MAPPING THE CANADIAN MIND

Reports of the Geological Survey of Canada, 1842-1863

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AMONG THE EARLY TEXTS available to students of Canadiana, the scientific reports penned by Sir William Edmond Logan, founding director of the Geological Survey of Canada (GSC), rank at first glance among the least likely to illuminate some aspect of Canadian culture. These reports, submitted annually to the governor of the province and appended to the House of Assembly's published *Journals*, seem to comprise a tedious catalogue of rock formations ensconced in the incomprehensible technical jargon of another century: "The next formation," Logan typically described a section of the province in his Report of Progress for 1843,

> consists of a group of rocks of more or less arenaceous quality. The lowest of these is a greenish argillaceous shale, which is followed by a development of green and black arenaceous shales, interstratified with thin beds of sandstone, yielding excellent durable flags, and forming a passage into a mass of thick-bedded sandstone above. Ripplemark and the casts of shrinkage cracks are common on the surfaces of some of the strata, but the fossils of the group are scarce. Fucoids, indeed, are frequently met with, and one species is found penetrating the beds in a vertical position. Some characteristic shells occur in the lower shales, and others in the centre of the group. The total thickness of the formation is estimated at 1,000 feet. (*J* 1844-45)

On the surface it is difficult to believe that Logan could have expected even an educated reader of his own day to decipher the messages he encoded in lengthy reports of this type. Yet closer inspection reveals a deliberate strategy on his part not simply to apprise Canadians of the geological and mineral realities of the land they inhabited, but also to confirm the credibility of his scientific method when it produced verdicts contrary to those he set out to attain. Logan's twin goals required nothing less than a fundamental reorientation of Canadians' perceptions and

expectations of their destiny in British North America, and his reports constitute a remarkable contribution to that achievement.

The establishment in September 1841 of the GSC itself reflected Canadians' faith in the power of science to locate valuable minerals in the province. In so doing they followed the lead of several American states which had initiated government-supported surveys during the 1820s, as well as of Great Britain in 1835 and the fellow colonies of New Brunswick in 1838 and Newfoundland in 1839. Members of the Canadian business and professional classes in urban centres like Toronto and Montreal had been calling for similar surveys of both Upper and Lower Canada in a growing chorus since the 1820s. But it was only after the Rebellions of 1837, with the relative stability that accompanied the Act of Union in 1841 and British bank loans to develop the St. Lawrence waterway, that the Canadian government turned to the science of geology to help develop the colonial economy along industrial lines. The need to locate and identify useful mineral resources such as coal and iron ore in Canada had found support in the famous *Report* of Lord Durham, whose own experience as a coal magnate in northeastern England underlined the importance of the fossil fuel to economic development. The enticing examples of enormous coal deposits nearby in Nova Scotia, New Brunswick, and the northeastern United States gave Canadians reason to expect that coal would be found within their own province; and the intellectual impact of the Scottish Enlightenment in turn instilled faith that this discovery would enable them to replicate the British industrial experience.[1]

In this experience, 'King' Coal represented the basis of modern civilization: it provided the power to modify the extremes and even to control the forces of nature. Coal had revived the British metal trades after 1750, and sustained them through unprecedented growth ever since. By the early nineteenth century the history of Britain's material greatness had become virtually identified with the history of coal. This connection rang especially true in Scotland, whose meteoric rise as a result of coal-based industrialization had been so dramatic. The University of Edinburgh, in particular, educated countless medical and natural history students, many of whom eventually made their way across the Atlantic, in geological fieldwork emphasizing the ordered sequence and characteristic fossils of the strata that made up the earth's crust.[2] British, and especially Scottish, coal-based values and ambitions spread to British North America during the early decades of the nineteenth century also through Scotland's public educational system, which imbued Scottish immigrants with a sense of geological knowledge as useful knowledge. As a result, the persistent hope of duplicating the British industrial experience influenced the subsequent course of Canadian history. When the Canadian government created the GSC to map the mineral resources of the province, its intention was to assess the province's industrial potential, and thereby to define a basis for the material improvement of the lives of its inhabitants.

