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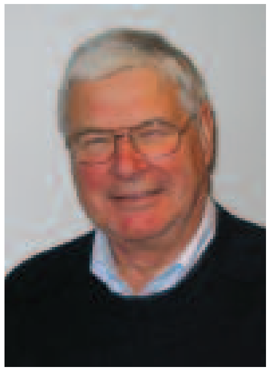
Science and the Policymakers



Ian Parsons

Richard Feynman's 'Minority Report to the Space Shuttle Challenger Inquiry' has become a modern scientific legend. His brilliant, independent mind scythed through a mass of engineering detail, half-truth and wishful thinking and made the key observation that explained the destruction of the most complex machine ever made. He brought his conclusion home to public and politicians by a simple piece of showmanship involving a glass of iced water and a fragment of O-ring. NASA management estimated the probability of a shuttle failure at 1 in 100,000 or one failure if a shuttle lifted off every day for 300 years. Engineers close to the project estimated the risk of failure at 1 in 100. 'What is the cause', Feynman asked, 'of management's fantastic faith in the machinery?' The report should be compulsory reading for all science students and can be found in several anthologies of Feynman's wonderful, often funny but always profound essays[1].

Disquietingly, however, it requires more than a little effort to find his report through 'official' channels. It is not reproduced in the report of the Committee on Science and Technology, 'Investigation of the Challenger Accident', that went to the House of Representatives in October 1986, although there are several references to Feynman and some short extracts. It can be found in its entirety in the report of the Presidential Commission on the Space Shuttle Challenger (the 'Rogers Report'), but you have to locate it in the contents list of Volume II, where it appears as Appendix F, 'Personal observations on reliability', with no attribution. One senses hidden establishment discomfiture here, where politicians and policy makers are confronted with the independence and detachment of an outstanding scientific mind, ranged against the technological and administrative might of NASA. Feynman's report ends with a famous line – pin it up near your desk: 'For a successful technology, reality must take precedence over public relations, for nature cannot be fooled'.

'In a science-based society our leaders should be exposed to science as it is, not an over-simplified, stripped-down version'.

The intersection of governmental policy and how we present science is particularly topical as I write, with the publication of the much trumpeted 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Press reports that I've seen include the assertion that it is the work of '2500 of the world's leading scientists'. Like NASA, the IPCC seems to believe that sheer weight of numbers will impress politicians and the public alike. If you go to their website, under the headline 'IPCC 4th Assessment Report – A comprehensive and rigorous picture of the global state of knowledge of climate change', you are invited to click on a button and are rewarded by a little movie in which the following lines appear one by one:

- 2500+ scientific expert reviewers
- 800+ contributing authors
- 450+ lead authors from
- 130+ countries
- 6 years work
- 4 volumes
- 1 report

Now I don't deny for one moment the importance of taking care of the environment, and I agree entirely that allowing levels of atmospheric CO_2 to increase much beyond present levels is a thoroughly bad thing. As Dan Schrag discusses in this issue, we could encounter tipping points in climate change that would have appalling consequences not for me but for my grandchildren, a prospect I truly find deeply worrisome. The political imperatives to get the burgeoning economies of China and India to adopt low-CO_2 ways of making power, and the United States and many other developed countries to make enormous cut-backs, are unquestionable and the most important social initiatives in the world today.

But we have to be very careful how we present the science. The IPCC approach implies that science reaches its powerful conclusions by a sort of international democratic consensus. Science is not democratic. Its lifeblood is not certainty, it is doubt. Because we reach our conclusions through experiment and development of mathematical theories, both of which may be repeated and improved, scientific concepts that survive do so because they have withstood repeated attempts to disprove them. It takes only one Feynman, one simple, crucial, robust experiment, to change the fabric of science for ever. I think the IPCC has strayed, although with the best of intentions, into the realm of what Feynman called, in his commencement address at Caltech in 1974, 'Cargo Cult Science'[1]. Cargo cults developed on islands in the South Seas after the second world war. During the war great aeroplanes landed with lots of good things, and the islanders wanted this to continue. So they built runways, lit fires alongside them, erected a wooden hut for a man to sit in with wooden headphones and bamboo antennae, and waited for the planes to come. They had done

Cont'd on page 156

[1] Richard P. Feynman, *The Pleasure of Finding Things Out*. First published in the U.S.A. by Perseus Books, 1999, and in the UK by The Penguin Press, 2000

EDITORIAL
(cont'd from page 155)

everything right, but the planes never came. Something essential was missing. In cargo cult science, what is missing is, using Feynman's words: '… a kind of scientific integrity, a principle of scientific thought that corresponds to a kind of utter honesty – a kind of leaning over backwards. For example, if you're doing an experiment, you should report everything that you think might make it invalid, not only what you think is right about it; other causes that could possibly explain your results; and things you thought of that you've eliminated by some other experiment and how they worked – to make sure the reader can tell they have been eliminated'.

