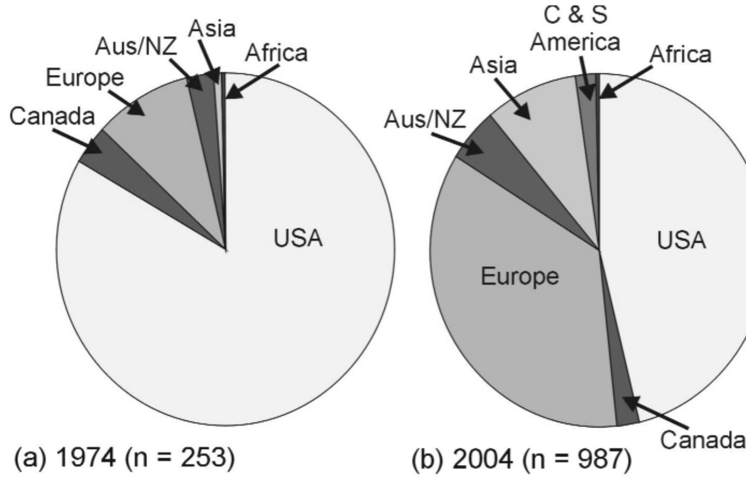

Figure 1. A comparison of the addresses of authors by region or country of papers published in (a) 1974 and (b) 2004 in the journal "Geology". "Geology" is published by the Geological Society of America, Boulder, Colorado. Abbreviations: n, total number of authors; Aus, Australia; NZ, New Zealand; USA, United States of America; C & S America; Central and South America.

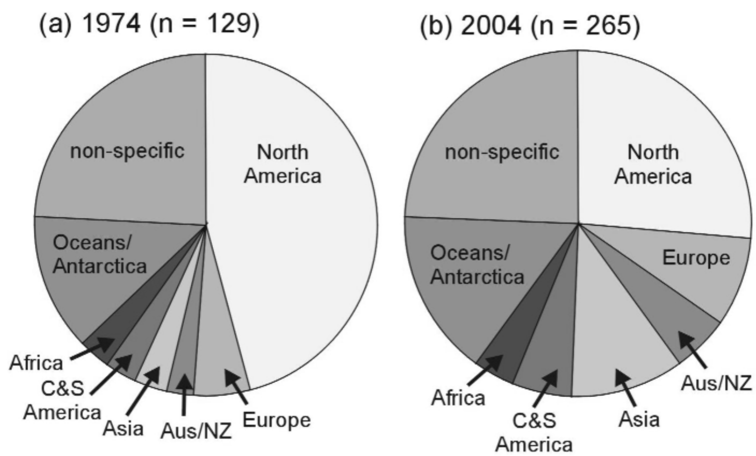

Figure 2. A comparison of the topics by region or country of papers published in (a) 1974 and (b) 2004 in the journal "Geology". "Geology" is published by the Geological Society of America, Boulder, Colorado. The non-specific category includes papers on topics not specific to any one region. Abbreviations: n, total number of authors; Aus, Australia; NZ, New Zealand; USA, United States of America; C & S America; Central and South America.

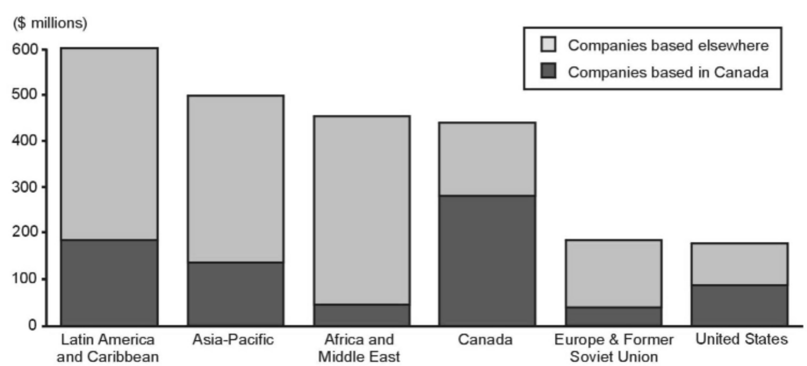

Figure 3. Exploration budget's of the World's larger companies for selected regions of the World in 2003. Companies included are those with worldwide exploration budgets of at least $4.3 million for precious-metal, base-metal, and/or diamond exploration. The diagram is modified from Canadian Intergovernmental Working Group on the Mineral Industry (2005), Fig. 39, p. 140.

ACKNOWLEDGEMENTS

The material presented here was derived from a variety of sources, in addition to personal experience and opinion. Much of the information concerning the early history of AGID was derived from the publication by de Vletter and Berger (1980), with additional details provided by Tony Berger, Tony Reedman (current AGID secretary-Treasurer) and Shrikant Limaye (Past-President, AGID). I am grateful for their encouragement in choosing the global geoscience topic for my presidential address. The following individuals also provided encouragement, as well as relevant information on the topics noted: Jim Teller (YEAR); Charles Gower (Canadian participation in IGCP); David Hastings (the role of volunteers). Saley Lawton of PDAC provided advice on finding information on the international mineral industry. The IUGS and IGC websites were the sources of much valuable detail on those organizations.