Not long before, geology had itself undergone a conceptual transformation which endowed the earth science with the means to participate in this inventory process. Only a decade earlier the British geologist Charles Lyell had published his *Principles of Geology* (1830-33), a synthesis of the mass of information that had accumulated since the late eighteenth century. Lyell eliminated the older dichotomy between aqueous and igneous explanations of the formation of the earth's crust to elaborate instead a "uniformitarian" theory of the earth which postulated geological change over far longer periods of time than had previously been imagined. He supported an actualistic approach to the study of geological processes, as products of forces that still continued to operate. Among these processes he included the "metamorphic," in which heat and pressure transformed the constitution of formations like those that comprised the Canadian Shield.[3]

THE ENTHUSIASTIC RECEPTION of Lyell's *Principles* signalled a growing consensus among geologists, and formed a new interpretive context for geological investigation. Perhaps the best example was William Logan, an admirer of Lyell who applied uniformitarian principles to confirm his theory of the origins of coal formations. Logan (1798-1875) was a native Montrealer who studied natural history at the University of Edinburgh before moving to Swansea, South Wales, to manage his uncle's copper works in 1831. There he forged a professional knowledge of coal seams and earned a reputation among British geologists for the accuracy of his topographical maps and cross-sections. Seeking to facilitate the practical search for fuel to smelt the copper, Logan recognized the *in situ* origins of local coal seams. In an important paper presented to the Geological Society of London "On the Characters of the Beds of Clay Lying Immediately Below the Coal Seams of South Wales" in 1840 and published in the society's *Proceedings*, he postulated a direct relationship between the seams and rootlike formations, or *Stigmaria ficoides*, found invariably in the underclay below the coal. (275-77) From this evidence Logan concluded that the plants actually formed coal when heat and pressure were applied to their remains over time. Upon his uncle's death that same year, Logan left the copper works for North America to test his theory on the massive carboniferous formations of Pennsylvania and Nova Scotia. There he met Charles Lyell on his first North American geological tour. Lyell's confirmation of the correlation of coal and the *Stigmaria* in both places attracted widespread attention and earned Logan the approbation of eminent members of the British geological community who had sought the key to the origins of coal unsuccessfully for many years.

Logan's timing could not have been better calculated in yet another sense, because the Legislative Assembly of the newly united province of Canada voted funds for its geological survey just as he arrived to visit his brother in Montreal.

He garnered the appointment as provincial geologist in 1842 not only because of his international reputation in scientific circles, but also because members of the Montreal business and professional classes believed him capable of furthering their interests as an incipient industrial community. Logan became the beneficiary of the popular assumption that coal would surely be located in Canada by the foremost expert on the origins of the precious fossil fuel. By the same token, in his reports for both 1842 and 1843 he fully accepted the need to ascertain the presence or absence of coal and iron ore in the province as one of the first priorities of his survey. (*J* 1844-45)

In preparation Logan undertook a preliminary sweep of the geological information already available from maps and published reports. As a dedicated uniformitarian he attributed particular importance to the geology of territories along Canada's borders, where outcrops of desirable mineral deposits might likely strike into the province. Logan focused his attention on "a gigantic trough of transition deposits, conformable from the carboniferous era downwards," stretching in length from just below Quebec down to Alabama, and in width from the north shore of Lake Huron across to the Atlantic Ocean. This area housed the "nucleus" of the eastern American coal-bearing measures, outliers of which he believed ran into Canada, and to which Logan turned his search. He judged the most readily identifiable "leading feature" of the province to be an enormous limestone "basin" occupying nearly half of its settled confines, in particular the southern peninsula of Canada West. "This well-marked zone of limestone," Logan recognized, abounded mainly in useful building materials, mineral springs, and fertile soils. More to the immediate point, he read the limestone as a geological signpost to the valuable minerals he sought, since it "at once determine[d] the direction in which to search for metals, and that in which to look for coal."

