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Challenges for the geoscientist: an international perspective

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STEVENS, R.L. (2008). Challenges for the geoscientist: an international perspective. *Proceedings of the Shropshire Geological Society*, **13**, 77–82. The field of environmental geology is used to address the topic of challenges for the geoscientist. A few diverse examples are used to illustrate some successful, and some questionable, applications of geoscience knowledge, and also the role that community contact has had in these applications.

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BACKGROUND

The field of environmental geology will be used to address the topic of challenges for the geoscientist.

A journalist tries to answer the questions "What?", "Where?", "When?" and "Why?", but not "How?". For a geoscientist this corresponds to understanding the geography and structure of earth materials and the processes that created them; the "How?" question is perhaps the one which is of greatest interest to the scientist.

When the modern environment is considered, an additional question is often "Who?", since the influence of Man is an increasingly significant environmental factor, in most cases depleting and degrading natural resources.

The on-going theme for geology is the continual re-instatement of its central importance to society.

Global warming for instance is not a trivial challenge, neither to explain nor to develop a mitigating strategy. Nevertheless, the media have quickly latched onto this concept, especially the possible consequences, and Al Gore has certainly demonstrated the need for, and the power of, marketing. A pessimistic view is that the topic of global warming is now effectively owned by the media, the politicians and the market, and that the focus of scientific study has become directed and sensitive to public opinion. The temptation is to perform for the audience rather than undertake scientific study in a rigorous manner. This is exacerbated by a tendency for the popular media to escalate reports into a drama in order to hold interest, inadvertently giving a somewhat false image of what science can explain and help society achieve.

However, the role of the media is crucial if such issues are to be successfully combated. Geology needs to help provide the ground-truth and a template of 'normality' against which recent developments can be compared, the ultimate goal being sustainable solutions, for which effective science communication is essential. Examples of how this might be achieved will be presented, moving down from global to local scales.

ENVIRONMENTAL CHANGE RECORDED BY THE PARANÁ DELTA

The first example is from South America, where land-use change and loss of forestation is of global concern. Yet Brazilian president Lula da Silva recently made clear, on a recent visit to Sweden (2007), that "the 21st century is for those countries that did not get their dreams fulfilled in the last century, and Brazil is not going to miss its chance".

An EU research initiative is currently directed toward evaluating climate change impacts on a continental scale in South America. However, a proposal emphasizing the *geological* control of response to past climatic change was turned down by the reviewers, who stated that the proposal "underestimated the role of climatic models to quantify the response of the catchment area to climate change". In other words, models are to be used for their own calibration and are being taken as being more reliable than the reality supplied by a geological baseline!

The situation can be illustrated by trees growing on the older sandy beach ridges which formed parallel to each other, the consequence of shore processes at the front of the Paraná Delta (Figure 1).

Figure 1. Paraná Delta, with tree-lined beach ridges separated by parallel and flooded troughs. See also Figure 2. – photo by J. Milana.

The delta has built out rapidly toward the SE, receiving sediment from the second largest basin in South America, which is drained by two large rivers: the Paraná and the Uruguay. The colour changes in the satellite image (Figure 2) show the changes in the Paraná Delta from wave to river domination over the last few thousand years as the delta grew toward the south-east.

