

Great Mining Camps of Canada 8. The Bathurst Mining Camp, New Brunswick, Part 2: Mining History and Contributions to Society

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[See table of contents](#)

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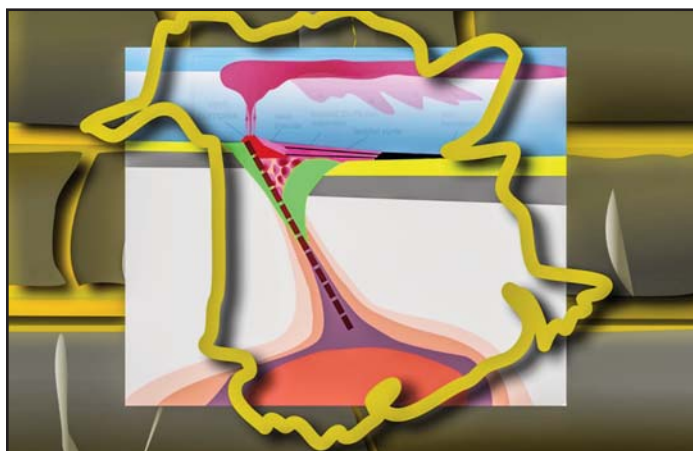
Article abstract

In the Bathurst Mining Camp (BMC), 12 of the 45 known massive sulphide deposits were mined between 1957 and 2013; one was mined for iron prior to 1950, whereas three others had development work but no production. Eleven of the deposits were mined for base metals for a total production of approximately 179 Mt, with an average grade of 3.12% Pb, 7.91% Zn, 0.47% Cu, and 93.9 g/t Ag. The other deposit was solely mined for gold, present in gossan above massive sulphide, producing approximately one million tonnes grading 1.79 g/t Au. Three of the 11 mined base-metal deposits also had a gossan cap, from which gold was extracted. In 2012, the value of production from the Bathurst Mining Camp exceeded \$670 million and accounted for 58 percent of total mineral production in New Brunswick.

Base-metal production started in the BMC in 1957 from deposits at Heath Steele Mines, followed by Wedge in 1962, Brunswick No. 12 in 1964, Brunswick No. 6 in 1965, Caribou in 1970, Murray Brook, Stratmat Boundary and Stratmat N-5 in 1989, Captain North Extension in 1990, and lastly, Half Mile Lake in 2012. The only mine in continuous production for most of this time was Brunswick No. 12. During its 49-year lifetime (1964–2013), it produced 136,643,367 tonnes of ore grading 3.44% Pb, 8.74% Zn, 0.37% Cu, and 102.2 g/t Ag, making it one of the largest underground base-metal mines in the world.

The BMC remains important to New Brunswick and Canada because of its contributions to economic development, environmental measures, infrastructure, mining innovations, and society in general. The economic value of metals recovered from Brunswick No. 12 alone, in today's prices exceeds \$46 billion. Adding to this figure is production from the other mines in the BMC, along with money injected into the local economy from annual exploration expenditures (100s of \$1000s per year) over 60 years. Several environmental measures were initiated in the BMC, including the requirement to be clean shaven and carry a portable respirator (now applied to all mines in Canada); ways to treat acid mine drainage and the thiosalt problem that comes from the milling process; and pioneering studies to develop and install streamside-incubation boxes for Atlantic Salmon eggs in the Nepisiguit River, which boosted survival rates to over 90%. Regarding infrastructure, provincial highways 180 and 430 would not exist if not for the discovery of the BMC; nor would the lead smelter and deep-water port at Belledune. Mining innovations are too numerous to list in this summary, so the reader is referred to the main text. Regarding social effects, the new opportunities, new wealth, and training provided by the mineral industry dramatically changed the living standards and social fabric of northern New Brunswick. What had been a largely poor, rural society, mostly dependent upon the fishing and forestry industries, became a thriving modern community. Also, untold numbers of engineers, geologists, miners, and prospectors 'cut their teeth' in the BMC, and many of them have gone on to make their mark in other parts of Canada and the world.

SERIES



Great Mining Camps of Canada 8. The Bathurst Mining Camp, New Brunswick, Part 2: Mining History and Contributions to Society

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SUMMARY

In the Bathurst Mining Camp (BMC), 12 of the 45 known massive sulphide deposits were mined between 1957 and 2013; one was mined for iron prior to 1950, whereas three others had development work but no production. Eleven of the deposits were mined for base metals for a total production of approximately 179 Mt, with an average grade of 3.12% Pb, 7.91% Zn, 0.47% Cu, and 93.9 g/t Ag. The other deposit was solely mined for gold, present in gossan above massive sulphide, producing approximately one million tonnes grading 1.79 g/t Au. Three of the 11 mined base-metal deposits also

had a gossan cap, from which gold was extracted. In 2012, the value of production from the Bathurst Mining Camp exceeded \$670 million and accounted for 58 percent of total mineral production in New Brunswick.

Base-metal production started in the BMC in 1957 from deposits at Heath Steele Mines, followed by Wedge in 1962, Brunswick No. 12 in 1964, Brunswick No. 6 in 1965, Caribou in 1970, Murray Brook, Stratmat Boundary and Stratmat N-5 in 1989, Captain North Extension in 1990, and lastly, Half Mile Lake in 2012. The only mine in continuous production for most of this time was Brunswick No. 12. During its 49-year lifetime (1964–2013), it produced 136,643,367 tonnes of ore grading 3.44% Pb, 8.74% Zn, 0.37% Cu, and 102.2 g/t Ag, making it one of the largest underground base-metal mines in the world.

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RÉSUMÉ

Dans le camp minier de Bathurst (CMB), 12 des 45 gisements de sulfures massifs connus ont été exploités entre 1957 et 2013; un de ces gisements a été exploité pour le fer avant 1950, tandis que trois autres étaient en développement mais pas en production. Onze gisements ont été exploités pour des métaux communs pour une production totale d'environ 179 Mt, avec une teneur moyenne de 3,12% Pb, 7,91% Zn, 0,47% Cu et 93,9 g/t Ag. L'autre gisement était uniquement exploité pour l'or, présent dans le gossan au-dessus du sulfure massif, produisant environ un million de tonnes titrant 1,79 g/t Au. Trois des 11 gisements de métaux communs exploités avaient également un gossan, d'où l'or était extrait. En 2012, la valeur de la production du camp minier de Bathurst dépassait 670 millions de dollars et représentait 58% de la production minérale totale au Nouveau-Brunswick.

La production de métaux communs a commencé dans le CMB en 1957 à partir des gisements de Heath Steele Mines, suivie de Wedge en 1962, Brunswick no 12 en 1964, Brunswick no 6 en 1965, Caribou en 1970, Murray Brook, Stratmat Boundary et Stratmat N- 5 en 1989, Captain North Extension en 1990, et enfin Half Mile Lake en 2012. La seule mine en production continue pendant la majeure partie de cette période était Brunswick no 12. Au cours de sa durée de vie de 49 ans (1964–2013), elle a produit 136 643 367 tonnes de minerai titrant 3,44% Pb, 8,74% Zn, 0,37% Cu et 102,2 g/t Ag, ce qui en fait l'une des plus grandes mines souterraines de métaux communs au monde.

Le CMB demeure important pour le Nouveau-Brunswick et le Canada en raison de sa contribution au développement économique, aux mesures environnementales, à l'infrastructure, aux innovations minières et à la société en général. La valeur économique des métaux récupérés du seul gisement Brunswick n° 12, aux prix d'aujourd'hui, dépasse 46 milliards de dollars. S'ajoute à ce chiffre la production des autres mines du CMB, ainsi que l'argent injecté dans l'économie locale par les dépenses d'exploration annuelles (des centaines à des milliers de \$ par an) sur 60 ans. Plusieurs mesures environnementales ont été lancées dans le CMB, y compris l'exigence d'être rasé de près et de porter un respirateur portatif (maintenant appliqué à toutes les mines au Canada); les moyens de traitement des effluents miniers acides et le problème des thiosels qui proviennent du processus de broyage; et les études pionnières pour développer et installer des boîtes d'incubation en bord de rivière pour les œufs de saumon de l'Atlantique dans la rivière Nepisiguit, ce qui a fait passer les taux de survie à plus de 90%. En ce qui concerne les infrastructures, les routes provinciales 180 et 430 n'existeraient pas sans la découverte du CMB; la fonderie de plomb et le port en eau profonde de Belledune non plus. Les innovations minières sont trop nombreuses pour être énumérées dans ce résumé, le lecteur est donc renvoyé au texte principal. En ce qui concerne les effets sociaux, les nouvelles possibilités, la nouvelle richesse et la formation offertes par l'industrie minière ont radicalement changé le niveau de vie et le tissu social du nord du Nouveau-Brunswick. Ce qui avait été une société rurale en grande partie pauvre, principalement tributaire des industries de la pêche et

de la sylviculture, est devenu une communauté moderne florissante. De plus, un nombre incalculable d'ingénieurs, de géologues, de mineurs et de prospecteurs «se sont fait les dents» au CMB, et bon nombre d'entre eux ont continué à faire leurs marques dans d'autres régions du Canada et du monde.

Traduit par la Traductrice

INTRODUCTION

The Bathurst Mining Camp (BMC) is known worldwide for its volcanogenic massive sulphide (VMS) deposits, especially the Brunswick No. 12 Mine, which closed on April 30, 2013 after 49 years in operation. During its lifetime, this mine produced 136,643,367 tonnes of ore grading 3.44% Pb, 8.74% Zn, 0.37% Cu, and 102.2 g/t Ag (Table 1), making it one of the world's largest underground VMS mines. This paper describes the history of mine developments in the BMC up to closure of Brunswick No. 12. A companion paper (McCutcheon and Walker 2019) entitled: *The Bathurst Mining Camp, Part 1: Geology and Exploration History* describes the geological setting of the BMC and the history of exploration.

Camp Overview

The location and definition of the BMC are described in McCutcheon and Walker (2019). Suffice it to say that the BMC occupies an area of approximately 3800 km² in the central part of northern New Brunswick (Fig. 1). Twelve of the 45 known massive sulphide deposits were mined between 1957 and 2013; whereas Austin Brook was mined prior to 1950 (Table 1). Although there has been development work on three others (Chester, Key Anacon and Hachey-Shaft), there was no production. Most of these deposits were discovered in the 1950s and 1960s by a combination of airborne geophysical, geological and stream geochemical methods (McCutcheon et al. 2003).

