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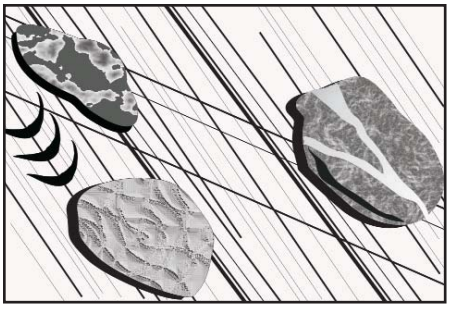

Robert J. Chalmers: Pioneer Surficial Geologist

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SUMMARY
Most Quaternary geologists working in Atlantic Canada view Robert J. Chalmers' investigations of the surficial geology of New Brunswick for the Geological Survey of Canada (GSC) as seminal contributions. Yet, the fullest biographical information available for Chalmers is a 7-page typescript by E.R. Faribault of the GSC, held at Natural Resources Canada Library in Ottawa. Therefore, it appeared necessary to bring Chalmers' little-known life, and the variety of his surficial geologic investigations, into the mainstream. Lists of Chalmers' published works in GSC reports and in periodicals are compiled from all available sources.

SOMMAIRE
La plupart des géologues du Quaternaire au Canada atlantique voient les études de Robert J. Chalmers sur 'la géologie en surface' de Nouveau Brunswick pour le Commission géologique du Canada comme des ouevres séminales. Mais, l'information biographique le plus pleine de Chalmers est un texte bref dactylographié par E.R. Faribault du CGC, tenue à la bibliothèque du Département des Richesses naturelles canadienne à Ottawa. Donc, il apparait nécessaire à porter au premier plan sa vie mal-connue, et le variété de ses oeuvres. Aussi, listes des oeuvres de Chalmers pour le CGC et dans les journaux scientifiques sont ici présentent des sources disponsible.

INTRODUCTION
Robert J. Chalmers (1833-1908) is well recognized and often cited for his pioneering work on the surficial geology of New Brunswick for the Geological Survey of Canada (GSC), work he also contributed to the journals of American, Canadian, and local scientific societies, and which spans the period 1881-1907[1]. In spite of this recognition, biographical information is scarce. In a seven-page typescript held at the Library of Natural Resources Canada, Ottawa, E.R. Faribault of the GSC sketched Chalmers' life and work (Faribault O-1924). Faribault, who studied under Abbé LaFlamme at l'Université Laval, worked for the GSC, mainly in Nova Scotia, from 1882-1932. According to Zaslow (O-1975), Faribault was by then the longest serving field geologist in the Survey's history. The unofficial form and brevity of this typescript suggest either that it was requested when the lack of a biography was noticed by the GSC, a dozen or more years after Chalmers' death, or that it was written unsolicited by a close colleague as a *post-mortem* mark of respect. That Chalmers' death long went unremarked officially at the GSC might have been due to the administrative turmoil surrounding the unseating of Robert Bell as Acting-Director in 1906, installation of A.P. Low in his place, Low's incapacitating illness, and R.W. Brock's succession in 1908, the year Chalmers died.

This contribution presents essential biographical information on R.J. Chalmers (drawing mainly on Faribault's typescript), outlines his primary contributions to surficial geology, and includes lists of his publications as complete as available sources permit.

BIOGRAPHY
Chalmers was born 31 December, 1833 at Belledune, Gloucester County, New Brunswick, on the south shore of Baie des Chaleurs, the only son of Robert Chalmers and his wife, Jean (née MacAllister), who also bore him a sister. He was schooled locally, but did not go to college. Adept at Botany and Mathematics, he trained as a teacher in Saint John, and then taught mostly at Campbellton, 100 km northwest of his home. After teaching for about ten years, in 1860 he journeyed to California, where he was Headmaster at Oakland Grammar School. He returned home during the Civil War, but crossed the continent again shortly after the war ended.

Returning to New Brunswick, Chalmers became Head of Campbell-

[1] Note that author citation in the Bibliography and References section is divided into "G" for Chalmers' GSC reports, "P" for Chalmers' periodical articles and abstracts, and "O" for references to other authors.

ton schools, and then engaged in newspaper work at Saint John, probably around 1880. Even before he moved to Saint John, however, Chalmers was an active member of the Natural History Society of New Brunswick, where he continued as committee member and lecturer until he moved to Ottawa in the late 1880s. It is not clear how his newspaper work dovetailed with assisting two field geologists mapping in New Brunswick, namely the GSC's Wallace Broad in 1882, and Loring Bailey of the University of New Brunswick (a long-term summer employee of GSC) in 1883. He was in his 49th year when he married Elizabeth Chalmers (relation, if any, unknown), with whom he fathered four children.

Little of Chalmers' correspondence survives; enquiries revealed only three letters to Professor Loring Bailey at Fredericton, dated January and April 1884. These letters are held by the New Brunswick Museum, part of the W.F. Ganong Collection, File 476, and are dated 1 and 22 January, and 22 April, 1884. The Ganong Collection also contains brief biographical notes compiled from an interview conducted by GSC colleague W.J. Wilson (palaeobotanist) with Chalmers' wife shortly after his death (Ganong Biography Scrapbook F358 – 36, 37, 38). These notes mostly lack dates, and one is erroneous.

