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Education In Geology*

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INTRODUCTION

I believe that a Section Chairman's Address should if possible be both instructive and provocative. If it cannot be both, then it is better to be provocative, so the remarks that follow are given in the hope of stirring up a fruitful exchange of views on the subject of education in geology, especially for New Zealand—how well it is being carried out with respect to the national requirements, and how it might be improved.

GEOLOGY IN THE SCHOOLS

At the secondary school level it is obviously a case of "geology in education" rather than the reverse. The earth sciences should be included in school science for several good reasons. Apart from the general claim that a curriculum in general education can hardly be considered complete without it, geology provides lateral support for the subjects of geography and biology, and by showing how the findings and methods of one science find applications in another it demonstrates the unity of knowledge and the arbitrary character of the divisions between the sciences. It provides excellent opportunities for training in observation and reasoning, and for illustrating the scientific method. So much can be done with no more in the way of equipment than a map, a hand-lens, a pocket knife, a hammer, and an alert mind. No other study is as effective in developing a proper perspective of time, through which the tempo of physical processes on the earth, the span of human history, the time-demands of organic life-cycles and organic evolution, and so on, are seen in true relative proportions, and a true appreciation gained of earth history in all its aspects. Local geological structures, rock types, and the later geological histories of regions determine landforms, soil types, sources of raw materials, water supply, and so help to determine the character and the groupings of human populations.

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I gather that geology is now satisfactorily covered in the general science curriculum for secondary schools in New South Wales, and in the general science text books to go with it, but in New Zealand the physical sciences and mathematics have traditionally been the basis of school science, so that generations of pupils have left school with the notion that science is chemistry and physics, and no more. Biological sciences have gained a footing in recent years, and now psychology and geology appear to be the only important sectors of observational and experimental science still receiving scant treatment in our schools.

As things are, most students enrolling for the first-year science courses are almost totally ignorant of geology, and many with high potential interest and aptitude fail to find out about it until after they have a considerable investment of study-time in other fields. It is true that the number who declare their intention of taking geology as their major subject, year by year, does not differ greatly from the number taking Geology III two years later, but they are not usually the same people. From conversations with students, I gather that many who have included Geology I as a subsidiary subject late in their undergraduate careers wish that they had taken it earlier and so could have advanced in it. Schools Liaison Officers do the best they can to advise senior school pupils in choosing their first-year university subjects, but it is obviously much easier for the students to grasp what is involved in the subjects already familiar to them, and the majority prefer the known to the unknown.

The obvious remedy is to introduce a substantial content of earth sciences in our secondary schools curriculum, but at the same time, in order to provide a definite, immediate objective for study, the earth sciences would also have to be included in the Upper Sixth courses and introduced as a special subject for the new Bursary Examination to be held at the end of the Upper Sixth year.

School teachers have remarked to me that relatively few of them, especially in the girls' schools, have studied the subject at all, and even fewer would feel confident to teach it to a standard comparable with that reached in the physical sciences at the U.E. level. This situation, however, should be improving. Geology has become a very popular one-year subject for both arts and science students, and two years in geology are often taken by those planning to become candidates for M.A. in geography. As Geography degrees are gained by many school teachers, some knowledge of the scope, objectives and methodology of earth science is slowly spreading into the schools. Most teachers would nevertheless have to be provided with a good deal of background information and assistance in other ways, including suggested programmes and materials for practical work, if more secondary schools are to be encouraged to offer geology, but I do not think there is any material obstacle in the way of introducing geology in the schools.

GEOLOGY IN THE UNIVERSITIES

The majority of students enrolling in geology courses at the university do so for reasons enabling them to be classified into three groups:

1. One large group consists of those for whom the subject holds no special interest, nor is it required as part of their training for some profession. Geology I has been included in their science or liberal arts degree structures because they have been advised that it is a good interdisciplinary subject, not fundamentally too difficult, or because it is supposed not to require much mathematical ability. They do *not* contemplate using their geological knowledge in the course of their careers, except perhaps as part of the stock of general knowledge which is valuable for school teaching. This group accounts for most of Geology I enrolments at Canterbury.