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ARTICLE

INVESTIGATIONS OF BURIAL DIAGENESIS IN CARBONATE HYDROCARBON RESERVOIR ROCKS

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SUMMARY

Investigations of burial diagenesis are instrumental for hydrocarbon exploration and exploitation. A proper investigation of diagenesis, with the aim to assist in exploration for and exploitation of hydrocarbons, should follow the "6 - Step Process". *Step 1*: facies analysis (including establishing the primary porosity and permeability distributions, and the "primary aquastratigraphy" - a term newly defined in this article); *Step 2*: petrographic analyses (paragenetic sequence, mapping amounts and spatial distribution of diagenetic phases); *Step 3*: geochemical analyses (isotopes, trace elements, fluid inclusions, etc.); *Step 4*: burial history and paleohydrology; *Step 5:* integration with extant data (especially petrophysical data), if available, and *Step 6*: modeling (not necessary, but desirable in at least some cases).

Diagenesis, at any depth from near-zero to several kilometres, is governed by various intrinsic and extrinsic factors that include thermodynamic and kinetic constraints, as well as microstructural factors. These factors govern diagenetic processes such as cementation, dissolution, compaction, recrystallization, replacement, and sulfate-hydrocarbon redox-reactions. Cementation, dissolution, and dolomitization require significant flow of groundwater (of whatever type and/or salinity, ranging from fresh to hypersaline), driven by an externally imposed hydraulic gradient. Other processes, such as stylolitization and thermochemical sulfate reduction, commonly take place without significant groundwater flow in hydrologically stagnant systems that are geochemically closed.

Two effects of diagenesis that are especially important for hydrocarbon reservoirs are enhancement and/or reduction of porosity and permeability. However, these rock properties can also remain essentially unchanged through diagenesis at depths from near-zero to several kilometres. In extreme cases, an aquifer or hydrocarbon reservoir rock can have highly enhanced porosity and permeability because of extensive mineral dissolution, or it can be plugged up by extensive mineral precipitation.

SUMMAIRE

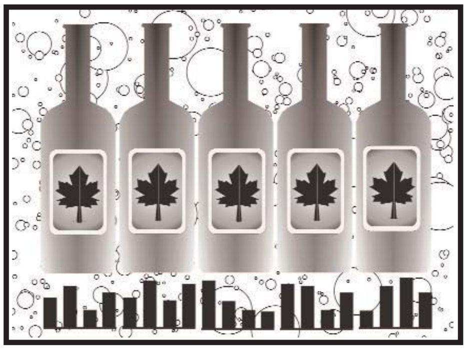
Les études de diagenèse d'enfouissement sont des instruments essentiels dans les domaines de l'exploration et de l'exploitation des hydrocarbures. Une étude de la diagenèse ayant comme objectif de contribuer à l'exploration et l'exploitation des hydrocarbures devrait suivre le processus suivant en six étapes : Étape 1) L'analyse des faciès (comportant la mesure de la distribution de la porosité et de la perméabilité initiales, ainsi que de l'" aqua-stratigraphie " - terme redéfini dans le présent article; Étape 2) Les analyses pétrographiques (séquence paragénétique, cartographie de la répartition volumique et spatiale des différentes phases diagénétiques); Étape 3) Les analyses géochimiques (isotopiques, d'éléments traces, des inclusions fluides, etc.); Étape 4) L'historique d'enfouissement et la paléohydrologie; Étape 5) L'intégration avec les données existantes (particulièrement les données pétrophysiques), et Étape 6) La modélisation (pas nécessaire mais utile dans certains cas).

Qu'il s'agisse de très faibles profondeurs ou de profondeurs de plusieurs kilomètres, la diagenèse est un phénomène qui est déterminé par des facteurs intrinsèques et extrinsèques, incluant des facteurs thermodynamiques et cinétiques, ainsi que microstructuraux. Ces facteurs déterminent des processus diagénétiques comme la cimentation, la dissolution, la compaction, la recristallisation, la substitution, ainsi que les réactions d'oxydoréduction sulfate-hydrocarbures. La cimentation, la dissolution et la dolomitisation suppose la circulation de volumes considérables d'eaux souterraines (peu importe le type et ou la salinité, qu'elles soient douces ou hypersalines), mobilisés par les gradients hydrauliques ambiants. D'autres processus comme la stylolitisation et la réduction thermochimique des sulfates, se produisent généralement sans apport substantiel en eau dans le contexte de systèmes hydrologiques stagnants et géochimiques clos.

La bonification et ou la détérioration de la porosité et de la perméabilité sont deux des effets diagénétiques particulièrement importants dans la caractéri-

sation des réservoirs d'hydrocarbures. Cependant, ces propriétés lithologiques peuvent demeurer presqu'inchangées par la diagenèse qu'elle se produise à des profondeurs faibles ou de plusieurs kilomètres. Dans les cas limites, un aquifère ou un réservoir d'hydrocarbures peut comporter des porosités et des perméabilités qui auront été grandement bonifiées par l'action d'une dissolution minérale importante, ou voir leurs pores colmatés par l'action d'une précipitation minérale importante.

