Hans Lundberg: Canada's (and possibly the World's) first minerals geophysicist is inducted into the Canadian Mining Hall of Fame

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Introduction

Hans Lundberg was a geoscientist whose career spanned the first half of the 20th century. He was part Indiana Jones, part Howard Hughes and part Jules Verne. He was born in 1893 in Malmö, Sweden and died in 1971 in Toronto, Canada. Early in his career, he discovered significant extensions to the Buchans ore body (Newfoundland Canada) and finished with a 'score card' of being directly involved in the discovery of mineral deposits worth $CAN5B in 29 countries, many of which became mines. He developed the first functioning airborne electromagnetic (EM) system for minerals prospecting and was an early adaptor of aeromagnetic survey techniques, including the first to apply helicopters to carrying magnetic sensors. He fostered the early development of airborne radiometrics, and experimented with an early version of airborne gravity. His interests were not confined to minerals and he provided consulting services for the oil industry. Besides the pursuit of mineral and oil deposits, Lundberg successfully applied geophysical techniques to hunt for evidence of early humans in what is now central Mexico, and to locating meteorite fragments inside a crater in the Arizona desert. He was an early proponent of the value of petrophysics to help design and interpret survey results. While never his primary focus, Lundberg played a critical role in advocating the early use of exploration geochemistry in Canada, encouraging a number of key scientists who were seen as laying the foundations for modern geochemical practice in North America. Lunderg's role was such that he has been called the father of Canadian geochemistry (Brummer, Gleeson, and Hansuld 1987). He presented over 70 papers on geophysical and geochemical technology at meetings in North America and Europe. He developed what we would now call 'best practice' as to how to conduct modern exploration, and had a strong entrepreneurial flare that allowed him to draw many investors into his projects. He shared a vision for the future of exploration that in many respects was uncannily accurate in describing the world fifty years ahead of the one in which he lived. While many significant contributors came after Lundberg, he stands as a titan who truly led the way. In 2020 Lundberg was inducted into the Canadian Mining Hall of Fame in recognition of his enormous contributions to the minerals industry and exploration in particular during its critical formative era.

Hans Lundberg at a joint USGS-GSC meeting on aeromagnetic technology in Ottawa, September 1946. The USGS was using Gulf technology, but Hans Lundberg built his own equipment to avoid patent issues.

A life lived

No formal biography or autobiography of Lundberg exists. If he kept a diary, it has not been preserved. While the official records show he travelled extensively, indirect evidence suggests he travelled much more than has been documented. The available record consists of dozens of professional papers spanning the 1920s – 1950s, plus a number of magazine articles about Lundberg, the most significant being in the *Maclean's magazine* (Newman 1957). As well, a collection of business papers donated to the Archives of Ontario provide some additional background on Lundberg's complex life. Given the importance of the Buchans discovery to the Newfoundland and Labrador economy and mining in Canada, Lundberg's role in this event was well documented. The exploration industry for much of Lundberg's early career (pre-World War 2) was for the most part a few individuals experimenting with techniques they had developed or modified from the work of others. Equipment manufacturing or survey companies did not exist in the form they do now. However, some comments from the era suggest that opportunists abounded and in the absence of any formal professional regulation, much practice of questionable value was carried out. Many of Lundberg's early career talks and publications were of a tutorial nature, as he tried to pass on the basics of survey systems and the best practice in their use. His technological reach expanded enormously post-World War II, when he could finally acquire high resolution geophysical data from an aircraft. While detailed records are lacking, there is more than enough evidence that Lundberg's teams travelled the world performing surveys for minerals and oil, both it seems on a straight fee-for service basis and for a possible piece of the action. While Lundberg made early contributions to airborne EM technology, in the 1950s he chose to, in effect, pause his own efforts and wait for the new technology that was being developed in Scandinavia. In this period as well, he developed an interest in airborne gravity. The complexity of airborne gravity measurement was not appreciated in this era, and Lundberg was seen to have attached his energies

and credibility to a problem that could not be solved. On the airborne EM front, in the later part of his career, he took considerable interest in the Barringer/ Selco INPUT system and, in 1965, facilitated a successful test of INPUT over the Kiruna Mine in Sweden. His career wound down through the late 1960s, and when he died in 1971 the Lundberg Epoch was over.