The Chalmers–Bailey letters mainly concern topographical work that Chalmers had done for Bailey the previous summer, in York and Charlotte counties, southwest New Brunswick. He thanks Bailey for recommending him to GSC Director Selwyn, and mentions having travelled to Ottawa, probably in March, 1884. He had not subsequently heard from Selwyn about an appointment, but expected to do so with the approach of summer, when he hoped to be engaged in mapping surficial geology. We know, of course, that he gained the position with the GSC, and from the title and date of his first report (Chalmers G-1885), that his first work for the Survey was in western New Brunswick in the summer of 1884, following independently from the work he had done there for Bailey in 1883. Faribault's typescript notes three papers Chalmers published previously in periodicals (Chalmers P-1881, 1883a, 1883b), each concerning Chalmers' home area, the latter (Chalmers P-1883b) for the inaugural meeting in May 1882 of the Royal Society of Canada. Both Bailey and G.F. Mathew were among the founding Fellows of the Society and had close relations with Chalmers, both in field-work and with the provincial Natural History Society, to which Chalmers contributed administratively and lectured on his surficial geology work. We may therefore suppose that, as Chalmers was not a Fellow, one of them arranged a place for him in the program of papers. Concerned with the action of shore-ice around Baie des Chaleurs, his paper was read (appropriately) by J.W. Dawson.

In a letter to Bailey, Chalmers' mentions reading a newspaper "*containing some strictures on the Director.*" This refers to the report of a Parliamentary committee which that Spring had investigated concerns being voiced about the effectiveness of the GSC as an engine of mineral exploration and discovery (Canada, Parliament O-1884). Little by way of hard recommendations resulted from the, in parts, rancorous testimonies to this committee, some of which slighted Selwyn's leadership, except the necessity to focus efforts aimed at faster, fuller, and more useful reports of activities. The appointment of Chalmers might be seen partly as a response to this by the Survey. Other appointments made that year or the next were McEvoy, White, Lawson, and Brumell (Zaslow O-1975); perhaps enough to appear as a minor flurry of hiring.

From the beginning, in Chalmers' GSC reports, his geological terminology and concerns are recognized. More than a century after they were made, the familiarity of his representations and interpretations is remarkable, considering he lacked formal training. Providing background for this involves some uncertainty, but at least gives some direction to other probes. His letters to Bailey show that Chalmers was living in Saint John early in 1884, perhaps to be close to a library and colleagues. Discussions were possible there with Bailey, R.W. Ells, Faribault, and Matthew, each an active Maritime geologist, domiciled in the region. His wife was also with him there, and had given birth to their first child, a girl, who died soon after, which slowed his progress on a report for Bailey, apparently on the previous year's topographical surveys; there is much in these letters to Bailey devoted to altitudes and their reliability.

As for Chalmers' contact with the GSC in Ottawa, he does not appear in city directories until 1888-89, from which time until 1893-94 he lodged annually at 129 Bank, 92 Metcalfe, 188 Queen, and 214 Gloucester Streets. From this we may suppose that, for the first ten years on the GSC permanent staff, he maintained a household in New Brunswick, and in the last four years lodged at Ottawa during the winter while he wrote reports and oversaw drafting. In 1895-96 and 1896-97 he is listed as a homeowner at 72 College St. (now gone), and from 1898-99 as a homeowner at 243 Chapel St., where he died. [For Ottawa city directories see www.collectionscanada.gc.ca/canadiandirectories/index-e.html].

While in Ottawa, Chalmers was able to discuss surficial geology with colleagues, including George Dawson (Director from 1895, deceased 1901), Robert Bell (Acting Director from 1901), Albert Low, James Macoun (botanist), Richard McConnell, and Joseph Tyrrell (resigned 1899). In his final year at the Survey (1906-07) Chalmers' annual salary was $1950, which reflected his 23 years of service. Within $100 of salary and one year's service of this were Ami, Barlow, Ells, Faribault, and McInnes, while the longer-serving Bell, Fletcher, Hoffman, Ingall, Low, Jas. Macoun, McConnell, and Whiteaves earned $2400–$3000.

Chalmers probably met Faribault soon after he was hired by the Survey, and it seems from Faribault's biographical notes, that they got to know each other quite well. Faribault described Chalmers (Figure 1) as:

> *"short, a bit stout, but strong and capable of excursions on foot without apparent fatigue. Mentally and morally he showed somewhat strongly his Lowland Scottish descent, his morals being Calvinistic and his mentality of more than average quality. He was tenacious, even to stubbornness, of acquired knowl-*