SERIES



Geology and Wine 9: Regional Trace Element Fingerprinting of Canadian Wines

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SUMMARY
New, and previously determined, trace-element analyses (20 elements) for 162 wines from five regions across Canada (Nova Scotia, Quebec, Ontario (Niagara and Pelee Island) and British Columbia (Okanagan and Vancouver Island)) test the hypothesis that wines can be regionally "fingerprinted", using routine ICP-MS analyses. Exploratory statistics show that wine trace-element composition is predominantly related to region of origin and wine colour. Compared to white wines (128 samples), red wines (34 samples) have higher Rb, Cs, Sr, Ba and Mo and lower Li, U and Th. This may be explained by extraction from grape skins (Rb, Cs, Sr, Ba, Mo) and adsorption onto grape skins (Li, U, Th) during fermentation of red wines, although other explanations (e.g., bisulfite addition) cannot be ruled out. Nearly all 20 trace elements are useful for creating discrimination diagrams that separate wines by region with considerable accuracy (≥90%). The geochemical behavior of trace elements in all wines suggests that a common mechanism, the effect of climate on trace element solubility, affects trace-element concentration patterns. Further, regional average concentrations of most trace elements correlate strongly with Degree Days, indicating that more heat results in increased evaporation, which in turn increases water uptake, thus yielding higher trace-element concentrations in grapes. High Sr and Ba in Okanagan wines may be derived from alkaline soils in this semi-arid environment. Thus, terroir-related climate and soil differences lead to quantifiable trace-element fingerprints for Canadian wines by region.

SUMMAIRE
Les résultats précédents et récents d'analyses d'éléments traces (20 éléments) sur 162 vins provenant de cinq régions du Canada (Nouvelle-Écosse, Québec, Ontario (Niagara et île Pelee) et de Colombie-Britannique (l'Okanagan et l'île de Vancouver)) permettent de tester l'hypothèse selon laquelle il serait possible de caractériser régionalement les vins à partir d'analyses de routine de SM/PIHF. Une analyse exploratoire statistique des résultats montre que la composition en éléments traces est principalement reliée à la région d'origine des vins et à leur couleur. Comparés aux vins blancs (128 échantillons), les vins rouges (34 échantillons) ont des teneurs plus élevés en Rb, Cs, Sr, Ba et Mo, et moins élevés en Li, U et Th. Cela pourrait s'expliquer par un phénomène d'extraction à partir des peaux de raisin (Rb, Cs, Sr, Ba, Mo) et d'adsorption sur les peaux de raisin (Li, U, Th) durant la fermentation des vins rouges, bien qu'on ne puisse exclure d'autres explications telle (l'ajout de bisulfite par ex.). Presque chacun des 20 éléments traces contribue à la réalisation de diagrammes de différenciation qui permettent de départager les vins par région avec une grande précision (=90 %). Le comportement des éléments traces dans tous les vins permettent de penser qu'un mécanisme commun, soit l'effet du climat sur la solubilité des éléments traces, affecte les profils de concentration en éléments traces. De plus, les concentrations régionales moyennes de la plupart des éléments traces montrent qu'il existe une forte corrélation avec les degrés-jours, ce qui indique qu'un surplus de chaleur amène un accroissement de l'évaporation, ce qui entraîne un accroissement de l'absorption d'eau, ce qui explique les plus fortes teneurs en éléments traces des vins. Les fortes teneurs en Sr et en Ba des vins de l'Okanagan pourraient s'expliquer par ses sols alcalins dans un environnement semi-aride. Et c'est ainsi que les facteurs climatiques et pédologiques permettent la caractériser de manière quantifiable les vins canadiens par région.

Reviews

Geochronology: Linking the isotopic record with Petrology and Textures

Reviewed by W.J. Davis
Geological Survey of Canada

In determining the age of minerals and rocks it is often possible to derive a precise number that can be interpreted as a date, it is another matter to accurately interpret the number in terms of the timing of a discrete geological event or process. This is the challenge addressed by the contributors to an edited volume in the Geological Society Special Publication series entitled Geochronology: Linking the isotopic record with petrology and textures. The volume consists of fourteen papers derived from a special symposium held at the 2002 Goldschmidt Conference in Davos, Switzerland.

Advances in analytical capabilities over the past 10-15 years allow geochronological studies to be carried out at a scale similar to petrological observation and within the realm of mineral processes. A variety of techniques is now available for high spatial resolution isotopic analyses (ion probe, laser ablation; microsampling). For example, reduction in sample size using careful grain selection or in situ methods permit isotopic analysis at the sub-50 µm scale. The power of these technical advances, and the importance of understanding the context in which they are applied, is highlighted by the papers in this volume.

The topic is very broad and this is reflected in the range of papers from detailed technical notes on analytical methods to a review paper on metamorphic reaction rates. As a single collection, the book is not a definitive representation of the current state of knowledge within any one area as only a handful of papers are of a review nature. This is alleviated somewhat by a very useful introductory chapter by the editors that outlines the current state of knowledge, ties the disparate papers together, and provides a solid reference list.

The volume is divided into four sections of unequal length: 1) Improving the link between accessory phase chronometers and petrological information; 2) Advances in the chronometry of major minerals – prograde histories; 3) Texturally controlled ('in situ') chronometry; and 4) Understanding transport processes in rocks.