Early career

Lundberg graduated from the Royal Institute of Technology, Stockholm, Sweden in 1917. His thesis was entitled "Electrical Prospecting". Lundberg's earliest contributions were carried out in Sweden on the application and interpretation of data from instruments designed for measuring electrical currents around sulphide deposits. Following the work of Conrad Schlumberger before WW I, Swedish physicists, led by G. Bergstrom, began developing prototype electromagnetic (EM) instruments that superimposed an applied electrical field and measured the resultant secondary field. Magnetic measurements were also obtained routinely using a variety of instruments. Lundberg and Harry Nathorst, while carrying out field surveys for an industry – government consortium, developed a new field variation of equipotential surveying that measured conductivity using two long, parallel electrical wires instead of the conventional two electrode mode. Designated by the Swedish Geological Survey as the Lundberg-Nathorst method, it proved much more sensitive and practical for field use in a cold climate and resulted in the discovery of two important orebodies in the Skelleftea District; Kristineberg in 1918 and Bjurfors in 1922. In this time frame Lundberg also showed an interest in conducting magnetic surveys from aerial platforms; he believed this would provide better access and faster coverage than afforded by ground surveys. To this end he experimented with instruments carried aloft by kites, gliders and large balloons. However, it was not until 25 years later, after World War II, that his vision of airborne geophysics could be practically realized.

In 1923 Lundberg joined the Swedish American Prospecting Corporation and for the next three years, carried out surveys in the US, Canada, Scandinavia, Belgium, France, Germany, Spain and Mexico. In 1926 ASARCO asked him to go to Buchans where he carried out equipotential surveys that resulted in several major mineral discoveries.

Mid-career: post-Buchans to World War II

During the period from 1926 – 1939, Lundberg continued working at Buchans and then broadened out when he started his own consulting business; Hans Lundberg Limited. It was during this time he developed a business model where his company could carry out contract surveys for a fee-for-service or take shares in the client company. If he invested, Lundberg would stay in until he could see if the company would take off or not and then move on, having no interest in being involved in the downstream development. In 1936, in Canada alone, his company worked in seventeen parts of Canada on 46 different projects. By 1940 he claimed to have been involved with 1 000 ground surveys covering 18 000 km^2.

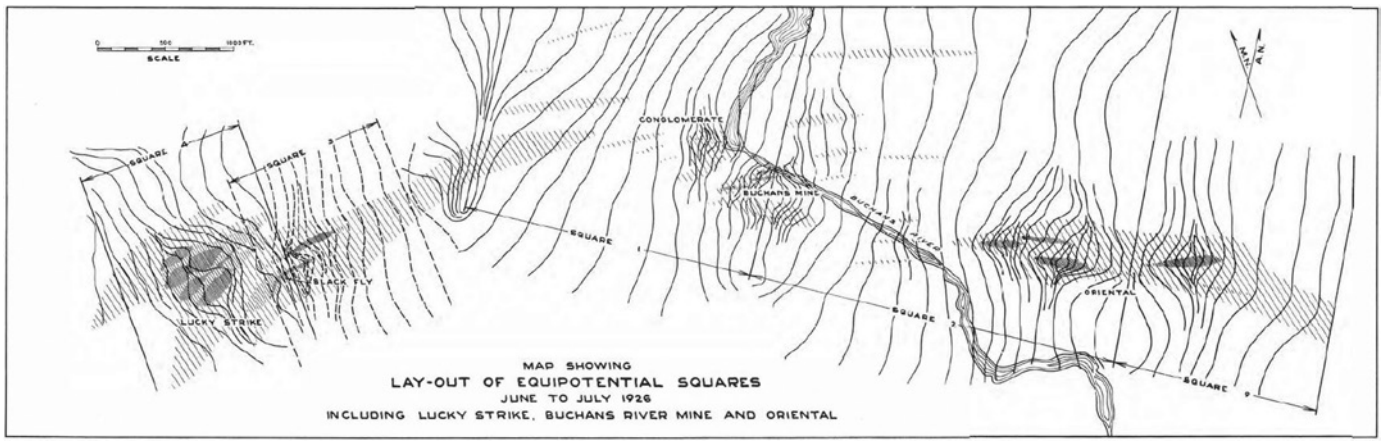
His interests were always varied and during this period he used his electrical techniques to locate 'lost' bootlegged champagne on a scion's estate. In 1937 he undertook a magnetic survey over the Barstow Crater in Arizona. Whereas previous efforts by another well-known geophysicist were inconclusive, Lundberg's survey produced clear evidence of a magnetic body located at the south end of the crater floor. Subsequent drilling in this location encountered blocks of Ni-Fe until, at 200 m depth, the drilling encountered an 'impenetrable' object, thought to be the main meteorite body.

In addition, during this time, he experimented with his ideas on using geo-botany, first around Buchans and then on other sites as a means to conduct geochemical exploration. He documented this work in an AIME publication in 1940.