The BMC is one of Canada's most important base metal mining districts, accounting for approximately 2.8% of total metal production in 2012 (<https://sead.nrcan-rncan.gc.ca/MIS/MISTable.aspx?FileT=01&Year=2012>), the last full year of production at Brunswick No. 12. This includes approximately 30% of Canada's production of Zn, 81% of its Pb, 21% of its Ag, and 2% of its Cu. Eleven massive sulphide deposits have been mined for a total production to 2013 of approximately 179 Mt, with an average grade of 3.12% Pb, 7.91% Zn, 0.47% Cu, and 93.9 g/t Ag (Table 1). In addition, 0.337 Mt of copper ore was mined from the Caribou supergene zone and 1.254 Mt of gold-bearing gossans, collectively from Caribou, Murray Brook, and Heath Steele (Boyle 2003), of which one million tonnes came from Murray Brook (Table 1). In 2012, the value of production from the Bathurst Mining Camp exceeded \$650 million and accounted for approximately 57% of total mineral production in New Brunswick (<https://sead.nrcan-rncan.gc.ca/MIS/MISTable.aspx?FileT=01&Year=2012>).

Information Sources

Much has been written about the geology and mineral deposits of the BMC since its discovery in 1952 but the best place to

Table 1. List of Bathurst Mining Camp deposits with Unique Record Numbers (URN) in the New Brunswick ‘Mineral Occurrence Database’, which have been mined since 1957, showing tonnages and average grades.

URN	Deposit	Tonnage	%Pb	%Zn	%Cu	g/t Ag	g/t Au	Date	Source
054	Brunswick No. 12	136,643,367	3.44	8.74	0.37	102.2		1964–2013	Production to mine closure in 2013 (P. Bernard written communication)
144	Brunswick No. 6	12,762,962	2.15	5.45	0.4	66.5		1966–1983	Milled at Brunswick No. 12 (P. Bernard written communication)
444	Caribou	4,426,874	2.8	6.1				to 2017	Includes production from several operators: Anaconda, East-West Caribou, Breakwater, Blue Note and Trrevali to end of 2017 (Jensen et al. 2018)
170	Captain North Extension (CNE)	39,000	4.42	9.97		134.7		1990–1992	Ore milled at Heath Steele (Luff 1995)
170	Captain North Extension (CNE)	62,720	3.22	8.13	0.44	111		2013	Ore milled at Brunswick No. 12; P. Bernard written communication)
409	Halfmile	125,569	1.61	4.83	0.45	44.0		2012	Ore milled at Brunswick No 12; P. Bernard written communication)
395	Heath Steele ACD Zone	553,100	4.18	11.26	0.29	111		to 1998	Heath Steele Mines (A. Hamilton written communication)
396	Heath Steele B Zone	20,723,000	1.75	4.79	0.98	65.5		to 1999	Heath Steele Mines (A. Hamilton written communication)
255 & 257	Heath Steele N-5 and Stratmat Boundary	1,137,000	2.98	8.11	0.35	44		1991	Luff (1995)
414	Murray Brook	1,014,000				61.4	1.79	1989–1993	Gossan production (Luff 1995)
138	Restigouche	795,801	5.00	6.5				to 2017	Jensen et al. (2018)
052	Wedge	1,503,500	0.65	1.61	2.88	20.6		1962–1968	Ore milled at Heath Steele (Luff 1995)
Total tonnage and average grade:		178,772,893	3.12	7.91	0.47	93.91			

URN = Unique Record Number; Total tonnage excludes Murray Brook; Caribou and Restigouche are excluded for average Cu and Ag grades

start is with *Economic Geology Monograph 11* (Goodfellow et al. 2003), because this volume provides extensive lists of references to previous work on various topics. There are also two special issues of *Exploration and Mining Geology* that are devoted to mineral deposits of the BMC (Davies et al. 1992; Lentz 2006). The website of the Geological Surveys Branch of New Brunswick Department of Natural Resources and Energy Development (NBNRED) (<http://www2.gnb.ca/content/gnb/en/departments/erd/energy/content/minerals.html>) has online databases that contain a wealth of information, including a ‘Mineral Occurrence Database’ that has information about mine development and production in the Province. Finally, Technical Reports filed on the ‘System for Electronic Document Analysis and Retrieval’ (SEDAR) website (https://www.sedar.com/homepage_en.htm) contain post-2008 mine development data for some deposits.

Historical information about mining in the BMC comes from published books and articles, most notably: *The Birth of the Bathurst Mining Camp* (Belland 1992), which describes the development history of the Austin Brook Iron Mine and Brunswick No. 6 base-metal deposit; Heath Steele (Gallagher

1999), which describes the history of that mine and the people who worked there; and *Brunswick Mine* (Jarratt 2012), which describes the history of the Brunswick No. 6 and No. 12 mines. A journal article by Kenny (1997) describes the development of New Brunswick’s base metal industry. In addition, articles from *The Northern Miner*, and New Brunswick newspapers, such as *The Northern Light*, *The Daily Gleaner*, and *Telegraph Journal* are too numerous to list. Finally, unpublished correspondence and photographs in the files of the New Brunswick NRED provide useful historical information.

HISTORY OF MINE DEVELOPMENT AND PRODUCTION

The history of mine development in the BMC begins with the Austin Brook Mine, originally called Drummond Mines, which produced approximately 145,000 tonnes (164,282 tons) of iron ore between 1911 and 1913, when Canada Iron Corporation closed the mine (Belland 1992). The mine was reopened in 1943 by the Dominion Steel and Coal Company (DOSCO) of Nova Scotia to obtain a secure supply of ore for its steel mill in Sydney. Prior to this, DOSCO’s ore had been coming from the Wabana Iron Mines in Newfoundland (Pollock 2019), but



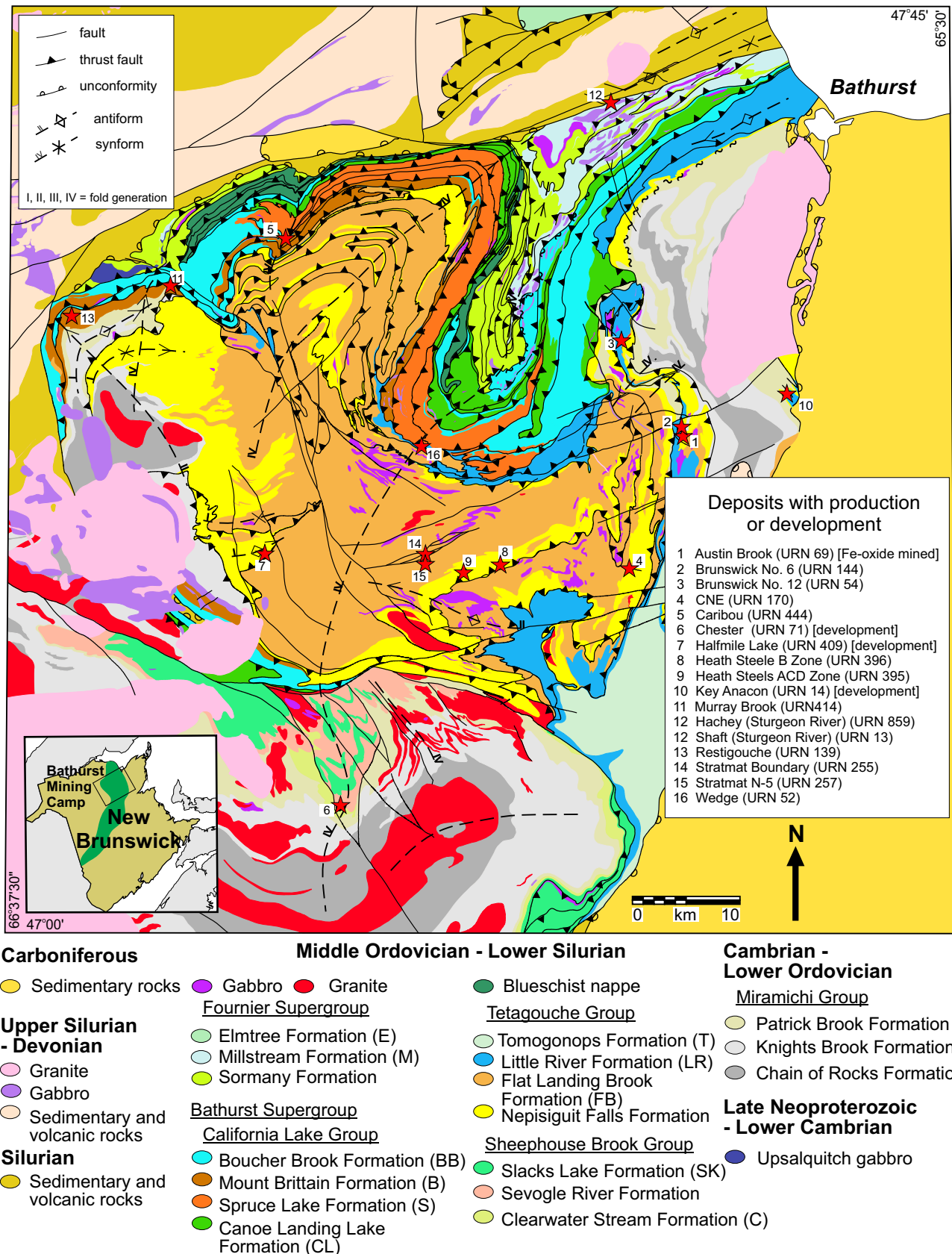


Figure 1. Simplified geological map of the Bathurst Mining Camp (BMC) showing the distribution of deposits and their Unique Record Numbers (URN) in the New Brunswick Mineral Occurrence Database, which have had development and/or been mined.