2. The second group consists of those who are *required* to study geology as part of their training for a profession, for a technical occupation, or for a career in applied science. It obviously includes civil engineers, mining engineers, soil scientists, architects, surveyors, and I would also put in the same group mining geologists, engineering geologists, petroleum geologists, hydrologists, as well as those already dedicated to a career as science teachers in secondary schools. Mainly because of the number of engineering students, this too is a large group at Canterbury.

3. The third and smallest group includes those attracted to a career as research scientists in geology, either broadly or in one of its specialized divisions. They intend from the outset to "major" in geology, and afterwards they expect to seek employment in state or privately supported research organizations, or else will aim to earn their living by university teaching.

If one accepts the traditional view that the prime function of a university is to provide the best facilities and the correct environment for learning the skills and cultivating the attitudes of the research scientist or scholar, then it would seem logical that universities should continue to exist essentially for the benefit of the last group, although in geology it may amount to only a few per cent of total enrolments. Incidentally, in this view university research may be regarded as a valuable by-product of the training of scholars and scientists, and not as the primary reason for the existence of the university.

The same kind of geological education does not suit the requirements of all three groups. The virtual absence of geology from high school curricula means that the first group can learn about geology effectively only in the university. It is also true that this most numerous group makes up a major part of the teaching load in this country. Geology departments in New Zealand carry a greater burden of this "non-career" type of student than any of the other sciences.

Up to a point it is gratifying for geology departments that the subject is found so attractive by non-scientist students taking it as a "sample" of science, as well as by science students seeking to broaden their general view of science. On the other hand, the sheer weight of numbers in the elementary classes tends to dominate in the internal teaching arrangements and absorbs a good deal of staff time. Some teachers enjoy this general education in geology and do it well, whereas others feel the reward for their efforts in Stage I teaching is small in terms of the number of students in the class that are likely to become research scientists in geological fields. Under the present conditions, this is a shortsighted view because of the limited opportunities for students to discover an interest in geology before entering the university.

A more serious objection is the mass effect of the needs of this dominating group upon the curriculum, and upon examination standards. It is difficult to decide upon a level of first-year teaching and examining in geology which will satisfy at the same time the requirements of both the career and the non-career groups. Every year the Stage I examination results disclose that some people have absorbed a useful elementary knowledge of geology, but have neither attained a high standard nor developed a real interest in the subject. We do not want to have these people starting advanced courses, because we can see little prospect for them other than an annual struggle for marginal passes leading at best to mediocre degrees and poor employment prospects.

One obvious solution is to provide for two separate pass standards, of which only the higher qualifies for entry to advanced courses. So long as the first-year standard continues to be influenced heavily by the requirements of the big non-career group, ground has to be covered in hard-pressed advanced courses which the more able students could easily have covered in their first year, unless ways can

be found of discovering the potentially more able ones soon enough in the first year to arrange for them to do additional work. This kind of separation has existed in other subjects in the past, but for geology there has always been the difficulty that admission into the appropriate stream cannot be decided on the basis of prior performance at school, and not reliably even on the basis of first-term examinations.

These difficulties will largely disappear when geology is introduced adequately into the secondary schools science curriculum, and is made alternative to the physical sciences or biology in the Upper Sixth. Those who make good progress in geology at school might be expected to cover more ground and reach a higher standard in their first university year, and valuable time would be saved for better use in the advanced courses. Separate, well-balanced, one-year terminating courses in the earth sciences could be provided for the non-career students. Another solution would follow the establishment in this country of something akin to the junior college system, a development which I believe may come in New Zealand, for economic reasons. General geology for the mass of non-careers would obviously be part of the work of the junior colleges. I will have more to say about junior colleges later.

