ON THE SCIENTIFIC METHOD OF J. ROSS MACKAY

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ABSTRACT

'Scientific method' properly includes all the endeavours from the conception of an idea until final presentation and judgement upon it. The formal conceptual aspects of this work are well known. In the field sciences, however, the qualities and characteristics of the scientist may be particularly significant in determining the success of work. In this paper, I consider some of the qualities that underlie J. R. Mackay's achievements, particularly his ability to define problems from field observation and to design and execute field investigations.

The term "scientific method" properly includes all the endeavours from the conception of an idea to its full-grown presentation in publication. Observation and measurement, design and execution of experiments in the field and in the laboratory, later analyses of the results together with the addition of data and concepts from other branches of science, manipulation of data with statistics and computer modelling, followed by preparation of text, tables, and diagrams may all be involved. Ross Mackay's works clearly demonstrate his competency in all these aspects, but he stands out particularly in his ability to identify problems from field observation and to design and execute field investigations. These characteristics I intend to stress and illustrate, emphasising his work in that most difficult of terrestrial environments the Arctic.

NATIVE ATTRIBUTES

Excellent health may not be an absolute necessity for an Arctic scientist but it surely helps. Ross Mackay enjoys the benefits of health. He is almost immune to the biting cold and darkness of the Arctic winter. He can remove his mittens at forty degrees below to write notes or to couple the spade lugs of a probe to its electronic sensor, and has done so without falling prey to frostbite. But it is not just his resistance to cold, but also his precautions light inner gloves and brief exposure of his hands that have enabled him to escape this hazard.

Another characteristic of great advantage is a keen memory. To be sure, Dr. Mackay is considered by the Mackenzie Delta Eskimos to have a simply atrocious memory and as evidence they point out that he has to write down every little detail in his notebook. My evidence is quite the contrary.

I have walked with him on a bright winter day around the university campus, observing the patterns of stripes created by needle-ice. I have been surprised to find him withdraw from his pocket, first, a compass with which he measured the orientation of these stripes, and then a notebook from a decade earlier in which he had recorded a similar orientation on a particular date at this very same site. He was thus able to produce documentary evidence, not just a recollection by a demonstrably good memory, that the orientation was unchanged.

ACQUIRED CHARACTERISTICS

Preparation

Now lest we have given the impression that Arctic scientists are born rather than made, we should note some acquired or developed characteristics that particularly help Ross Mackay in his work. Probably the foremost of these can be summarised simply as 'preparation.'

He is widely read. At home, much of his time in the winter evenings is devoted to reading: history of the western Canadian Arctic, studies of frozen ground in any polar area, treatises on soil mechanics. With this he becomes armed with questions, ideas, methods, as background for future work.

An example of this type of preparation can be cited from his study of gas-domed pingos. After the unexpected, indeed almost catastrophic, discovery of open space beneath the active layer of a pingo and the discharge of its contained methane (more of this below), he entered the chamber. The frost crystals of the chamber roof caught his attention. The inner layer, in contact with the roof, occurred as plates and needles of ice, shapes which he had learned from his reading could be attributed to crystallisation at temperatures of 0 C to -5 C. An outer layer of hollow prismatic columns recorded later temperatures of crystallisation between -5 C and -8 C. From this he was able to infer the temperature conditions under which the ice crystals grew and confirm later with temperature measurements that the frost accumulation was the product of a single fall and winter. How many of us would have both the presence of mind and the background needed to observe and record the critical data on these fragile crystal forms before the opportunity was lost?

When he makes his winter visits to the Mackenzie Delta he carries with him a compact repair kit for his electronic gear, complete with a variety of spare parts. Most of the time the latter would prove to be unnecessary, a point that arouses envy and frustration on the part of some colleagues whose equipment does not behave as well as his. When, however, there is a breakdown he almost always has the necessary parts and tools to get his equipment back into service immediately.

Innovation

Included in Mackay's skills is a remarkable capacity for innovation. One of his guiding principles is that "the simplest thing that will do the job is the best thing to do the job." This, incidentally, leads to economical research (more of this later). A recent demonstration of this arose when he found that wooden doweling, to be used for survey stakes, was becoming hard to obtain and expensive when available. What could he find to substitute for this item? His answer bamboo chopsticks! These are inexpensive, available in quantity, pre-cut, pre-packed, and are remarkably distinctive when inserted into the Arctic tundra.

A more sophisticated innovation has been spurred by his interest in learning the precise time of day, as well as the time of year, when an ice wedge cracks open with the chilling of permafrost. He had already pioneered the technique of embedding a slender wire in the topsoil, after it had thawed in the summer sun, across the axis of the ice wedge. The wire, later frozen in with the winter cold, would snap at the instant the wedge split open. Accutron clocks are available, at a price, to time the breaking of the wire. Why not, he reasoned, use an inexpensive electronic watch, disconnect one battery terminal and reconnect it via the 'breaking wire.' When the wedge cracks the wire breaks and the watch stops. Moreover a watch that records both the day and the date can be left untended for 7 months before it repeats the pattern of days and dates. As a result it is possible to recapture both the time and the date for the rupture using a single, relatively inexpensive wrist watch.