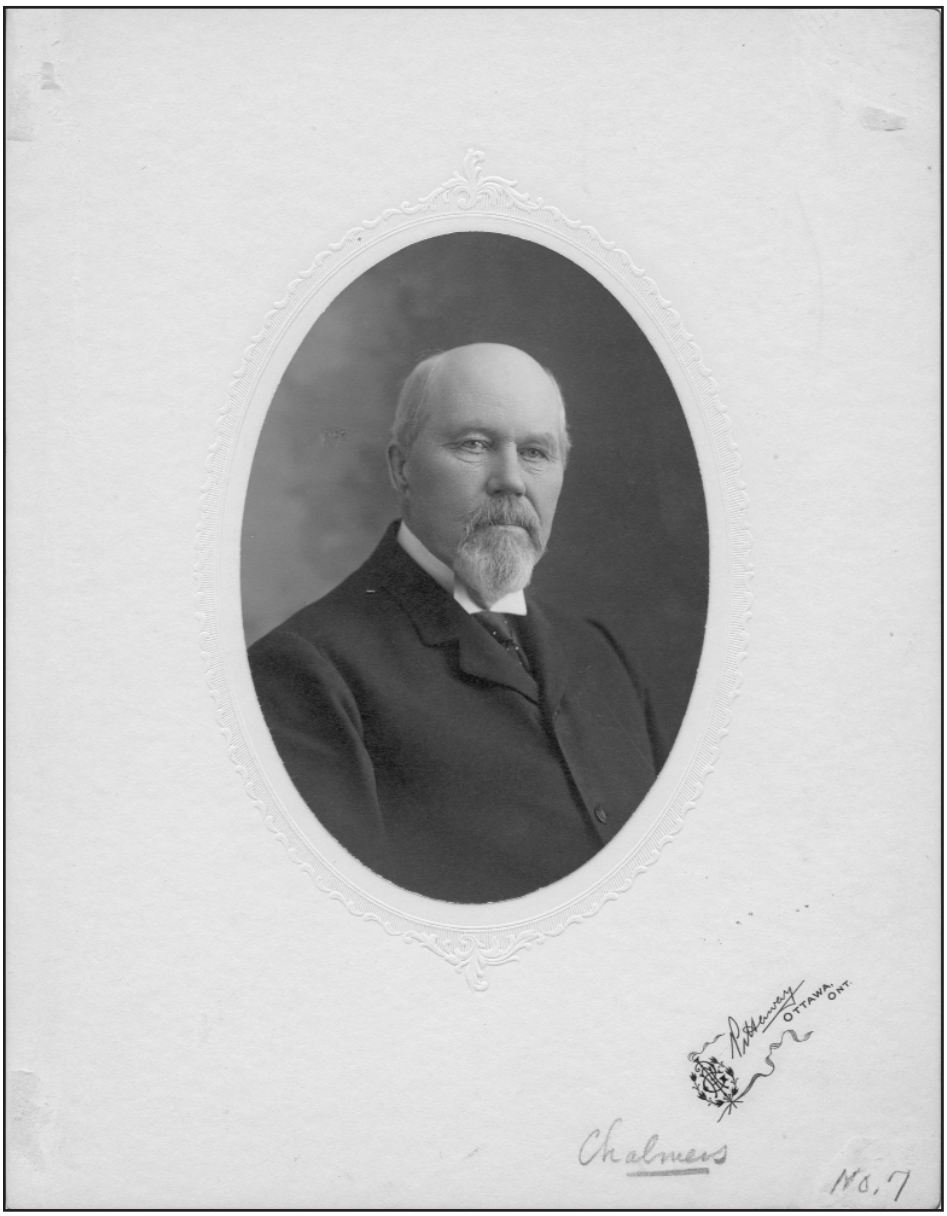

Figure 1. Robert J. Chalmers, ca. 1900, aged ca. 66. Original is a gelatine silver print, mounted on card 22.6 X 17.5 cm., studio of A.G. Pittaway, 58 Sparks St., Ottawa. New Brunswick Museum Archives, Saint John, NB; William Francis Ganong Collection, Accession number 1987.17.506.

> *edge and opinion, a quality helped by a retentive memory. Though quiet, he was an entertaining talker and good companion. His chosen branch[es] of science, botany and mathematics, were his principal hobbies and his amusements were limited pretty well to his own fireside. He had no particular politics. If anything, he was a Conservative. Adherent of the Presbyterian Church."*

Most of these traits are best understood as those of a man past middle-age. Faribault continued:

> *"the following appreciation is furnished by his daughter Annie J. Chalmers, who is employed in the office of the Consul of the Netherlands at Vancouver: 'He was a man of considerable mental capacity, possessing a remarkable memory, and in addition to his scientific attainments, was a keen mathematician. In his younger days he was an ardent botanist.'"*

In 1902, after 18 years on GSC permanent staff, Chalmers was honoured by the University of New Brunswick with the LL.D. degree. Although enquiries have yielded no record of the occasion, Loring Bailey, then head of the UNB Geology Department, probably was his sponsor.

Faribault transcribed newspaper notices of Chalmers death on 9 April, 1908; the cause, "*heart failure, the result of a general breaking-up of the system, at his home at 243 Chapel St., Ottawa.*" The previous autumn he had been working in the St. Lawrence valley, so it appears that his health deteriorated over the winter. Following a service in Ottawa, his body was taken by train to Belledune, to be buried in the family plot.

SURFICIAL GEOLOGY

New Brunswick

Chalmers began mapping for the GSC in western New Brunswick (Chalmers G-1885), probably the region of the province characterized by the most complex surficial geology; this area is traversed by the Saint John River valley, where more was involved than the simple distinction of tills and tracing of glacier movements. The valley contained terraces marking proglacial areas, and ice-marginal zones with complex depositional patterns separating simpler environments of glacial, glaciofluvial, and glaciolacustrine sedimentation. Chalmers classified topographical features as, i) moraines, ii) till (eschewing the traditional 'boulder clay'), iii) lake basins, iv) kames and gravel ridges (the first use of the term 'kame' in Canada), and v) terraces of the Saint John River. What makes this report such a remarkable opening to Chalmers' *corpus* is his use of section diagrams of kames and terraces, the first to illustrate a GSC report, presumably drawn from river and railway cuts.