The requirements of the second group are quite distinct. For one thing, the professional degrees in civil engineering, mining engineering, architecture, and so on have rigidly specified curricula with little choice of alternative routes. A general "educational" grounding in geology is better than nothing for this group, but a certain amount of special emphasis on some aspects is desirable. For this reason it is less satisfactory to expect these people to pick up what they need from the courses designed for either the geological research scientist or the non-career student, than to provide them with separate special geology courses. At Canterbury for many years there have been separate geology courses for B.E. (Civil) students, spread over two professional years. The first year prescription, on paper, looks very similar to physical geology for Geology I plus a brief inspection of historical geology, but when teaching it I found it a great advantage to be able to give the course separately. Besides being able to stress the aspects relating to engineering, I could also take advantage of the fact that the whole class had about the same seniority—all were at least third-years, and I am positive that they now gain much more from the courses than formerly, when they merely "sat-in" with Geology I.

Wherever possible, therefore, the teaching of geology for the professional degrees should be done separately so that it can be tailored more accurately to fit requirements. A proliferation of special geology courses for small numbers of geophysicists, miners, soil scientists, hydrologists and so on is in my mind a desirable development though obviously limited by the extra demand thus placed on staff time.

I will return to the question of whether the university nowadays should still be concerned with scholarship, research and training for research, and thus have to serve merely the third and smallest of our groups. The time has come to face this question squarely. I am inclined to think that this function is still the only proper one for a true university, and that a university is the only place where it can be performed properly. Moreover, I seriously doubt whether the function can be carried out effectively at the same time and in the same institution as that of tertiary education for the masses. To some extent our university system has found itself forced to assume this burden, but also in part has assumed it voluntarily because it can divert towards purposes of scholarship and research some of the funds received because of public demand for tertiary education facilities. Broader issues are obviously involved here but the question is relevant to

the subject of this address because of my belief that the different purposes of geological education might be better achieved in different institutions. The entire geological training for many in the second group should take place within appropriate special schools, such as the Engineering Schools at Auckland and Canterbury, the Faculty of Technology at Otago or Lincoln College. The first degrees of this type of institution tend to be regarded as an essential qualification for professional practice rather than as a mark of scholarship or research ability.

For those wanting, or deserving, merely a liberal tertiary education, the junior college system seems to have much to recommend it. A degree or diploma from a college would be an appropriate qualification in fields like primary school teaching, journalism, business administration, library work, and so on. For some time I have felt that the higher education requirements of the different groups would be served more efficiently by a university system remodelled and rationalized along these lines, and that it is extravagant to go on trying to build, equip and staff more and more, bigger and bigger universities, all wishing to compete in the same fields and trying to carry out all three functions within the one type of institution.

I am aware that where there are exclusive, separate, graduate research schools it is essential to take steps to prevent staff segregation and isolation, and also that there are difficulties in selecting suitable candidates reliably and early enough, and in transferring them smoothly from one system to another. On the other hand, there are clear advantages for an institution of advanced study and research not to have to suffer the mechanization, regimentation and mass-thinking associated with providing tertiary education in the liberal arts and sciences for an ever-growing proportion of an ever-growing population, and at the same time providing specialized professional training. There seems to be a serious conflict of purposes here and a real danger that university policies will inevitably tend to be dictated by the demands of the larger groups.

Supply and Demand—and Wastage

Returning to New Zealand requirements of geological education, I would question whether all four of the older universities should aim not only to serve groups 1 and 2, but also to provide at the same time for research over the whole spectrum of the earth's sciences. The case for consolidating university research in certain fields at one or two of the existing universities, or even at a special separate institution, is stronger in New Zealand than it was in Australia, on grounds of population, resources and geography. The resulting conservation of our resources of manpower and finance should enable us to provide facilities and to offer status and salaries that would attract and retain staffs of the highest calibre.

We now have six or seven hundred students each year studying geology in the universities. About 200 are studying geology as part of professional degrees (e.g., civil engineering, mining, surveying), about 25 to 30 are aiming to be career scientists in some field of earth science, while the large remainder are taking it as part of liberal arts and science degrees (to use the convenient American phrase).

Two questions may now be asked. Is the national expenditure on geologically educating all these people justified? Is the expenditure producing the right kinds of graduates, in about the right proportions and numbers for New Zealand's requirements?

The justification in the case of the non-career one-year students is little more than the broadening of their general education, their exposure to the disciplines and the philosophy of what may be claimed as the best subject for them to take as a "sample" of science. But individually they are the least expensive to educate in geology, absorbing less staff time per student and requiring less elaborate laboratory equipment. For the 200-odd "professionals" the cost per head need be no more, and here the justification is the necessity for these people to know some geology in order to do their work properly.