Two important stratigraphical premises underlay Logan's reasoning: first, that geological strata were ordered in reliable sequence even in territories yet unexplored; and second, that coal deposits occupied only strata dating from the carboniferous era within that sequence. An indiscriminate search for coal "in districts which are now ascertained to be composed of noncarboniferous strata" would therefore no longer be considered "desirable and proper" or at all justified. "Geological experience," he explained, "teaches that the metalliferous rocks are below [the limestone], the carboniferous above." The most efficient procedure, he continued, was to pursue the logic of the science by mapping out the limestone expanse; then, he felt assured, "it will be by transverse sections in the direction of its dip that we shall gradually approach to coal" which overlay the limestone at some undetermined point. Logan admitted his concern that such a point might not rest within the province, but for the time being he chose to deliver his caveat in code: "in consequence of the small removal from horizontality the limestone in so many places exhibits, the lineal superficial distance between the two formations will

probably be very considerable." He appreciated the futility of taking transverse sections where the near-horizontal limestone offered no obvious "dip" from which to take directions, as was the case in what is now southwestern Ontario. In his preliminary report of 1842 Logan nevertheless anticipated that at least at Gaspé, where the limestone dipped to about 25 degrees below the horizon, the northern outcrop of New Brunswick coal reached Canada with "space enough" to "hold the total thickness of the various formations that may occupy the interval, even should they measure as much as their equivalents in Pennsylvania." (*J* 1844-45)

Logan played out his rational plan of action during his first season in the field in 1843, which he duly reported in November 1844. Accompanied by only one assistant, Alexander Murray, he divided the province into three geological districts: a Western Division from Georgian Bay and along the north shore of the St. Lawrence River to Quebec City; an Eastern Division along the south shore of the St. Lawrence to Gaspé; and a Northern Division across the top of the entire province. As planned, Logan and Murray began with the Western Division, orienting their search by the relation of its dominant limestone basin to formations already explored south of the border, the uppermost of which was the coal of Pennsylvania. Considering the intermediary nature of the strata in the entire division, Logan cautioned:

> taking into consideration the extremely moderate dip and undisturbed condition of the strata, and the general even geographical surface of the country, that no deposit higher in the series than the gray sandstone will be found in any part of Canada between that line [from Collingwood to Oakville] and Quebec. There are still to be interposed between the gray sandstone and the true coal measures, a mass of strata equal at the lowest computation to between 4000 and 5000 feet; and we are not warranted reasonably to anticipate the occurrence of any part of those true measures in the district in question.

He carefully coupled his negative verdict with the positive note that geology had the power to eliminate wasteful effort. It could prevent many "adventurers . . . ready to expend their money in search of coal by boring in that district" from being "deceived . . . by the dark colour and the mineralogical character of the deposit of bituminous shales overlying the great limestone formation" simply because they remained "unacquainted with true geological inferences." Coal echoes, he recognized, reverberated throughout the Western Division in the form of these black inflammable shales, as well as fossil plants coated with crystallized coal which gave strata other than the carboniferous "very much the semblance of coal measures." "Even practical miners might be deceived by the appearances" of these carbonaceous [as opposed to carboniferous] substances, Logan admitted, "but no workable coal seams are found associated with the deposit, while its organic contents, agreeing with its stratigraphical position, point out that its age is anterior to the true carboniferous era."

Logan lingered just long enough to offer evidence that iron and copper ores might well be found in the Western Division, but preferred to move on to the Eastern Division in the hope of answering the coal question more optimistically. His attempts to "ascertain the north limit of the coal deposit" which underlay much of Nova Scotia and Cape Breton Island, as well as parts of New Brunswick and Newfoundland, led Logan to fear that "there is a large portion of it lost beneath the gulph of St. Lawrence." Moreover, his search was often thwarted by the complexity of the region's geological structures. Unlike the uniformity exhibited by the great limestone basin farther west, these eastern formations consisted in "the violent contortions of the strata, the altered nature of some of the rocks, and the want of conformability in probably more than one member of the series of formations." The utter disarray in which these strata had come to rest, sometimes at right angles to one another, also affected the location of any coal measures that might be present. Logan believed that the normal "carboniferous perimeter" in these circumstances offered "no guide to the geographical range of any thing coming from beneath." The bewildering confusion of these formations permitted Logan to postpone his verdict for yet another season, but the writing was on the wall: those deposits which he had managed to unravel were, he confessed in the Report of Progress for 1843, "too low down to contain any of the profitable beds of coal." (*J* 1844-45).