Chalmers' second GSC report (Chalmers G-1886), rather than dealing with a region, deals in broad terms with the surficial geology of the entire province. Clearly, then, he had become familiar with it earlier, through his work as assistant to Broad (in 1882) and Bailey (in 1883), and also prior to his association with the GSC, when, during summers, he was free to travel and familiarize himself with published works. There were also papers on surficial geology in New Brunswick (Math-

ew O-1872a, b) that would have alerted him to locations for visits and checks. In this overview report, he had already concluded that the main ice-flow directions in the province were, i) north and east, and ii) south and southwest, from a divide roughly along that between the Saint John River and the Gulf of St. Lawrence, while declining glaciation saw more variable flows from "*a number of smaller glaciers*" (Chalmers G-1886, p. 32GG). Horizontal, paired terraces showed that a lake had flooded the Saint John valley between Grand Falls and Edmundston, while to the south, terraces above the river sloped south and were often unpaired, so appeared to be fluvial in origin. Shells in marine 'Saxicava Sand' and 'Leda Clay' around the coastal fringe, identified by GSC's Whiteaves, indicated a sub-arctic climate. Subsequent reports by Chalmers on New Brunswick appear as elaborations of these conclusions, with copious records of field observations.

In this report we also encounter, in a section on Grand Lake, the only poetic expression Chalmers allowed himself in his entire *corpus:*

> *"The numerous islets and headlands, narrow, intricate passages and deep inlets expanding into broad sheets of water, the dark green slopes of the surrounding hills, rising with sweeping outlines 400-600 feet above – all combine to form some of the most diversified views in New Brunswick. The wildness and solitude of the scenes also lend them a particular charm, the only sound the voyager hears day after day being the weird cry of the loon which frequents them."*
> (Chalmers G-1886, p. 17GG)

The second regional report on the province was for northern New Brunswick and adjacent southeast Québec (Chalmers G-1887). Here, he was quick to note that evidence of ice flow from north of the St. Lawrence estuary was lacking. Along the Gaspé shore, striae indicated only south-to-north ice flow from the Notre Dame Mountains, while along the St. Lawrence, striae recorded flow either to or from the northeast. In New Brunswick, striae were directed eastward, toward Baie des Chaleurs. Crystalline erratics were from the Gaspé highlands and/or from unidentified igneous 'bosses' in the northern New Brunswick highlands, but there were no definitely foreign boulders.

Deposits were classified, as in other reports of his, as i) M1 - till, moraines, and erratics; ii) M2 - ice-contact kames and proglacial and post-glacial river terraces, marine Leda Clay and Saxicava Sand, the latter found in thicknesses up to ~ 200 feet (61 m); or iii) M3 - recent 'alluvions' and lake sediments, and beach and saltmarsh deposits. On the derivation of the till, Chalmers followed convention in ascribing it to glacial modification of pre-glacial regolith (Chalmers P-1898). In this later paper he concluded that the regolith, often several tens of feet thick, had survived because the Laurentide ice-sheet had not invaded New Brunswick. Recognition of till as glacially transported regolith could be seen as an effect of the low erosive power of small separate ice masses, which he said 'slid' slowly over the decayed rock.

Similar broad conclusions were reached in Chalmers' third report, on northeastern New Brunswick (Chalmers G-1888), focusing on the district south of Chaleur Bay. Again, no 'foreign' (Laurentide) boulders were evident; ice-flow had been centripetal towards the bay. Additionally, he noted, as he had previously in a periodical (Chalmers P-1883b), that boulders at the submerging coast of the bay were being moved by shore-ice, a phenomenon he was prepared to give space to in most of his reports.

Avoiding the neighbouring (but less accessible) Northumberland Strait hinterland, the more open, settled country of southern New Brunswick was mapped next, stretching from St. Stephen on the Maine border to Shediac on the Gulf of St. Lawrence (Chalmers G-1890a, b). Here, the upland east of Saint John (known as the Caledonia Hills) drew attention to pre-glacial denudation history. He concluded that in the Tertiary period the Fundy shore and hinterland had stood much higher than present, leading to incision of valleys, but no explanation was offered for the level upland surface.

All glacial striae over the southern region were directed generally southward, with most showing departure to the east, and some to the west, by up to 60^0. East of Saint John and falling steeply to the Bay of Fundy, the Caledonia upland was striated, but hosted no erratics. Glacial deposits were dealt with in more detail than in other regional reports, perhaps because better exposures made them more accessible to observation. Rock-cored drumlins were noted in the southwest, but Chalmers' description reminds one more of crag-and-tail features. Kames, again, demanded full treatment; four types were classified: i) accumulations associated with glacier margins, some possibly morainic, mainly in highlands; ii) terraces around lake margins, some hummocky (kettled?); iii) valley kames and terrace residuals; and iv) marine kames, which would later become known as emerged glacier-marginal deltas. Marine submergence at the Fundy shore attained ~220 feet (67 m), but tracing it up the Saint John valley was problematic. Chalmers appeared puzzled at not finding marine cliffs associated with submergence, which later works would recognize as evidence of rapid deglacial emergence. He did not mention any influence of the Bay of Fundy on glacier flow; in fact, the most southerly striae in the south showed an easterly, rather than westerly, component. Explanation of this emerges from an important conclusion of the final New Brunswick report, discussed next.