And how to measure the minimum depth of an ice-wedge crack after it opens'? Simply insert a length of stiff surveyor's tape until it can be worked down the crack no farther. And how wide is the crack at depth? Attach to the bottom end of the tape a knob of known diameter. When this jams in the downward-narrowing crack, its width at a measurable depth can be ascertained. An array of such tapes, with a range of terminal knobs, can be used to estimate the rate of taper of the crack with depth.

Curiosity

The happy combination of the curiosity to look and the ability to recognise is another characteristic of Ross Mackay. Details catch both his eye and his interest, whether these be delicate ice needles growing from damp, rotten sticks, the striping of the ground after needle ice has melted, stones frozen within the ice of a pond and lifted off its floor, or the crook developed in the basal trunks of trees by the downslope creep of winter snow.

And not all the features attracting his attention and curiosity need be small. He was the first to associate some topographically high areas along the Beaufort Sea coast with basins directly upstream with respect to the flow of the former ice sheet covering this area. Why, for example, was Herschel Island, standing approximately 10 km square and 150 m high, matched in the waters of Mackenzie Bay by a hollow also about 10 km square and 100 m deep? To satisfy his curiosity he considered the possibility that the ice-thrust beds of Herschel Island had been dragged there by the overriding ice from the hollow to the south-east. When seismic exploration of Mackenzie Bay was later undertaken and the thickness of post-glacial beds thereby determined, it was shown that the match in volumes was even better than Mackay had estimated.

Observation and association only whet more curiosity. Why, for example, do ice wedges crack in the winter along the site of cracks of previous years'? What makes pingos grow'? How are pebbles hoisted into the ice of a freezing pond and which rock types are most susceptible to this process'? How fast does a rock stream move'? These questions and many more, arising from sharp observation and perceptive recognition of the anomalous or of the unexplained, constitute the curiosity that has served him so well. This curiosity has provided the fuel for his projects.

Dedication

Though his early training allowed him to opt for many careers, Mackay has concentrated on his Arctic exploration. True, he has also looked at alpine and winter conditions farther south, but principally because these were related to the problems of the northern lands and their frozen ground. For more than thirty years now he has devoted a high proportion of his time to this one field of endeavour. He has done much to pioneer winter research in the barren lands of the western Canadian Arctic. During recent years he has devoted up to a week in December and another week in March to the Mackenzie Delta

checking on depths of snow, subsurface temperatures, behaviour of ice wedges, changes in dimensions in the patterned ground.

Judgement

Judgement is a quality not easy to assess objectively. It represents a selection amongst choices. What might have followed from a different choice than the one that was made remains a matter of speculation a what if'. Nevertheless, if a high proportion of the choices are the right ones the cumulative effects become recognisable. I suggest, therefore, that the recognition that Mackay has received in his professional career can be credited in part to his exercise of good judgement. Thus, for example, his decision to avoid much of the committee work in favour of research, combined with hi decision to set aside time for planning and preparation at the expense of some other activity, plus his choice of instruments or methods to conduct his investigations, and so on, in concert if not individually, contribute to his success as a research worker in his chosen field.

Other judgements lie hidden within the written product of his research. In drawing conclusions he may give the impression of being very conservative. Notwithstanding this impression, he first considers a variety of hypotheses, some of which could indeed be considered outrageous, to explain some phenomenon he is investigating. Those hypotheses that fail to satisfy his evidence he soon rejects, and by degrees he arrives at a very limited number of explanations. He then considers their implications and designs a further test to narrow down the possibilities still more. What he finally commits to print may indeed be conservative but it is not for lack of consideration given to other perhaps less conservative viewpoints. What is presented has been thoroughly judged. The impression of conservatism is created not by the ultimate hypothesis but by his reluctance to speculate in public.

Interpersonal Relations

In his dealings with others during the planning and operation of his studies Ross Mackay is consistently polite, notwithstanding the frustration all too often experienced these days in the purchase and delivery of material or services. The junior clerk is treated with the same respect as the president of the firm. If the firm fails in its assignment it will, I am sure, be remembered, and where a suitable alternative is available business will be transferred. However, the acquisition of supplies, equipment, or service remains the prime consideration; recrimination made for its own sake plays no part.

This diplomatic approach has paid off. For example, when he sought consent both from native groups and from government officials for the artificial drainage of a lake near the Arctic coast, no ardent conservationist complained about the forthcoming devastation, nor did officials object to the catastrophic change. He had, of course, already convinced the natives and the authorities that the drainage of this lake by natural coastal retreat was inevitable within a few decades and that the turbidity created would be minor compared with the contribution of the Mackenzie River or of the wave erosion by a periodic storm. And the fact that the drained lake-basin would soon become good goose-hunting ground was not lost on some of the local residents.

