

Scientific Sovereignty: Canada, the Carnegie Institution and the Earth's Magnetism in the North

Gregory A. Good

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Résumé de l'article

Les travaux de mesure du champ magnétique terrestre débutèrent en 1905 sous les auspices du Department of Terrestrial Magnetism (DTI) de la Carnegie Institution of Washington sous la direction de Louis Agricola Bauer. Le DTI désireux de récolter des données à l'échelle mondiale, voulait effectuer des mesures au Canada, ce qui posait le problème de la souveraineté du pays. Bien que le DTI ne fut pas une agence gouvernementale américaine, il était néanmoins étranger. L'effet de ses activités au Canada fut de stimuler la recherche géophysique au Service de météorologie du Canada et à l'Observatoire du Dominion. Ce projet fut entrepris dans un climat de rivalité interministérielle et eut pour résultat le contrôle du domaine par l'Observatoire du Dominion.

SCIENTIFIC SOVEREIGNTY: CANADA, THE CARNEGIE INSTITUTION AND THE EARTH'S MAGNETISM IN THE NORTH

Gregory A. Good¹

ABSTRACT

In 1905, magnetic survey work began under the auspices of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington directed by Louis Agricola Bauer. The DTI, wanting world-wide coverage, wished to make observations in Canada but this raised the question of sovereignty. Although the DTI was not a government agency, it was foreign. The impact of its work in Canada was to stimulate geophysical research by the Canadian Meteorological Service and by the Dominion Observatory. This research was undertaken in the context of inter-departmental rivalry which finally resulted in control of the field by the Dominion Observatory.

RESUME

Les travaux de mesure du champ magnétique terrestre débutèrent en 1905 sous les auspices du Department of Terrestrial Magnetism (DTI) de la Carnegie Institution of Washington sous la direction de Louis Agricola Bauer. Le DTI désireux de récolter des données à l'échelle mondiale, voulait effectuer des mesures au Canada, ce qui posait le problème de la souveraineté du pays. Bien que le DTI ne fut pas une agence gouvernementale américaine, il était néanmoins étranger. L'effet de ses activités au Canada fut de stimuler la recherche géophysique au Service de météorologie du Canada et à l'Observatoire du Dominion. Ce projet fut entrepris dans un climat de rivalité interministérielle et eut pour résultat le contrôle du domaine par l'Observatoire du Dominion.

INTRODUCTION: GEOMAGNETISM IN 1900

In 1902, Louis Agricola Bauer proposed to establish an International Magnetic Bureau as part of the new Carnegie Institution of Washington. According to

1 Dept of History, West Virginia University, Morgantown, WV.

Bauer's prospectus,

The purpose of the proposed Bureau is to investigate such problems of world wide interest as relate to the magnetic and electric condition of the earth and its atmosphere, not specifically the subject of inquiry of any one country, but of international concern and benefit.²

In short, Bauer advocated a world-wide geomagnetic survey, just as Halley, Gauss and Sabine had done before him. But now the time was ripe for such an ambitious undertaking. Many European nations had completed magnetic surveys of their own territories, including some of their colonies.³ Moreover, Bauer was just the man to do it. He had completed a PhD on secular variation of the Earth's magnetism at Berlin, he had trained in practical magnetic survey work at the US Coast and Geodetic Survey, and he had organized and set underway the first comprehensive magnetic survey of the United States. He knew the phenomena, the instruments and how to coordinate a large observational program involving dozens of workers. An ambitious and energetic man, he did not shrink from literally taking on the world. The Carnegie Institution approved his project, and the Department of Terrestrial Magnetism -- the DTM -- was born. Active survey work began in 1905.

- 2 L.A. Bauer, 'Proposed International Magnetic Bureau,' *Carnegie Institution of Washington Yearbook*, No. 2, 1903, 203. The proposal was presented to the Board of Trustees on 26 January 1902.
- 3 The state of the magnetic survey of Europe and Asia just before 1900 is discussed by Alexis de Tillo, 'Magnetic Survey of Europe and Asia,' *US Weather Bureau Bulletin*, No. 11, (Washington, DC, 1894-96), 465-9. European and Asian surveys and some others are discussed by Georg Neumayer, in 'Fber die Bedeutung und Ziele erdmagnetischer Landesvermessungen,' Sonderabdruck aus den *Verhandlungen des IX. Geographen-Tages in Wien, 1891* (Berlin, 1891), 11-27. Little attention has been given to national or colonial geophysical surveying. Exceptions to this include Joanneke de Bruin and Lewis Pyenson, "Gentleman-Scientist": Elie van Rijkevorsel and the Dutch Overseas Effort in Exact Sciences at the End of the Nineteenth Century,' *Annals of Science*, 1986, 43: 447-73 which discusses geomagnetic surveying in the Malay archipelago; Gregory A. Good, 'The Study of Geomagnetism in the Late-19th Century,' *EOS: Transactions of the American Geophysical Union*, April 19, 1988, 69:218-228.

A magnetic survey of the oceans and unexplored areas like the Antarctic presented no serious questions of protocol. No national government wanted to assume the expense or trouble of updating magnetic charts, but they all acknowledged their value to navigation and commerce. The willingness of the Carnegie Institution to undertake this survey was welcomed warmly.

But countries such as Canada presented Bauer with a delicate problem. Here there was an issue of sovereignty. This was not always a problem of political sovereignty, since the DTM was not a branch of the US government, but a privately-endowed institution. And DTM observers always obtained permission from appropriate governments for their travels. Nevertheless, an issue of scientific sovereignty remained, regarding claim not over territory, but over a discipline and over the ability of Canada's scientists to execute research in this discipline. The issue was one of prerogative and pride. Canada had a well-known history of active research in geomagnetism.⁴ Several officials of the Canadian government had experience in the science and intended to develop it. The DTM could not simply step in with its plans for a world-wide survey and launch expeditions into Canadian territory. What followed, then, was several decades of interaction between Canadians and the DTM, caught somewhere between cooperation and competition. Another interaction induced by the DTM's work in Canada occurred between two agencies of the Canadian government, the Meteorological Service and the Dominion Observatory, to decide which of them could lay claim to a Canadian magnetic survey, and more generally to geophysics. This article is the story of this three-way struggle for sovereignty in geophysics.

4 See: F. Heider, 'One and a half centuries of geophysics in Canada,' *Mitteilungen, Arbeitskreis Geschichte der Geophysik*, June 1988, 7. Jahrgang, Heft 3, 4-33. G.D. Garland, 'Trends in Geophysical Research in Canada,' in E.R.W. Neale, ed, *The Earth Sciences in Canada: A Centennial Appraisal and Forecast* (Toronto, 1968), 37-51. Suzanne Zeller, *Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation* (Toronto, 1987). C.J. Taylor, 'Science and the North, a thematic context for the Churchill Rocket Research Range,' internal report for the Historic Sites and Monuments Board of Canada. Trevor H. Levere, 'Magnetical Instruments in the Canadian Arctic Expeditions of Franklin, Lefroy, and Nares,' *Annals of Science*, 1986, 43:57-76. Gregory A. Good, 'Toronto Magnetic Observatory and International Science ca. 1850,' *Vistas in Astronomy*, 1985, 28:387-390. Gregory A. Good, 'Between Two Empires: The Toronto Magnetic Observatory and American Science before Confederation,' *Scientia Canadensis*, 1986, 30:34-52.

GEOMAGNETISM IN CANADA BEFORE THE DTM

In 1893 at the Chicago Meteorological Congress, Charles Anthony Schott of the US Coast and Geodetic Survey discussed the magnetic survey of North America. While he mentioned the Toronto Magnetic Observatory as being in operation since 1840, he especially commended the 1840s magnetic survey of John Henry Lefroy in Canadian and Hudson Bay Company territory.⁵ This, he said, was 'the most extensive survey as yet undertaken on this continent.'⁶ But while he listed many independent explorers who had executed magnetic work in the Arctic, and while he detailed the systematic surveys of various American governmental agencies, the Canadian government was conspicuously absent from the discussion.

This was not merely Schott's ignorance, though there had been some Canadian magnetic observations of which he was unaware. In fact, no Canadian government department had adopted terrestrial magnetic surveying as had the US Coast and Geodetic Survey. The Toronto Magnetic Observatory might have done so, but instead its directors from 1860 on shifted their attention to the development of a weather service. Although some magnetic records had been maintained, none of them had been published since 1875.⁷ The Observatory Director through the 1880s, Charles Carpmael, 'had discarded the V[ertical]

5 Charles Anthony Schott, 'Magnetic Survey of North America,' *US Weather Bureau Bulletin*, No. 11, (Washington, DC, 1894-1896), 460-464. This paper was part of a special issue 'Papers Read Before the Chicago Meteorological Congress, August 21-24, 1893.'

6 *Ibid.*, 462.