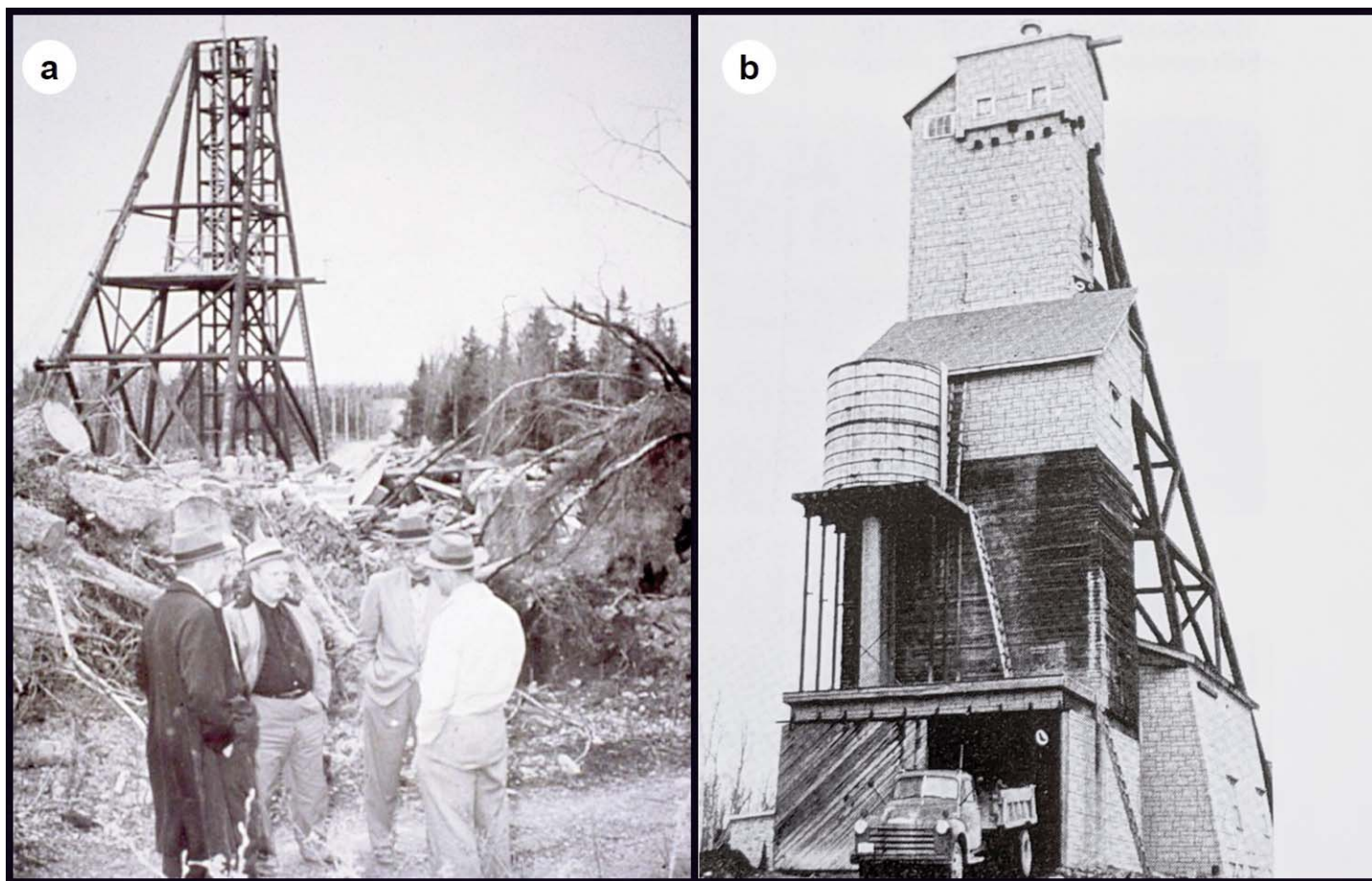


Figure 2. 1950s developments: a) Key Anacon (New Larder U) 1954, looking east with M.J. Boylen being the shortest guy, others unknown (New Brunswick Natural Resources and Energy Development archives); b) Brunswick No. 12 (#1 shaft), circa 1957, looking northwest (Brunswick Mining and Smelting archives).

in late 1942, German U-boats had attacked, and sunk ore carriers destined for Sydney, so the company acquired the mining rights to Austin Brook. During 1943, DOSCO mined approximately 118,000 tonnes (129,778 tons) of ore from Austin Brook before closing it at the end of the year.

The connection between iron ore at Austin Brook and the base-metal deposits of the BMC was not discovered until 1952 when Bennett (Ben) Baldwin, a graduate student at the University of New Brunswick, was examining samples of Austin Brook ore that had been collected by his supervisor, Dr. Graham MacKenzie, in 1943. Baldwin found lead and zinc in samples near the footwall of the iron ore deposit, which ultimately led to the discovery of the Brunswick No. 6 deposit in October of 1952, and the birth of the BMC (Belland 1992).

Subsequent mine development activity is described chronologically below by decade from the 1950s and ending with developments that postdate 2000. Deposits that have been mined or had some production work are shown in Figure 1 and production and resource numbers are shown in Table 1. Photographs of mine sites at various stages of development are also included.

1950s Development

The chronology of mine development in the 1950s is recorded

in the pages of *The Northern Miner*, starting with the front page of the September 10, 1953 edition, entitled: “Multi-Million Dollar Deal for New Brunswick Mines”. In this article, it was announced that the jointly owned property of Anacon Lead Mines and Leadridge Mining (Canadian subsidiary of St. Joseph Lead Co.) would be merged with the property of Brunswick Mining and Smelting Corporation. St. Joe would loan Brunswick \$7.5 million (with provision for another \$17.5 million) to develop both properties (now known as No. 12 and No. 6, respectively) and to do metallurgical research on the ores. St. Joe was to manage the project, but control of Brunswick was to remain with the Anacon–Boylen group.

In 1954, more developments were reported in *The Northern Miner* newspaper. The April 8th edition had the following text: “Preparations for shaft sinking are going right ahead at New Larder U Island Mines [now Key Anacon], near Bathurst N.B.” The bridge over Nepisiguit River “was completed this week and heavy equipment, which had been piled up on the west side of the river, can now be brought across and assembled at the shaft site” (Fig. 2a). The May 13th edition reported: “Plans of Brunswick Mining and Smelting Corp. for 1954 call for continuation of the present research program on ore treatment and it is planned to build a pilot mill for testing ore from both deposits [No. 6 and No. 12], on a larger scale”. The June 10th edition reported: “Erection of the headframe [at No. 12] is nearing the final stages of

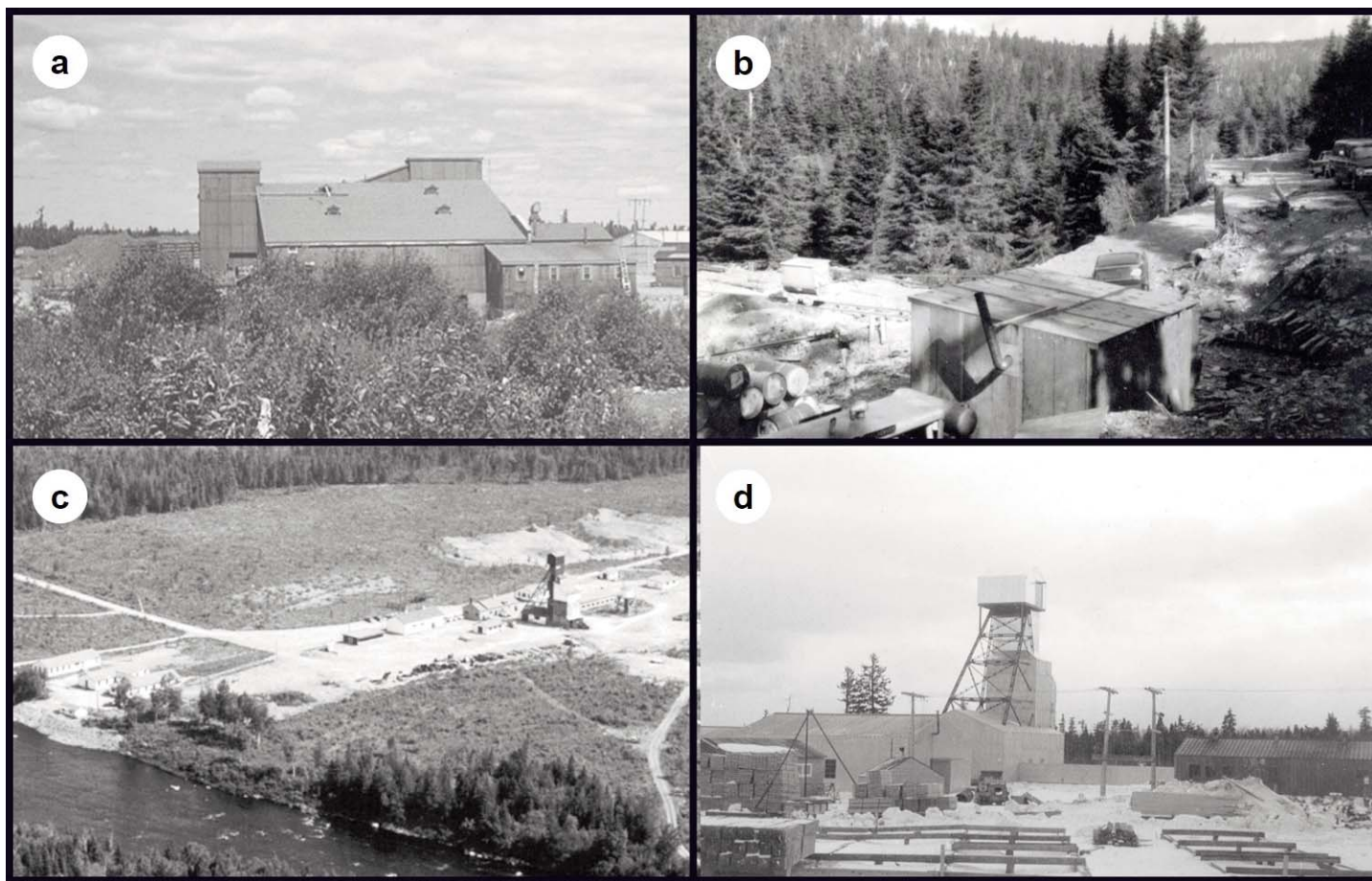


Figure 3. 1950s developments: a) Brunswick No. 6 pilot plant circa 1957, looking east (New Brunswick Natural Resources and Energy Development archives); b) view looking northeast over the Caribou adit entrance or portal (behind shed at bottom right; note ore car to the left of shed) circa 1959 (courtesy of Richard Cavellero); c) aerial view of Key Anacon (New Larder U) circa 1956, looking northeast with Nepisiguit River in the foreground (NBNRED archives); d) Brunswick No. 12 (#2 shaft) circa 1957, looking northeast (Brunswick Mining and Smelting archives).

completion...". Then on November 18th: "The present development shaft [Fig. 2b]...will open up the orebody on two levels (200 and 350 ft.) and provide muck for feeding the 150-ton test mill ...[that] is expected to be ready for operation by the end of January.....The test mill is situated close to the Brunswick [No. 6] orebody, about six miles from the Anacon [No. 12] shaft." Not much mine development work was reported in 1955. One article entitled: "Magnificent Orebody Unfolds in Brunswick Crosscutting" appeared on the front page of the May 26th edition of *The Northern Miner*. It states: "The 150-ton pilot plant, situated six miles away on the No. 6 project [the original Brunswick or Austin Brook orebody], is in regular operation [Fig. 3a]. Currently it is working on ore from development headings at No. 12 but later in the season will start testing ore from the open pit at No. 6 mine." Further along it is reported that: "Lateral work is well along at the 350-ft. level but the crosscut from the (#1) shaft is only just now getting started at the 200-ft." The September 22nd edition reported that "Construction of a permanent collar for the sinking of a second shaft (#2) to a depth of 2000 feet is rapidly nearing completion".