The small group of career earth-scientists undoubtedly costs far more per head. They require more individual attention from staff, and their training for research work in almost any geological field nowadays demands expensive equipment. I would suggest that it is actually in large part for the benefit of this group that the community supports the cost of maintaining geology departments at each of the four universities. Is this justifiable? My answer is "yes", because I feel that the group belongs to the most important section of the student body, that for which the university traditionally exists. The regulations governing the Ph.D. degree reflect an academic opinion to the effect that *only* the university can provide the correct environment for their training as research scientists and scholars. Since it is the members of this group alone that cannot get what they require in any *other* type of educational institution, their requirements must therefore be given the highest priority, preceding the needs of those who take geology courses merely as part of their "tertiary" education, or of their training for a profession.

What satisfaction does the community obtain in return for this expenditure? It can feel assured that a substantial part of the annual crop of science graduates from the main universities have some knowledge of earth science, and that those going in for school-teaching are thereby all the better prepared to teach general science and geography; it can feel secure in the thought that its civil and mining engineers receive an essential grounding in geology. But the community may not see the importance of having available each year a small regular supply of people who have completed a year or two of post-graduate study and supervised research in earth science, and have been judged fit and ready to embark upon independent careers as professional research earth-scientists. How well does this output measure up with the country's requirements? We can investigate this by enquiring into what happens to these graduates.

Government departments and other public organizations with scientific activities may absorb on the average 15 graduates each year; another 6 or 8 may go on to pre-doctoral studies in New Zealand universities, or proceed to overseas universities to work for Ph.D. in a special field. Some doctoral candidates have in mind returning to university teaching, but I estimate that between one half and one third of our geology graduates sooner or later seek employment overseas. and their services are lost to New Zealand.

Considering the cost of training these career-scientists, I am sure this wastage could not be supported if it appeared likely to be a permanent state of affairs. but I feel rather optimistic about the future for geological employment in New Zealand, and I believe that it would be a mistake at the present time to reduce the output of geology masters and doctors. I understand that at least some Government employers of graduates in geology have plans or hopes for expansion. Semi-governmental bodies such as soil conservation and river-control authorities, highway authorities and museums employ geologists to a greater extent overseas than they do in New Zealand. There are signs of more openings in these directions in this country, and a large potential demand for geologists properly trained to work with civil engineers. Mining geology has been in the doldrums, but it would only require the successful establishment of one sizeable new mining enterprise to

transform the outlook for geological employment and even for private consultant practice in New Zealand. Given a change in the orientation of mineral search in this country from the hope of bonanza finds, to be worked by individuals or small companies, to a more sophisticated kind of mining development involving the proving of vast tonnages of quite low grade ore, the possibilities for a mining revival in New Zealand are far from negligible. Modern-style mineral search involves a great deal more attention to geology, together with petrology, chemical and geophysical investigations. The scope for permanent or long-term employment would therefore improve greatly following one good discovery. Needless to say, the discovery of one respectable petroleum field would likewise create many new vacancies for geologists.

The immediate effect of either kind of discovery would be more jobs for graduates at all levels, but the greater advantage of being able to retain most of our best scholars should follow. The need for a background of free research by people with the inclination, enthusiasm and the right kind of training must become increasingly obvious to those who hold the purse strings.

I do not see any need to discuss the details of geology courses or degree structures. There will always be more than one road to Rome. Now that our universities are at least in theory separate and independent, the differences of approach and emphasis already noticeable are bound to become more pronounced. So long as all students receive sufficient grounding in the main branches of earth science it is better that each graduate should show something of the distinctive philosophy or some particular field of interest of his school, rather than that a standardized product should result from any misguided efforts to retain equivalence and interchangeability of units between departments.