Part of the Buchans crew (ca 1928): J. Ward Willaims is seated next to the doorway and Hans Lundberg is standing next to him. George Gilchrist is standiing on the left of the photo (source: Buchan Miners Museuem).

War years

In 1942, Lundberg was asked by the US government to carry out an exploration program in Greenland to investigate the presence of the mineral cryolite (an uncommon mineral then used as a flux in the manufacture of aluminum) at that time a strategic mineral for the war effort. Greenland was deemed as "occupied territory" (Demark was occupied by Germany at the time) so Lundberg's clandestine mission was likely sponsored by the OSS (precursor to the CIA). Lundberg also authored a number of position papers regarding the war effort, including a co-authored paper with Norm Keevil Sr. entitled "Geophysics and the Ontario War Effort". In 1941 Lundberg also authored a paper entitled "Emanations over Oil Fields and Ore Deposits and Geochemical



Hans Lundberg's iso-potential image from Buchans (source: Lundberg 1957).

Possibilities in Canada". This was the first Lundberg paper that discussed petroleum, a topic which he focused on in later years.

Post-war years

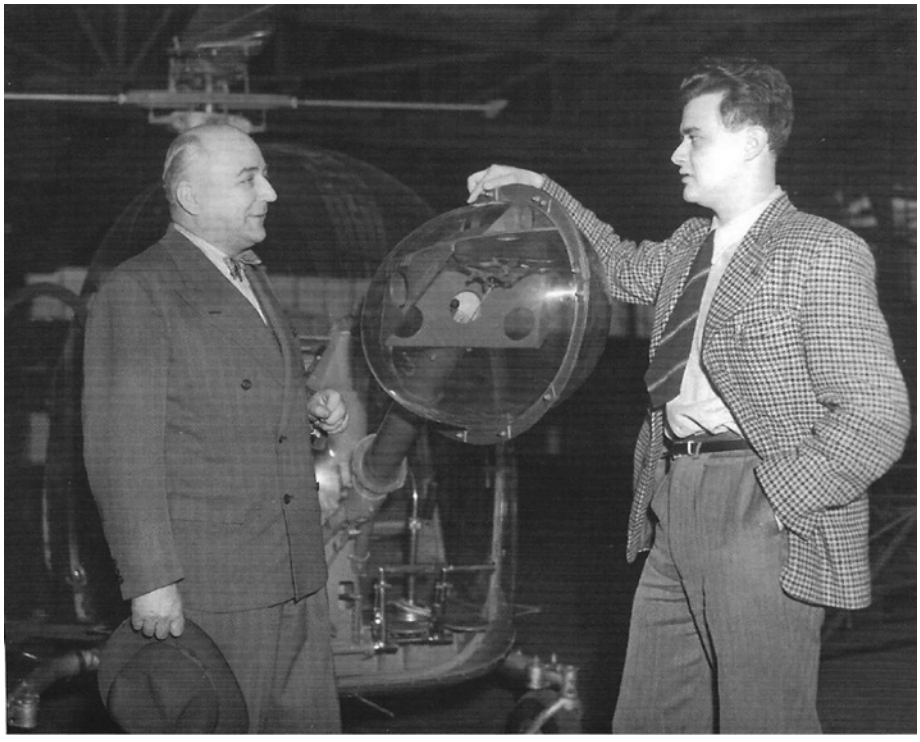
In the post-war era, Lundberg's "dream" of aerial geophysics developed rapidly. Governments and industry were intrigued with the concept of aerial geophysical surveys, and airborne magnetics was the first of these ideas to be implemented, largely due to work by the US Navy in refining magnetic sensors developed in the late 1930s by Gulf Research, which were commercialized in the post-war era. While most of the industry focused on fixed wing applications for airborne surveying, Lundberg was intrigued by the very new helicopter platform, and was the first to bring this technology into Canada for commercial use. His younger son Sten, a former RAF fighter pilot, became the first commercial helicopter pilot in Canada. In 1946, with great fanfare (*The Globe and Mail* 1946), Lundberg lead an expedition to "the north" where the new heli-borne magnetic surveying would be applied. In that year Lundberg also developed the first airborne EM system. While the system was very limited in its capabilities, it fired the industries' imagination and within a few years, two functional commercial systems were built; one by Lundberg for Conoco Oil who were looking for an innovative means to find petroleum, and the other by McPhar Geophysics for INCO. In the early 1950s, he began investigating the application of radiometrics to minerals and oil exploration, and then in the mid-1950s he championed technology which claimed to measure gravity from the air. This technology in the end provided unviable and Lundberg's reputation likely suffered as a result. As an explorer-geoscientist however, taking risks and not being overly concerned with the opinion of the community were likely critical factors in his career-long success at innovation and discovery.