Financial Matters

Ross Mackay is particularly circumspect on financial matters. He could have received premium fees for his own services as a consultant to the major companies engaged in the exploration and development of the petroleum resources of the north, both in Alaska and in the Northwest Territories, but he chose not to prostitute his science. He has eschewed all monetary rewards from the companies for the advice he has freely given them. He has accepted non-financial aid for his research, such as logistical support in the field for some of his students, use of company drill holes for some of his own instruments, and company observations on subsurface temperatures and soil types. One of the companies provided him with a field assistant, a trusted employee who, incidentally, learned the details of permafrost while serving on the job. One wonders who benefited most from this happy arrangement.

Financial support for his research has come largely from the Canadian government through the former Geographical Branch, the Geological Survey of Canada, the National Research Council and its successor fund- granting agency, the Natural Sciences and Engineering Research Council of Canada, and the Department of Indian and Northern Affairs. University funds and services have also been a major help. Transportation in the field, a major consideration in Arctic research, has been provided in large measure by the Polar Continental Shelf Project, another federal organisation. His policy in authorising expenditures from research grants is careful and his accounting meticulous. His care in spending coupled with the guiding philosophy that "the simplest thing that will do the job is the best thing to do the job" has given him an enviable reputation among funding organisations in terms of research production per dollar invested.

Views on Transport

Transport, to Ross Mackay, is a means to an end to reach the site for his investigations. Walking and snowshoeing are legitimate if slow and inefficient. Skiing is, surprisingly, not one of his favoured means of locomotion. The appeal of the snowmobile is also limited. Neither mode of travel appears to be completely controlled and safe.

In his early summer operations he first adopted the boat as a means of reaching sites along both Mackenzie River and the Arctic coast. For a few years he was accustomed to ordering a freight canoe to be delivered to Fort Providence, near the outlet of Great Slave Lake, from which point he would use it to cruise down Mackenzie River and work in the Delta for the summer. He would sell the canoe at Inuvik at the end of the season and fly out. He was introduced to the helicopter rather belatedly, and this has proved to be a persisting love affair. He is now convinced that no Arctic explorer should be without one.

Views on Adventure

Adventure is something a good scientist shuns. To Ross Mackay an adventure, in which something unexpected takes place, represents some miscalculation. Even such serendipitous adventure as the discovery of methane supporting the 'gas domed pingos' he investigated in 1963 falls into this category. The drilling of a small mound had been planned and a suitable power drill acquired and transported to the site. One of several pingos was chosen for investigation and a hole was started into the summit of the mound. Suddenly the drill stem and motor dropped to the ground as the bit entered open space. With the withdrawal of the drill gas started escaping from the hole. What gas? A match was struck to test the gas and it became immediately obvious that the gas was flammable. Soon the tundra adjacent to the pillar of burning gas was alight and with it the residue of gasoline on the keg of fuel. Some minutes were required to extinguish the fires. Not-withstanding the happy ending of this adventure Mackay, I am sure, wished, most particularly during those few tense minutes, for a better planned investigation.

Another adventure occurred while he was captain of the Tulik, a thirty foot schooner used for his early exploration of the Beaufort Sea coast. During one of his sessions at the helm, one of his two crewmen staggered from below decks in an obviously confused condition. Diagnosing the problem as a case of carbon monoxide poisoning, he had to rescue the second assistant from below and lash both of the dazed victims to the mast, all the while keeping watch that the vessel was not heading for trouble. Once again the adventure

had no lasting ill effects; once again Mackay wished it had never happened. Still another adventure was forestalled by his practice of checking his instruments. We were camped on the treeless coastal lowlands of northernmost Yukon Territory studying the local geomorphology to better understand the geological history of an archaeological site. On one of the first days the camp was thoroughly and persistently fog-bound. I undertook to make some measurements in camp, but Mackay wanted to pursue an investigation well out in the field and left our tent to set out by himself into the wilderness. Within minutes he was back in the tent, thrusting his pocket compass into my hands with the request that I check it. I soon identified his problem the north end of the compass needle was pointing south! Had he slipped off into the fog before checking his bearing he would likely have become disoriented and might well have strayed far from camp before breaking clouds could reveal the compass error an adventure averted this time!

Pure and Applied Research

All too often these days there are attempts to identify some scientific endeavour as either 'pure' or 'applied,' the former being motivated by curiosity and its results, by implication, of no immediate practical value to mankind; and the latter being of practical value, perhaps being of direct financial benefit, even though it may not advance the frontiers of science. Mackay's career clearly demonstrates the weakness of this classification.

His work throughout his career has been undertaken to satisfy a very active curiosity and with no claim for financial benefit or personal gain. For some eighteen years his efforts would have been designated 'pure science' until the discovery of oil at Prudhoe Bay. Then a very urgent need arose to understand the behaviour of ice-rich permafrost penetrated or overlain by pipes carrying hot oil. Mackay's pioneer work suddenly became transformed into very practical 'applied science.' Nothing had changed in the nature of his work or of his motivation; all that had altered was someone else's conception of its value.