In the report on eastern New Brunswick, northwest Nova Scotia, and part of Prince Edward Island, Chalmers (G-1892a, b, 1893, 1894, 1895a, b) again devoted space to pre-glacial denudation, the topic arising from the physiography of the Cobequid Mountains, where evidence pointed to the same conclusions as reached for the Caledonia Hills in the previous report. His conclusions here on "upheavals" depart the most from those we credit today. Chalmers apparently viewed them as a continuation of the tectonics that had deformed the bedrock, rather than those effecting post-glacial emergence at the coast. This "confusion" might have arisen from the inability, itself arising from the lack of a chronology, to distinguish i) movements deforming the bedrock; ii) uplift leading to river incision into

uplands; and iii) deglacial emergence. Some rationale for this misapprehension might lie in Chalmers' recognition of tectonic offset of striae on glacier-smoothed surfaces, which mimics structures produced in bedrock by much earlier tectonics. On the other hand, Chalmers left no doubt of his opposition to what is today known as glacio-isostasy (Chalmers G-1896a, p. 42M-43M).

On glaciation, Chalmers (G-1896a) listed over 300 striae readings, ten percent of which he ascribed to shore-ice (but his photograph of the latter, Plate IV, facing page 81M, is definitely mistaken). No moraines or drumlins were identified, so the section on glacial deposits is devoted to an expanded discussion of kames and '*osars'* (eskers). Some of Chalmers' earlier descriptions of kames, in the other districts of the province remind one of eskers, so that his kames category might be seen as a broad one, into which some eskers and perhaps some minor moraines were grouped. Chalmers' classification needs to be seen in light of contemporary confusion of terminology. *Osar* was recognized at the time as a Swedish term imported to describe long, sinuous, gravelly ridges, whereas 'esker' was the English transliteration of the Irish '*eiscir'* for such features, and 'kame' was a Gaelic term, also rarely spelt 'kaim', meaning 'comb', as in 'cockscomb'. This was a long, narrow, steep-sided ridge, and therefore similar to esker, but kame was used in Lowland Scots more generally to signify irregular gravelly and sandy hills, including eskers, deltas built into proglacial lakes and seas, and other ice-contact features. Robert Bell had experienced related terminological confusion (Bell O-1898) when he tried to introduce such terms (e.g. till, *osar*) into the section on Superficial Geology he wrote for Logan's 'Geology of Canada' (Logan O-1863) (see also Note 1 at end of text).

In this eastern region of the province, Chalmers (G-1895) included a section on the deposits and landforms of the Magdalen Islands, which he concluded had remained free of glaciers. Foreign boulders were ascribed to floe-ice transport. This doubtless influenced greatly his regional map, included in the body of this report, showing the extent and flow directions of former glaciers in the Gaspé Peninsula and the Maritime provinces. With no evidence, except from the Magdalens, on which to base even speculation on their offshore extent, Chalmers' map showed glacier limits at or close to the present coasts of New Brunswick, Prince Edward Island and Québec. Ice had crossed Northumberland Strait, but did not extend far off the outer coast of PEI. Even around Baie des Chaleurs and Bay of Fundy, the ice margin traced the coastline fairly closely, even though Chalmers (G-1888) had previously noted the former bay as a focus of glacier movements around it. Clearly, this is where a present-day reader needs to be wary of modern interpretation of early observation; it would be quite natural for a present-day reader to infer that Chalmers meant that the Baie des Chaleurs had 'drawn-down' ice-flow toward it. That Chalmers showed no glacier in the bay, means that he regarded the influence only as topographic, not glacio-dynamic. As a general point, with the notable exception of Logan (O-1847), reports on glacial geology in Canada showed little appreciation of the dynamical behaviour of glaciers, until Bell's (O-1890) startlingly apposite analogy of erosional microforms on granite at Killarney, Ontario, comparing them to *"… plastic clay...stroked by the hand"* (p. 291), and broader landscapes to sculptures produced by *"land ice acting as a plastic fluid"* (p. 292).

Chalmers (G-1895) also made some detailed observations in peninsular Nova Scotia, not just in the area adjoining his New Brunswick studies. He had measured northwest-directed striae on North Mountain, which borders the north side of the Annapolis–Cornwallis lowland, and had concluded that peninsular Nova Scotia had supported another "*local*" glacier that had moved over North Mountain, thus conforming to his *"multi-centred*" conception of (at least the "final") glaciation in New Brunswick.

The concept of local glacier divides was to suffer much in later studies, particularly by New Englanders such as Goldthwait (O-1924) in Nova Scotia and Flint (O-1951) over the wider region of Appalachian America, who both argued for Laurentide glaciation as documented in their home region. In Nova Scotia, Goldthwait also observed erratics of South Mountain granite on basaltic North Mountain, but made nothing of them. It was more than 60 years after Chalmers' last report on New Brunswick that Hickox (O-1962) revived Chalmers' interpretation, proposing a late-glacial ice-cap isolated over western peninsular Nova Scotia, which he explained by growth of a calving bay in the ice-front receding up the Bay of Fundy.