7 Frederic Stupart to Charles Chree (Director, Kew Observatory), 9 October 1894, Atmospheric Environment Service Library Archives, File 1894B, Item 696. Hereafter items from this archive will be listed in the form AES.1894B.696.

F[orce] [magnetic] balance altogether.⁸ Magnetism simply was not the observatory's main duty any longer.⁹

When Frederic Stupart (1857-1940) assumed control of the Meteorological Service (and thus the Magnetic Observatory) in 1894, he wanted to revive its reputation for magnetic work. Stupart started in the Meteorological Service as a boy. All his training was with the Service and he never attended university. Nevertheless, he conscientiously developed meteorology in Canada and came to know personally meteorologists and magnetic scientists in the USA and Europe.

As the new director, Stupart focused on disseminating the continuous photographic record of the magnetic elements to scientists in other countries.¹⁰ He attended the International Meteorological Congress in Paris in 1896, where he participated in discussions on international standards in magnetic work.¹¹ Moreover, he was thinking of expanding the Observatory's work into cognate areas such as seismology and climatology.¹² But the strongest evidence of Stupart's renewed commitment to geomagnetic research was the campaign he launched, and won, for the construction of a new magnetic observatory beyond Toronto and the electromagnetic disturbances caused by the trolleys. In 1898, he opened the Agincourt magnetic observatory.¹³

A magnetic observatory in the 1890s did not necessarily have anything to do with

8 Stupart to Chree, 18 June 1901, AES.1901B.20.

9 Only one publication of magnetic observations appeared during the directorship of Charles Carpmæl: *Abstracts and Results of Magnetical & Meteorological Observations at the Magnetic Observatory, Toronto, Canada, from 1841 to 1871 Inclusive* (Toronto, 1875).

10 For example, Stupart to M.A. Veeder, 12 October 1894, AES.1894B.710; Stupart to P. Tachini (Central Meteorological Office, Rome), 9 November 1894, AES.1894B.810. The records are replete with such correspondence about magnetic disturbances, earthquakes, and sunspots.

11 Stupart to F. Gourdeau (Deputy Minister of Marine and Fisheries, Canada), 3 November 1896, AES.1895B.675-676.

12 Stupart to Gourdeau, 13 March 1897, AES.1895B.823.

13 Stupart to Gourdeau, 27 August, 1 October 1897, AES.1897B.15-17; 26 February 1898, AES.1897B.264-5; and 24 September 1898, AES.1897B.505. This story is also told in R.F. Stupart, 'The Toronto Magnetic Observatory,' *Proceedings of the Canadian Institute*, New Series, September 1899, vol.2, part 2, 31-33.

magnetic field work. Stupart initially had no interest in sending observers hither and yon about Canada. Rather, his magnetic research concerned magnetic storms and their possible relationships to sun spots and the weather. Hence, in Stupart's first years as director, the Toronto Observatory conducted no magnetic surveys. But others had. These surveys were, as the Canadian magnetic scientist W.E.W. Jackson later described them, spasmodic.¹⁴ They were the work of individual explorers and surveyors -- some of whom later became important in government science.¹⁵ French states here that before 1907, 'magnetic work had been confined, for the most part, to the activities of explorers, surveyors and to the Toronto Magnetic Observatory....' Stupart himself, for example, had been attached to an expedition to Hudson Strait and Bay with Capt Andrew R. Gordon, RN, in the 1880s.¹⁶ At least one government agency, the Topographical Survey, had done some partial magnetic surveying starting in the 1880s.¹⁷ And another agency showed interest in 1896, when Stupart ordered a magnetometer for the Hydrographic Survey of the Department of Marine and Fisheries.¹⁸

But after returning from the 1900 International Meteorological Congress, Stupart evinced a new interest in bringing magnetic surveys under the Meteorological Service's control. He wrote his Deputy Minister:

- 14 W.E.W. Jackson, 'The Development of the Magnetic Survey of Canada,' *Terrestrial Magnetism and Atmospheric Electricity*, 1932, 37:215-216.
- 15 C.A. French, 'Magnetic Results, 1907-1920,' in *Publications of the Dominion Observatory* [Pubs DO], vol.5, no.5 (Ottawa, 1921), 131.
- 16 Stupart to Deputy Minister (Department of Marine and Fisheries), 15 July 1909, AES.1908D.453-454; Stupart to Bauer, 20 September 1909, AES.1906D.308. The survey work of Gordon is also discussed in the diary of Frank Davies, NAC.MG30.B73, 306-307. Gordon was an assistant to Charles Carpmael, director of the Toronto Magnetic and Meteorological Observatory, before being placed in charge of the Quebec Observatory for a short while. The expedition to Hudson Bay was in 1884. Cf. Richard Jarrell, *The Cold Light of Dawn: A History of Canadian Astronomy* (Toronto, 1988), 49-51.
- 17 C.A. French, 'Magnetic Work of the Dominion Observatory, Ottawa, 1907-32,' *Terrestrial Magnetism and Atmospheric Electricity*, 1932, 37:335-342, 336. Two of the people who worked for the Topographic Surveys Branch in the 1880s were Otto Klotz, later Dominion Astronomer, and Noel Ogilvey, later Chief of the Geodetic Service. These surveyors measured mainly declination, and infrequently the inclination or dip. Part of the development of this and related surveys in the late-19th century are discussed in Don W. Thomson, *Men and Meridians: The History of Surveying and Mapping in Canada*, vol.2, 1867-1917 (Ottawa, 1967), chapter 7, especially 116-120.
- 18 Stupart to Elliott Brothers, 31 March 1905, AES.1904D.921.

Scientific men of today are becoming more and more convinced of the paramount importance of a knowledge of the laws which govern terrestrial magnetism and one by one the various civilized countries are organizing to vigorously attack the problem and it will not be long before this country will be asked to make a complete magnetic survey of the Dominion. Our stationary magnetic observatory will most certainly play an important role in such a survey.¹⁹

Stupart was preparing the Deputy Minister for a new project.

The discussions of magnetic surveys at the Congresses had induced Stupart to begin considering new functions for his observatory. In 1901, Stupart had no doubt that his Service was the right home in Canada for a magnetic survey. As he told a professor at the University of New Brunswick, the time for a magnetic survey of the Dominion was 'nearly ripe' and

...I know of no Dominion Officer who could approach the Government with better prospect of success than myself owing to my position as Director of the Toronto Magnetic Observatory.²⁰

Exactly how the Meteorological Service would participate in a magnetic survey would later be a hotly debated question, something Stupart did not yet suspect.

Within a few months, Stupart was recommending that magnetic research be carried out on an Arctic expedition to be led by Capt J.E. Bernier.²¹ But he did not have adequate equipment for field work. When in 1901 Robert Bell, the Acting Director of the Geological Survey, inquired about borrowing magnetic instru-

19 Stupart to Gourdeau, 8 November 1900, AES.1899B.272-3.

20 Stupart to A. Melville Scott, 15 January 1901, AES.1900C.307.

21 Stupart to Sir Louis H. Davies (Minister of Marine and Fisheries, Canada), AES.1899B.382-3.

ments, all Stupart had was one portable magnetometer, and it was in constant use at the observatory. One on order would arrive too late.²² The opportunity for ordering a magnetometer was the willingness of the New Brunswick professor to conduct a regional survey. A birth announcement of a magnetic survey, however, would have been premature.²³

Nonetheless, the Magnetic Observatory had been helping the Surveyor General's office in its magnetic work for several years. Since 1899 Stupart had officers of the Dominion Surveys Branch trained at the Observatory in the operation of magnetic instruments for land surveys in the west.²⁴ He had also offered to train employees of the Geological Survey.²⁵ In 1901, Stupart saw training and the standardization and lending of instruments as either the function of the Meteorological Service within a Canadian magnetic survey, or he saw these as his thin wedge toward a more comprehensive role.²⁶

But by 1904, the extensive data on magnetic declination, dip and total intensity gathered by the Surveys Branch had not been brought together and published.²⁷ This was not Stupart's fault, but it might have shown him a major drawback to a survey split between several departments. Yet when Bauer, in the first blush of his DTM in the summer of 1904, asked Stupart if there were a magnetic survey of Canada afoot, Stupart replied that it was not possible for the Meteorological Service to do it alone. He would approach William F. King (1854-1916) at the

22 Stupart to Robert Bell, 4 May 1901, AES.1900C.825.

23 Stupart to Scott, 5 March 1901, AES.1900C.549-550.

24 On the training of Mr. White-Fraser see Stupart to William Menzies, 26 January 1899, AES.1898B.650 and of Mr. Tyrrell see Stupart to Capt. E. Deville (Surveyor General, Department of the Interior), 15 January 1901.

