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Article abstract

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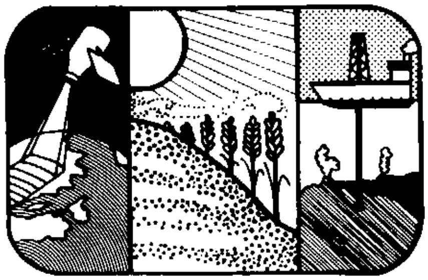

Earth Science — A Contemporary Challenge

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Summary
Earth scientists in academia must become more involved in radical education by applying their geological data base and experience to current affairs.

Humankind is facing a crisis due to unprecedented explosions in human population, affluence, and energy use, and their resultant pressures on Earth's natural resources. Stark documentation of this is provided, for example, by the US Department of State publication commonly known as "Global 2000" (1980), to which, speaking as a geologist, one could usefully add Preston Cloud's deeply thoughtful article entitled Entropy, Materials, and Posterity (1977). One startling statistic is that every six years we are now adding (excess of births over deaths) half a billion humans, a number equivalent to Earth's whole human population in the year 1650.

Discernible components of this crisis include:

1. The (eventual) depletion of the fossil fuels on which we have become dependent.
2. (Ongoing) deforestation, desertification, and topsoil loss generally.
3. The pollution of, and man-induced changes to, the atmosphere, hydrosphere, and biosphere (perceived but imperfectly understood).
4. The interlinked processes of proletariatization, urbanization, and material and cultural impoverishment (a sad omen for the future).

We can add another:

5. A marked lack of informed knowledge (as opposed to opinions) about resource and environmental issues among the general public.

Some might say that mankind has always faced both crisis and challenge and that there is therefore no reason to become unduly alarmed by some present-day trends. The current easing in the supply/demand position and price in petroleum products is also conducive to complacency. However, an appreciation of the scale, interlinkage, and momentum of environmental and social collapse in such diverse places as the Gangetic watershed, sub-Saharan Africa, prairie lands, the dying industrial wastelands of the UK (pioneer of the industrial revolution), and the burgeoning megalopolises of Mexico City and São Paulo (to name but a few conspicuous examples of various categories) soon shakes one's complacency.

The initiative of the new Global Change program (National Academy Press, 1983, 1986) is clearly desirable in that scientists will be encouraged to document and monitor ongoing and emerging environmental changes (see, for example, Fyfe, 1985). Nevertheless, one can readily foresee impediments to useful progress. One grave difficulty is likely to be that of adequately disseminating "scientific" results to policy-makers, and the consequent lack of any linkage of data to constructive programs of action. Indeed, there may well be excuses for inaction, such as for example President Reagan asking for more scientific information on acid rain before initiating clean-up policies.

A more radical approach — ultimately, it seems to me, inevitable if we are to survive — is a decisive change in the thrust of our education programs, in the direction of a dedication towards understanding the situation of *Homo sapiens* on spaceship Earth (Hughes, 1982). Such an education, integrated rather than compartmentalized, and necessarily involving scientists participating in humanities subjects and humanists versed in science, could comprise:

(a) Earth history;
(b) Physical environment;
(c) The fossil record;
(d) Ecology;
(e) *Homo sapiens* in prehistory;
(f) History in resource terms;
(g) Man's intellectual and spiritual achievements; philosophy and comparative religion;
(h) The industrial revolution and man's technological achievements;
(i) The population explosion, urbanization, the family, birth control (the essential *sine qua non* for any future);
(j) Natural resource depletion, pollution, and environmental destruction;
(k) Current affairs;
(l) A necessary conservational ethic and resource management. (Two courses attempting to cover this ground, "Natural Resources and the Past", and "Natural Resources and the Future", are now given at Memorial University of Newfoundland).

Could earth science contribute? Some think so. For example, after documenting the two successive "ages" of science, each a century long, and characterized by the amateur scientist and the technician respectively, M. King Hubbert (1977) foresaw a coming third age in which:

"the knowledge essential to competent intellectual leadership in the impending difficult situation is pre-eminently geological." [1]

What insights and initiatives can the database and experience of geology provide? Perhaps, as geologists, we are so intuitively aware of them that we may take them for granted without consciously realizing their significance and importance to all.

Geology adds the dimension of *time* to science. Historical geology provided first a relative, and later an absolute (and corroborative), time frame within which living things, including ourselves, have demonstrably evolved and physical processes have taken place. In establishing this great conceptual framework, the nascent science of geology had to learn to rely on a sober assessment of evidence, not only to resolve internal controversies but also to battle opposition based on dogma and ignorance.