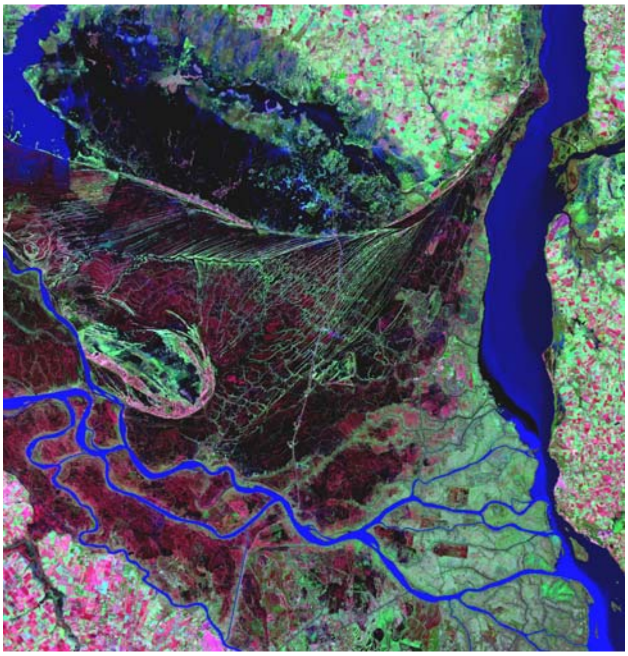

Figure 2. The Paraná Delta in Argentina records the balance between sediment supply and coastal processes. Shoreline erosion is seen as lines in the centre of this satellite view, and this was followed by rapid infilling and delta growth toward the south-east (dark areas). In addition to climate changes and sea-level rise, the agricultural revolution has a major impact on the river system (note the checkerboard patterns on all sides of the delta).

Deltas provide a sediment record that integrates over time the net effects of influences such as: climate, weathering, erosion sources and human impact. These are difficult to measure and nearly impossible to predict in such complex settings. Climate modellers use mainly historical data to gain resolution over short-term variations, but if the models do not successfully predict past changes, then there is need for scepticism regarding their forecasting ability. It would be unfortunate if the same debate about climate model reliability is repeated for each new study where modelling proponents present their prognoses without the baseline investigations that provide verification.

DEEP BASINS IN THE BALTIC SEA

A comparable example comes from the Baltic Sea, whose deep basins are frequently oxygen depleted (“anoxic”) (Figure 3). This arises because stratification and slow bottom water renewal is limiting the oxygen available for degrading organic material, mainly from plankton blooms. These are believed to have increased as a result of increased nutrient supply from land, especially phosphorus (P) from sewage and agricultural discharge.

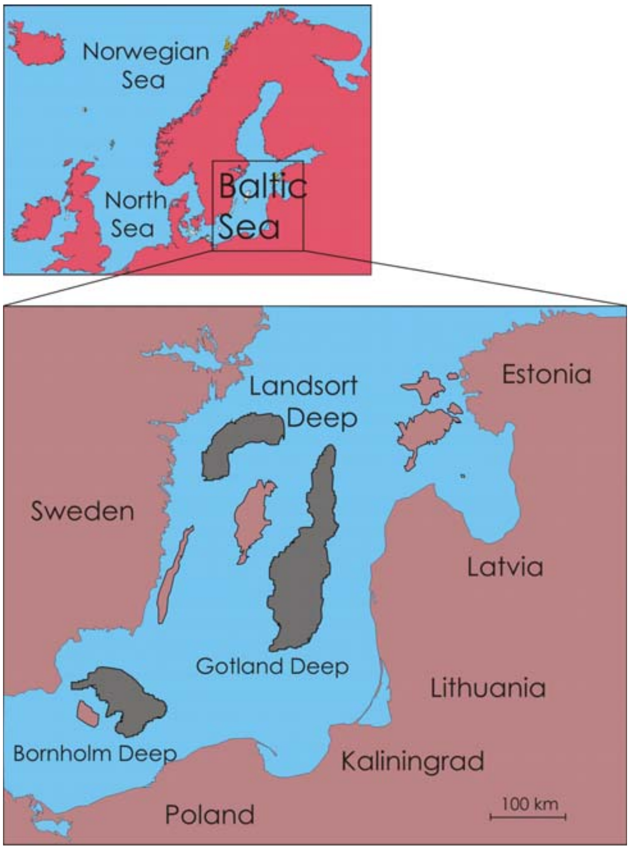

Figure 3. Deep basins in the Baltic Sea – after Lepland & Stevens (1988).