25 Stupart to Bell, 4 May 1901, AES.1900C.825.

26 This early activity is briefly discussed in W.E.W. Jackson, 'The Development of the Magnetic Survey of Canada,' *Terrestrial Magnetism and Atmospheric Electricity*, 1932, 37:216. Jackson credits the Dominion Surveys Branch with providing thousands of magnetic readings 'as a by-product' of their land survey.

27 Stupart to Bauer, 4 June 1906, AES.1904C.491-2.

Dominion Observatory 'to organize a systematic survey.'²⁸ Not coincidentally, within a few weeks of this statement, Stupart hired a fresh, University of Toronto honours graduate in mathematics, Jackson, who would become the central figure in Meteorological Service magnetic work in the decades to come.²⁹

There are a number of possible reasons that the Canadian government did not readily develop a magnetic survey: low level of resources, little appreciation of science, little conscious science policy and so on. One reason not to be ignored, though, is the uncommon level of expertise required with recondite instruments and procedures. Magnetic research requires awareness of instrumental subtlety and a knowledge of magnetic principles far beyond those required for topographical surveying at the time. And while the analytical expressions of the theory of magnetic measurements may be mathematically trivial, they are time-consuming in practice, and hence costly. A manual for magnetic researchers published in 1921, dedicated thirty pages to this preliminary training.³⁰ The manual then turned to directions for magnetic observations on land: forty-four more pages.³¹ Moreover, the commitment of time and expense in the actual surveying work was not trivial. Magneticians, as these observers were called, were at least extremely well-trained technicians, skilled at a variety of delicate measurements and involved calculations. The best among them also understood current ideas on electricity and magnetism, geomagnetism, aurorae, solar-terrestrial relations and exploration geophysics. These more advanced magneticians moved beyond field work and developed independent research programs.

An observer conducting only magnetic measurements around 1900 required at least a theodolite magnetometer, a dip circle, a chronometer, a specially designed observing tent and in most cases some auxiliary back-up instrument.

28 Stupart to Bauer, 4 June 1904, AES.1904C.491-2.

29 Stupart to Walter Jackson, 22 June 1904, AES.1904C.605. Jackson was hired as an assistant in the main office of the service, not for the magnetic work. He was an honours graduate in mathematics (Stupart to Gourdeau, 13 July 1907, AES.1906C.969-970).

30 Hazard, Daniel L., *Directions for Magnetic Measurements*, 2nd ed. (Washington, DC, 1921), 6-35.

31 *Ibid.*, 36-79.

The DTM issued a 'universal magnetometer' which could measure all three primary magnetic elements: the declination, inclination and intensity.³² The cost of the entire outfit was roughly half the annual salary of a college-educated magnetician. The 'occupation' of an observing station required getting there (no minor consideration in the Barrens!), precise determination of latitude, longitude and the magnetic elements. The most time-consuming measurement was magnetic intensity. Usually the horizontal component of the intensity was measured. But in areas where the daily variation of declination and horizontal intensity is significant, or where the horizontal intensity vanishes, as in northern Canada,³³ the total magnetic intensity had to be measured using a dip needle, likewise a delicate operation. Assuming that sightings of the sun were possible and that no magnetic disturbances due to solar activity compromised the measurements, occupation of a site required one or two days. A single observer travelling quickly might occupy twenty or thirty sites in one season. Clearly, to cover Canada would require many seasons, or a greater investment in instrument sets and observers. The inauguration of a full-fledged magnetic survey by any government was not an easy step from, say, topographical surveying.

ACTIVITY OF THE DTM IN CANADA

The DTM began its magnetic survey work in Canada with a vengeance. Its rapid entry into the field, in hindsight, could have been expected. Part of Bauer's background included the management of field work for the American Coast and Geodetic Survey, an operation that had reduced exploration to a system, with hydrographic, geodetic and geomagnetic mapping as the primary functions. The DTM was even more single-minded, with its sights focused tightly on magnetical measurements. Its world-wide agenda required intense activity. Nowhere was this more evident than in Canada.

32 Ibid., 40. On universal magnetometers, see L.A. Bauer and J.A. Fleming, 'Land Magnetic Observations, 1911-1913,' *Researches of the Department of Terrestrial Magnetism* (Washington, DC, 1915), Publication No.175, vol.2, 7-12.

33 As one approaches the north magnetic pole, the direction of the Earth's magnetic field is more and more vertical. Hence the horizontal component of the force vanishes. Likewise, near the magnetic pole, declination and horizontal force vary rapidly with time.

The level of activity of the DTM in Canada was generally underestimated and underemphasized by American spokesmen, a fact possibly significant in itself. Daniel Hazard, who was later Chief Magnetician of the Division of Terrestrial Magnetism at the Coast and Geodetic Survey, told an audience in 1925 that:

In some instances, as in Canada, one season's work by an observer of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington was sufficient to stimulate local interest to a point where means were provided for continuing the work under local auspices.³⁴

This remarkable simplification bears no relation to the actual interaction between the DTM and Canadian magneticians.

The driven activity of Bauer's expeditionary machinery greatly over-powered the indecision and infighting of the Canadian governmental agencies before 1910. In its first six years of field work, 1905 to 1910, thirty-five DTM observers travelled on every continent except Antarctica. They established 1,298 observation stations, 162 of these being in Canada and twenty-seven in Newfoundland and Labrador, then foreign territory to Canada, too. At almost every one of these stations, readings were taken of all three magnetic elements.³⁵

In addition to the observations for the world magnetic survey, the DTM also sent out parties on special projects. In the first season of field work, four parties went to locations in Canada or Labrador to observe the magnetic elements and atmospheric electricity during a total solar eclipse.³⁶ Part of the motivation for these expeditions was to test new designs of apparatus, and part to investigate possible influence of the sun on the Earth's magnetic and electric states.

The magnetic survey work of the DTM in Canada was extensive. Every observing season between 1905 and 1910 saw teams from the DTM north of the border. In 1905, the eclipse teams undertook survey work in Nova Scotia (four stations), New Brunswick (one station) and Ontario (one station) and in Newfoundland

34 Daniel Hazard, 'Terrestrial Magnetism in the Twentieth Century,' *Smithsonian Institution Annual Report*, 1925, 243-256, 246. Hazard presented this address to the Washington Academy of Sciences as its retiring president.

35 L.A. Bauer, 'Land Magnetic Observations 1905-1910,' *Carnegie Institution of Washington, Researches of the Department of Terrestrial Magnetism [RDTI]* (Washington, DC, 1912), Publication No.175, vol.1, 53-56.

36 L.A. Bauer, 'Land Magnetic Observations 1905-1910,' *RDTI* (1912), Publication No.175, vol.1, 57.

and Labrador (seven stations). In 1906, sixty-six survey points were either established or revisited, counting the extensive comparison of instruments undertaken at the Meteorological Service magnetic observatory at Agincourt, Ontario. Much of this work was undertaken by Bauer himself, but there were also two other DTM observers in Canada that year.³⁷ In 1907, the number of survey points was twenty, with two observers; in 1908, forty-four stations (including five in Newfoundland and Labrador), with three observers; in 1909, fifty-two stations (seventeen in Newfoundland and Labrador), with two observers; and in 1910, six stations with one observer. Altogether, over a dozen DTM observers crisscrossed Canada, Labrador and Newfoundland from 1905 to 1910. It is clearly inaccurate to say that one observer in one season was adequate to start the indigenous Canadian magnetic survey.

The DTM observation program had two purposes. The first was simply to map the current geomagnetic field. But since this field is constantly changing, its second goal was to map this change. This required the observers to make their measurements at stations previously occupied. A few such repeat stations existed. Lefroy's famous survey had reached far north and west in 1843-44 and in the 1880s, Otto Julius Klotz (1857-1923)³⁸ visited some of Lefroy's Manitoba stations again and Noel J. Ogilvey³⁹ made magnetic measurements in the Yukon Territory. The DTM observer of 1907, J.C. Pearson, traveled throughout Yukon, British Columbia, the Northwest Territories and Manitoba. While Pearson had descriptions of the locations, the best he could manage was to observe in their 'vicinity.' As he said, local inhabitants generally knew absolutely nothing of the observations twenty-five and sixty-four years earlier. This underlined the difficulty of establishing repeat stations.⁴⁰

The stories of several other DTM observers highlight other important points. The expeditions were not massive undertakings involving large numbers of people in the field. The DTM tended to send out only one or two observers on each trip, whether they were using the Canadian Pacific Railway or a combination of steamers and canoes. The DTM also asked for assistance from regional agencies, not necessarily governmental. Observer J.P. Ault and an assistant coor-

37 L.A. Bauer, 'Land Magnetic Observations 1905-1910,' *RDTI* (Washington, DC, 1912), Publication No.175, vol.1, 78-83.

38 Klotz became director of the Dominion Observatory after King's death in 1916.

39 Ogilvie later became superintendent of the Canadian Geodetic Survey.

40 *Ibid.*, 110-112.

dinated closely with the Hudson's Bay Company commissioner in Winnipeg for their 1908 survey in the lake and river country of northern Manitoba and Saskatchewan.⁴¹ Speed of travel and efficient observation required this. Ault's survey involved 105 days of travel, during which nineteen stations were occupied. He traveled 1800 miles in the field, 1600 by canoe, including seventy-one portages. The stations established were, on average, ninety-five miles apart. Rail and Hudson's Bay Company steamer, combined with the raw energy of the observers, made this survey possible.