The three papers in the first section focus on petrological observations combined with trace element and isotopic data of accessory minerals to link their formation with major mineral phases, and ultimately to the pressure-temperature-time path of metamorphic rocks. The paper by Foster and Parrish on metamorphic monazite is a useful review that also contains some new ideas on establishing monazite within a quantitative metamorphic framework. Papers by Whitehouse, and Moller et al. are good examples of the type of information that can be extracted through integrated trace element and isotopic analyses of zircon

The second section contains four papers on dating major rock forming minerals. The paper by Anczkiewicz and Thirlwall is a technical paper dealing with improved analytical methods for preparing garnet for Sm-Nd analyses. The paper by Stowell and Tinkham provides a case study integrating geobarometric data with Sm-Nd garnet age dating in the Cordillera of western USA. Zheng et al. use stable isotope data to demonstrate the importance of evaluating chemical and isotopic equilibrium in the interpretation of isotopic mineral isochrons. Romer and Rotzler demonstrate the importance of understanding the reaction history of metamorphic rocks for accurate interpretation of U-Pb data in metamorphic titanite.

Cliff and Meffan-Main's paper in the section on texturally controlled 'in situ' chronometry further highlights the importance of considering isotopic disequilibrium. Careful in situ microsampling of petrologically defined domains is used to isolate material that attained equilibrium at different times. VanHaecke et al.'s paper on using ICP-MS for Rb-Sr analyses, although an interesting technical investigation, seems at odds with the overall theme of increasing accuracy through increased analytical and contextual precision.

The last section includes five papers focused on transport processes in rocks and their role in interpreting geochronological data. As the editors point out, our generally poor understanding of these processes remains a major impediment. Baxter presents a useful review of natural metamorphic reaction rates and suggests the discrepancy between lab based and natural estimates for regional metamorphic reactions reflects the very important role fluids play in rock reactions. Kriegsman and Nystrom present a review of melt segregation rates in migmatites along with a companion paper outlining a detailed case study. Papers by Wartho and Kelly and Kramar deal with in situ argon geochronology and the interpretation of diffusion profiles. The important role of fluids and deformation to the interpretation of thermal histories of minerals is highlighted.

In general, the papers in this volume are well presented and illustrated.

The index is particularly useful. The volume will be of general interest to geochronologists and metamorphic petrologists. Its message of employing multiple analytical techniques to fully interpret geochronological data within petrological context represents the current benchmark for accurate geochronological calibration of polymetamorphosed rocks in orogenic belts.

Encyclopedia of Sediments and Sedimentary Rocks

Edited by Gerard V. Middleton
Kluwer Academic Publishers
P.O. Box 17, 3300 AA Dordrecht, The Netherlands
2003, 928 p., US$390.00, hardbound
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Reviewed by Robert B. MacNaughton, Benoit Beauchamp, Keith Dewing, I. Rod Smith, Nick Wilson, and John-Paul Zonneveld
Geological Survey of Canada (Calgary)

Encyclopedias occupy an uncertain position on the intellectual landscape. Embattled teachers may revile them as purveyors of superficial information, much favoured by students seeking to complete term papers with minimal research. And yet, a well-prepared, rigourous encyclopedia is an invaluable learning resource and reference compendium that can command immense loyalty from its users. So enamoured was Aldous Huxley of *Encyclopedia Britannica* that he seldom travelled without at least one volume, and his entire set once accompanied him on a world cruise. Now, Gerry Middleton has edited a new encyclopedia devoted to sediments and sedimentary rocks, a Herculean volume that runs to 821 pages of main text (including index), divided among more than 250 subject entries. Reviewing so massive a distillation of sedimentological information would daunt even the most enthusiastic polymath, and so we six scientists who have contributed to this review have divided our labour. Each of us has read a number of entries, some in our areas of specialty, some not. Although we have not tried to read every entry in the volume, we have studied enough of it to form a group consensus regarding its many merits, tempered by the recognition of some problems that are probably unavoidable in any book of this scale. We are unanimous that this volume is user-friendly, broadly summarizes an immense body of knowledge, and should become the intellectual travelling companion of any student or professional of the field of sedimentary geology.

The encyclopedia has benefitted from an army of top-notch workers, helmed as it is by Professor Middleton and four associate editors (Michael Church, Mario Coniglio, Lawrence Hardie, and Frederick Longstaffe) and anchored by an impressive roster of authors, the names of many of whom will bring nods of agreement at the propriety of their having been chosen to contribute. Thanks to the good efforts of so many people, many things about the book deserve unalloyed praise. It provides an entry point into numerous topics through entries that are, on the whole, up to date and of high quality. At their best, the sections in the encyclopedia provide adequate background data, sufficient illustrations to support their written explanations, and appropriate references for the interested reader wishing to delve into more specialized aspects. Indexing is thorough and the editors provide a very powerful tool by cross-referencing related topics. Treatment of topics is relatively basic and thus accessible to the broadest range of users, and coverage of historical developments is balanced with current thinking. A specialist may not learn much that is new about her or his field but will find much new and interesting information when reviewing entries from unfamiliar fields. The book is attractively and durably bound, the paper, typeface, and page layouts are easy on the eyes, and line drawings are generally clear and reproduced at an appropriate size.

It is probably inevitable that any volume of this size and scope, written by one-hundred and ninety-three contributors, will suffer from some unevenness in tone and level of treatment. Editors must make decisions about how material is to be partitioned and not everyone will agree with an editor's choices. Editors must also impose standards as to writing style and level of treatment, but not all authors will faithfully follow an editor's instructions. It is also probably inevitable that six geologists will not stay unanimous for very long. Thus, our opinions diverge on the question of how consistent the book is in its overall treatment of its subjects. Four of us, in particular, were struck by some unevenness, wondering if the editors had wielded sufficient control on the format, length, and general level of treatment of various subjects. Although variability in these matters does not detract excessively from the encyclopedia's overall usefulness, it does mean that some entries are more helpful than others.