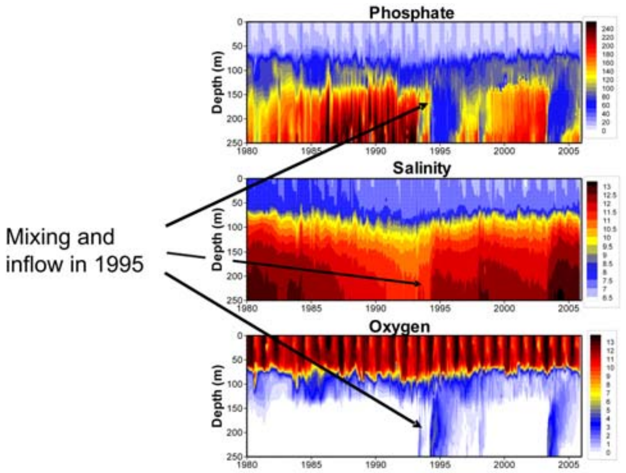

Figure 4. Changes in both oxygen and phosphorus levels following a major Baltic Sea storm in 1995 – after Stigebrandt & Gustafsson (2007).

When mixing does occur, for instance following a major storm, as happened in 1995, the changes in both oxygen and phosphorus can be quite dramatic (Figure 4). Such natural "experiments" have led oceanographers at Göteborg University to suggest an engineering remedy that involves wind turbines to pump down oxygenated surface waters on a large-scale.

Although the historical record clearly documents the recent spread of oxygen depleted areas, reflected by laminated sediments lacking a bottom fauna, the geological record also tells us that the Baltic basins have been prone to oxygen depletion in the geological past as well (Figure 5).

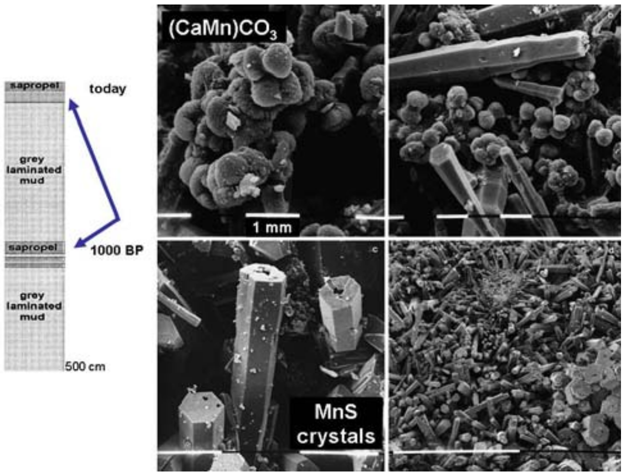

Figure 5. Manganese minerals demonstrating anoxic environments., both in recent sediments and about 1000 years ago - after Lepland & Stevens (1998).

A sediment core from the deepest basin, including the characteristic crystals of calcium/manganese carbonate, reflects a strongly reducing environment, as does the unique occurrence of manganese sulphide. Notably, these extreme conditions are found at the sea bed surface, the result of current conditions, but are found in layers sedimented about 1000 years ago. In fact, the mineralogy here, at 3 m depth, suggests more extreme conditions than those which occur today.

Therefore, the question is whether human factors are necessarily so dominant. One hypothesis is that, since these earlier conditions coincide roughly with the Medieval Warm Period, climate warming may have a greater importance relative to nutrient supply than is normally considered in contemporary models. If so, then reduction of human nutrient sources may not have the desired effect, and eutrophication may continue. Artificial respiration, such as pumping down oxygenated waters, may have to continue much longer if we have actually decided to prevent the changes that might actually be a part of the environment's natural development.

This leads to the conclusion that a system perspective is necessary if human interaction with natural processes is to be correctly evaluated.

HARBOUR SILTATION IN CALIFORNIA

Moving down in scale, the environmental problems in the bay of Port San Luis, California, are part of a 3-week study tour for Swedish university students (Figure 6). This not only provides an element of baseline data collection but importantly provides an invaluable educational experience of human and environment interactions, including harbour siltation, pollution from urban and agricultural runoff, oil spills and other issues that are typical for local management concerns.

It has consistently been successful for students to have contact with practical problems and local people who have to deal with this environment; textbook lessons alone are insufficient if a goal is to provide the training necessary for graduates to be able to develop practical solutions to real-world problems.

