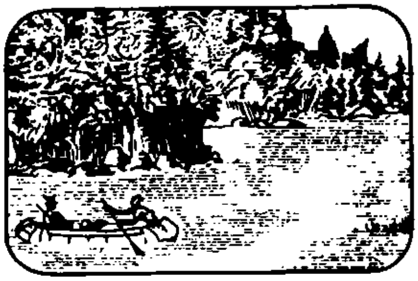
Features

History of Canadian Geology



The Scintillation Counter: Its Early Application as a Geophysical Instrument

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Summary
The portable scintillation counter as first used in prospecting for uranium was a distinctly Canadian invention, as was also the portable geiger counter which preceeded it. Its use as a geophysical instrument was an instant success. The Canadian Patent Office was at that time inundated with patent applications on improvements in ionization chambers and geiger counters but with the advent of the scintillation counter most applications concerning counters using gas in their detecting process ceased abruptly, they were obsolete. With a counting rate a hundred times or more above that of gas counters and its ability to discriminate gamma ray energy, the scintillation counter was quickly adopted for oil well logging, airborne and ground radioactivity surveys as well as expanded scientific research and medical applications. Much of the rapid advance in the field of radioactivity since 1950 is due to the scintillation counter.

Introduction
"Suppose we could make a portable instrument that was a hundred times more sensitive than the best hand model geiger counter, would this be of any use in prospecting for uranium?"

This question was put by Dr. R. W. Pringle to Dr. G. M. Brownell one day in January, 1949 as the two of them sat in latter's office in the Geology Department of the University of Manitoba. Dr. Pringle had only recently arrived from the University of Edinburgh where he had been working for a year or two on scintillation counters before coming to Winnipeg to take up his duties on January 1st, as Associate Professor of Physics. He led a research team in the Physics Department at Manitoba University which applied these devices to fundamental problems in nuclear spectroscopy, and later became the Chairman of the Department.

Uranium, an element discovered in the eighteenth century, was for more than a hundred years used merely as a colouring agent. Canada's only source of uranium at this time was the Eldorado Mine at Great Bear Lake in the Northwest Territories, which was discovered in 1930 and developed as a source of radium. However, later in 1945 this mine was suddenly taken over by the Government of Canada as a war measure and for the next three years prospecting for new uranium sources was restricted to that carried out by the Geological Survey of Canada and the Atomic Energy Control Board.

Then late in 1948 the Government of Canada and the United States both lifted restrictions on general prospecting for uranium. Looking back we now realize that Dr. Pringle's question could not have been better timed. So, early in 1949 three professors, Dr. R. W. Pringle the nuclear physicist; Asst. Prof. K. I. Roulston then a lecturer in Physics specializing in electronics; and Dr. G. M. Brownell, Professor of Geology; proceeded to develop a portable scintillation counter for uranium prospecting. This instrument was a success from the start and has played a major role in the discovery of uranium deposits all around the world. Moreover, its usefulness rapidly extended to the logging of oil wells, as well as to a host of medical and scientific applications.

Half a century earlier Sir William Crookes developed the "sprinthariscope", which was the earliest type of scintillation counter for the study of alpha particles. In this simple device, flashes of light or "scintillations" are produced when an alpha ray strikes a zinc sulphide screen as viewed at the bottom on a tube through an eyepiece. Although other crystalline salts were investigated and developed as phosphors at this time, early attempts to record these scintillations with photosensitive devices failed because the resulting electrical impulses were so feeble. Not until the late 1930s was the modern electron multiplier photocell developed and this in combination with single crystals of thallium-activated sodium iodide in the later 1940s made the modern scintillation counter for beta and gamma rays possible. Because of the high density (sp. gr. 3.6) of this crystal, and the higher atomic number of iodine, it has a high efficiency in stopping or absorbing gamma rays. By contrast, the rarified gas of geiger tubes as used in portable instruments captured only about one gamma ray for every several hundred rays which passed through the tube. The portable scintillation counter, or *scintillometer* as it was named, had a counting rate of at least one hundred times higher than that of any portable geiger counter in a given radiation field. The cosmic ray count which is proportionally high in a geiger counter, is relatively so low in the scintillation counter as to be negligible and usually can be ignored. This results in a much more favourable signal to background ratio. Moreover, it was the pioneering work of the Manitoba research effort which showed that sodium iodide scintillation counters could be used as gamma ray spectrometers and could distinguish in energy between the radiations from potassium, uranium and thorium.

Portable Instruments

The first (Mark I) Scintillometer was ready for field testing in April, 1949, in the Falcon Lake area of southeastern Manitoba. It was a success, although its bulk made it awkward for carrying. Two new gamma ray spectrometers (Mark II) were then assembled within the next several weeks which were light and readily portable so the next step was to put them to practical use. Accordingly, negotiations were initiated with Dr. Garnet McCartney of Toronto that led to systematic radioactivity surveys carried out during June, July and August of 1949 over several mining properties and uranium concessions in the Lake Athabaska territory, starting with the Nicholson Mine at Goldfields (Fig. 1). Interesting areas were here delineated by means of lines of equal radiation intensity or "isorads".