An example of this variability is provided by significant variations in depth of treatment. In some cases this reflects the relative significance of topics. Yet in other instances the handling of subjects is genuinely uneven. Some contributors seem to have written their articles with an encyclopedic format very much in mind. Such articles concisely but thoroughly cover the history of a concept, as well as its modern context. Those topics presented with a methodical approach are fine examples of how the encyclopedic format should work, e.g. the treatments of alluvial fans and of fluid inclusions. Some other entries are all right as far as they go but are marked by odd omissions or curious redundancies. For example, the rather terse section on storm deposits deals at moderate length with the formation of hummocky cross-stratification, a subject dealt with at length in a separate entry. It also briefly discusses currents and suspended sediment, but it essentially ignores carbonate and mixed carbonate-siliciclastic storm deposits. Similarly, the section on debris flows is almost entirely devoted to subaerial examples. There are entries that ably document a concept's history but say little about the state of the art (see, for example, "Sedimentary Structures as Way-up Indicators"); others present only a summary of the latest research. Neither approach is necessarily invalid, but the emphasis in some entries seems to depend more on authorial enthusiasms than on editorial oversight. Of course, it may just as well be to the credit of the editor and associate editors that the book is as uniform in style, content, and breadth as it is!

The partitioning of larger subjects is, perhaps, more likely to reflect editorial decisions. Certainly, the editors had little choice other than to group subjects into larger themes; the alternative–to include a heading for every single topic–would have produced a dictionary rather than an encyclopedia. Nonetheless, there is a good deal of inconsistency in how subjects are broken down. For example, topics dealing with carbonate rocks are finely divided, including short, separate entries as limited in scope as "Tufas and Travertines", "Stromatolites", "Ancient Karst", and "Cements and Cementation". Most of these short entries are excellent; they summarize the recent literature and briefly discuss possible interpretations. By contrast, a large subject like "evaporites" is treated in a single entry, in which, in limited space, the authors attempt to produce an encyclopedic entry covering such disparate topics as the economic uses, social history, environment of formation, and geochemistry of evaporites, as well as the Phanerozoic evolution of seawater. Many of these topics could have used a separate entry. Yet, coverage of some topics is repetitive. Soft-sediment deformation structures are treated in detailed entries that focus on individual types of structure, but also in an overview article that is superficial and mainly repeats what is stated more effectively in the detailed entries. There are also strange overlappings and splittings of topics in some of the book's otherwise excellent historical/biographical entries. A brief biographical sketch of R.A. Bagnold is largely repeated in a more entertaining entry focused on his scientific contributions. "Sedimentology, History" is a useful overview but is focused almost entirely on Europe and North America; meanwhile, the history of Japanese sedimentology is in a separate entry. A section devoted to "Sedimentology–Organizations, Meetings, Publications" covers organisations reasonably well and provides a cursory discussion of journals and special publications. However, with regard to conferences, this section provides only a list of generalities and platitudes about what conferences are supposed to achieve. Treatment of economic aspects of sedimentary rocks also is regrettably patchy. Placers are well represented, but laterites are absent and the discussion of "Bauxite" focuses on spectroscopic characterization, omitting any mention of the origin of bauxite. Other sediment-hosted ores (SEDEX, banded iron, or MVT lead-zinc) are not treated.

As noted above, the illustrations are generally of good to excellent quality. However, there are strange omissions here as well; flame structures, which are strikingly visual features, are described without any accompanying photograph or sketch. Sizing and choice of images are not everywhere optimal. In the section on glacial sediments, Figure G12 takes half a page to show a braided river emanating from a glacier terminus that is not even clearly visible in the picture. Referencing is also somewhat uneven, as in the well-written section on "Substrate-Controlled Ichnofacies", which excludes some key references from the past decade. In some cases, the editors have missed an opportunity by not requiring contributors to develop more comprehensive bibliographies, which would have been a particular boon to novice users.

But enough of criticism, for this book's failings pale alongside its virtues. The book will be useful to graduate students, senior undergraduates, and practicing sedimentary geologists of all stripes; every practicioner of sedimentary geology should have access to a copy. It deserves a place on every desktop but the very high price–about $475 in Canadian funds at this writing–probably means it will be found only the desks of workers with generous paycheques or bountiful research grants. Inevitably, it will fall to libraries and research departments to make the book available, although in these days of tight book budgets the price may also give pause to institutional purchasers. Because we do not wish to divide this excellent volume, Solomon-like, into six equal pieces, we are donating the review copy to the G.S.C.'s Calgary library.

Finally, because this review is to appear in a Canadian journal, it is appropriate to comment upon the pleasingly high level of Canadian expertise reflected in this book. Canadian contributors include the editor, three of the associate editors, and many of the individual contributors. This is a tribute to the strength of sedimentology and its subdisciplines in this country. Professor Middleton can take pride in the tremendous accomplishment that this book represents. He can also take pride in the vigour of the sedimentary profession in this country, for this is owed, in no small part, to his sterling efforts and intellectual leadership.