LOGAN'S FIRST REPORT OF PROGRESS initiated a longterm dialogue between his science and members of the Canadian public who held "the winning and getting of Coal" as an immediate goal of "great importance" to the province. (*Statutes* 1843, 7 Vic., c. 45) Many insisted that Canada *must* contain workable coal deposits, and they did not wish to be told otherwise. Logan was well aware of this fact, and he understood only too well one of the major ironies of his position as provincial geologist: the very power of predictability afforded by his scientific method could easily foster public disillusionment. A measure of this possibility reflected in the reaction of William Dunlop (1792-1848), the elected representative of Huron County and one of the GSC's earliest, most ardent supporters, in the House of Assembly debates. Dunlop had studied natural history at the University of Edinburgh, and as Warden of the Woods and Forests for the Canada Land Company he had surveyed its enormous Huron Tract during the 1820s, but he refused to accept Logan's geological conclusions. To predict the absence of coal in Canada, he insisted, was "a statement of theoretical reasoners" which he thought ridiculous and lacking foundation. Dunlop charged sarcastically that he "could not see because the coal vein in Pennsylvania dipped upward that therefore there should be coal up in the moon." He contended instead, the *Montreal*

Gazette reported, that "he himself had seen coal on the banks of the Ottawa" during his rambles. (23 Jan. 1845)

Yet even while Dunlop protested so bitterly, Logan was once again busy in the field checking his facts. His Report of Progress for 1844, submitted in May 1845, summed up the evidence from a more thorough examination of the Gaspé region. Confronted by numerous claims of actual coal sightings from fishermen, businessmen, and even the Literary and Historical Society of Quebec, he now patiently and confidently deflated each hope by reiterating the rational basis for his judgments. "Now none of the material where it has come before me *in situ*," he explained,

> bears any analogy in the mode of its occurrence to workable coal. This is always found in extensively continuous beds conformable with the stratification; where as the mineral in question occurs in cracks cutting the strata across for greater or less distances. It is true that where faults or dislocations exist among coal seams, there is often met with running across the stratification what by Scotch miners is termed a *vise*, and by Welsh a *leader* of coal, which in general is a thin, confused, irregular black more or less carbonaceous sheet, conducting up or down as the case may be, in the plane of dislocation, from the termination of a coal-bed on one side to that on the other; and there is no doubt it is the result of the grinding of the terminal edges of the strata against one another, when the slip producing the dislocation occurred. Without a slip or displacement, therefore, no leader would be found, and none in any case would hold true coaly matter extending beyond the distance between the separated edges of the coal-bed. Now in the case of the bituminous mineral, the cracks in which it occurs are, in many instances, unaccompanied by any displacement of the strata, and in others, where the extent of the dislocation (that is the upthrow or downthrow, as it is called) is visible, no layer holding any of it occurs among the beds. Independent of all this, the formation in which the mineral is found, is an inferior member of a group of rocks, whose place is in all probability a very considerable distance below the position of the true workable coal-bearing measures, and we are, therefore, not warranted in expecting coal seams to exist in it.

Numerous examples later, Logan finally uttered the dreaded conclusion that

> The conglomerate rocks with which they are associated appear to be the very base of the coal series, in so far as Gaspé is concerned, and their distribution in Canada is just sufficient to shew that a very narrow margin on the north shore of the Bay Chaleur may be considered the limit in that direction of the great coal-field of North America. (*J* 1846)

Geology, in other words, precluded any expectation of ever finding workable deposits of coal in the province of Canada.