The DTM also tried to build on past attainments and current circumstances. When Ault returned to Washington, his assistant C.C. Stewart continued west through Manitoba and Saskatchewan into Alberta by rail, stopping at towns with Mounted Police garrisons or Hudson's Bay Company Compounds, where observation stations could be established with some hope they would remain undisturbed till the next observer returned some years hence. He was careful to work at stations established in 1907 by Jackson of the Meteorological Service. Ault and Stewart established thirty-three magnetic stations in this area, about ten times as many as had Canadian observers.⁴²

The DTM's efforts included well-settled places like Winnipeg and Edmonton, but also reached outwards 'beyond civilization.'⁴³ C.C. Stewart, who had proven his ability to mix canoeing and science, was sent in 1909 to the last outposts of Moose Factory and Fort Rupert on James Bay, then by the 'Lakes Route' southeastward to Lac St Jean, Quebec.⁴⁴ This 500-mile survey was accomplished mostly by canoe, with local Indians hired as porters, and again with the aid of the Hudson's Bay Company.

Another DTM employee, C.C. Craft, accompanied Robert E. Peary's 1908-1909 expedition to the Arctic, the DTM having paid a fee for this service. While Peary focused on the North Pole, Craft worked exclusively on geomagnetism. He observed at stations in Nova Scotia, but more importantly in Labrador and Baffin

41 Ibid., 112-113.

42 Ibid., 112-113.

43 Ibid., 113-114.

44 This route to James Bay was actually suggested by Frederic Stupart: Stupart to Bauer, 23 March 1905, AES.1904D, 872-873.

Island, these being the first observations in these areas since the mid-19th century.⁴⁵

DTM activity in Canada and Labrador was at its peak from 1905 to 1910, far outpacing Canadian magnetic survey work in both geographic scope and in thoroughness of coverage. But it did not end even then. In 1913, H.M.W. Edmonds was sent to northwestern Ontario with an assistant, where they undertook an extensive canoe-survey.⁴⁶ They also surveyed along the shores of Hudson and James Bay from Fort Severn to Fort Albany, establishing altogether thirty-six stations. In 1914, two other DTM observers chartered a schooner from the Grenfell Association and sailed through Hudson Strait and into Hudson Bay, established eight stations on Canadian soil, fourteen in Newfoundland and Labrador, and executed a detailed magnetic survey of Battle Harbor, Labrador 'to determine the desirability of that place as a location for a magnetic observatory.'⁴⁷ In addition to these land stations, observations were obtained thirteen times while at sea.⁴⁸ Lastly, between 1921 and 1924 a new surge of DTM activity in Canada produced observations at thirty-three locations, and at twelve more in Newfoundland and Labrador. Most of the Canadian observations were on Baffin Island, but one (Camp Clay, Cape Sabine) was at 78 degrees north, on Ellesmere Island. All but one of the Canadian sites were above 60 degrees, suggesting a perception at the DTM that Canada was neglecting magnetic work in the High

45 Ibid., 115.

46 L.A. Bauer and J.A. Fleming, 'Land Magnetic Observations 1911-1913,' RDTI (Washington, DC, 1915), Publication No.175, volume 2, 46-47 and 84-94.

47 L.A. Bauer, J.A. Fleming, H.W. Fisk, and W.J. Peters, 'Land Magnetic Observations 1914-1920,' RDTI (Washington, DC, 1912), Publication No.175, vol.4, 69-70, 217.

48 W.J. Peters, 'The Hudson Bay Expedition, 1914,' in 'Ocean Magnetic and Electric Observations, 1915-1921,' RDTI (Washington, DC, 1926), Publication No.175, vol.5, 289-301.

Arctic.⁴⁹

In conclusion of this section, it is a significant fact that the DTM did not end its magnetic survey work in Canada until it ended magnetic survey work altogether in the late 1940s. Even in the 1930s and 1940s, observations were made at eleven locations in Canada and eight in Newfoundland and Labrador, including locations one might have thought the Canadian government would have taken over by then.⁵⁰ The detailed evidence, far from supporting the conclusion that the DTM's activity in Canada ended after one season's work by one DTM observer, demonstrates that the DTM managers saw continuing opportunities in Canada over four decades. This also suggests that during these four decades, the Canadian government never supported a complete magnetic survey. The evidence for deciding this question is presented in the next section.

TWO CANADIAN MAGNETIC SURVEYS

The first foray of a Meteorological Service employee into the field for magnetic work was to observe the same solar eclipse of 1905 that the DTM observed. In fact, Stupart coordinated the magnetic research at Hamilton Inlet, Labrador,

49 H.W. Fisk, 'Land Magnetic and Electric Observations, 1918-1926,' RDTI (Washington, DC, 1927), Publication No.175, vol. 6, 62-63, 67, 144-149, 204, 253-255, and 264-265. These observations were made by a DTM observer, R.H. Goddard, assigned to the North Greenland Expedition of Dr. Donald B. MacMillan. The magnetic elements were also observed at many places in Greenland, as far north as 78 degrees.

50 W.F. Wallis and J.W. Green, 'Land and Ocean Magnetic Observations, 1927-1944,' RDTI (Washington, DC, 1947), Publication No.175, vol.8, 25-26 on the Louise A. Boyd Expedition of 1941 to Newfoundland, Labrador, Baffin Island, Devon Island, and Greenland, 112, 115, 192-193, 198-199.

with Bauer.⁵¹ William Menzies, long an employee of the Service, was the only possible observer other than Stupart. Stupart also cooperated with Dominion Astronomer King, though for different reasons.⁵² King sought authorization to send an astronomical expedition at the government's expense. Stupart asked approval to send Menzies with King's party to conduct magnetic work. To add weight to this request, he pointed out that the Magnetic Department of the US Coast and Geodetic Survey was asking what Canada intended to do.⁵³ The expedition ultimately sailed for Labrador, with Menzies, at little expense to Stupart's department. This was the last time that King and Stupart collaborated so congenially.

Bauer and Stupart continued to cooperate in 1906, and Bauer continued to press Stupart about a magnetic survey.⁵⁴ Stupart acted as Bauer's intermediary with the Canadian Customs Commissioner, for the growing number of DTM survey teams bringing instruments north. But as for a Canadian survey, Stupart could only say that the approval for him to purchase a new magnetometer might be a good sign.⁵⁵ Later in the year, Stupart was more optimistic. He had received the magnetometer and planned to have observations made at all his field meteorological stations in 1907. He also planned to ask for the creation of a new position for 'a young physicist ... who shall devote all his time to Magnetic Survey work.'⁵⁶ To encourage this independent survey, Bauer sent a DTM observer to Agincourt to compare their instruments and establish correction factors between them. As further evidence of mutual congeniality, Bauer himself visited Toronto, where Stupart shared with him magnetic readings taken in Hudson Straits in the

- 51 Stupart to Bauer, 30 December 1904, AES.1904D.434 and no date, AES.1904D.695. Stupart also wrote to Bauer about this eclipse expedition on 23 March 1905, AES.1904D.872-873. He sent a copy of this last letter to W.F. King, 23 March 1905, AES.1904D.877.
- 52 The founding of the Dominion Observatory and its participation in this solar eclipse of 1905 are discussed in Richard Jarrell, *The Cold Light of Dawn*, chapter 4, 87ff. Stupart's letters to King about the eclipse include 19 July 1905, AES.1905C.375.
- 53 Stupart to Gordeau, 30 December 1904, AES.1904B.268-69.
- 54 Stupart to Bauer, 28 June 1906, AES.1906D.201.
- 55 *Ibid.*
- 56 Stupart to Bauer (General Delivery, Quebec City), 20 September 1906, AES.1906D.308.

1880s, of which Bauer had been unaware.