In this final report on New Brunswick, Chalmers (G-1895b) allowed himself broader considerations of the causes of glaciation. He granted the combined influences of local topography, "*upheavals*", and lowered temperatures, but felt that these must have been governed by "*general or cosmic influences as to affect simultaneously the whole circumpolar and north temperate regions of the earth during Pleistocene time, otherwise glacial conditions cannot have occurred synchronously in both hemispheres or even on both continents*" (Chalmers G-1895, p. 108M-109M).

Québec

Chalmers' major report on surficial geology in Québec was that which also dealt with gold-bearing unconsolidated sediments (Chalmers G-1898). He conducted an exhaustive review of the previous literature on regional gold occurrences in the Québec Appalachians, whether worked or not, and worked previously or actively, from Logan (O-1852) to Ells (O-1890).

In Québec, south of the St. Lawrence, Chalmers listed almost 100 stations where striae were assigned to an Appalachian glacier complex. Striae at 300 stations indicating south- and southwest-moving Laurentide ice were recorded only upstream of Québec City, extending to the Thousand Islands. On the basis of apparent weathering of north-directed striae crossed by south-directed ones, Chalmers (G-1898) concluded that the earliest glaciation of the region had been by an "*Appalachian system of glaciers*" (a term that he introduced in earlier journal correspondence; Chalmers P-1890), with a "*nevé*" (divide) roughly over the crest of the range. This glaciation was succeeded by

invasion of the St. Lawrence valley and Appalachians by an "*early Laurentide*" glacier, which, however, did not reach the region southeast of Québec City (roughly east of the Chaudière River). Farther south, this ice did move east into the upper Saint John River valley, across it and into northern New Brunswick, where Chalmers' earlier work had convinced him of invasion by ice from the west, bringing no Laurentide erratics. On the Appalachian slope west of the Chaudière, gold had been known to occur in stratified sands and gravels in major valleys, underlain and overlain by till (e.g. Logan O-1852; Ells O-1890). Chalmers pondered the origin of these stratified sediments – were they marine, glacio-lacustrine, non-glacial lacustrine or fluvial, or the products of subaerial base-levelling of the regional terrain? He specifically discounted the glacio-lacustrine option, on the basis of what he saw as an unlikely pattern of deglaciation in such terrain. He preferred a marine origin for those sediments occurring at an elevation comparable to known marine sediments around the St. Lawrence lowland. For sediments higher in the Appalachian valleys he reserved judgment.

Evidence from striae and stossing of rock knobs indicated a second Laurentide ice advance moving up the St. Lawrence valley above Québec. This was the same ice that invaded the Great Lakes basins, which today would be known as Late Wisconsinan. In the Eastern Townships, some higher hills showed no sign of this glaciation, which led to introduction of the term 'nunatak' into the text (Chalmers G-1898, p. 53J). In this report, Chalmers made prescient remarks on boulder accumulations (p. 60J-63J). He described what would today probably be recognized as boulder lags in the lee of Rigaud Mountain, west of Montréal. He viewed them as local weathering products and wondered why they had not been swept away by the glacier. This is strange, because he next refers to similar accumulations around the confluence of the Ottawa and Gatineau rivers, and to huge 'Shield' boulders in the Mattawa River valley, as possibly resulting from washing of boulder-rich 'Saxicava Sand'. He ventured finally, *"whether or not the upper Great Lakes once found outlet by the Mattawa-Ottawa valley is a question which appears to the writer to require further detailed investigation" (Chalmers G-1898, p. 63J).* F.B. Taylor had investigated this question during the previous several years, and also discussed the origin of the Mattawa valley boulders (Taylor O-1897).

Another case of a glacially dammed lake in this region had been proposed by Upham (O-1895a), who drew isochrones on the margin of the Laurentide ice sheet as he envisaged it retreating northeastward across the St. Lawrence valley and the bordering highlands. These ice margins were undated, but Upham gave them stage names. Upham then goes on to state that:

> *"Earlier than that time of occupation of the depressed broad [St. Lawrence] valley by the sea, it was filled from Lake Ontario to near Quebec, by a great glacial lake, held on its northeast side by the retreating continental ice-sheet.....the latest remnant of the ice barrier blockading this valley was melted away in the neighborhood of Quebec, then admitting the sea to a large, low region westward. Until this barrier was removed, a glacial lake, which here for convenience of description and citation, is designated as the Lake St. Lawrence, dating from the confluence of Lake Iroquois, and Hudson-Champlain, and growing northward and eastward, spread over the Ottawa valley probably to the mouth of the Mattawa, and down the St. Lawrence, as fast as the ice-front was melted back."* (Upham O-1895a, p. 16).

Chalmers was not impressed. As for Upham's isochrones, Chalmers (P-1895) returned to his conclusion that no Laurentide ice had crossed the St. Lawrence downstream of Québec City, and further, that

> *"the glacial phenomena on the slopes and the higher grounds seem to be entirely due to local sheets of land-ice of greater or less extent, moving in different directions on the slope facing the St. Lawrence, being mainly northward. In the bottom of the St. Lawrence valley, however, a northeast to southwest set of striae occurs, which seems referable to the action of floating ice"* (Chalmers P-1895, p. 273).