Sediment processes such as erosion, movement, and accumulation are important for dredging and disposal activities. Relatively simple geological observations, interpretations and budget calculations have both economic and ecological importance. This requires the students to integrate theory with the site-specific information that only local practitioners can supply. This type of cooperative activity is not only valuable for

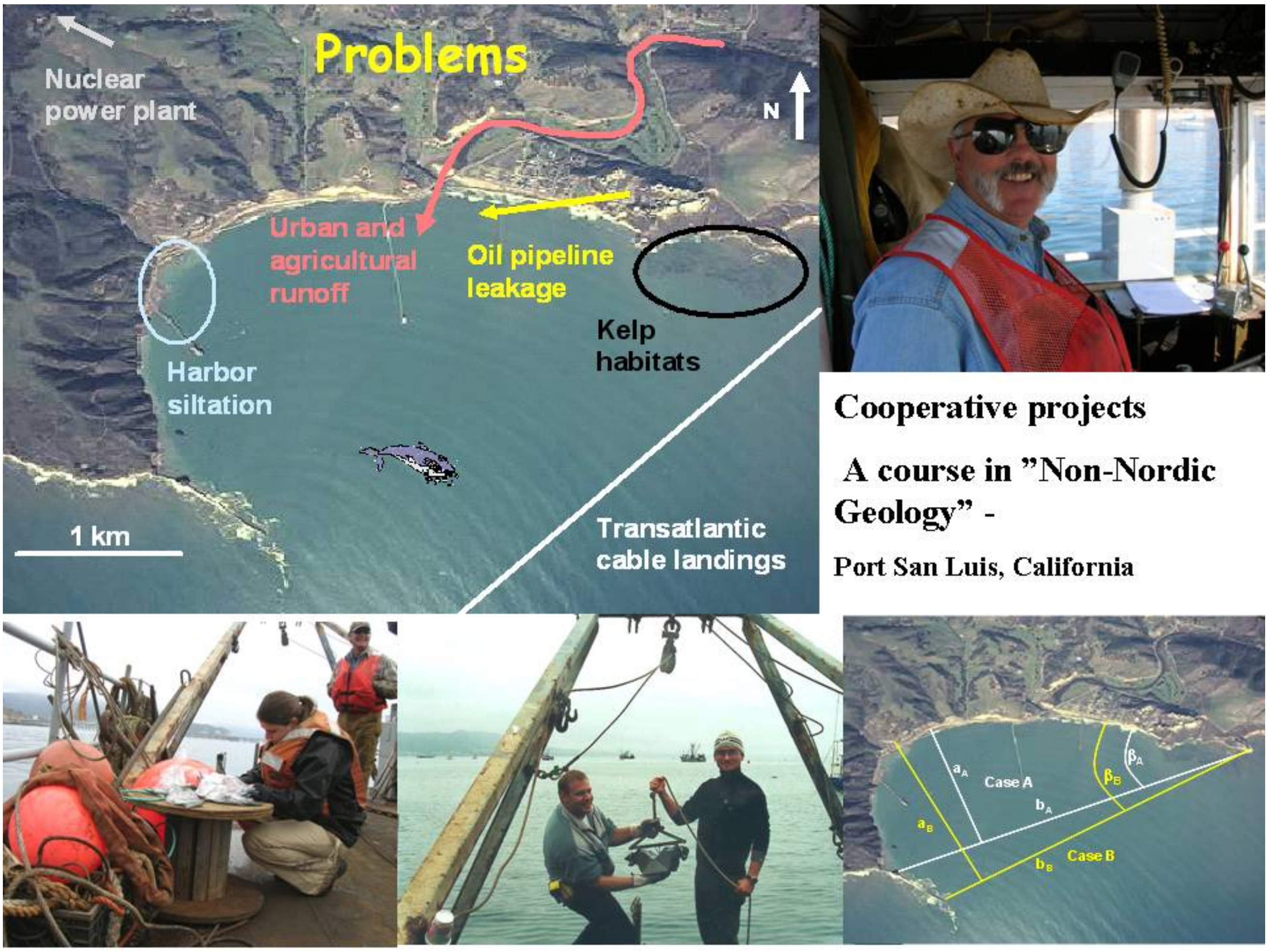

Figure 6. Poster illustrating the 3-week study tour for Swedish university students to Port San Luis, California.

teaching, but also improves the status of geoscience in the community.