Most *Elements* readers will have this requirement in their minds when they write their papers or reports, but when I go to the IPCC website and look at the 'Summary for Policymakers' and 'Technical Summary' of Working Group 1, 'The Physical Science Basis', in the 4th Assessment Report, I find something very different. The IPCC have adopted a system of 'Confidence Terminology', on a five-step sliding scale in which 'very high confidence' equates with 'at least 9 out of 10 chance [of being correct], 'very low confidence' with 'less than 1 out of ten chance'. Some of the uncertainties are 'value uncertainties' which are comparable with the analytical uncertainties with which we are all familiar. Others are 'structural uncertainties' which 'arise from an incomplete understanding of the processes that control particular values or results, for example, when the conceptual framework or model used for analysis does not include all the relevant processes… Structural uncertainties are generally described by giving the authors' collective judgement of their confidence in the correctness of a result'.

This, I fear, was exactly the mind-set that led to NASA's 'fantastic faith' in the space shuttle. Structural uncertainties cannot be quantified by resolutions of committees, and the IPCC summary documents (probably the only parts policymakers and news reporters will read) should lean over backwards to make clear the problems and mysteries of the climate change field. By doing so their presentation would be strengthened, not weakened, and the IPCC would be protected from still common assertions that it is glossing over difficulties. In a science-based society our leaders should be exposed to science as it is, not an over-simplified, stripped-down version. As scientists we must never lose sight of the powerful ground-rules under which we operate. Policy should be made by people who understand those rules. Nature cannot be fooled.

Ian Parsons
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FROM THE EDITORS

ABOUT THE ENERGY ISSUE

So much could be written on the topic of energy, and several approaches could have been taken for an issue of *Elements* on this theme. We liked Guest Editor Allison Macfarlane's proposal to focus on some emergent technologies and to put this century's energy requirements in the context of climate change.

NEXT EDITORIAL MEETING

The editors are planning to meet at the Frontiers in Mineral Sciences conference in Cambridge. We will be firming up our line-up for the remainder of 2008 and the beginning of 2009. We continue to solicit proposals, but many of our thematic issues have resulted from potential guest editors contacting us and expressing interest in leading an issue. Please do not hesitate to contact any of us with an idea or a proposal.

ABOUT THE ZIRCON ISSUE

We received several positive comments about the zircon issue. You liked the international diversity of the contributors. It was hard to put down. It had an "Excellent set of articles, with outstanding photos and images." Our favourite comment was sent by a colleague, who related that he missed his bus stop because he was so immersed in his reading.

EARTH CITIZEN

In the energy debate, let's not forget the three Rs: reduce, reuse and recycle. And as Earth scientists, shouldn't we lead by example? Having a smaller car and a smaller home, and using public transportation, for example, do not change one's lifestyle much, but taken together such gestures, no matter how small, make a difference. We therefore plan to introduce a new feature called Earth Citizen in which we turn the writing over to you. We are seeking inspiring opinion pieces from scientists who not only study the Earth but also have made changes to their lifestyles as they have recognized the stress the human population puts on our planet. Give us facts and relate your experience. Perhaps you have helped your campus become greener for example. For our part, we will investigate how we can make *Elements* greener.

Ian Parsons, **Susan Stipp**, **Bruce Watson**,
and **Pierrette Tremblay**

LETTERS TO THE EDITORS

IN PRAISE OF THE OPTICAL MICROSCOPE

As Ian Parsons points out (*Elements*, 2007, volume 3, issue 1), cutting-edge instrumentation and techniques, like the atomic force microscope and the ion probe, are producing exciting new results that are leading to a more complete understanding of Earth processes. In order to devote more time to introducing such advanced techniques to undergraduates, he suggests they spend less time learning crystal optics. Of course, future advances in the geosciences will, of necessity, depend on these techniques. But it is also true that the majority of students leaving university with a bachelor's degree in geology will never come near high-performance instruments like the atomic force microscope during their careers. In my own business of Cu-Ni deposit research in a government geological survey, my everyday, bread-and-butter tools are (still) the optical microscope (transmitted and reflected light) and whole-rock chemical analyses. If I need exact mineral compositions, the local university has a microprobe. These are the tools that help me evaluate, on a first-order basis, the characteristics and potential of Cu-Ni showings I study in the field. For the price of a polished thin section, you can't beat the amount of basic information that you can obtain with an optical microscope. For example, an exploration geologist looking for Cu-Ni would be very interested to know the texture of pentlandite, the composition of plagioclase, and if olivine is absent or present in his or her rock samples. An optical microscope gives these answers routinely. But it took me a long time to really understand how to determine the composition of plagioclase with an optical microscope—a lot of practice and theoretical understanding was necessary. I wonder if it is in the best interest of a student to use an optical microscope like a "black box," not really understanding what he or she is doing. Ian Parsons is not suggesting dropping crystal optics completely. But I think it would not be an advantage to make changes in the geology curriculum that would limit the average field geologist's ability to get as much practical information as possible out of his or her field work.

Thomas Clark
Quebec City, Canada

FROM A NEW MEMBER

I am a member of AAG and have just received my first *Elements* magazine. What a superb publication! I love the thematic nature of the issues and the review nature of the articles to catch up on aspects outside my own speciality! Congratulations to all involved with this publication—I look forward to many more issues! And I have already started browsing at back issues online also. Excellent stuff!

Kingsley Burlinson
Darwin, Australia