Anaconda Minerals Company carried out preliminary surface mapping and exploration work on their Caribou property in 1955 and began drilling the deposit in 1956. In 1959, Anaconda excavated a 380 m long 2.4 m by 2.7 m adit (Fig. 3b) to obtain a bulk sample of the mineralization (Zhang et al. 2014).

The Northern Miner focused on other mine developments in 1956. A front-page article in the April 26th edition reports: "In New Brunswick, lateral development is getting under way at Anacon's New Larder 'U' property [Fig. 3c]. The long job of sinking the shaft to 1,500 ft. depth has finally been completed and crosscuts to the ore zone ore [sic] now advancing on the 550, 850 and 1,300-ft. levels." Then on June 7th, the following headline appeared: "Amco's Heath Steele Operation Hive of Construction Activity". It states:

"A large area has been cleared at the site of the main plant, foundations for the mill and other buildings are pretty well completed and erection of the structures should be starting shortly... [Fig. 4a, b]. Additionally, four orebodies are being prepared for production. Two are being developed underground from shafts and two are being exposed in surface open pits." Furthermore: "Underground development is farthest advanced on the D orebody, the most westerly of the known deposits. Here, the No. 1 shaft has been sunk to 480 ft. and some 1,500 ft. of lateral work completed on the 200 and 350-ft. levels.... To the east of the mill is the No. 2 shaft [Fig. 4c] and to the east of it is B open pit [Fig. 4d]. So far, only temporary plant and headframe have been erected at No. 2 shaft. Sinking has advanced to 250 ft. on the way to an objective of 480 ft."

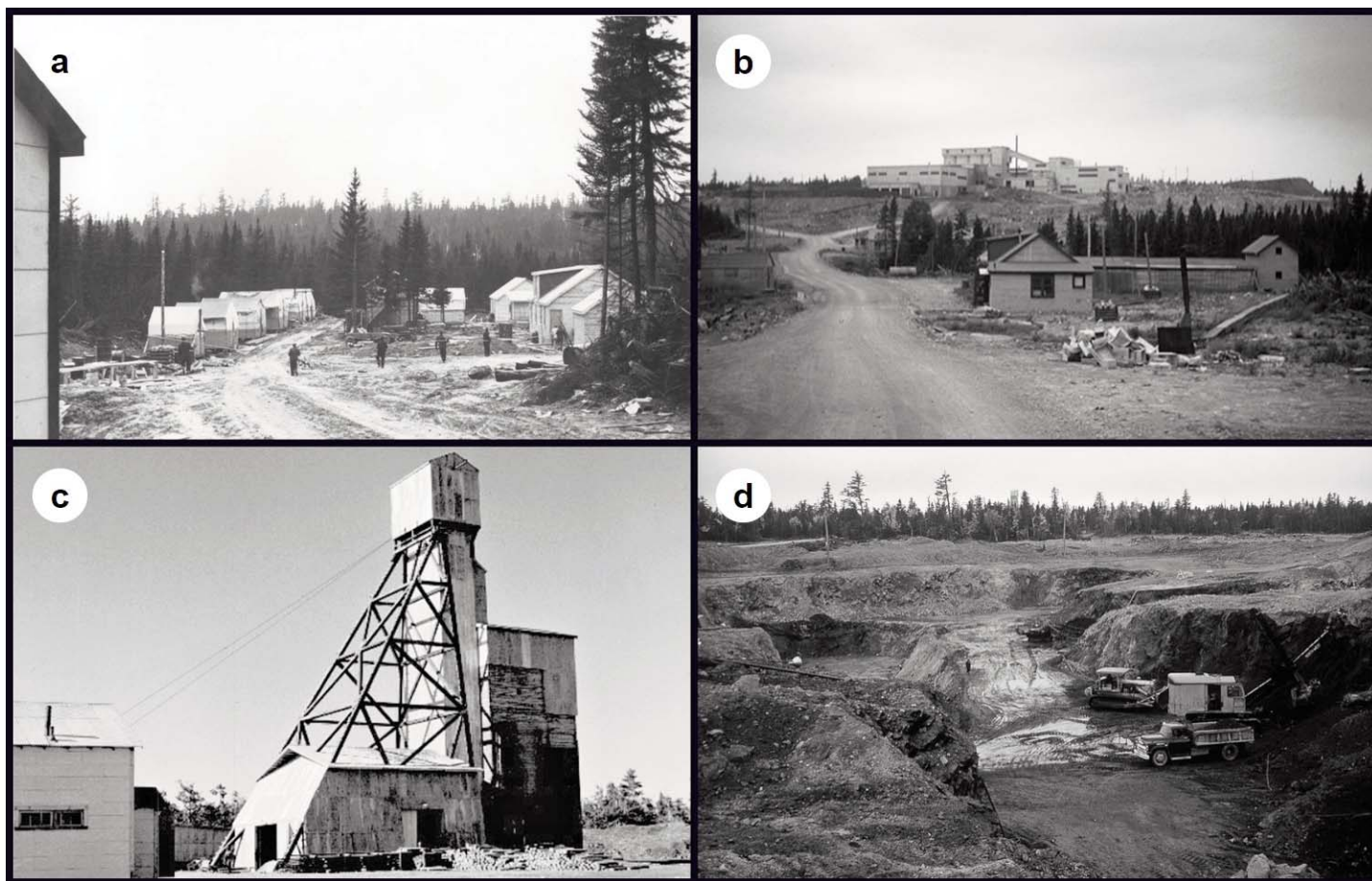


Figure 4. 1950s developments: a) site of Heath Steele gatehouse with construction camps in the background in 1955, looking north (Our Miramichi Heritage Family archives); b) entrance to Heath Steele (foreground) with the mill complex on the hill in the background in late 1956, looking north (OMHF archives); c) headframe of No. 2 shaft at the B-Zone circa 1957, looking northwest (OMHF archives); d) Heath Steele B-Zone open-pit circa 1957, looking west with the headframe of No. 2 shaft (arrow) barely visible in the tree line (New Brunswick Natural Resources and Energy Development archives).

Then on June 14th, the following text appeared: “At its No. 12 project, formerly termed the Anacon–Leadridge orebody, Brunswick Mining and Smelting Corp. is going ahead with preparations for the new 5-compartment No. 2 shaft which will be sunk to a depth of 2000 ft.” (Fig. 3d). Finally, on June 21st, this headline appeared: “Production Planned by Sturgeon River”. It states: “This summer should see construction started on a concentrator of at least 400 tons capacity and the development underground of the indicated orebodies [Shaft and Hachey deposits] on the New Brunswick property of Sturgeon River Mines.... A mining plant has been installed, electric power provided, and sinking is now underway to initial depth of 600 ft.”

In 1957, *The Northern Miner* did not report on any new mine developments but provided updates on operations that existed in 1956. In the February 28th edition, there was a headline: “Rush Construction on Railway Line for Heath Steele”. This article describes a 37 km spur line under construction between the CNR main line and Heath Steele (Fig. 5a). The June 6th edition reports that:

“East drift headings on both the 200 and 500-ft. levels at Sturgeon River Mines [Fig. 5b] have just come into ore.... These east faces are into the west end of what is known as the Original shaft

showing [now Shaft deposit]. The west drifts, headed for the Hachey showing [now Hachey deposit], have still some distance to go before they can expect to tap the start of the ore”. The May 30th edition had the following news: “...Brunswick Mining and Smelting Corp. is proceeding with plans to bring the property into production.... The initial production unit will consist of a 2,000-ton flotation mill, plus a lead smelter and associated sulphuric acid plant.... The target date for production has been set for the spring of 1960.” Further along, the article states: “The production plan contemplates mining the high grade north end of the No. 12 orebody [Fig. 5c] for the first three and one half years and then swinging over to the No. 6 orebody for the next three and one half years A total of eight stopes has been laid out which will provide the 2,500,000 tons needed for the first 3^{1/2} years production.”

The front page of the June 20th edition has the following headline: “Amco’s Heath Steele Embarked on Profitable Metal Output”. The article states: “The mill [Fig. 5d], with a rated capacity of 1,500 tons daily, was put into operation last February and tuning up has been in process since.... Two separate circuits are being operated in the mill. One is for treating the chalcocite [copper] ore and the other is for han-