EDUCATION

Geoscience education in Sweden is now almost entirely lacking within natural science courses taught in the country's secondary schools. The universities have therefore tried to bridge the gap by introducing some field case studies whereby the students can gain an introduction to geological process (Figure 7). However, funding is limited, as are staff time and teaching resources, not to mention the problems of timetabling for both university and school.

Nevertheless environmental problems, such as leakage from old landfills, are not only common in practice but offer a platform for demonstrating the stratigraphic architecture of the valleys nearby.

Around Gothenburg the valleys are filled by Quaternary glacial deposits. Basic processes such as groundwater flow and contaminant dispersion are not easy concepts to begin with, but their relevance to real-life issues grabs the pupils' interest and attention. However, somewhat different teaching skills are needed from those normally required of a research-active university academic – Swedish youth have the usual distractions, like cell phones, that can compete with almost any lesson plan! Nevertheless the local issues provide an active learning experience and group enthusiasm can build on this.

In Sweden, during the last 4 years there has been a 50% drop in enrolments onto natural science programmes at secondary schools. The social sciences (business and economics) have gained at the expense of the natural and physical sciences. This is a real crisis for the latter, and the university programmes can expect this trend to pass on to them, preventing full recruitment onto existing programmes or requiring a revised curriculum to take account of the lower levels of base knowledge and initial ability. There will be an inevitable knock-on effect on higher degree programmes, research and international competitiveness.

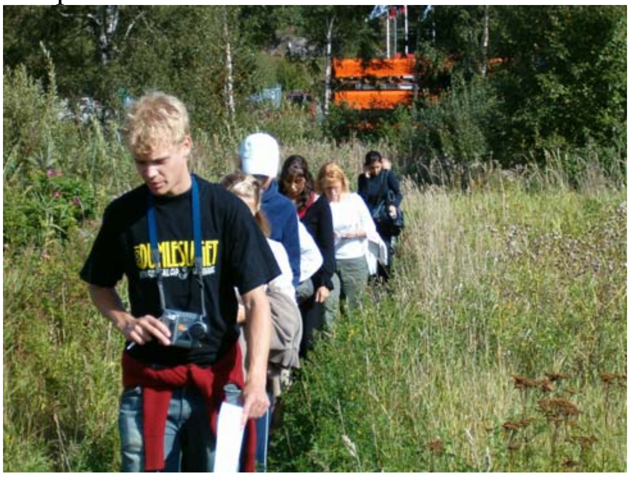

Figure 7. Extra curricula courses for Swedish school pupils exposing them to geoscientific issues in the context of environmental concerns.

GEOSCIENCE COMMUNICATION

These examples lead to the conclusion that (geo)science communication is most effective when it involves more than just one source of information. Interaction with societal factors and, ideally, integration with knowledge obtained from all possible perspectives is conducive to most goals, including education and the promotion of science within society. The latter is not in a particularly healthy state (Figure 8).

Stockholm, S

What do Swedes think of Researchers and Scientists?

The latest opinion study from the Swedish organisation Vetenskap & Allmänhet reveals some surprising results. Nearly a quarter of Swedes, 23% consider astrology to be scientific. Fourteen per cent consider that Intelligent Design is a scientific subject. At the same time, more than half dismiss these as completely unscientific. This is one result of a new opinion study from the Swedish organisation Vetenskap & Allmänhet, VA (Public and Science). VA has carried out an annual survey on the public's attitude to science and researchers since 2002. The

technological developments have made life better for ordinary people

- The public has high trust in researchers, but this trust is diminishing.
- An increasing proportion believes that science and technology are too hard to understand, reversing the

This shows a marked increase since 2005.