Logan had learned from the experience of the short-lived geological surveys of New Brunswick and Newfoundland that if he hoped to be able to justify continued public support for the GSC, he had to be seen as accomplishing something positive. During the following season he left both the monotony of the Western and the violence of the Eastern Divisions to pursue the promise of metallic mineral wealth in the Northern. In this field he was once again a pioneer, since these oldest

"Precambrian" formations of the earth's crust lacked both the stratigraphic and the fossil keys that had enabled geologists to unlock the Cambrian series above them during the 1830s. In addition, the region remained a *terra incognita* even geographically, and Logan was pleased to be able to fill numerous blanks on the official map of Canada being constructed by Joseph Bouchette. Largely for commercial reasons, he chose the Ottawa River over the Saguenay as a starting point for his analysis of the Northern Division, but after only one season he remained convinced that the "general relations" of the vast metamorphic series would not reveal their geological and mineralogical secrets "until a great collection of facts shall have been accumulated beyond the northern bounds of the Province." In the meantime, he hinted at the existence of workable deposits of both iron and copper ores on the fringes of settlement. Logan's hints instigated a mining rush to the shores of the upper Great Lakes, where he had alluded to successful searches in the same formations in Michigan's Upper Peninsula. (*J* 1847) As a result, he spent the seasons from 1846 to 1849 surveying mining locations and mineral veins on the shores of Lakes Huron and Superior. (*J* 1849, 1850) Yet despite discoveries of the ores, his own Swansea experience taught Logan that the location of coal determined that of metal works, and not vice versa; in his report for 1846-47 he warned that until new technological developments, fuelled perhaps by electricity, changed the impersonal "fiscal laws," Canadian ores would end up in the United States for processing. (*J* 1847)

For obvious reasons the Canadian public had not surrendered its hopes on the issue of coal. By 1849 Logan and Murray were both pursuing the question once again in the Eastern Townships, an area of transition between the Western and Eastern Divisions, where bituminous limestones had once again deceived "several persons worthy of credit," including the Commissioner of Crown Lands. Logan expended great efforts to quash such false hopes, and replied bluntly that "Among the economic minerals . . . it is a matter of regret that I have it not in my power to include the coal reported to have been discovered" in the region:

> Wherever workable seams of coal have yet been found on the face of the globe, the evidences connected with them prove beyond a doubt, that their origin is due to great accumulations of vegetable matter, which has been converted into a mineral condition. The vegetable structure is detected in the mineral by microscopic examination, and as might be expected, the strata associated with coal beds are profusely stored with fossil plants; even where the seams are too thin to be workable, . . . the vegetable remains disseminated in the masses of rock dividing the seams, are still in vast abundance. . . . There being not the remotest doubt whatsoever of the geological age of the limestones of [this region], supposing the specimens were really derived from the strata, and that the species of plants should at the same time be ascertained to be identical with those of the carboniferous period, it would prove that all evidence up to the present time has been imperfect, and that the flora of this period is of hitherto unsuspected antiquity. (*J* 1850)

Nor did Logan see any reason to alter his hardearned geological assumptions to accommodate rumours of coal discoveries that were time and again unsubstantiated by evidence of actual workable deposits.

LOGAN SPENT THE REMAINDER of his career fending off persistent challenges to his credibility, but he did so by reinforcing his meticulous geological work with international recognition of its accuracy and value. His Canadian mineral exhibit for the Crystal Palace Exhibition of 1851 won lavish praise (*J* 1852), and helped the GSC to survive a parliamentary inquiry in 1854 which completely accepted his defence of geology as a guard against pointless searches for coal in the province (*J* 1854). A repeat performance at the Paris Exposition of 1855 earned him a knighthood, the Wollaston Medal of the Geological Society of London, and induction into the French Legion of Honour. Logan continually emphasized Canada's wealth in ores that required only charcoals to produce first-rate metal products and did not threaten British manufacturers. (*J* 1857, 1858) But his most far-reaching contribution continued to be conceptual, as exemplified in his impressive geological map, unveiled at Paris, of Canada in relation to the contiguous formations surrounding the province, including the coal of New Brunswick and Nova Scotia. By 1857 Logan had also unravelled the Precambrian series he now termed "Laurentian" and "Huronian," making the Canadian Shield the international prototype of these formations and integrating the region into the province to a degree that had not been done before, and which the expansionist Department of Crown Lands adopted almost immediately. (*J* 1857)