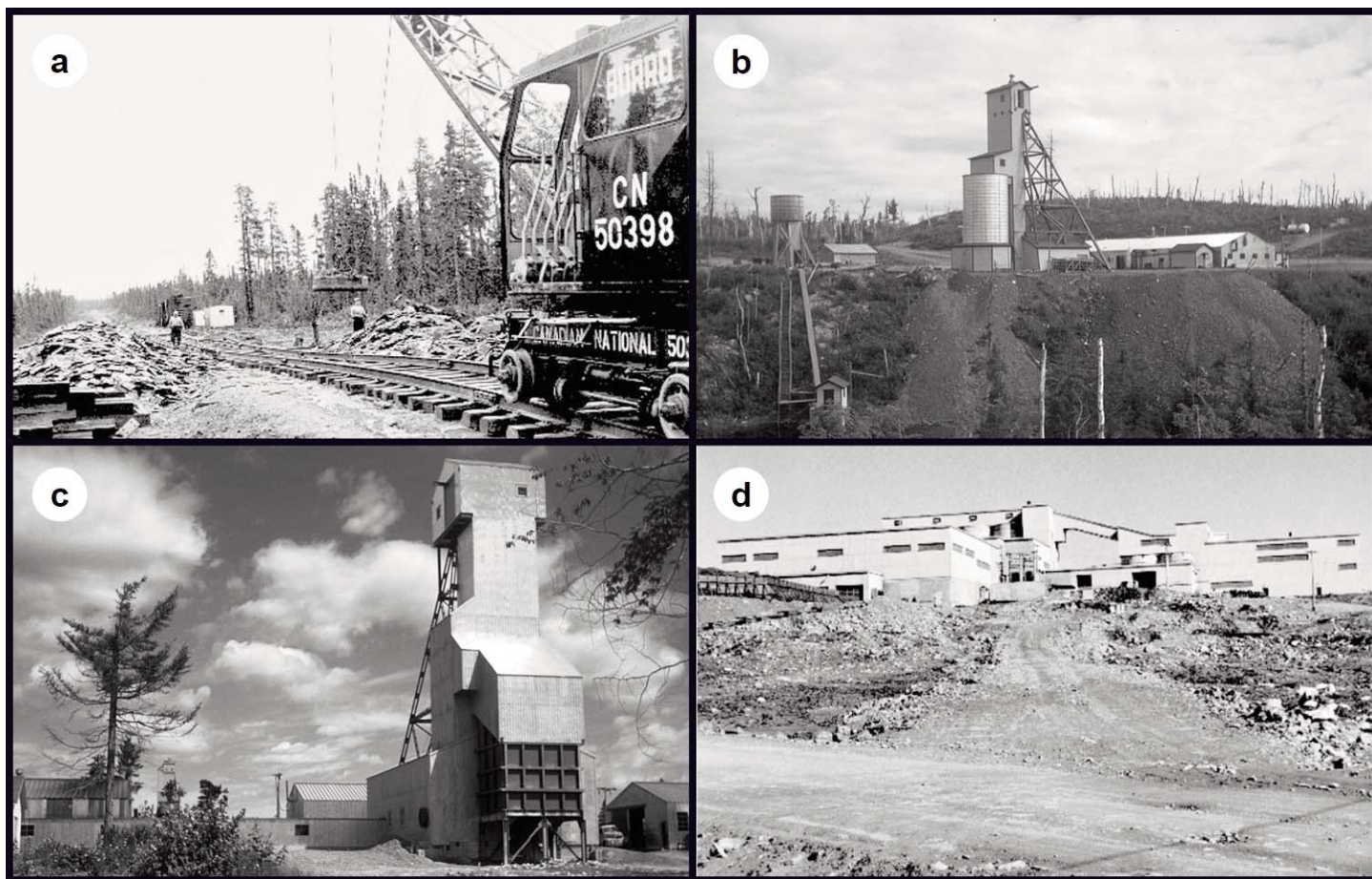


Figure 5. 1950s developments: a) construction of the CN spur line to Heath Steele in 1957, looking west (CN Images of Canada Collection); b) Sturgeon River Mines head-frame at the Hachey-Shaft deposit circa 1957, looking north (New Brunswick Natural Resources and Energy Development archives); c) Brunswick No. 12 (#2 shaft in foreground with #1 shaft in background above bushes to the left) circa 1957, looking north (NBNRED archives); d) view of the Heath Steele mill in 1957, looking north (Our Miramichi Heritage Family archives).

dling the lead–zinc.... The three concentrates presently being made are: chalcocite, lead–copper and zinc. They are trucked out to Newcastle and shipped by rail to the smelter, but concentrates are now being accumulated for shipment by boat.”

Gallagher (1999) noted: “In June, the first shipload with 3,000 tons of Heath Steele copper concentrates left for a smelter in New Jersey.”

Finally, the December 12, 1957 edition of *The Northern Miner* had the following headline: “Continued Selling in Base Metals Leads Toronto Market Downward”, heralded a downturn in the metals markets and changed development plans. In April 1958, Heath Steele Mines, the first producer in the BMC, was shut down because of low metal prices (Gallagher 1999) and because the United States imposed a quota on lead–zinc imports in 1958 (Kenny 1997). Conversely, in early 1959, the Consolidated Mining and Smelting Company of Canada Limited (Cominco) decided to proceed with development of its Wedge deposit, by extending the power line from Heath Steele to the site, improving the road access, constructing a permanent camp, and sinking an exploration shaft (Douglas 1965). Other operations were put on care and maintenance mode in the late 1950s, including the project of Sturgeon River Mines, which was ultimately abandoned.

1960s Development

Mine development in the 1960s is largely described in books by Gallagher (1999) and Jarratt (2012) as well as a paper by Kenny (1997), but a paper by Douglas (1965) provides details about development of the Wedge Mine, and a Technical Report (Barrett 2014) describes developments at the Caribou Mine. The mining methods used at Brunswick No. 12 up to 1970 are described by Grebenc and Welwood (1971).

Shaft sinking began at Wedge in July, 1959, and “was completed to a depth of 1,136 feet in 1960.....Arrangements were completed with the Heath Steele Company to use one half of their mill for treating the Wedge ore.....It was agreed that the portion of the road between Heath Steele and Nepisiquit [sic] river, as well as the bridge across the river, could be built under the Federal “Road to Resources” program, in which the Federal and Provincial Governments share the costs equally” (Douglas 1965). The 4.8 km access road from the north side of the bridge to the Wedge property would be cost shared between Cominco and Government. Finally, the decision to proceed with production at 680 tonnes (750 tons) per day was made in early 1961 (Douglas 1965). Production began at Wedge, the second producer in the BMC, in January of 1962 (Fig. 6a, b) and ended in May of 1968. The following text is extracted from Gallagher (1999):

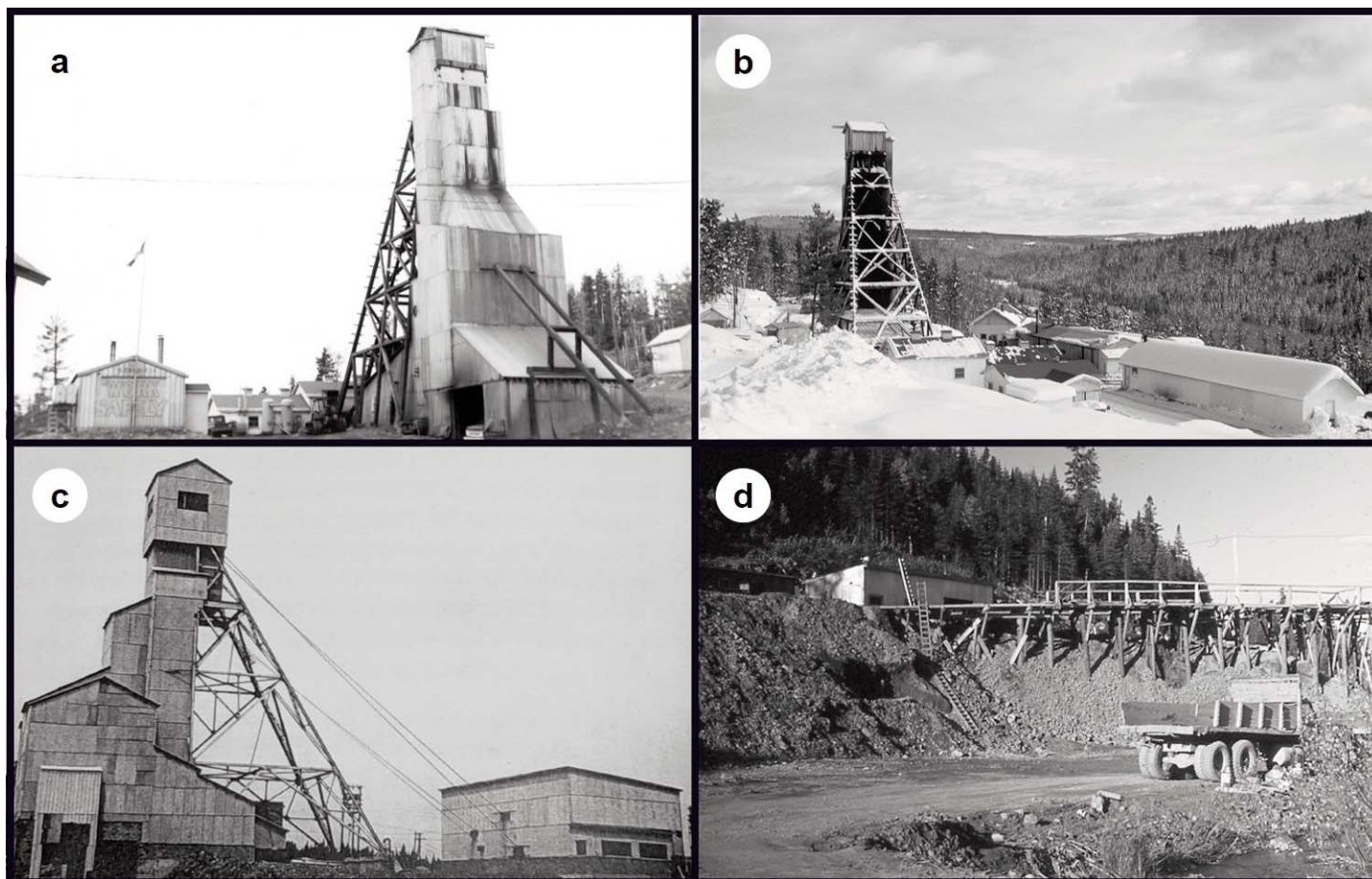


Figure 6. 1960s developments: a) Wedge circa 1962, looking northwest (New Brunswick Natural Resources and Energy Development archives); b) Wedge mine site looking east with the Nepisiguit River valley to the right, winter 1966 (NBNRED archives); c) Heath Steele #3 headframe looking north?, circa 1966 (Our Miramichi Heritage Family archives); d) entrance (portal) to the Caribou adit looking southwest, fall 1966 (courtesy of Richard Cavellero).

“On June 5, 1962 the first Heath Steele ore, since February 1958, went through the mill – 16,445 tons of it that first month, including 9,659 tons directly from B-zone, and another 6,786 tons from the development stockpile.... For the next few years, the mill ran at 1,500 tons a day, with about half the ore coming from Wedge, and the other half from B-Zone.”

In 1965, a comprehensive exploration program in the ‘ACD’ zone area resulted in the discovery of two new ore zones, as well as extensions to the known zones. In 1966, the No. 3 shaft was sunk to a depth of 518 m to further develop the ‘B’ Zone (Fig. 6c). In May 1968, ore shipments from the Wedge Mine ceased, and production from Heath Steele increased to 1600 tons per day to utilize the concentrator circuit previously used to process Wedge Mine ore. In July 1969, the concentrator was temporarily closed to permit expansion to 3000 tons per day.

At Caribou, in 1965, Anaconda extended the adit (Fig. 6d) that it had begun in 1959 to cover the entire deposit, as it was known at the time, and in the process of excavating a ventilation raise discovered a near-surface, supergene-copper gossan that was mined in 1971 and stockpiled.

Meanwhile, Brunswick Mining and Smelting Corporation’s plan to bring its No. 12 and No. 6 properties into production

in 1960 fell through when St. Joseph Lead withdrew its financing in 1958 (Jarratt 2012). In 1960, Jim Boylen turned to the provincial government of Louis J. Robichaud (Fig. 7a) to guarantee \$20 million in bonds for East Coast Smelting, a company that he promised to establish to smelt lead–zinc concentrates on the north shore of New Brunswick. In March of 1961, Robichaud’s government agreed to the guarantee, with the caveat that Boylen had to find investors (within 45 days) to buy out St. Joseph’s 40% interest in Brunswick (Kenny 1997). Subsequently, Boylen recruited Patiño Mines, a Bolivian mining multinational, and K.C. Irving, an industrialist, (Fig. 7b) to join his own Maritimes Mining Corporation in buying St. Joseph’s share of Brunswick. Under the agreement, they contributed \$3.16, \$2.52, and \$4.82 million, respectively (Kenny 1997).