Collapse

By Jared Diamond
2005, Viking

A Short History of Progress

By Ronald Wright
2004, Anansi Press

Reviewed by Ward Chesworth,
Department of Land Resource Science,
University of Guelph

"You think that a wall as solid as the earth separates civilization from barbarism. I tell you the division is a thread, a pane of glass. A touch here, a push there, and you bring back the reign of Saturn."

John Buchan, 1916.

Opulent materialism can only be sustained for the relatively few in society - the king and his court, the tyrant and his favourites, the president and his bagmen. The eighteenth century radical, Tom Paine, believed that the prototype of them all was the thief and his gang. The rest of us aspire to the more modest version of opulence called affluence. The problem is that the most fortunate part of the human population has now attained an affluence that approaches historical opulence. The affluence of a Canadian or American for example, is roughly the equivalent of 10 to 15 inhabitants of the third world, in terms of life-time consumption and waste generation (Zen, 2000). All 10 to 15 hope to enjoy our level of luxury someday, and indeed the Brundtland report states its goal to be exactly that (WCED, 1987). If achieved, it would scar the biosphere so badly that the downfall of the civilization we currently enjoy would be assured. Ten thousand years of trial and error, reaching back before Sumer, would simply be another failed experiment. And even if the goal is not achieved, as seems more likely, the stress between the haves and the have-nots would leave little chance for the development of a stable world community.

People who contemplate the downfall of society are commonly criticised as pessimists, and labeled as being too negative to deserve a hearing. However, pessimism as much as optimism has survival value or natural selection would have removed it from our heritage long ago. In any case civilizations have collapsed in the past, so it is no more than prudent to consider the possibility of a collapse in the future. It is part of the due diligence we must exercise if we wish to sustain any but the most brutish existence over the long term. The authors of both books under review perform their due diligence, and both believe that there are important lessons to be learned from history.

Civilizations, says Ronald Wright (Progress p. 33), are “a special kind of culture: large, complex societies based on the domestication of plants, animals, and human beings”. They “vary in their makeup but typically have towns, cities, governments, social classes, and specialized professions.” It’s what we pay taxes for, and I am grateful to Wright for exhuming a quotation of Oliver Wendell Holmes (Progress p. 127): “I don’t mind paying taxes, they buy me civilization.”

Wright’s reference to domestication in the previous paragraph (with its sly inclusion of Homo sapiens) is an allusion to farming and to the fundamental importance of the farmers’ surplus in support of a civilized existence. Look a little deeper and you find that the real basis of civilization is geological. We use a geological substrate, the soil, to grow our food; we rely on geological delivery systems – the water, weathering and erosional cycles – to keep our crops irrigated and supplied with nutrients; and we exploit geological resources, particularly oil, gas and fertilizer raw materials, to maintain the high yields needed to support our growing billions. As a result we have largely taken over two biomes in the temperate regions – the grassland and the forest. Like a doomsday parasite, we are consuming the biosphere from within. Progressive deforestation, soil erosion, excessive demand on water resources, and a loss of biodiversity, are amongst the most obvious effects of our depredations. Reform is called for if we want our civilization to continue for much longer, and both Diamond and Wright call for it.

Jared Diamond scored a great popular success with his Pulitzer Prize winning book Guns, Germs and Steel. It dealt with the origins of civilized societies and of inequalities in the wealth of nations. The book gave new life to old ideas, including the notion that “earth resources, particularly arable land and useful minerals, are strongly localized, so that some areas 'have' while others 'have not'” (Whittlesey, 1939). His current book “Collapse” examines the complementary problem – why complex societies fail. Incidentally, Ronald Wright reviewed the book in the Globe and Mail for January 15, 2005.

Diamond states that his objective is to investigate societal collapses “involving an environmental component, and in some cases also contributions of climate change, hostile neighbours, and trade partners, plus questions of societal responses.” He insists that he makes no claim that environmental problems are at the root of all societal collapses, perhaps hoping to avoid the charge of environmental determinism. This is the doctrine that history is determined by some environmental cause that leaves humanity with little or no control over its fate. Northrop Frye (1957) made a waspish academic wisecrack on the subject: “the fallacy of what in history is called determinism, where a scholar with a special interest in geography or economics expresses that interest by the rhetorical device of putting his favourite subject into a causal relationship with whatever interests him less.” The charge of environmental determinism was leveled at Guns, Germs and Steel by heavyweight professional historians such as William H. McNeil in the New York Review of Books for May 15, 1997, and Richard Evans in a debate with Diamond, broadcast on BBC Radio 4 in Melvyn Bragg’s programme “In Our Time” (March 11, 1999).

It is Diamond's contention that every one of a dozen problems needs to be solved if our society is to avoid collapse. He identifies eight of these problems (Collapse p. 6) from a consideration of the difficulties and the downfall of societies in the past. They are "deforestation and habitat destruction, soil problems (erosion, salinization and soil fertility losses), water management problems, over-hunting, over-fishing, effects of introduced species on native species, human population growth, and increased per capita impact of people." Four (Collapse p. 7) he identifies as threatening current societies - "human caused climate change, buildup of toxic chemicals in the environment, energy shortages, and full human utilization of the earth's photosynthetic capacity." But is the total twelve in fact, or is it eleven? Isn’t over-fishing just another form of over-hunting? Actually, it’s likely to be only one big problem – the problem of human population growth and greed – or is that two?