Specialization

One aspect of curriculum that might usefully be discussed is specialization—how soon, how much, and for whom? Constant pressure to pack in more and more specialized material at earlier and earlier stages is combined with resistance against abandoning or reducing some of the traditional content of geology courses. The remedy according to some people is to allow greater concentration by the undergraduate in the whole field of geology, at the expense of a more general scientific education. According to others it is to allow some specialization within the major subject in or before the final undergraduate year. If the objective of the initial degree in science is to inculcate the scientific attitude rather than to produce a working model of a geologist or a chemist, then the second alternative may be less objectionable.

Looking at specialization in another way, I find it hard to accept that fundamental thinking processes in evaluating grand generalizations or inventing your own are totally different, or necessarily more or less difficult, compared with those in performing and applying the results of technically specialized investigations. Training should be sufficiently broad so that students comprehend the essential importance of both kinds of investigation, and therefore feel neither superior nor inferior to another person whose interests are either broader or narrower than their own. It is important not to present geology to undergraduate students as anything less than a whole, integrated science, albeit composed of many inter-related sub-disciplines. Moreover, to counteract any impression that the specialist is necessarily more important or valuable than the scientist with broader interests, it should not be any easier, or even appear to be easier, to qualify for scholarships

or fellowships for travel or advanced studies on the basis of a more specialized-sounding programme. Knowledge is a continuum, and as with geological time, the man-made divisions are arbitrary, justifiable only to a limited extent on grounds of convenience.

In my opinion, one of the advantages in the " unit " system in the New Zealand degree structure is that it maintains continuity within the major fields. It is still true to say that our geology graduate, at least at the bachelor level, and probably even at the master's level, is a geologist, and not yet a petrographer or a palaeontologist.

POPULAR EDUCATION IN GEOLOGY

Finally, what about the geological education of the masses, the general public, the complete layman? Apart from a small number of enlightened amateurs with a genuine understanding of the philosophy and objectives of the science and with some conception of the magnitude of geological time and the tempo of geological processes, I would say that the general public is enormously ignorant of geological matters. Of all the main sciences geology seems to be the least understood by the layman. Ideas of contrasting spans of time of large order and the ability to think in terms of different large orders of time are both quite foreign to most people.

What are the reasons for this? The basic ideas of the science are not particularly difficult to comprehend. Historically, the religious prejudices of fundamentalists undoubtedly delayed the introduction of geology into the school curricula, as well as biology, but this is no longer a serious obstacle in New Zealand. Public ignorance and indifference exists rather because geology has not been successfully presented to the public as a dynamic science. Many people certainly think of it still as having to do only with cold inert minerals and stones, long-dead fossils, and useful only because in some vaguely conceived way it seems to help in finding deposits of valuable substances like oil and gold. Too little has been made of palaeogeography as a means of catching the lay imagination, demonstrating the real objectives of the science, and showing its truly dynamic character.

Does this public ignorance and indifference matter? It tends to make the activities of geologists appear mysterious and therefore subject to suspicion and misunderstanding, which can be embarrassing in the field. The Minister of Science has already stated during this Congress that the lack of public appreciation of their work is a major source of dissatisfaction among scientists in New Zealand. We can hardly expect the public, uninformed or misinformed about the objects of geology, to go on supporting through taxation the annual bill for research and teaching in geology, which must amount to six figures in New Zealand.

The geological community in New Zealand could do more, individually, to make better known the objects of geological research. What is needed is not propaganda, or arguments in defence or justification of the science, but better ways of showing what it is really trying to do, and how it goes about its business. This is not easy, partly because most of the audience usually have either no idea at all to begin with, or else they have faulty ideas, and partly because it is so easy to lose their interest through leaving them behind in an excess of enthusiasm for one's own subject or in trying to communicate too many ideas at one time.

There is scope for good radio talks on geological subjects, and television is practically unexploited in New Zealand. In preparing programmes, it is essential to select suitably limited topics illustrating a basic principle or operation, presenting them in sufficient depth to hold the intelligent listener's attention without over-saturating it. More articles should be written for the magazine sections of the newspapers, for the school journals, even the parish magazine.

I am sure it will be agreed that a public with sound ideas on the subject is more likely to be interested and co-operative in the support of geological research, and in advocating the introduction of geology as a subject regularly taught in the schools and examined for University Entrance.

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