With St. Joseph out of the picture, Brunswick lawyers set about negotiating a list of legislative concessions for Brunswick and East Coast from Robichaud’s government (Kenny 1997). The concessions included: 1) the right to enter tax agreements with municipalities for up to 30 years; 2) the right to divert rivers and streams for its operations; 3) protection from ‘nuisance’ suits arising from pollution caused by their operations, although the attorney general could authorize a suit against the company; and 4) the exclusive right to smelt



Figure 7. Important participants in the development of Brunswick Mining and Smelting (BMS) during the 1960s: a) Premier Louis J. Robichaud, circa 1963 (BMS archives); b) Kenneth C. Irving, circa 1965 (BMS archives); c) Edward G. Byrne, circa 1970 (courtesy of Terrance Lenihan); d) Alfred Powis, circa 1974 (Toronto Public Library).

New Brunswick base metals for 10 years, but East Coast had to offer its smelting services at a competitive rate. In 1962, these concessions were supplemented by orders in council that gave three additional concessions: 5) ownership of the 'mines and minerals held under lease' by Brunswick was transferred from the Crown to the company; 6) the province pledged that it would not increase mining taxes; and 7) the export tax on unprocessed minerals leaving the province would not be imposed. The latter concession allowed Brunswick to enter an agreement with Sogemines, a Belgian company in Brussels, whereby an exclusive five-year right to buy Brunswick's concentrates was given to Sogemines, in return for an investment in Brunswick of \$11.52 million; at the end of the five-year period, Sogemines was permitted to purchase surplus concentrates (those not needed by East Coast) for an additional seven years (Kenny 1997).

The 1961 buyout of St. Joseph had left Boylen with a 40% controlling interest in Brunswick, with K.C. Irving and Patiño Mines having 27% and 14%, respectively (Kenny 1997). However, Irving's influence in the company was much greater than his minority shareholder status suggested, and he was able to exercise a great deal of control over its development. In fact, in 1962 one of his newly formed companies, Engineering Consultants Ltd., was given the contract to manage construction of the mill at Brunswick No. 12 and the smelter at Belledune. Construction began at Brunswick No. 12 on May 15, 1962 (Fig. 8a, b, c) and continued through to June 30, 1964. Mine production began in April of that year (Luff 1995), although the official opening occurred on June 12, 1965 (Jarratt 2012).

In 1964, Anacon Lead Mines Limited was reorganized as Key Anacon Mines Limited. Underground work resumed at New Larder 'U' (Fig. 9a) and continued until 1966 (New Brunswick Mineral Occurrence Database). In 1955, all assets of New Larder 'U' Mines had been acquired by Anacon Lead Mines Ltd.; a pilot plant (mill) had been installed, and a 457 m (1499 ft) deep shaft was sunk, and nine levels excavated. Work was suspended on the property in 1957. By 1964, Irving had acquired 38% of Brunswick and controlling interest in the company, by quietly purchasing (through his shipping company, Kent Line) shares of Boylen's Key Anacon Mines, which held 11% of Brunswick's stock (Kenny 1997).

As Irving's share in Brunswick got larger, so did the size of the smelter development that began at Belledune in 1964 (Kenny 1997). In October of that year, Robichaud announced that an additional \$117 million was to be invested to expand the project. Two new mines, Brunswick No. 6 and Key Anacon's New Larder 'U', were to be opened, with a new concentrator to be constructed at each one. In addition, fertilizer and acid plants were to be built at the smelter as well as an electric refinery to process iron pyrite into steel. Lastly, a \$12 million ore carrier was to be constructed by Irving's Saint John Shipbuilding and Dry Dock Co. and chartered by Brunswick to ship base metals. Originally, the smelter was to be built at Daly Point on the east side of Bathurst Harbour (*The Northern Miner*, May 30, 1957), but ultimately, Belledune Point was selected as the site for construction (Kenny 1997). Furthermore, the Robichaud government, at Brunswick's insistence, helped convince Ottawa to contribute \$9 million to the construction of a new year-round, deep-water harbour at Belledune, to be used almost exclusively by Brunswick.

By the summer of 1965, pre-production stripping was under way at the No. 6 site (Jarratt 2012). Production began in the fall of 1966 at 2,041 tonnes per day (t/d) but periodically increased to as much as 4,100 t/d to supplement under-production at the Brunswick No. 12 mine.

By 1966, Brunswick was having serious financial problems, created in large part by the cost of smelter construction by East Coast (Fig. 9b), so in September of that year Boylen asked the Robichaud government to guarantee another \$20 million in long-term East Coast bonds and another \$10 million in short-term notes. At the time, East Coast owed \$2.7 million to suppliers and more than \$7 million to mostly Irving-owned com-

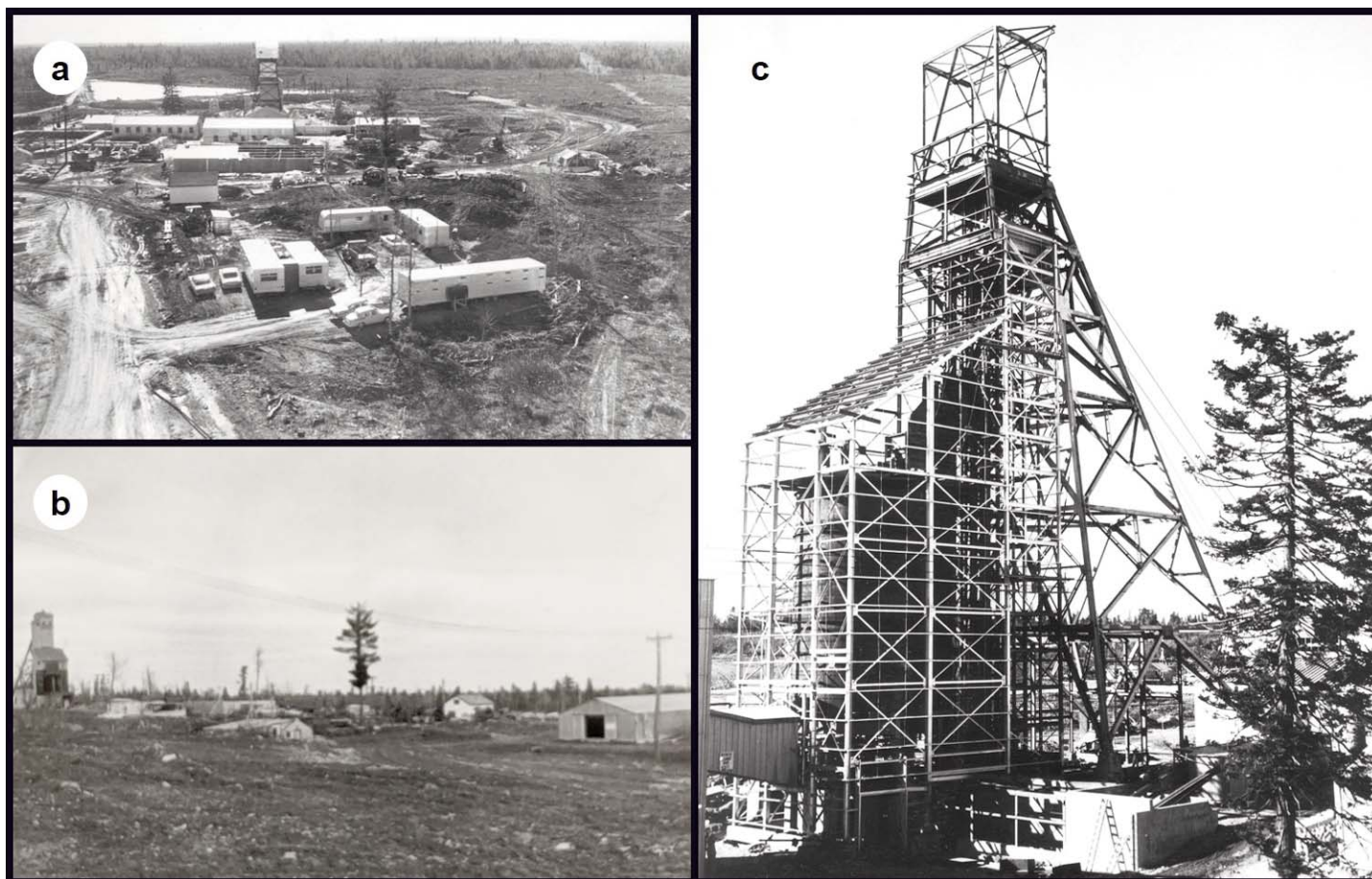


Figure 8. 1960s developments: a) Brunswick No. 12 (#2 shaft in background) in December 1962, looking south from #1 shaft (Brunswick Mining and Smelting archives); b) Brunswick No. 12 (#1 shaft at left) in December 1962, looking east (BMS archives); c) Brunswick No. 12 (#2 shaft expansion) in May 1963, looking northwest (BMS archives).

panies (Kenny 1997). The government reluctantly approved Boylen's request but considered it a temporary solution, realizing that the real problem lay in Irving's management of Brunswick. The local population was also dissatisfied with K.C. Irving's monopoly on construction contracts and his plan to build a large town site at Belledune (Kenny 1997). Furthermore, the personal relationship between L.J. Robichaud and K.C. Irving was also souring. The combination of three factors: 1) distrust of Irving's management, 2) local discontent, and 3) the growing animosity between Irving and Robichaud, made a compelling case for government to find a way to remove Irving from the picture (Kenny 1997).

In early 1967, Robichaud initiated a secret search for a new investor to wrest control of Brunswick from Irving (Kenny 1997). His confidante Edward Byrne (Fig. 7c), with the help of Boylen and Carte of Patiño, both of whom wanted Irving out of the project, convinced Noranda's Alfred Powis (Fig. 7d) to take over Brunswick. Noranda agreed to pay off \$50 million in Brunswick debts and to loan \$20 million to complete the smelter, in return for 51% control of the company. Noranda also insisted on a \$20 million loan guarantee. The shareholders approved the takeover in June of that year, the same year that the No. 2 shaft at Brunswick No. 12 was deepened to 925 m (Luff 1995). At the time, Brunswick's accounts payable

amounted to more than \$19 million, of which nearly \$15 million was owed to Irving companies. Eventually, Noranda paid off all the Irving group's outstanding accounts (Kenny 1997).