So objectionable did he find Upham's paper that, compared to earlier impressions, a Chalmers entirely different, temperamentally and intellectually, emerged a few months after Upham's paper appeared, as expressed thus:

> *"…on whose authority has he* [Upham] *reversed the courses of the striae there [along the lower St. Lawrence], those being shown on Sir William Dawson's map* [Dawson O-1894, p. 150] *as pointing southwestward and are supposed to have been produced by floating ice moving up the valley? … No lacustrine deposits have been found anywhere in the St. Lawrence valley beneath the* [Champlain Sea] *Leda Clay"* [Chalmers P-1895, p. 274].

I have noted above that Chalmers was usually willing to devote some space, where relevant, to the action of shore-ice, but nothing prepares one for this apparently wholesale endorsement of J.W. Dawson's half-century-long belief in the 'Drift Theory', at least as it applied to striae. Chalmers maintained this view into his last years, as shown by more detailed assertions in Chalmers (G-1906b, p. 254-255). For an elegant modern treatment of the entire question of glacial events in the St. Lawrence–Ottawa lowlands and the Appalachian slope, see Parent and Occhietti (O-1988, 1999).

Reinforcing the role of shore-ice around Gaspésie, Chalmers (G-1906b) attributed the presence of Laurentian boulders along the coast to this agent, and concluded that "*No [glacier] ice seems to have impinged against it [the north coast of the Gaspé], or passed over it from the north, south, east or west"* (Chalmers G-1906b, p. 253). Present-day partial support for this observation comes from Olejczyk and Gray (O-2007, p. 1603), who report only a slight onlap of the Laurentide Ice Sheet against the north coast of Gaspésie.

Chalmers' studies in New Brunswick and neighbouring districts in Québec appear to have provided the foundation of a later scientific edifice less admirable than that he built in his home province. His argument against

Upham's glacial Lake St. Lawrence was based on his belief that Laurentide ice had not crossed the valley to dam such waters. In spite of his recognition of Laurentide ice affecting southwest Québec, Chalmers was sceptical of glacial Lake Iroquois in the Lake Ontario basin. Rather than a glacial dam, Chalmers preferred uplift of the Precambrian rocks of the Frontenac Arch to isolate late-glacial freshwater from marine water in the Brockville area, and oscillations in the arch to account for lower lake stands during its general lowering (Chalmers G-1906b, p. 252). Harking back to his interpretation of crustal movements in New Brunswick, he saw two other belts of "continuation of orogenic movements", in the Monteregian alignment, and in the geologic-topographic constriction at Québec (Chalmers P-1904, p. 179). Not content to plead the "inadequacy of glacial dams", tectonic influence was seen as sufficient explanation, rather than the "adventitious and epigene agencies as are sometimes employed" (Chalmers P-1904, p. 179).

Chalmers' aversion to glacio-isostasy must be understood in the context of very rapidly changing views concerning this mechanism. Although Spencer (O-1889, 1890) had attributed the northeastward tilt of the Lake Iroquois shoreline in Ontario and New York to glacio-isostasy, it was not until Goldthwait (O-1910) adopted Upham's (O-1890, 1895b) glacio-isostatic proposition to explain deformation of Lake Algonquin and Iroquois beaches that the process became accepted generally for these Canadian cases. As a matter of general concern, it is not clear why the brilliant early work of Jamieson (O-1865, 1882) on tectonics induced by glacial loading and unloading, had not earlier crossed the ocean, especially considering the close cultural ties between Canada and Scotland.

Ontario

As Chalmers had, under Director George Dawson, already made 'surficial' inroads into Ontario for the GSC, when Robert Bell was appointed Acting Director in 1901 he was eager to see Chalmers continue tracing evidence of deglacial marine conditions up the St. Lawrence, and to map in more detail the glacial lake shorelines farther southwest. Thus, in 1901, Chalmers was in southwest Ontario, mainly to supervise drilling operations for urban water supply. Incidental to this work, and in accordance with his and Bell's interests, he mapped abandoned glacial lake shorelines (Chalmers G-1902, 1903). He clearly had located the most prominent, which marked the extent of what later was named glacial 'Lake Whittlesey'. This work could be seen as the beginning of investigations continued in Ontario by F.B.Taylor from 1908, which became best known in combination with similar work in the American mid-west (Leverett and Taylor O-1915). Tracing glacial-age shorelines out of the central area of the peninsula between lakes Huron, Erie and Ontario, Chalmers clearly made erroneous identifications. The most lamentable was his identification, in Simcoe and Dufferin counties, of a shoreline at ~1200 feet (~365 m), which was in fact the prominent 'Clinton-Cataract' bedrock bench below the main Niagara scarp. More correctly argued was Chalmers' case for each of the lower Great Lakes having fallen in level far below present at some stage in their history, as marked by the drowning of deeply incised river valleys at their mouths.

Western Canada

The timing of Chalmers' western Canadian field-work coincided with the accession of Saskatchewan and Alberta to Confederation, and the consequent "showing of the flag" by the GSC, under the fierce western promoter, Interior Minister Frank Oliver. The western move, however, had the most mundane of rationales. Acting Director Robert Bell had in 1905 commissioned a national inventory of clays, and the next year expanded this to include other unconsolidated materials used in domestic and commercial (including agricultural) construction. Western clays were almost unknown.