- 60% believe that there is a strong possibility that research can contribute to reducing climate change. This is a significant increase since 2003.
- An increasing number of people, now over 80%, want research into gene technology for the treatment of diseases to be supported.
- Medicine holds its position as the area considered most scientific by the general public.
- 90% believe that research results should be confirmed by

Figure 8. A recent excerpt from "Living Knowledge", a European network for community based learning.

The following diagram (Figure 9) illustrates how any number of activities could be added, but the basic idea is that involvement brings forward both understanding and invested interest.

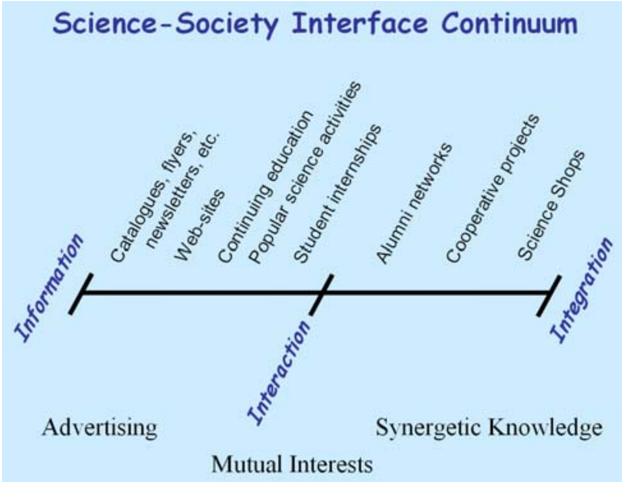

Figure 9. A diagram to illustrate how involvement brings forward both understanding and invested interest.

Political interaction is not explicitly included but it may be noted that Al Gore concluded a talk at the American Geophysical Union meeting in December 2006 with a plea for scientists to more actively engage with (i.e. influence) politicians. Nevertheless politicians will continue to respond primarily to public consensus, especially when it grows by understanding and invested interest. Gore's film on climate change has helped create an amazing growth in public consciousness over the last couple of years. Perhaps this will give the push politicians need to move on climate and other natural resource issues.

CONCLUSIONS

Hopefully these examples have helped bring forward the message that basic, even simple, science is very applicable to the needs of society. This symposium has been a celebration of geology, indeed two centuries of geology. Nevertheless geology is as relevant to the questions and concerns of today as they were 200 years ago.

Both dead-ends and turning points can be seen as essentially two perspectives on the same situation, just as strengths, weaknesses, opportunities and threats are all closely related. Perhaps it is not so ironic as it would first seem that now, when we have such an obvious, even desperate, awareness of the need for understanding the Earth, that the real impact of geoscientists is marginalised in all too many cases.

Science communication is a challenge at all levels of society, and it is essential that this be effective if we are to maintain or increase our impact concerning important issues. Science communication is seldom effective if kept at the beginning of the continuum: "information – interaction – integration", used to describe the interface between science and society.

A few diverse examples have been used to illustrate some successful, and some questionable, applications of geoscience knowledge, and also the role that community contact has had in these applications. Climate change will induce continental-scale changes in large-scale systems, such as the Paraná/La Plata river basin in South America, and also very local effects, such as flooding and landslide risks along the Göta älv River in Gothenburg, Sweden.

Technology allows proposals for larger and bolder schemes to "remedy" threats. Pumping oxygen to the deeper parts of the Baltic Sea to fix poor oxygen levels may counteract recent algal blooms, but is probably not compatible with the natural variability of this system as a whole.

Another questionable "solution" to a common problem is "dig-and-dump" for polluted ground and sediments, rather than "concentrate and contain", where short-sighted economies are mainly equated with time, that is to say, the time of the building project rather than a historical or geological scale. The issues of contaminated land, denial to development, and long-term (ill) health may be equally important yet too often are not adequately considered.

Integrating research, education and practical demonstrations of the applicability of science can sometimes be achieved. The small harbour in California and an abandoned waste repository in Göteborg are two case-studies that have been described which have brought secondary and university students into direct contact with earth science theory and application.

Yet one of the most alarming facts to emerge is that the dependent relationship between science and society is often not apparent to those who have a central role for moulding our future: decision-makers and youth.

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