Under Noranda's management, the Belledune industrial complex was brought into production, but on a less grand scale than originally planned and with mixed results (Kenny 1997). The steel project and the construction of Belledune Harbour were shelved, with Noranda choosing instead to use Dalhousie Harbour, approximately 57 km to the northwest. The Brunswick smelter came into production in 1967 but was plagued with problems and did not reach maximum operating capacity until 1970; then it was converted from a zinc-lead to a lead only smelter in 1972. The fertilizer plant, Belledune Fertilizer, came into production in 1968 but had trouble finding buyers for its product.

In late 1968, a fire (oxidizing sulphides) started in the No. 6 open pit (Fig. 9c) when a blast was touched off in a pyrrhotite-rich part of the deposit; the spontaneously oxidizing sulphides were spread out on the waste-pyrite dump. It was expected that the fire would burn itself out, but instead the fire spread to the pyrite creating acid mine drainage that killed juvenile salmon in the Nepisiguit River in 1969. To extinguish the fire, the burning material was mixed with waste rock and over 1.3 million tonnes were trucked to the No. 12 mine (Fig.

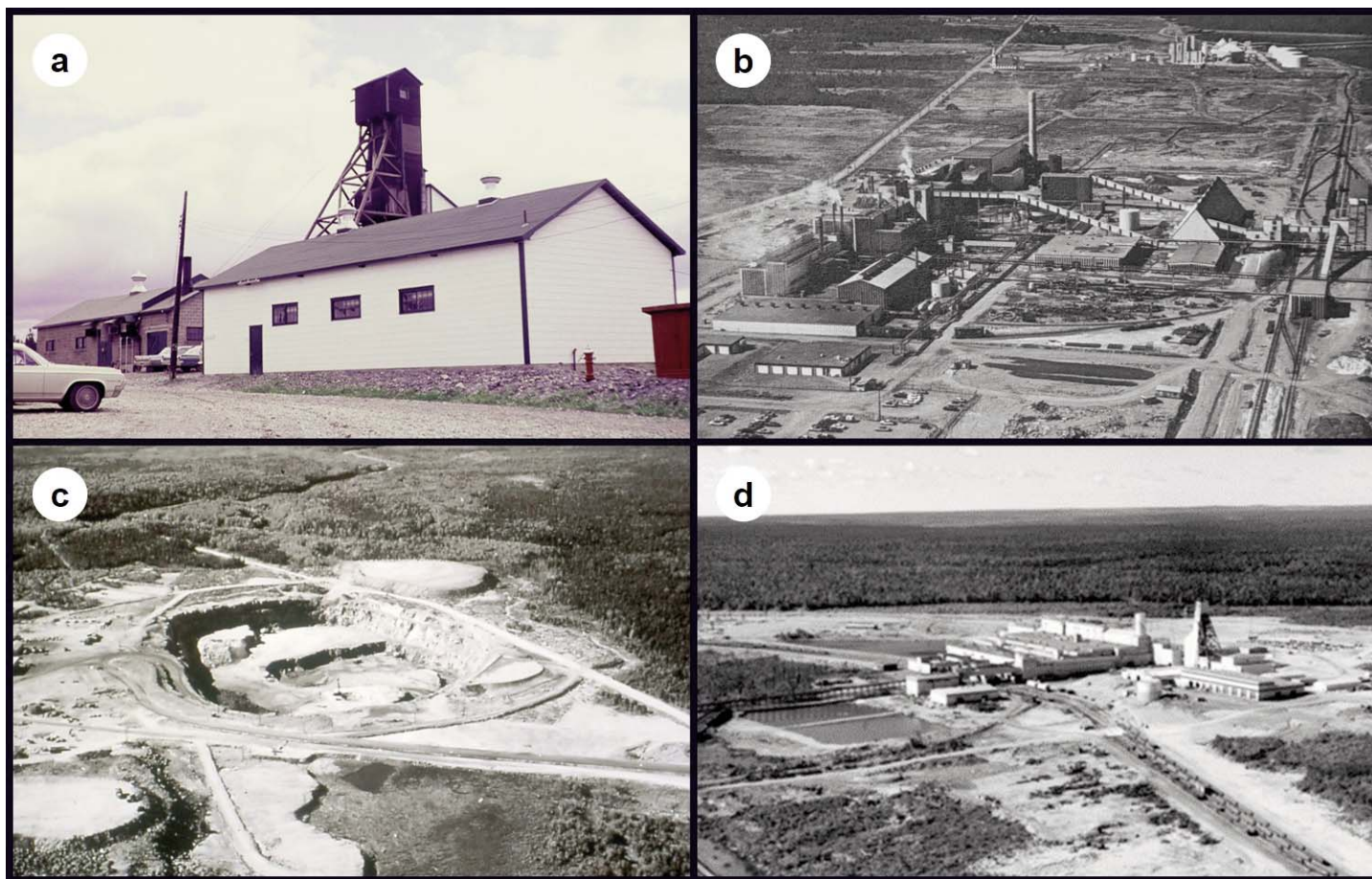


Figure 9. 1960s developments: a) Key Anacon (New Larder U) in 1966 looking east (New Brunswick Natural Resources and Energy Development archives); b) aerial view of Belledune smelter in 1966, looking northwest (Brunswick Mining and Smelting archives); c) aerial view of Brunswick No. 6 in 1969, looking southwest (NBNRED archives); d) aerial view of Brunswick No. 12 in 1969, looking southeast with #2 shaft to the right (BMS archives).

9d) and used as backfill underground in the upper part of the orebody. However, this caused oxidation of sulphides (spread the fire) in the mined-out stopes and subsequently necessitated the installation of bulkheads, a separate ventilation course and a 23 m stack to exhaust the resulting sulphur dioxide (SO_2) gas that was generated by the fire (Belland 1992).

1970s Development

Mine development in the 1970s is briefly described by Luff (1995), and Brunswick No. 12 is specifically described by Jarratt (2012). The mining methods used at Brunswick during the 1970s are described by Dufresne (1981). Additional information is found in the NBNRED online Mineral Occurrence Database (<http://dnr-mrn.gnb.ca/mineraloccurrence/>). Subsequently, some deposits were more fully described in Technical Reports, one for Trevali Mining Corporation (Zhang et al. 2014) and the other for First Narrows Resources Corporation (Sim and Davis 2008), which are filed on SEDAR. Two deposits, in addition to those first developed in the 1960s, saw development during this decade, namely Caribou and Chester. Surface exploration was carried out on the Key Anacon property in the early 1970s, but it saw no further mine development (Fig. 10a).

In 1970, the oxidized (gossan) zone at the Caribou deposit was mined to extract the supergene copper (Fig. 10b); in 1971, mining continued in the sulphide body, which was accessed from a ramp. Production ended in December of 1971, but Anaconda initiated a second phase of production in 1973–74 (Fig. 10c), which ceased in November of 1974 (Zhang et al. 2014).

In 1970, Sullico Mines Limited (Sullivan Mining Group) acquired 100% interest in the Chester deposit (Fig. 1). When initial plans for open pit mining were abandoned, Sullico drove a 470-metre decline in 1974–75 in order to explore the Copper Stringer Zone (i.e. Chester West Zone) and confirm diamond drill-indicated grade and tonnage, as well as to check rock competency and water flows for a potential underground mine operation (Sim and Davis 2008). Reportedly, 31,750 tonnes (35,000 tons), grading 2.06% Cu, were taken from underground in 1977 and processed at the Nigadoo mill, a Sullivan operation north of the BMC (Luff 1995). Further development was postponed, reportedly due to low copper prices, and the project was later abandoned (Fig. 10d).

In 1971–72, the No. 4 shaft at Heath Steele was sunk to 417 m on the C-Zone (Luff 1995). From 1974 to 1976, mining of the A and C zones was conducted from a ramp driven from

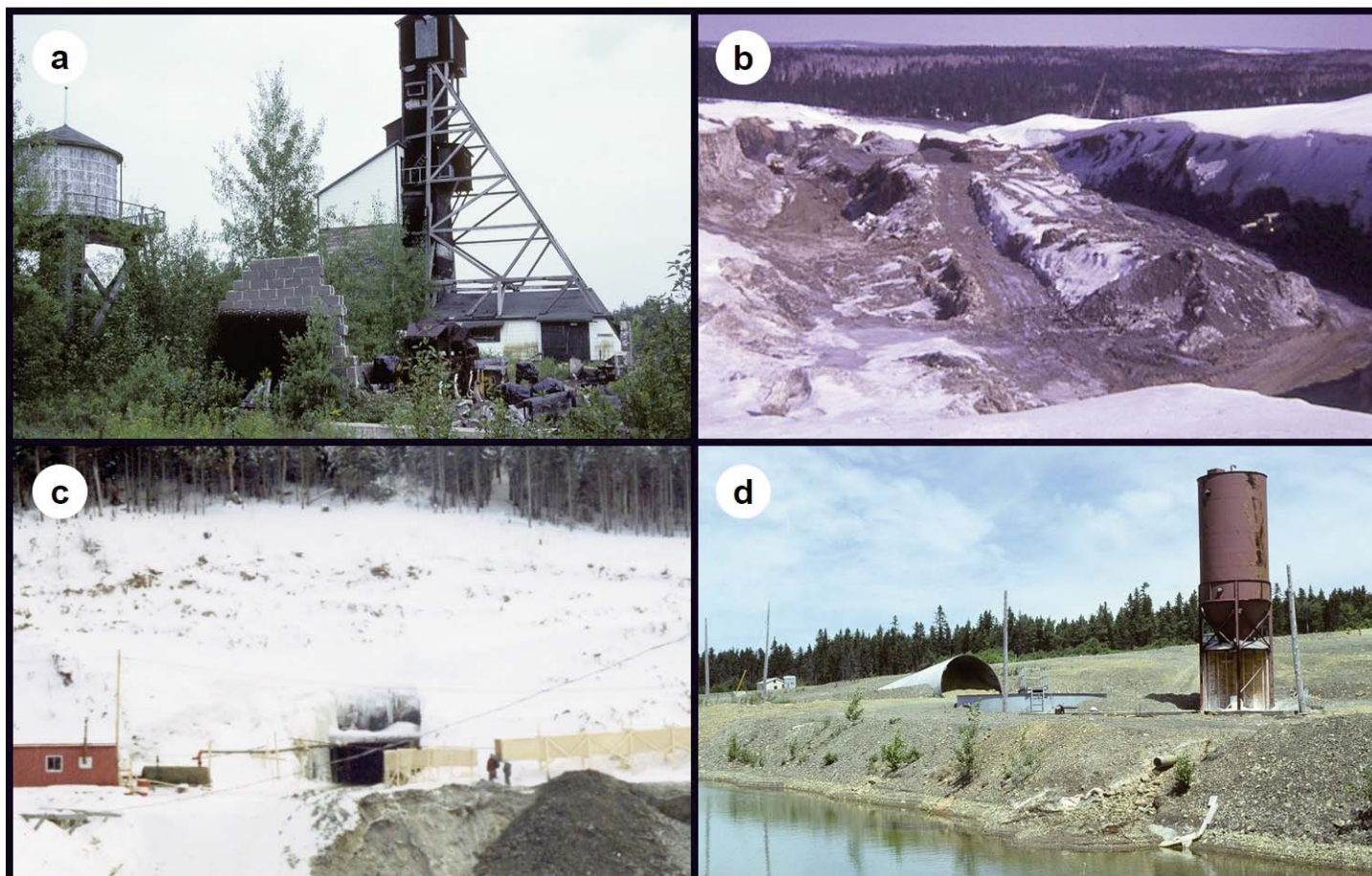


Figure 10. 1970s developments: a) Key Anacon 1979, looking southwest (New Brunswick Natural Resources and Energy Development archives); b) Caribou open pit looking north, circa 1971 (courtesy of Richard Cavellero); c) the mine portal at Caribou looking south, circa 1973 (courtesy of Richard Cavellero); d) the portal at the Chester deposit in 1978, looking northeast (NBNRED archives).