Again in the time dimension, but more fundamentally, geologists are accustomed, indeed obliged, to think in terms of *processes* rather than *states*. I consider this aptitude for scientific thinking in terms of processes to be a vital contribution of geology, not only to science but also to a realistic appreciation of our human predicament.

Many geological processes are *diachronous*, that is to say similar things happened but at progressively different times in different places. This, incidentally, is reminiscent of the oft-observed phenomenon of the rise and fall of civilizations. The technique of investigating and understanding diachronous processes, and venturing a degree of extrapolation therefrom, is thus very familiar to geologists.

Examples of how we should be prepared to extrapolate from an observed *state* to an inferred, possibly diachronous, *process* include the following pairs: hydrosphere *versus* the hydrological cycle; present-day climatic zones *versus* climate changes on various time scales; deserts *versus* the process of desertification; population *versus* population changes (and rates of change of change!); poverty *versus* ongoing per capita resource depletion; cities *versus* the twin phenomena of proletariatization and urbanization; a creationist viewpoint *versus* an evolutionary viewpoint.

It was, of course, as recently as the 1960s that the geological profession had the remarkable and salutary experience of living through a great scientific revolution in which so much suddenly became explicable by the realization of the one fundamental process of the movement of plates. We geologists thus have first-hand knowledge of personal attitudes ranging from radical to conservative that accompanied a revolutionary change in perspective. One has to say that acceptance of this great scientific advance, now seen to be an essential central and unifying theme of geological science, was delayed by inertia and narrow-mindedness and by the sarcastic disdain, persecution even, of radical innovators. Perhaps this recent and very human experience may serve to forewarn us in considering other similarly radical but desirable new approaches, this time to resource, environmental, educational, and ethical issues. Hopefully, we may do so with better grace.

Because many geological data are not precisely quantifiable or experimentally verifiable (it was Nature that performed the experiments for us), students sometimes remark that geology is not "scientific". This, however, is not true: the proper handling of available data, and the formulation and testing of hypotheses in geology exemplifies scientific method not only as well as in other disciplines but also frequently demands, for this same reason, good powers of observation and a high ability for synthesis. Geology has given to science the tradition of "multiple working hypotheses" — in plain English, keeping an open mind on various possibilities.

Geological methodology is thus pragmatic, empirical, and common sense. It is accustomed to tackling problems to do with processes using multivariant data that are incomplete and of varying quality. Much of geology thus addresses itself to the type of problem, very typical of many real world problems, designated as "divergent" by Fritz Schumacher in his *Small is Beautiful* (1973), as opposed to a "convergent" type of problem like a crossword puzzle where one knows beforehand that there is some unequivocal and final answer. Divergent problems are, of course, also frequently encountered in other fields, for example in biology, where there are numerous complex and still imperfectly understood interactions, cycles, and feedback mechanisms in the natural environment.

There is something else that geology students have long suspected, namely that geologists never know for a certainty what they are talking about! In the laboratory, crucibles and test tubes can never reproduce the scale of inferred geological processes. We can only, in all humility, observe and theorize, and frequently having observed a little more, theorize afresh. There is often room for a honest difference of interpretation and we learn to debate, to criticize, to respect the other's point of view. In short we learn, as in life itself, that there are problems that may have no single unique answers. This important lesson earth science teaches us perhaps more generously than do the other scientific disciplines.

The study of geology thus encourages individual thinking, and it is no accident that aspects of geology have had a very strong appeal for some of the greatest minds of the past — Leonardo da Vinci, Franklin, Jefferson, Goethe, to name some who are certainly better known for outstanding achievements in other fields. This inherent appeal is itself a "renewable resource" in much the same way that the simple wonder of a growing child repeats the wonder of past generations at the mystery of life, the stars and planets, hills and dales, rocks and minerals, the stories and patterns of history. The development of man contains the story of his understanding of stone and metal, and more recently matter itself. A well-constructed program and a skilled teacher can use this spring of natural curiosity to foster the spirit of observation and rational enquiry, the true spirit of science, indeed of the Renaissance, to which noble tradition our universities are dedicated.

An incidental attribute of geologists is that, by virtue of work and field excursions, at times undertaken abroad, many are accustomed to getting along with colleagues of other nationalities, creeds, and political persuasions. The experience and culture shock of travel lend a certain breadth of vision and tolerance to those who experience it — if anything, one tends to become less tolerant of the intolerant and uninformed attitudes one may meet at home!