But I’m nit-picking, and will take the number to be twelve for the sake of argument. Diamond certainly recognizes that all twelve are interconnected. Leave any one unsolved and we could go the way of the Easter Islanders he says (Collapse p. 79-119). This is the favourite cautionary example of several scholars, amongst whom Joseph Tainter (1988) should be singled out perhaps, as the author of the classic Collapse of Complex Societies, an influence acknowledged by both authors under review.

When they first arrived, the Easter Islanders found a cornucopia of easily exploited, low entropy resources – especially large trees, large marine mammals which they hunted from wooden boats, and fertile volcanic soils. They used up the trees completely, stopped singing their equivalent of “I’se the bye that builds the boats”, couldn’t catch the big marine meals anymore, and watched as the island’s good soils were gradually flushed or blown into the sea. The basis of the complex society they had developed was gradually dissipated. At its most abstract, they were defeated by increasing entropy, as we all shall be in the fullness of time.

Why didn’t the Viking settlers of Iceland meet the same fate? They had nothing like Easter’s natural advantage of a relatively warm climate. Just below the Arctic Circle it’s cold, dark and wet for much of the year. Volcanoes erupt under glaciers, causing gigantic floods that make the island a fearsomely dangerous place for human colonization. Like their Polynesian counterparts, the Vikings chopped down trees, although not quite all. The settlers’ sheep and goats ate the seedlings and prevented regeneration. Wind erosion carried exposed topsoil into the Atlantic Ocean. (Collapse 197-205).

In spite of everything, Icelandic society has survived for over a thousand years. It had three big advantages not enjoyed by the Easter Islanders. First, the Icelanders, with the usual ups and downs of any human population, have developed a deep sense of community – an all for one and one for all attitude which appears to be quite common in human groups living close to the edge of survival. Second, the religion they espoused was relatively benign in its material demands. Not for them the mad and ruinous expenditure of resources in a futile competition to impress their gods with bigger and better stone statues. However, the most important advantage was that they were not isolated from their roots – help was available when the going got tough (which inevitably it did). They could extend their ecological footprint back to Europe. Significantly, the Norse settlement in Greenland did not survive after it lost support from Europe.

But to return to Diamond's twelve problems: every one is technical and it is easy for him to suggest technical solutions. Take soil erosion for example: we can control it in a number of ways, among which are ridging and furrowing along contours as in East Africa, contour ploughing and leaving stubble in the fields over winter as the corn farmers of Eastern Canada do, converting arable land to pasture as the Azoreans have done, reforesting as the Icelanders are doing, or, most elaborately of all, constructing terraces as the Incas did. In part 4 of Collapse, Diamond shows that we can glean many practical clues on how to deal with such problems by studying the trials and tribulations of ancient and modern societies. He states once more (Collapse p. 438) that he is not an environmental determinist, and to underline the point stresses the importance of "courage" amongst peoples and leaders, in the survival of societies. Relegated to the notes at the back of the book (Collapse p. 521-525), he gives a prescription of practical measures that the ordinary citizen can take to lessen the environmental dangers we face. On the whole, although he admits that the subject of Collapse is a pessimistic one, the lessons he learned leave him "cautiously optimistic".

An earlier review concluded that Collapse is "probably the most important book you will ever read" (Flannery, 2005). That judgment is way over the top. There is no doubt that the book is an interesting and instructive roundup of the problems that beset human societies, but it doesn't probe deeply enough, and in addition it is rather prolix. Diamond's well-meant prescriptions, for example, will make you feel good, but they will not come anywhere near to touching the hard men who have the real power. They are little more than a set of band-aids for a system that actually needs radical surgery. Consider a few of Diamond's recommendations: boycott businesses you do not like, praise those that you do, talk to the people at your church, synagogue or mosque (would it be politically incorrect to include your favourite pub), make a donation to Ducks Unlimited (but why give money to people who eliminate the ducks' predators so that human hunters will have more ducks to kill). Still, band-aids are not a negligible addition to the social medicine chest, and they sometimes enable us to win small victories, especially in local arenas. The overall effect however, is transient and disappears like tears in rain. Even exercising our vote may turn out to be no more than palliative in a democracy continually subverted by the power of money. If anything, all of this makes me more of a cautious pessimist than cautious optimist.

We need to delve below the symptoms and find the disease, and at the technical level, part of the disease lies in the nature of agriculture, the unique geological process of the Holocene (Chesworth, 1996, 2002). Angus Martin (1975) asks the crucial question: "how many millennia of deforestation, dust storms and soil erosion has it taken for us to realize that our agricultural methodology has had serious flaws in it from the start." Wes Jackson believes that the critical mistake was to base our agriculture on annual species requiring a yearly cultivation (Jackson, 2004). This leads to exposure of the soil-surface in preparation for planting, the oxidation of organic matter, the break down of crumb-structure, the development of no more than a meagre root system (especially in the case of corn and soybeans). All of the foregoing increase the tendency of wind and water to carry the soil away. Jackson's answer is to start all over and to base our agriculture on the perennial plants of the Tall Grass Prairie. Not only that, he advocates the perennialization of existing annuals by embryo rescue which he describes in the following way. "We make a wide cross. The embryo forms but the endosperm does not or if it does is inadequate to keep the embryo going until it can take care of itself. That is biotech of sorts but not high biotech. When our geneticists rescue that embryo they, place it in a test tube with nutrient agar to keep it going until the young plant can collect sunlight on its own" (Jackson, pers. com. Feb. 10, 2005). This is not the contentious can of worms we refer to as genetic engineering (the "high biotech" of his comment). I do not have the space to go into that, but anyone interested will find an intelligent airing of the issue on Ann Clark's website at http://www.plant.uoguelph.ca /research/homepages/eclark/.