A watershed for a Canadian magnetic survey was crossed in 1907. Stupart lobbied harder now, as he perceived a possible threat from the Dominion Observatory for this activity. Having heard that a Commission had been appointed to consider reorganization of the various scientific surveys, he urged his superior to establish a magnetic survey and he reminded him that magnetic field work fit in well with maintenance of far-flung meteorological stations.⁵⁷

Stupart saw another reason his Service should have authority over the magnetic survey: the utility of the Agincourt Observatory as Canada's magnetic standards station. He pursued this argument in his annual report for 1906-07. As the exacting comparisons by the DTM observer had shown, the Agincourt instruments agreed sufficiently with those of the DTM that Canadian field instruments could safely be standardized at Agincourt.⁵⁸ He argued, too, that as the magnetic survey of the United States was 'progressing rapidly, ... it has become incumbent on Canada to make a Magnetic Survey of the Dominion.' Moreover, he stated in his report, the Meteorological Service had already detailed someone to begin such a survey in the western provinces. Stupart was not waiting for approval any longer.⁵⁹

This was quite true. Stupart had sent Jackson out in the summer of 1907 to measure all the magnetic elements at a dozen western points. He was to go as far as Edmonton. It is significant that this is all he was to do. He had no meteorological duties. Indeed, Stupart expected that Jackson would only conduct magnetic work in the future. This surely looked like the beginning of a magnetic survey, if only a one-man survey.⁶⁰ He was to do similar work in Ontario and Quebec in the fall.⁶¹

Stupart needed to argue strongly if he wanted the Meteorological Service to get the magnetic survey under its umbrella. Bauer's and Stupart's observers were not

57 Stupart to Gourdeau, 10 January 1907, AES.1906C.350.

58 Stupart to Gourdeau, August 1907, AES.1906C.600-602.

59 Ibid.

60 Stupart to Bauer, 9 May 1907, AES.1907C.544 and Stupart to Jackson, 29 May 1907, AES.1907C.652.

61 Stupart to Bauer, 18 June 1907, AES.1907C.761.

the only ones in the field. The Dominion Astronomer King accepted Stupart's 1904 invitation to participate in a systematic magnetic survey more eagerly than Stupart had anticipated. Steps taken by the Dominion Observatory included buying instruments, sending a field party to the 1905 eclipse in Labrador, hiring a new magnetician, C.A. French, to run a magnetic survey from Banff westward and beginning to plan an independent full magnetic survey of the Dominion. The Dominion Observatory had even established its own 'magnetic hut' for calibrating instruments. DTM observer P.H. Dike stopped there in 1906 to standardize instruments and tie Ottawa directly into the international standards of magnetic measurement.⁶²

This three-way activity was coordinated, but perhaps not as well as it could have been. Jackson overlapped with DTM work and was instructed to observe at the same locations as much as possible.⁶³ This would allow comparison of results and generate secular change data. Moreover, Stupart still encouraged Bauer to send DTM crews to places like James Bay that he doubted the Meteorological Service, i.e. Jackson, could reach that season.⁶⁴

Beyond this, however, cooperation was minimal. The two Canadian agencies sent their observers where they wanted to, for their own purposes, and meeting their own standards. Thus, the Toronto-based observer concentrated in turn on the prairie railway routes, Hudson Bay and Strait and the Mackenzie River Valley, where meteorological stations required inspection. And the Ottawa-based

62 L.A. Bauer, 'Land Magnetic Observations 1905-1910,' RDTI (Washington, DC, 1912), Publication No.175, volume 1, 82-83 and 156-7.

63 Stupart to Bauer, 18 June 1907, AES.1907C.761.

64 Stupart to Bauer, 27 June 1907, AES.1907C.788.

observer concentrated on establishing a grid of repeat stations coast to coast, below 55 degrees north, mostly along routes of easy transportation.⁶⁵

One of the greatest coups of the Meteorological Service magnetic survey came in 1908, when Stupart was granted permission to assign a magnetic observer to Captain J.E. Bernier's expedition on the DGS *Arctic*. This expedition spent over a year in the High Arctic. Stupart assigned Jackson, of course, and sent him to the DTM in Washington for yet more extensive training. Jackson also borrowed the latest portable instruments from Bauer.⁶⁶ Jackson returned to Toronto with magnetic results from eighteen Arctic locations, including Winter Harbor, first occupied in the early-19th century.⁶⁷

These forays by Jackson, however, seemed to lack system. French claimed, with apparent justification, that a *systematic* magnetic survey had started at the Dominion Observatory in 1907.⁶⁸ The goal was explicitly to establish a planned network of stations, in some regions one every twenty-five miles, and to return to these periodically to establish secular variation trends. Up to the First World War, Ottawa's magnetic survey primarily established new stations, averaging forty-four per year.⁶⁹ After the War, the focus was on repeat stations. In 1922, the scope of the Dominion Observatory's magnetic survey was expanded to include the Arctic.⁷⁰

The following picture emerges. Stupart had repeated contact with International Meteorological Congresses where magnetic surveys were urged on all participating parties in the 1890s. Bauer and other foreign scientists were consistently in-

65 C.A. French, 'Magnetical Results, 1907-1920,' *Pubs DO* (Ottawa, 1921), vol.5, no.5, 131-132.

66 Stupart to Gourdeau, 13 July 1908, AES.1906C.969-970. This expedition is also discussed in L.A. Bauer, 'Land Magnetic Observations, 1905-1910,' *RDTI* (1912), publication no.175, v.1, 56.

67 Stupart to Deputy Minister, no date, AES.1908D.849-851. This is the Annual Report of the Magnetic Observatory for the year ending 31 March 1910.

68 C.A. French, 'Magnetic Work of the Dominion Observatory, Ottawa, Canada, 1907-32,' *Terrestrial Magnetism and Atmospheric Electricity*, 1932, 37:336.

69 C.A. French, 'Magnetical Results, 1907-1920,' *Pubs DO* (Ottawa, 1921), vol.5, no.5, 132. In comparison, 84 stations were used as repeat stations.

70 R.G. Madill, 'The North Magnetic Pole,' *The Beaver*, June 1949, Outfit 280, 8-11, 11. Despite its title, this is an informative memoir of magnetic work generally at the Dominion Observatory by the magnetician who replaced C.A. French and W.E.W. Jackson.

PLATE 1. DTM Observer. H.M.W. Edmonds, observing at a magnetic survey station at Greenwood Rapids on 29 or 30 September 1913. [Photo 3143, Archives of the Department of Terrestrial Magnetism, Carnegie Institution of Washington]



terested in and supportive of the Agincourt Observatory's research, and Stupart thought seriously about organizing Canada's full magnetic survey as early as 1901. At Bauer's urging, Stupart and King each began thinking of his own survey. These parallel, and sometimes intersecting, magnetic surveys seemed bound to come into conflict.

CONFLICT BETWEEN THE METEOROLOGICAL SERVICE AND THE DOMINION OBSERVATORY

Problems began for Stupart's magnetic survey in 1909. While Jackson was on the *Arctic* with Bernier, Stupart needed to order another magnetometer if he wanted to send out another observer till Jackson's return.⁷¹ Officials in his department were apparently concerned that Stupart was expanding the magnetic work into a full magnetic survey. Indeed, that was his goal.

Stupart's defense was spirited. The magnetometer was required for the obvious: magnetic measurements. However, he attempted to soften his superiors' apprehensions. The observer using this instrument primarily would be checking meteorological stations. But then he launched into a detailed indictment of Canada's half-hearted magnetic work. It was 'altogether too unsystematic....' He objected to its on-again, off-again status. He objected to the Dominion Astronomer sending out a magnetic observer. This survey work, he asserted, belonged more to meteorology than to astronomy, especially since the Meteorological Service had the only magnetic observatory in the country. But even more, because Canada had not organized its magnetic work properly, the Carnegie Institution was 'now doing work for Canada which should be done by the Government.' Stupart wanted a Canadian magnetic survey, and he wanted it run out of his office.⁷²

The Deputy Minister was not happy with this defense, and Stupart had to answer his queries and criticisms. Over what territory did he propose to range? Stupart answered, over all of the Dominion. Did he intend to start a special magnetic survey? No, the magnetic measurements would be subordinate to visiting and maintaining meteorological stations. Did he intend to duplicate the work of the Dominion Observatory? Stupart replied with some indignation to this query:

71 Stupart to Cecil Doutre (Purchasing, Department of Marine and Fisheries), 31 May 1909, AES.1908D.373 and 8 July 1909, AES.1908D.448.

72 Stupart to Deputy Minister (Department of Marine and Fisheries), 15 July 1909, AES.1908D.453-454.

I have not the smallest wish to duplicate the work of other Departments, but I have a very strong objection to another Department, quietly, without consultation, assuming work originally begun and still carried on by the Meteorological Service and the Toronto Magnetic Observatory...