Even so, part of Logan's continuing task was to monitor discoveries of "carbonaceous combustibles" which, "if not scientific coal," were claimed to be "coal nevertheless." The worst examples were cases of fraud in which samples of real coal were imported and planted in wells on private land; in Bowmanville in 1858 a cheese sandwich came up with the last such bucket lowered to extract coal. But by then Logan commanded the utmost scientific respect and while he continued to reiterate his explanations, those who questioned his authority risked ridicule from his many supporters both in science and in government. In 1863 he synthesized all of his previous reports in his masterful *Geology of Canada*, which pronounced the final word on Canada's coal predicament in declaring that the only representatives in the province of the true coal-bearing series afforded nothing but a few carbonized plants. When Premier John Sandfield Macdonald dared to suggest that the GSC had failed to locate even the mines that did exist in the province, his own party joined in lampooning him for objecting to Logan's fossil studies because that was "carrying personalities too far." In 1858 it was Logan's

colleague at McGill University, the geologist J. W. Dawson, who articulated in *The Canadian Naturalist* the expansionist vision that uniformitarian geology had brought to Canada through the work of the GSC:

> Physically considered, British America is a noble territory, grand in its natural features, rich in its varied resources. Politically, it is a loosely united aggregate of petty states, separated by barriers of race, local interest, distance, and insufficient means of communication. As naturalists, we hold its natural features as fixing its future destiny, and indicating its present interests, and regard its local subdivisions as arbitrary and artificial. (392-93)

Logan's annual geological reports record the growth of uniformitarian geology as a powerful ideological force in Canadian culture, in encouraging Canadians to look beyond their traditional political boundaries for the resources which they believed were crucial to their material future, and which their own province was shown to lack. In Logan's view, Confederation was but a natural outgrowth of his uniformitarian outlook, and he had prepared for it by expanding his survey informally to most of the other British North American colonies well before 1867. In an address Dawson wrote in 1868 "On Some Characteristics of the British American Mind," Dawson could look back with satisfaction to declare that nature, indeed, had "already taken hold of the mind of young Canada," and was "moulding it in its own image." Logan's reports had, indeed, gone a long way to ensure it.

NOTES

[1] Roy Porter, "The Industrial Revolution and the Rise of the Science of Geology," in Mikuláš Teich & Robert Young, eds., *Changing Perspectives in the History of Science: Essays in Honour of Joseph Needham* (London: Heinemann 1973), 320-43; David Daiches, Peter Jones, & Jean Jones, eds., *A Hotbed of Genius: The Scottish Enlightenment, 1730-1790* (Edinburgh: Edinburgh Univ. Press 1986); Suzanne Zeller, *Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation* (Toronto: Univ. Toronto Press 1987): chap. 2.

[2] Roy Porter, *The Making of Geology: Earth Science in Britain 1660-1815* (Cambridge: Cambridge Univ. Press 1977): 152, 171-73; see also Martin J. S. Rudwick, *The Meaning of Fossils: Episodes in the History of Palaeontology* rev. ed. (New York: Science History Publications 1976).

[3] Stephen Jay Gould, *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time*, The Jerusalem-Harvard Lectures (Cambridge, Mass.: Harvard Univ. Press, 1987): chap. 4.

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GCS. "Report of Progress 1849-50" in *Journals* (1850) App. V.

GSC. "Report of Progress 1850-51" in *Journals* (1852) App. O and OOO.

GSC. "Report of Progress 1853-54-55-56" in *Journals* (1857) App. 52.

GSC. "Report of Progress 1857" in *Journals* (1858) App. 32.

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Montreal Gazette, 23 Jan. 1845.

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