Again, most geologists, although not very articulate and characteristically preferring beer to philosophy, carry somewhere a love and respect for Nature and the natural environment. If you look closely, you may sometimes see in their eyes the far look of those who have ventured into the deserts, or the polar regions, or the oceans, or any of the remaining clean and lonely places on Earth where birds have no fear of man. Geologists have good reason to be well aware of the majesty of Gaia (Lovelock, 1979) and man's transient place in the ongoing drama of evolution.

We geologists as a breed *are* different from long-winded philosophers, long-haired hippies, brainwashed economists, brainless preachers and the like and, potentially, we *do* have something to contribute. Can we, should we, pull ourselves away from our fascinating subject for a while, break with our habit of looking at time through a rear-view mirror, and use our geological acumen in the service of humanity by looking our (natural-resource based) future in the face?

Conclusion

Both the philosophy and the experience of the science of geology emphasize the vital dimension of time in an understanding of the human condition. They provide several powerful, forward-looking leads into a realistic appreciation of *processes* at work in the environment and our societies today. We should not necessarily accept the present as a normal, sustainable, *state* of affairs.

We geologists *are* well placed to participate in, even initiate, a revolution in the thrust of *education*. This, of course, is *in addition to* the numerous practical and essential contributions of earth science in civil engineering, waste disposal, and the utilization of resources of coal, oil, gas, minerals, and groundwater, and in environmental studies.

It is at the same time both encouraging and depressing to note the following: whereas many of an older generation of well-respected geologists (*e.g.*, M. King Hubbert, Preston Cloud, Digby McLaren, Tuzo Wilson, Ward Neale, Bill Fyfe) are increasingly concerned in these matters, the great bulk of our profession in academia and elsewhere cannot afford to travel otherwise than along the tramlines of convention. There is much to be gained by further scientific research with some social purpose. There may be even more to be gained by considering how to apply our present knowledge with the same end in view.

Some of us in academia *should* become more involved in putting together, in collaboration with colleagues from biology, chemistry, sociology, history, geography, religious studies, political science, etc., coherent programs in "Science, Technology, and Society" or "Gaia studies" or "Natural Resources and the Future" (or some such similar name). All education students and as many others as possible should study them. Ideally, all teachers should be brought back for summer courses in them, leading to recertification! To achieve these kinds of goals, existing priorities in the earth sciences as dealt with in our universities and in our educational system generally will need some re-examining and re-orienting.

Education for all in these vital areas (very often cutting across traditional pigeonholes in our educational programs) *is the only route by which a population in a democracy can participate in and support sensible policies for a future.*

The urgency of this matter is overwhelming.

Sometimes, — this may sound like heresy to some — it does seem to me that in our preoccupations with materialistic goals, "pure" science, and contemporary political debate, we may well be judged by posterity (if there will be one) to have been as curiously myopic and ill-informed as medieval churchmen, because all around us our bases of renewable and non-renewable resources, our very environment, the fabrics of our societies, are collapsing while we do little of relevance!

I would be very interested in exchanging information with others who may be engaged in teaching non-traditional earth-science courses or in collaborating with colleagues from other disciplines in teaching this kind of material.

Note

Part of the above material has been adapted from the introductory chapter of my *Mother Earth and the Future of Humanity* (in press, Abacus Press, 1987), where these issues are explored at some length.

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Canadian Proposals for the Ocean Drilling Program

The Canadian National Committee (CNC) for the Ocean Drilling Program (ODP) is pleased to announce publication of *Canadian Proposals for the Ocean Drilling Program*. This 300-page volume is based on the themes and proposals developed during the Canadian Ocean Drilling Workshop, held in Montreal, 25-27 September 1986.

This volume contains the proceedings of this stimulating and successful workshop which was sponsored by NSERC and reflects a broad-based and vigorous ocean drilling community in Canada. The proceedings, as edited by Felix M. Gradstein and Louisa V.B. Horne, are arranged in five chapters according to the thematic sessions in Montreal, including:

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5. Deep sea sedimentology and geochemistry.

Each chapter starts with themes followed by drilling proposals. Themes are notes or miniproposals, which total 17 drilling proposal, 11 for the Pacific, 2 for the Indian and 4 for the Atlantic Ocean. Appendix A contains the names and addresses (90 in all) of the workshop participants and all authors.

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