Moreover, he argued, it was not the International Astronomical Association that included magnetism within its sphere. Magnetic surveys had always been discussed by the Meteorological Congresses and indeed, Stupart said, he was placed on the 'Magnetism' sub-committee at the last Meteorological Congress.⁷³

Stupart apparently lost this battle. Though he continued to advocate magnetic research, sometimes asking to have government officials from other departments trained in magnetic work, he had difficulty even getting magnetometers shipped back from previous work.⁷⁴ The Agincourt Observatory was expected to help the Dominion Observatory magnetic workers by calibrating their field instruments before and after each season's survey, as they did in 1910.⁷⁵ Stupart continued to defend his Service's involvement in geomagnetism by pointing out in the Annual Report for 1909-1910 the further role of the Observatory in calibrating sixty-two compasses for the Surveyor General and the Topographical Branch. As he wrote, the importance of the Agincourt Observatory as a base station for magnetic work in Canada and for comparing Canadian instruments with those of other countries was obvious.⁷⁶

73 Stupart to Deputy Minister (Department of Marine and Fisheries), 18 August 1909, AES.1908D.479-480.

74 Stupart to Deputy Minister (Department of Marine and Fisheries), 22 March 1910, AES.1908D.756; 23 May 1910, AES.1908D.900; and 21 July 1910, AES.1908D.970.

75 Stupart to Deputy Minister, no date, AES.1908D.849-851. This is the annual report for the magnetic observatory for the year ending 31 March 1910.

76 Ibid.

PLATE 2. Magnetic Hut (right) at the Dominion Observatory, October 1913.
[Photo 3211, Archives of the Department of Terrestrial Magnetism, Carnegie Institution of Washington]



Possibly this argument was too convincing. The Meteorological Service quickly settled into the primary role of the base magnetic observatory for 'all the observations of Dominion surveyors, and surveyors of the [Dominion] Observatory at Ottawa.'⁷⁷ It only rarely sent observers into the field itself.⁷⁸ Indeed, when the Canadian Magnetic Survey was discussed in a 1915 DTM publication, it was a reference only to work at the Dominion Observatory.⁷⁹

There was a positive aspect of the 1910 accommodation for magnetic research at the Meteorological Service. Any magnetic observations best done over a long period at a fixed observatory became Stupart's. During the remainder of his directorship of the Service, Stupart capitalized on this. Under his direction, Jackson developed a research program using Fourier analysis of the photographic traces of the magnetic elements. Based on Charles Chree's search for periodicities in the variation of the magnetic elements, Jackson used Agincourt to investigate possible connections between sunspots and variations in the Earth's magnetism.⁸⁰ By 1916, Stupart secured government funding for another self-recording declination instrument, which was placed in a modest observatory at Meanook, sixty miles north of Edmonton, Alberta.⁸¹ In this resolution of scientific sovereignty, the Dominion Observatory gained control over magnetic surveys, but the Meteorological Service gained authority over magnetic observatory work.

77 Stupart to Deputy Minister (Department of Marine), 5 July 1915, AES.1915E.179-180.

78 The only significant field work done by the Meteorological Service between 1910 and WWI was an expedition sent into Hudson Strait and Hudson Bay in 1912, which also inspected meteorological stations.

79 L.A. Bauer and J.A. Fleming, 'Land Magnetic Observations 1911-1913,' RDTI (Washington, DC, 1915), Publication No.175, volume 2, 85.

80 W.E.W. Jackson, 'On the Diurnal Changes in Magnetic Declination at Agincourt, 1902-1912,' *Trans RSC*, 1914, series 3, 8:105-112; 'On the Diurnal Changes in the Magnetic Horizontal Force at Agincourt, 1902-1912,' *Trans RSC*, 1915, series 3, 9:17-25. On Chree's approach, see Charles Chree, 'Terrestrial Magnetism,' *Encyclopaedia Britannica*, 1911, 11th edition, 17:353-385.

81 The first year of operation of the Meanook Observatory is discussed in W.E.W. Jackson, 'A Comparative Study of Magnetic Declination at Agincourt and Meanook, During the Year 1917,' *Trans RSC*, 1918-19, series 3, 12:99-108.

Yet the accommodation of 1910 was not entirely satisfactory, neither to the scientists in the Meteorological Service and Dominion Observatory nor to the government officials who oversaw their budgets. There was always the appearance of overlap, which to bureaucrats implied waste that could be eliminated. In 1921, in reply to a proposal by the Finance Department to merge the two old rivals, Stupart answered at length that the two sciences of meteorology and astronomy were utterly unrelated. The only overlap of functions, he said, involved magnetism. He implied that Canada was an anomaly in this since in England and Europe, the Meteorological Services conduct magnetic surveys, while in Canada it was done by the Dominion Observatory.⁸² He still resented the allocation of geomagnetic and seismic research to the Dominion Observatory in Ottawa.

Stupart stubbornly maintained a stake in magnetic surveying into the 1920s. In 1921 an observer was sent into the Mackenzie River valley to investigate upper air movements, but he was also provided with magnetic instruments. He was instructed to observe all three magnetic elements, and to cover all hours of the day, though one presumes he was not to do this every day. He was also to conduct a survey as he returned up the valley at the end of the year.⁸³

The magnetic survey of Canada, however, was fully claimed by the Dominion Observatory by the 1920s. French had charge of this work and a new magnetic

82 Stupart to Deputy Minister (Department of Marine), 23 February 1921, AES.1920D.423.

83 Stupart to Bauer, 1 April 1922, AES.1922B.5. This letter included a report Bauer was to present for Stupart at the Rome meeting of the International Union of Geodesy and Geophysics. The MacKenzie River observer was a Mr. Bibby.

observer, R.G. Madill, was hired. French wrote a series of memos for the Observatory, reporting the status of this survey for the IUGG. In 1922-23, two field observers measured all three magnetic elements at 120 stations, including the old Meteorological Service territory along the Mackenzie River. French was clearly organizing for a decades-long survey, as he had planned the return to repeat stations for secular variation studies.⁸⁴ Moreover, beginning in 1922, the Dominion Observatory's survey was to include the Arctic.⁸⁵ The only reference to Agincourt was for the pre- and post-season calibration of instruments. The report for 1924-26 indicated a continuation of interest in repeat stations, as well as in a more even distribution of stations. Another ninety-five stations were occupied in these three seasons.⁸⁶ By the late 1920s, the Dominion Observatory could not expand the survey at the same rate because of the need to visit a growing number of repeat stations on a frequent basis. Of seventy-two stations visited in 1927, for example, only sixteen were new stations.⁸⁷ The 1932 report stated that activity was by then 'restricted to making observations ...at repeat stations.'⁸⁸ This trend became even more notable in later reports.⁸⁹

The influence of the DTM was evident with French as it was with Jackson, mainly through DTM instruments. Instruments were purchased from the DTM, others were borrowed, and always careful comparisons were made. The main route for tying Canadian magnetic measurements into the international standard

- 84 C.A. French, 'Magnetic Survey in Canada by the Dominion Observatory, 1922-23,' National Archives Canada [NAC], RG48, vol.16, File 1527-9. French says at the beginning of this memo that a report discussing magnetic survey work in Canada up to 1922 had previously been presented, but no copy of it has been found. Published accounts are printed in C.A. French and R.G. Madill, 'Magnetic Results, 1927-1937,' *Pubs DO* (Ottawa, 1940), vol.9, no.7, 263-321 and R.G. Madill, 'Declination Results at Canadian Stations North of 60°N, 1938-47,' *Pubs DO* (Ottawa, 1949), vol.11, no.9, 343-352.
- 85 R.G. Madill, 'The North Magnetic Pole,' *The Beaver*, June 1949, Outfit 280, 8-11, 11.
- 86 C.A. French, 'Magnetic Survey Work in Canada by the Dominion Observatory, 1924 - 1926,' NAC, RG48, vol.16, File 1527-9.
- 87 C.A. French, 'Magnetic Survey Work in Canada by the Dominion Observatory, Ottawa, 1927-9,' NAC, RG48, vol.16, File 1527-9.
- 88 C.A. French, 'Report on Magnetic Work Accomplished by the Dominion Observatory in Canada,' no date [1932], NAC, RG48, vol.16, File 1527-9.
- 89 [Anonymous, almost certainly C.A. French], 'Magnetic Secular Variation Work by the Dominion Observatory in Canada, 1933 - 1936,' and 'Magnetic Work by the Dominion Observatory in Canada 1936 - 1939,' NAC, RG48, vol.16, file 1527-9.

was via the DTM.⁹⁰ In 1931, the Dominion Observatory forewent calibrations using Agincourt as intermediary and an observer took the instruments directly to the DTM.⁹¹ When one type of DTM instrument proved unreliable, the Dominion Observatory purchased a newer DTM design.⁹²

As French's reports continued, it became clear that the Dominion Observatory had not only taken over the magnetic survey, it had also appropriated the history of survey activity. In his report for 1927 to 1929, French not only claimed that the general magnetic survey began in 1907 -- an assertion debatable on several grounds -- but he also stated unequivocally that it was begun by the Dominion Observatory. He ignored entirely the earlier activities of both the Meteorological Service and the Topographic Survey.⁹³

There was a similar overlap between the Meteorological Service and the Dominion Observatory in seismology. The interest for Stupart originated in the accidental utility of magnetographs for recording seismic waves. He formalized this activity in 1906 with the purchase of seismographs, which were installed in the Meteorological Office in Toronto. He later installed another one in Victoria, British Columbia.