The initial attempt to measure radioactivity from aircraft was made on first approaching the Nicholson mine on June 18, 1949. Before landing, the pilot was instructed to fly over the main vein and in doing so a significant increase in radioactivity was noted with the instruments. A day or two later several flights were made with the two instruments connected in parallel from heights of approximately 400 feet and good signals of several times background were recorded over the uranium occurrences.

Figure 1
The first Scintillometer Surveys—June 1949, Nisto Property, Black Lake, Athabaska Area. Two Mark II spectrometers with ratemeters and controls suspended in front and separated from the battery, photomultiplier and crystal assembly carried in the bags at the side. R.W. Pringle—G. M. Brownell—K. I. Roulston.

Upon returning to Winnipeg in August, arrangements were made for the manufacture of the instrument by a local firm, Halross Instruments Corp. Ltd., and the portable Halross Scintillometer became widely used in the search for uranium over the next few years.

Airborne Instruments

It was about September 1st, 1949 when work was started on a scintillation counter specifically for use in aircraft. These instruments each with five photomultiplier tubes and with Na I(T1) crystals two inches in diameter and two inches long, were completed and in March, 1950, several successful flights were made. A radon source from the Manitoba Cancer Clinic was placed on the ground and with a small plane from the Winnipeg Flying Club, Dr. Pringle and later Dr. Roulston flew over the source at varying heights and made recordings of radiation intensity as a function of altitude and position of the aircraft. The following month Dr. Pringle in company with Dr. Hans Lundberg took an instrument to Colorado Springs and during one week demonstrated its capability to Dr. Tavelli of the United States Atomic Energy Commission in "rim flying" along the steep faces of mesas and canyons where the edges of horizontal strata are best exposed in the Colorado Plateau area.

Commercial demands for airborne Scintillometers soon followed and this necessitated the establishment in April, 1951 of Nuclear Enterprises Ltd., of Winnipeg to manufacture instruments. Dr. Hans Lundberg acquired the first one and this was followed by shipments to the Raw Materials Division of the United States Atomic Energy Commission, the Atomic Energy Commission of France and many others.

Oil Well Logging

Dr. Pringle in collaboration with P. W. Martin of the McCullough Tool Company of Los Angeles, ran the first Scintillometer logging tool in the Union Oil Company's T and G3 well at Orinda, California, in August, 1950.

Radioactivity logs are the only type that can be run in oil wells after the steel casing has been installed. Practically all such logs to 1950 were made with geiger counters which were three feet or more in length in contrast with the three inch crystal as the sensitive element in the scintillation counter. The much greater efficiency of the new instrument was demonstrated in a competitive test made in a Humble Oil Company's test well near Houston, Texas. In this test the log of the in-hole run of the Scintillometer at 250 feet per minute gave an excellent repeat record with that obtained during the out-hole run at the same speed. By contrast, the corresponding geiger counter runs, in-hole and out-hole at 10 feet and 18 feet per minute respectively, gave logs that had little resemblance to each other. The scintillation counter had the following indisputable advantages over earlier counters:

1) It is not affected materially by cosmic rays. (With the geiger counters, the cosmic ray count at the surface and many feet deep is the chief measurable effect.)
2) Sedimentary boundaries are clearly and accurately defined. (The three inch crystal defines contacts sharply as compared with the broad curves obtained with the three foot long geiger counters.)
3) Thin bed resolution. Three inch beds can be defined more readily than were three foot beds with the earlier counters. (In the Texas Gulf Coast area, good wells were brought in from twelve inch sand layers that could not be detected with the earlier counters.)
4) Content of formation can be determined, such as sands with shale stringers.
5) Good repeatability is obtained with the much higher counting rate.
6) Lack of drift due to temperature change in the well because the scintillation counter is held at a constant temperature by enclosing it in an insulated container with ice.
7) Direct recording of logs is possible. (Virtually all radioactivity logs prior to the use of the scintillation counter were hand-drafted, the logs being corrected by human interpretation. Thus the final logs included much guess work.)
8) Much faster logging speeds are possible because of the higher counting rate.
9) Because of the scintillation counter's ability to discriminate gamma ray energy, the discriminator can be set at the best energy level to produce the most meaningful log.

The above advantages of the scintillation counter resulted in rapid expansion of the use of radioactivity in oil well logging.

Berylometer

Another form of scintillation counter was developed specifically for the detection and analysis of the element beryllium during 1955-57 and named the *Berylometer*. The fundamental process here is the detection of photoneutrons which are emitted when beryllium is bombarded by gamma rays of sufficient energy. With the assistance of Dr. F. L. Funt in the Chemistry Department of the University of Manitoba, a phosphor with a high neutron detection efficiency was adapted to a portable scintillation counter which possessed a superior neutron:gamma discrimination ability. This combination together with an antimony 124 source produced a portable prospecting instrument which detects and measures beryllium only.

General

Beyond the realm of geophysics, scintillation counters have found very extensive use. Laboratory, industrial, and medical instruments of all kinds are in general use today. The human eye which used to count scintillations in Crookes' spinthariscope has been replaced by the more discerning photomultiplier tube and associated electronics of high complexity, and the simple zinc sulphide screen has been succeeded by a range of phosphors each adapted to scintillate under the bombardment of some specific characteristic of radiation, many of which were undreamt-of in Crookes' day. The scintillation counter must indeed take its place among the wonders of modern technology and has opened up a whole new world of most exciting applications.

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