Through the 1940s, Lundberg encouraged a number of younger scientists to study geochemical techniques for minerals exploration. This group, documented in Brummer, Gleeson, and Hansuld 1987, went on to form the foundations of modern exploration geochemistry in Canada.

The inquisitive Lundberg continued to provide his talents for "interesting" problems and in 1947 assisted with an anthropologic investigation near Mexico City. A piece in *Life* (1947) highlighted how Lundberg used electrical survey methods to find millennium-old early human burial sites.

The communicator

Lundberg's first paper was in 1919 and last in 1960; a total of 70 were in English and there are likely another 15 in Swedish (Lundberg was conversant in eight languages). Almost all of the papers involved an oral presentation as



Hans Lundberg and his son Sten (to the right of the Bell 47B2) standing next to the magnetometer that projects from the bubble (source: Bell Helicopter/Jeff Evans and Ned Gilliand Collections).

Bell 47B2 helicopter showing the magnetometer attached to the front of the bubble. Bell pilot Jay Demming is in the left seat (on the right in the photo) and Hans Lundberg is seated next to him (source: Bell Helicopter/ Jeff Evans and Ned Gilliand Collections).

well as a full paper. This required a large amount of often time-consuming travel, usually by train since the commercial airline industry was in its infancy during most of Lundberg's career. The early papers were very instructional in nature as Lundberg (as well as a few others) tried to educate the emerging minerals exploration community about what geophysics and then geochemistry could achieve. Lundberg made an impression on his audiences. An emeritus professor in his mid-80s from the University of Toronto was asked about whether he had encountered Lundberg. He remembered a talk Lundberg gave in 1951, when he was a student and Lundberg was speaking to a group of physics and geology students at an event called the "Skule Dinner". Lundberg related the story about finding the 'lost' cases of champagne. Being a good scientist, Lundberg did not undertake this exercise without a trial and had a number of cases with empty bottles buried to establish that a signature could be obtained with his equipment before he went after the real target. He was paid for his efforts in champagne.

Hans Lundberg conducting an iso-potential survey at Tepexpa in Mexico (source: Life 1947).

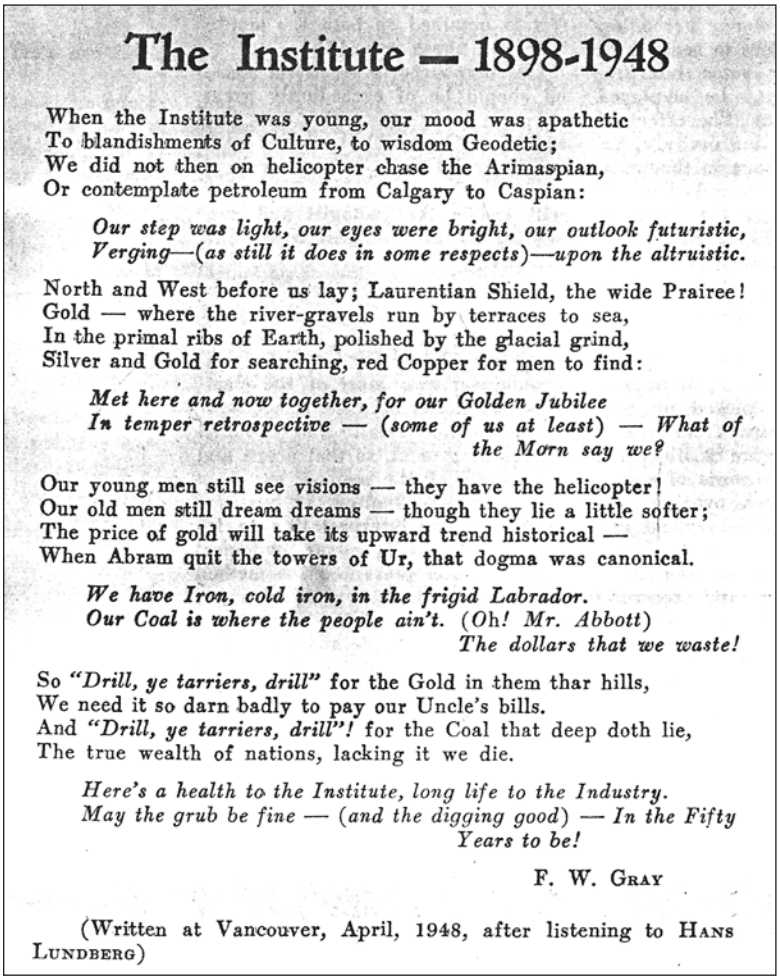
At a CIMM (Canadian Institute of Mining and Metallurgy) conference in 1948 Lundberg presented some of his ideas as to how exploration would look like in the future. Several of his "predictions" were:

- *To reach orebodies with geophysical methods, we gradually have to increase our range at depth. The so-called ' transient methods' have already shown, in encouraging experiments, that depths as great as 10 000 feet (~3 km Ed.) may be reached without too many difficulties. Without much imagination, we may anticipate developments within the next few years to show remarkable new methods. All topographic mapping, as well as magnetic and electrical surveys, will be carried out from the air. For detail surveys, the helicopter-borne magnetometer and electrical equipment may render as much detail information as any ground survey. Regional studies employing radioactive and geochemical methods may cover very large areas in surprisingly short time.*
- *The habit of drawing maps that show two dimensions only will be succeeded by new stereoscopic projections so that the geophysical results will be seen in three dimensions, either on a screen or by using polarized light and specially prepared maps. Such maps will show, besides the topography, the position of the anomalous body at its proper position below the surface. In this way, when the orebody can actually be seen at depth, in this way it will be easy to aim drill holes or plan mining operations.*

This was in 1948 when much of modern exploration practice was still in its infancy. What Lundberg suggested has become common practice in the last decade, 60 years after he presented his ideas in Vancouver. A geologist in the audience was so moved by Lundberg's presentation, that he wrote a poem expressing the feelings that Lundberg's talk invoked in him; the CIMM published the poem following year (see following page).

In January 2020, Lundberg was inducted into the Canadian Mining Hall of Fame in recognition for his contributions to the Canadian mining industry and development of modern geophysical practice.

All references cited in this article plus more information on Lundberg's career is being assembled and will be posted onto the DMEC web site (www.DMEC.ca) under the "Resources" section in the next couple of months.



The Institute — 1898-1948

When the Institute was young, our mood was apathetic
To blandishments of Culture, to wisdom Geodetic;
We did not then on helicopter chase the Arimaspian,
Or contemplate petroleum from Calgary to Caspian:

Our step was light, our eyes were bright, our outlook futuristic,
Verging—(as still it does in some respects)—upon the altruistic.

North and West before us lay; Laurentian Shield, the wide Prairee!
Gold — where the river-gravels run by terraces to sea,
In the primal ribs of Earth, polished by the glacial grind,
Silver and Gold for searching, red Copper for men to find:

Met here and now together, for our Golden Jubilee
In temper retrospective — (some of us at least) — What of the Morn say we?

Our young men still see visions — they have the helicopter!
Our old men still dream dreams — though they lie a little softer;
The price of gold will take its upward trend historical —
When Abram quit the towers of Ur, that dogma was canonical.

We have Iron, cold iron, in the frigid Labrador.
Our Coal is where the people ain't. (Oh! Mr. Abbott)
The dollars that we waste!

So *"Drill, ye tarriers, drill"* for the Gold in them thar hills,
We need it so darn badly to pay our Uncle's bills.
And *"Drill, ye tarriers, drill"!* for the Coal that deep doth lie,
The true wealth of nations, lacking it we die.

Here's a health to the Institute, long life to the Industry.
May the grub be fine — (and the digging good) — In the Fifty Years to be!

F. W. Gray

(Written at Vancouver, April, 1948, after listening to Hans Lundberg)

Poem written by F.W.Gray after listening to Lundberg's 1948 presentation on the future of exploration.

Ken Witherly (with glass of wine) and colleagues celebrating Lundberg's induction into the Canadian Mining Hall of Fame. Left to right; Norm Paterson, Frank Jagodits, Edna Muller, Mandy Long, Jenna McKenzie, Ken Witherly, Lynda Bloom, Emily Farquhar and Richard Smith. Photo taken by Tim Dobush.

References

Brummer, J. J., C. F. Gleeson, and J. A. Hansuld. 1987. A historical perspective of exploration geochemistry in Canada – the first 30 year, in R.G. Garrett (Editor), Geochemical Exploration 1985. *J Geochem Explor* 28: 1–39.

Lundberg, H. 1957. The discovery of large lead-zinc deposits at Buchans, Newfoundland. In *Methods and Case Histories in Mining Geophysics*, 141–154. 6th Commonwealth Mining and Metallurgical Congress.

Newman, P. C. 7 December 1957. The Hottest treasure hunter in history. *Maclean's Magazine*.