The Dominion Observatory also introduced seismic work in Ottawa. Klotz adopted seismology, as well as gravimetry and geomagnetism, as his areas at the

90 C.A. French to R. Meldrum Stewart, 24 March 1924, NAC, RG48, vol.16, File 1527-9. This is a detailed discussion of the problems encountered in inter-calibrating DTM, Agincourt, and Dominion Observatory instruments.

91 C.A. French, 'Report on Magnetic Work Accomplished by the Dominion Observatory in Canada,' no date [1932], NAC, RG48, vol.16, File 1527-9.

92 C.A. French, 'Magnetic Survey Work in Canada by the Dominion Observatory, 1924 - 1926,' NAC, RG48, vol.16, File 1527-9.

93 C.A. French, 'Magnetic Survey Work in Canada by the Dominion Observatory, Ottawa, 1927-9,' NAC, RG48, vol.16, File 1527-9. Of course, he was correct that the Dominion Observatory did not begin to collaborate until this date. But he tacitly claimed more credit to the Observatory than was due.

Dominion Observatory shortly after its founding. Klotz drew the Observatory into the international work then developing in seismology and was even president of the International Seismological Association.⁹⁴ Stupart and the third Dominion Astronomer, R. Meldrum Stewart, clashed over this shared activity in 1925.⁹⁵

Yet another measure of the conflict between the two agencies for primacy in Canadian geomagnetism, and geophysics generally, was the right of representation at the IUGG. Between the formation of the IUGG in 1919 and 1930, the Meteorological Service sent no representative to its General Assemblies, of which there had been three. Five committees were constituted at the first General Assembly of the IUGG in Rome in 1922. Notably, Canada's representative on the Committee on Magnetic Surveys and International Comparisons of Instruments was Klotz, not Stupart. Stupart was named to the Observatory Committee. In these actions, the IUGG formally recognized the division of magnetic research in Canada.⁹⁶

The Deputy Minister of Interior went further in 1922, claiming seismology and terrestrial magnetism were 'essential functions' of Interior, i.e. of the Dominion Observatory. Further, he said, the new IUGG fell exclusively 'within the sphere' of Interior.⁹⁷ The new director of the Meteorological Service, John Patterson, did not see it this way. He sought permission to send Jackson to the 1930 Assembly. Jackson's attendance was especially important, he said, because this Assembly was to consider the organization of geomagnetic research for the upcoming International Polar Year of 1932-33. With the North Magnetic Pole in Canadian territory, Patterson stated, Jackson's attendance was 'very desirable.'⁹⁸

94 Richard A. Jarrell, *The Cold Light of Dawn*, 92.

95 R. Meldrum Stewart to Stupart, 2 April 1925, AES.1925A.17 and Stupart to Stewart, 7 April 1925, AES.1925A.17.

96 Bauer to Otto Klotz (Director, Dominion Observatory), 17 November 1919, NAC, RG48, vol.16, file 1527 and 'Resolutions of Section Terrestrial Magnetism and Electricity (Approved at the Rome Meeting, May 9, 1922),' NAC, RG48, vol.16, File 1527-9.

97 W.W. Cory (Deputy Minister, Department of Interior, Canada) to Col. F.M. Gaudet (Honorary Advisory Council for Scientific and Industrial Research), 13 February 1922, NAC, RG48, vol.16, file 1527.

98 John Patterson (Director, Meteorological Service) to Acting Deputy Minister (Department of Marine), 8 April 1930, AES.1930A. A number of other letters in this file and several others concern the Service's plans for the Polar Year. The full story of Canada's participation in the Second International Polar Year must be told separately.

Like the Dominion Observatory, the Meteorological Service proposed beginning Arctic magnetic research in 1930. Patterson suggested the establishment of a magnetic station at Bathurst Inlet, about 500 miles from the North Magnetic Pole. An observatory was indeed established under the Meteorological Service at Chesterfield Inlet for the Second Polar Year. Opportunity for conflict, as well as cooperation, continued for a quarter of a century between the Toronto and Ottawa agencies.

PERSONALITY, PARTY, PATRONAGE

It is legitimate, indeed essential, to ask to what extent this story is shaped by factors beyond the needs of the science of geomagnetism. Strong personalities were involved, within the frameworks of a rigid, yet changing, bureaucracy. This bureaucracy was affected by political party affiliation, with appointment and promotion sometimes based on patronage. A complete investigation of this side of the story has not been undertaken, but enough evidence is available to suggest the extent and limits of these intertwined moderating influences. The main *personae dramatis* are few. For the period of this story, the heads of the agencies included Bauer for the DTM, Stupart and Patterson for the Canadian Meteorological Service, and King, Klotz and R. Meldrum Stewart for the Dominion Observatory. The few other critical characters ranged from Edourd-Gaston-Daniel Deville (who for much of the period was in charge of all technical surveys undertaken by branches of Canada's Interior Department) to the individuals who built careers as magneticians, gravity specialists, or seismologists within those agencies. The latter included Jackson, French and Madill, among others. Each of these people were individuals, with their own characteristics and aspirations. These certainly coloured some of the events that occurred on this tightly-circumscribed field of action. But it is exceedingly difficult to learn anything about the characters of most of these people. For this reason, this section concentrates on Klotz, Noel Ogilvie and Jackson, three individuals for whom more information exists.

Personality conflicts were fairly common in all the scientific agencies in the Canadian government. Some conflicts were within a single agency and some were between heads of competing agencies. An example of the former is provided by the interminable quarrels both Klotz and Stewart engaged in with

J.S. Plaskett about the Dominion Astrophysical Observatory, which was established as part of the Dominion Observatory in the teens.⁹⁹ Klotz, who was generally a courteous and considerate man, found it difficult to be so with Plaskett.

One particular clash within the Meteorological Service may have reflected the lack of opportunity there for an ambitious scientist interested in geomagnetism. According to a scientist visiting the Service from the DTM in 1934, Jackson and Patterson (then Director) had developed 'an intense personal dislike.' This arose in their very different goals for the Service and some resulting professional jealousy. Patterson viewed Jackson as inefficient and not up-to-date in magnetism. Jackson thought it was wrong that the magnetic research was controlled by a meteorologist and that this led to inadequate support and the choice of the wrong people for the magnetic staff. Some of these people, he claimed, were uninterested in magnetism and others were uneducated. This particular claim by Jackson was certainly true.

Whether either party was correct in his views of the other person's character is not so clear, but neither is it the issue. Jackson, who had worked on geomagnetism at the Meteorological Service since 1904, was discouraged to the point that his interest in the research was waning.¹⁰⁰ Jackson was, strange to say, isolated in Toronto with his staff who had not been to university and who took no special interest in geomagnetism. It probably did not improve his morale to see the level of magnetic research increasing at the Dominion Observatory during the 1920s and 1930s. The lack of opportunity for advancement for magneticians in the Meteorological Service had also encouraged the migration of a number of Canadians to the United States in these decades. Andrew Thomsom, Harry Vestine and Frank Davies, all of whom became prominent researchers after World War II, were among them. Jackson and Patterson's personality conflict points to this flattening of opportunity for magneticians in the Service.

A personality clash between the heads of two agencies indicates the extent of the

99 Richard Jarrell, *The Cold Light of Dawn*, 100-125.

100 Frank Davies, *Diary*, 21 September [1934], NAC.MG30.B73, 2:331-332. Davies had spent the Second International Polar Year on leave from the DTM to lead the Meteorological Service's temporary magnetic-auroral-meteorological observatory at Chesterfield Inlet.

power of branch heads within their realms. The pertinent case is the total enmity between Klotz and Ogilvie in the period just after World War I, when Klotz was head of the Dominion Observatory and Ogilvie of the Geodetic Survey of Canada. Klotz's diary, which rarely impugns anyone, amply indicates his dislike of Ogilvie. He was offended that Ogilvie claimed gravity and magnetic work among the activities of the Geodetic Survey, since it had proper instruments for neither. 'For the first the Observatory has the only equipment in Canada, for...the latter for the whole of Canada the Observatory is engaged while some other branches do detached work therein.'¹⁰¹ Klotz tried to express himself in impersonal terms: 'invasion of fields not properly belonging to the Geodetic Survey when these fields were already occupied by others.'¹⁰² But he lapsed, calling Ogilvie presumptuous, incompetent and grasping.¹⁰³ With the retirement of Ogilvie's main patron, he lost support at the Interior Ministry.¹⁰⁴ Klotz nearly rejoiced, saying that if Ogilvie had not been so aggressive, he would not have ultimately been so humiliated. 'I have no pity for him, for he wanted to invade the Observatory work too.'¹⁰⁵ Clearly in this case a personality clash amplified the intensity of the jurisdictional debate over areas of scientific research.