Chalmers' efforts towards economic geology in the West were largely directed to compilation in the office (Chalmers G-1906a, 1906c, P-1889), although the 'pure' geologist shows through in places. He commented on the "*tremendous erosion*" exhibited in the Rocky Mountains (Chalmers G-1906a, p. 68), which he felt furnished much of the sediment of the plains to the east, although it is unclear whether he meant the Tertiary or the Quaternary successions. He made several observations, including i) the occurrence of surface "*boulder clay*" across the plains, apparently in "*streams*" rather than sheets; ii) two boulder clays on the plains (already reported by Dawson and McConnell (O-1885), separated by "*interglacial*" sediments; iii) potential sources of clay (as sources of clays, lake basins occupied notable space in his writing, later to be incorporated into a retreat history of the Laurentide ice-margin); and iv) significant localized areas of black paludal sediments, allied to what was generally referred to as the "black loam", or predominant surface soil.

CONCLUSION

Chalmers' surficial mapping of New Brunswick covered the entire province, and has since been appreciated as foundational to later work, more than half a century in the future. In the 1950s, surficial mapping was conducted by the GSC in a broad swath of terrain along the Saint John River valley (Lee O-1955, 1957, 1959a, 1959b, 1961, 1962a, 1962b, 1966) in preparation for damming of the river and flooding of the valley for hydro-electric power generation. In the 1970s, as part of federal – provincial economic development initiatives, bedrock and surficial mapping intensified, including a comprehensive surficial mapping program by Rampton and others (O-1984). Chalmers' conclusions on glacial history and its geomorphic effects show through this later work, which, compared to conditions in Chalmers' time, benefitted from road access, automotive travel, subsurface exposure and drilling, and aerial photography.

Chalmers' work in Québec can be seen as seminal also, as far as it concerned i) the absence of evidence of Laurentide glaciation on the south side of the lower St. Lawrence, below Québec City; and ii) farther southwest, indicators of northerly ice-flow from the Appalachians. Unfortunately, he used both of these conclusions to ill effect, arguing i) against glacial damming of Pleistocene lakes in the Lake Ontario basin and St. Lawrence lowland, before ice cleared the con-

striction at Québec City, and ii) resorting to dubious tectonics to dam lakes on the Appalachian slope south of the lowland and on Frontenac Arch in Ontario, to separate glacial Lake Iroquois from glacial Champlain Sea. His work in southwestern Ontario, although brief and, in places, erroneous (even in the contemporary context), seeded the reconstruction of ice sheet and glacial lake history, elaborated by F.B. Taylor for the GSC not many years later.

Apart from his compiled work on gold in Québec, Chalmers' surficial studies in New Brunswick, Québec, and Ontario had little to say about the value of the work for the tracing of metalliferous ore bodies. Perhaps this resulted from his unfamiliarity with the identification of mineralized 'float', the general pessimism, at least concerning New Brunswick, for the possibility of locating significant ore bodies, and perhaps from the paucity of mineralized clasts in surficial deposits.

NOTES

1. On the question of terminological first use, in 1862 William Logan asked Robert Bell to write the section on Superficial Geology for "*Geology of Canada*" (Logan O-1863). Logan, as usual, travelling abroad to various "*Expositions*", had left T. Sterry Hunt the task of editing at least parts of the manuscript for this volume. Thirty-five years later Prof. Herman Fairchild, University of Rochester, New York, wrote to Bell enquiring of the authorship and dates of certain terms used in Canadian surficial geology (Fairchild O-1898). Bell replied, referring to the 1863 volume,

> *"…[T. Sterry] Hunt changed some of the terms I had used – as for example – I had written 'till' throughout for 'boulder clay', 'hard pan', 'drift', etc. … I had also mentioned eskers or osars and other words now much used, but which were all new to him as he was a chemist and not a pleistocene geologist…".* (Library and Archives Canada, Robert Bell Fonds, MG29. B15, v. 40 (Letterbooks), p. 343, RB to HF, 1 March 1898).

But for Hunt's blue pencil, Bell would have advanced introduction of these terms to Canadian reports by 20 years.

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Randall Miller at the New Brunswick Museum in Saint John contributed a very useful review, as well additional materials which improved considerably the biographical section of the paper. The Faribault typescript biography of Chalmers was provided by Natural Resources Canada, Ottawa, from the Geological Survey of Canada History files. The New Brunswick Museum Archives provided Chalmers' three letters to Bailey and the photograph of Chalmers, from the W.F. Ganong Collection. Earlier research for a biography of Robert Bell was assisted by staff at Library and Archives Canada, Ottawa. Allen Seaman, New Brunswick Department of Natural Resources, commented helpfully on the manuscript, and assisted with acquisition of bibliographic items. Reg Wilson acted as an efficient and helpful journal editor.

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See [http://search-recherche.collectionscanada.ca/] (for Robert Bell Fonds, textual material, and Canada, Parliament, O-1884).

See [www.gnb.ca/0078/GeoscienceDatabase/Bibliography/Bibliography-e.as] (additional source for Chalmers GSC reports, particularly in Summary Reports).

GSC Reports by Chalmers (Chalmers "G")

Notes:

i) Not every GSC report authored by Chalmers is referred to in the text.

ii). Date following author refers to year of publication of entire GSC report; this usually post-dates by one year the date shown on the separate field report, when one was issued.

iii). Names and their spelling are reproduced below as in original, e.g., 'Quebec' for Québec, 'Chaleur Bay' for Baie des Chaleurs.

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