Jackson believes that his reforms could buy us another 10,000 years, and technically speaking he may be correct, but he's proposing radical surgery, and radical ideas get a frosty reception amongst the agricultural establishment. Tell the faculty of your friendly neighbourhood school of agriculture that farming needs a drastic makeover and you will quickly come to appreciate that such reform has profound behavioural aspects that overwhelm the technical problems. The farmer is the cynosure of all eyes and ranks right up there with the noble savage. The apologists for modern industrial agriculture and agribusiness have their wagons form a circle at virtually any sign of criticism.

A Short History of Progress is the text of the five Massey Lectures for 2004 given by archeologist and novelist Ronald Wright. Amongst his books is the novel A Scientific Romance, which won the David Higham Prize in 1997. Progress is short but by no means slight. Each lecture is a marvel of concise narrative, graphically expressed. The author takes his objective from the title of a painting by Gauguin: "Where do we come from? What are we? Where are we going?" The first two questions are easily answered: "There is no room for rational doubt that we are apes, and that regardless of our exact route through time, we came ultimately from Africa" (Progress p. 27). The third question is the most interesting one and it takes Wright into the past where he crosses some of the same ground as Diamond. He sees the ruins of once great civilizations as "fallen airliners whose black boxes can tell us what went wrong" (Progress p. 8).

Wright's particular hook is the notion of the "progress trap"; an evolutionary path that initially brings desirable improvements to a society, but that eventually leads to excess, to decline and sometimes to fall. The first trap was set in the long run-up to civilization, when we perfected our hunting techniques. Everywhere we reached after leaving Africa we encountered large mammals and birds, too ignorant of our ways to be wary of us. We considered them to be no more than big meals, and the "bad smell of extinction" (Progress p. 37) dogged our footsteps. We became "serial killers beyond reason" (Progress p. 63), with the biosphere our abattoir. Unfortunately, efficiency in hunting in the unmanaged commons of the pre-Neolithic world, leads only down the road towards Malthusian crisis. Still, the trap was sprung when we invented agriculture and civilization, though seen from the perspective of the 21st century that looks as if it may be the greatest trap so far (Progress p. 32).

For all of its brevity, Wright's book digs beneath the proximate causes of concern that Diamond emphasizes and looks for ultimate causes. His thoughts in the first lecture about our encounter with the Neanderthals provide an example. Was it our first genocide? Does it represent "Stone Age forebodings of the final solution and the slaughter on the Somme?" Are we hardwired always to prefer the path of short-term gain, no matter how grisly? Wright seems to be pointing in that direction: "our inability to foresee – or watch out for long range consequences may be inherent to our kind, shaped by the millions of years when we lived from hand to mouth by hunting and gathering" (Progress p. 108). Let's call it "Darwin's Trap" – the impulse to out-compete and out-breed our rivals. If it exists it might explain all the destructive behaviour detailed by Jared Diamond, and underlie all the progress traps of Ronald Wright.

At an even deeper level of causality, built into the very structure of the universe, there is a thermodynamic or "Terminal Trap". Fred Hoyle (1964), who believed that we were nearing the point of no return, put it this way: "It has often been said that, if the human species fails to make a go of it here on earth, some other species will take over the running …. This is not correct. We have, or soon will have, exhausted the necessary prerequisites so far as this planet is concerned. With coal gone, oil gone, high grade metallic ores gone, no species, however competent can make the long climb from primitive conditions to high level technology. This is a one shot affair."

The fight for democracy in the Second World War, and the construction of an affluent society after it, were based on the fossil energy we exploited by scaling Hubbert's Peak (Deffeyes, 2001). We are close to the top now and set to slide down the other side. We do not have a lot of time to put things right and the next energy source will be nothing like as cheap, portable and versatile. Wright reminds us: "each time history repeats itself, the price goes up" (Progress p. 107).

We are spending our planetary capital like drunken sailors in the Last Chance Saloon. We have to use what low entropy resources we still have, to make our one kick at the can count, or increasing entropy will deny us the energy to climb that hill again. More than anything we must recognize that for all our technical and scientific expertise, we have a behavioural problem. Let's face it, we're a mess, too easily seduced by will-o'-the-wisp promises of salvation through fundamentalist religion, dogmatic political ideologies, post-modern quackery, voodoo economics, the so-called Free Market, or that 20th century contradiction in terms, sustainable development, (to name, as Gore Vidal might say, but a few). We need to change our behaviour in double quick time and Ronald Wright is surely correct in saying that we must switch "from short-term to long-term thinking. From recklessness and excess to moderation and the precautionary principle" (Progress p. 131). It's easier said than done of course, especially if Darwin's Trap really exists, but it isn't impossible if we maintain a strong social structure, financed by an equitable tax system, and "governed by laws, not men".

As the Victorians understood, we are doomed by the Second Law anyway; but let's not worry about the inevitable. The Heat Death of the Universe won't happen tomorrow, and I'll take Wes Jackson's 10,000 years for want of a longer term.

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