Although political patronage played a part in the histories of the scientific branches of the Canadian government in the first third of the century, it is worthwhile to approach this topic cautiously. Scientists did not come and go with changes of the party in power. The lengths of service of the various government scientists testifies that the effects of patronage were not unrestrained. In fact, all of the Canadians listed at the beginning of this section began and ended their careers in government service. While initial hires, advancement of agencies and individuals, and perhaps forced retirements were sometimes affected by patronage, the effects of party politics on the Meteorological Service and the Dominion Observatory are more subtle. The comparative immunity of government scientists to patronage politics may be an important contrast with other parts of Canadian government service.

Nevertheless, this immunity was not complete. One way to get a new position

101 Otto Klotz, *Diary*, 5 November 1919, NAC.MG30.B13, 31:164.

102 *Ibid.*, 18 November 1919, 31:167.

103 *Ibid.*, 3 March 1921, 32:110.

104 This patron was the private secretary to the Minister of the Interior William James Roche.

105 Otto Klotz, *Diary*, 6 April 1921, NAC.MG30.B13, 32:119.

was to match it with the needs of patronage. In 1919, Klotz was granted a new position for a gravity-specialist when Minister of the Interior Arthur Meighen (soon to be Prime Minister) saw an opportunity to appoint a fellow Manitoban to the position. Klotz called this 'killing two birds with one stone.' In this case, patronage provided a superbly qualified candidate: A.H. Miller was an honours graduate in physics and mathematics and a Rhodes scholar. He also had spent two years in post-graduate research at Wisconsin and had an excellent war record.¹⁰⁶

Patronage at the higher levels tended to limit the number of acceptable candidates, and sometimes led to underqualified people holding technical positions. One person hired as a seismologist on the basis of paper qualifications quickly demonstrated to Klotz in an interview that 'he had not the educational equipment...to carry on research work....' Klotz lamented that there might be no Canadian with the mathematical skills required for seismology or for geophysics more generally.¹⁰⁷ But even when good people were found, they did not always accept. In November 1919, two candidates in a row turned down a position as magnetician.¹⁰⁸ The position was finally filled as a summer job.¹⁰⁹

Patronage undoubtedly had a greater effect at lower levels, where university qualifications did not dictate minimum requirements. These jobs were much more akin to those given out in the Printing Bureau, Post Office or Public Works than to those of researchers in the Meteorological Service or Dominion Observatory. Klotz complained of politicians appointing their friends, and of 'timber' he wanted to eliminate at the Observatory. But the head of a technical office, he said, could not wield the axe as a politician could. Politicians controlled patronage.¹¹⁰

106 Ibid., 4 November 1919, 31:164.

107 Ibid., 2 August 1919, 31:134-135.

108 Ibid., 18 November 1919, 31:168.

109 Ibid., 25 May 1920, 32:24; and Richard Jarrell, *Cold Light of Dawn*, 116-120. The summer researcher was Joseph A. Pearce, a Toronto graduate and astronomer who went on to collaborate with Plaskett on galactic structure.

110 Otto Klotz, *Diary*, 22 June 1921, NAC.MG30.B13, 32:142.

Klotz found the actions of the Civil Service Commission as inhibiting as patronage-hiring. Following World War I there was a government-wide effort to rationalize job descriptions and pay scales. They ran into repeated difficulties with the technical branches, most notably the Dominion Observatory. The heads of these agencies were asked to provide organizational charts and job descriptions. Klotz did so, and was incensed when the Civil Service 'expert' changed the list of qualifications for gravity specialist. No one in Canada could meet the educational requirements. The misguidance of this meddling, in Klotz's mind, was underlined when the Civil Service officer, at the end of an interview, asked him 'What is a Gravity Specialist anyway?---!!!!' [quoted by Klotz]. Klotz mused that he would probably impress the Civil Service Commission more if he sprinkled the term engineer around liberally: astronomical engineer, seismologic engineer, magnetic engineer, gravity engineer.¹¹¹

While Stupart was suspected by some to let his Tory politics influence his decisions,¹¹² others whose politics were anything but Tory worked well with him. Klotz, who flirted with socialism but usually supported the Liberals, had a good relationship with Stupart and termed him 'a decent fellow.'¹¹³ Political differences were not the basis of the rivalry between the Meteorological Service and the Dominion Observatory. Indeed, it should be noted that Tory Stupart's Service thrived during the Liberal ministry of Sir Wilfrid Laurier and that Liberal Klotz's Dominion Observatory did not suffer during the Conservative and Unionist ministries of the teens and 1920s.

But perhaps the most difficult political problem had little to do with party. Top government officials, especially ministers and their advisors, often had little or no scientific training. The heads of the scientific agencies nevertheless had to turn to them for their budgets, for approval of projects, and for new positions. Minister of the Interior Roche (1912-1917) had known little about the technical services he oversaw. And his replacement Meighen, Klotz complained, was a disappointment. He was an honours graduate in mathematics. Klotz had hoped Meighen 'appreciated to some degree science & its aims --but he doesn't.'¹¹⁴

111 Ibid., 2 and 3 December 1919, 31:171-172.

112 A.-P. Roy, professor at Collège de Lévis, believed Stupart had recommended against creating a purely astronomical position at the Québec Observatory in the late 1890s because Roy, who might have gotten the position, did not agree with Stupart's politics: Roy to Wilfrid Laurier, 30 September 1897, quoted in Richard Jarrell, *The Cold Light of Dawn*, 51-52.

113 Otto Klotz, Diary, 18 May 1920, NAC.MG30.B13, 32:22.

114 Ibid., 7 August 1919, 31:136. This problem almost certainly affected other technical services, including the Meteorological Service.

Personality, patronage and politics certainly did have their effects on the development of geophysics in Canada in the early-20th century. But it is premature to make too large a claim about the extent or nature of these effects. This must await further historical research. Nevertheless, it can be seen that these effects were more moderating than determining, more mixed and not purely pernicious. The requirements of the sciences involved -- whether astrophysics or geophysics -- were not completely subverted by these factors.

A number of events occurred to bring this chapter of Canadian scientific history to an end. In 1936, there was a major reorganization that ended the curious division of government geophysical research. The seismic and geomagnetic observatory work of the Meteorological Service was merged into the Dominion Observatory in Ottawa.¹¹⁵ This included the transfer of Jackson. Second, the magnetic survey of the world that had been driven by the DTM was drawing to a close. Third, the rising of the curtain on World War II emphasized other requirements in geomagnetism than more survey work. And lastly, Canada's first two magneticians retired: French in 1940 and Jackson in 1945, passing geomagnetism on to a younger generation with new interests.¹¹⁶ But most importantly, the story of government geomagnetic research in Canada after World War II no longer involved the Meteorological Service.

CONCLUSION: SCIENTIFIC SOVEREIGNTY

Sovereignty -- the control over territory -- generally becomes an issue only under special circumstances: when new territory opens up, when old territory is unexpectedly discovered to be valuable, when forgotten border disputes arise anew or when new national or controlling entities are created. This perspective applies to 20th-century geophysics in two distinct ways. First, there is the literal territorial problem. Because geophysics ranges over the globe, and because many remote regions came within the reach of economic and political activity only in this century, geophysics has placed the spotlight on political sovereignty in places as diverse as the Arctic Archipelago and Equatorial Africa.

But the problem more central to this article concerns the shifting disciplinary

115 C.A. French, 'Magnetic Work by the Dominion Observatory in Canada 1936 - 1939,' NAC, RG48, vol.16, file 1527-9.

116 R.G. Madill, 'Progress Report of the Division of Terrestrial Magnetism, Dominion Observatory, 1939 - 1947,' NAC, RG48, vol.16, file 1527-9.

landscape of science. A science like geophysics presents myriad opportunities for border skirmishes amongst scientists and institutions. Geophysics is a complex constellation of sub-disciplines: seismology, geomagnetism, theoretical meteorology, gravimetry and so on. One can even question whether it *is* a discipline. The boundaries between its parts often seem better defined than do their relationships. Moreover, its associations with neighboring disciplines such as physics, geology, astronomy and meteorology are equivocal. And none of this is constant. In early-20th century Canada, the threat of a foreign scientific power -- the Carnegie Institution's Department of Terrestrial Magnetism -- conferred new value on these unexplored disciplinary hinterlands. This produced a protracted conflict between two of the country's primary scientific institutions over control of this landscape. Control ultimately was wrested by the Dominion Observatory. Scientific sovereignty -- at least for a time -- was decided.

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Gregory Good, currently a Humboldt Fellow in Germany, is an Associate Professor of History at the West Virginia University, Morgantown.