the A Zone open pit (Fig. 11a). In 1975–76, the No. 5 shaft on the B Zone was sunk to a depth of 890 m (Fig. 11b, c). In 1979, Noranda acquired a 75% interest in Heath Steele from American Metal Climax (Amax) and Asarco Inc. acquired 25% from Inco; in 1986, Asarco sold its 25% share to Noranda's Brunswick Mining Division (Gallagher 1999).

At Brunswick, open pit mining in the northern part of the No. 12 deposit occurred in 1971 (Luff 1995). In 1974, the No. 3 shaft, with an 88 m (288.5 feet) headframe, was collared and by 1977, it had been sunk to approximately 1125 m (3700 feet) (Fig. 12a, b, c). By 1977, the No. 6 open pit bottomed out at approximately 170 m (547 feet). Underground production began at 205 m via a ramp driven from the bottom of the pit, and production continued until 1983 when the ore was exhausted (Fig. 13a, b, c).

1980s Development

Mine developments in the 1980s are briefly described by Luff (1995), Gallagher (1999), and Jarratt (2012). Additional information is found in the NBNRED online Mineral Occurrence Database. A Technical Report for Trevali Mining Corporation (Zhang et al. 2014) has details about development at Caribou during this period. The Murray Brook (Fig. 14a) and Stratmat

deposits saw developments during this decade, as did deposits that were worked in the 1970s.

In 1980, Anaconda conducted additional drilling on its Caribou property to test the continuity of the deposit at depth. The company also carried out limited test mining, extracting a 25,400-tonne bulk sample that was milled at Brunswick No. 12 (Zhang et al. 2014). In 1982–83, Anaconda operated a gold–silver heap leach plant at Caribou, the first heap-leach gold operation in Canada (Luff 1995). Approximately 61,500 tonnes of gossan, which were stockpiled in 1970, were processed, yielding 106,000 ounces of silver and 8100 ounces of gold (Zhang et al. 2014).

Heath Steele shut down in April 1983, but the company decided to mill its stockpile (approximately 1000 tonnes) of gossan ore from the B-1 Zone to recover gold and silver, which was completed in June 1984 (Gallagher 1999). Heath reopened in 1989, milling ore from the Stratmat Boundary and Stratmat N-5 deposits (Table 1) until 1993 (Fig. 15a), and continued mining from the B-Zone until 1999, when Heath Steele closed permanently (Fig. 11d).

In 1985, Northumberland Mines Ltd. optioned the Murray Brook property (Table 1, Fig. 1), primarily to look at the precious metal content of the gossan (oxidized sulphides) cap on

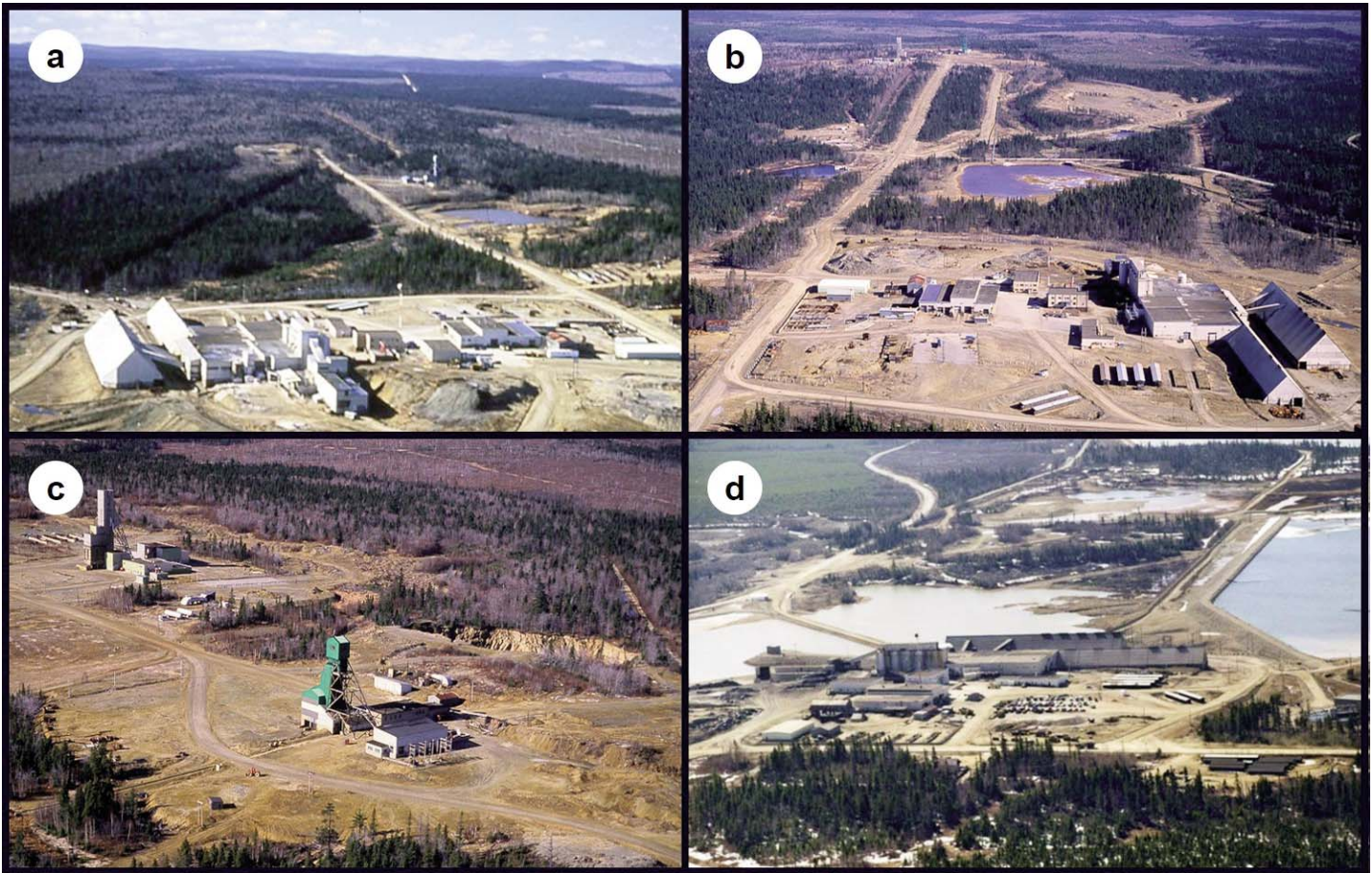


Figure 11. 1980s Heath Steele: a) aerial view of the Heath Steele mill in the foreground with the headframe to the No. 4 shaft (C-Zone) in the middle distance and the A-Zone open pit (flooded) in between, circa 1988, looking west (New Brunswick Natural Resources and Energy Development archives); b) aerial view of the Heath Steele mill in the foreground with the headframes to the No. 3 and No. 5 shafts (C-Zone) in the distance, circa 1988, looking east (NBNRED archives); c) close-up of the No. 3 (foreground) and No. 5 (left rear) headframes at the C-Zone, circa 1988, looking northwest (NBNRED archives); d) aerial view of the Heath Steele mill and water treatment ponds looking southeast, circa 1999 (Our Miramichi Heritage Family archives).

this massive sulphide deposit. In 1986, an open pit mine development and vat-leach processing facility were approved by government regulatory authorities. In 1988, Northumberland Mines and the Murray Brook deposit were acquired by Nova Gold Resources Ltd. The latter company commenced production in September 1989 and continued until 1992, at which time the gossan ore was exhausted (Fig. 14a, b).

In 1986, Caribou was acquired by East-West Minerals NL of Australia and in 1988 became East West Caribou Mining Ltd. Between 1987 and 1988, East West initiated pre-production construction, which included underground development and the construction of a concentrator on the property (Fig. 14c, d). East West began production in 1989 but the mine was shut down shortly afterward because of operating problems. In 1989, Caribou was acquired by Breakwater Resources Ltd.; the mine briefly re-opened, producing 728,400 tonnes, before closing in 1990 due to poor metal recoveries (Zhang et al. 2014), which resulted from the fine-grained nature of the ore.

Meanwhile at Brunswick, the \$56 million expansion program at No. 12, which began in 1974, was completed in 1981; this included increasing the mill capacity to 10,000 tonnes per day (Jarratt 2012). The No. 6 mine closed in 1983 after 18 years

of production (Fig. 13a). In 1987, the No. 12 mine produced its 50 millionth tonne of ore, and the No. 3 shaft (Fig. 12b, c) was deepened to 1325 m the following year. In 1989, the 25th anniversary of the mine opening, a new sulphide zone was discovered 1.5 km north of the No. 12 deposit at a depth of 1100 m.

1990s Development

Mine developments of this decade are described in the New Brunswick Mineral Occurrence Database, in Jarratt (2012), Luff (1995), Whaley (1992), and in Technical Reports for Trevali Mining Corporation, which are filed on SEDAR. New mining operations were established at the Restigouche (in conjunction with Caribou) and Captain North Extension (CNE) deposits (Table 1, Fig. 1). During the 1990s, reclamation projects began at Heath Steele and Brunswick. The Port of Belle-dune, which was originally built in 1968 to address the shipping needs of what was then the Noranda Smelter (Glencore), expanded in 1995 and again in 1998 (<https://www.portofbelle-dune.ca/history.php>).

Stratabound Minerals Corporation optioned the CNE deposit in 1988. Trenching in 1989 and 1990 exposed a 20 by

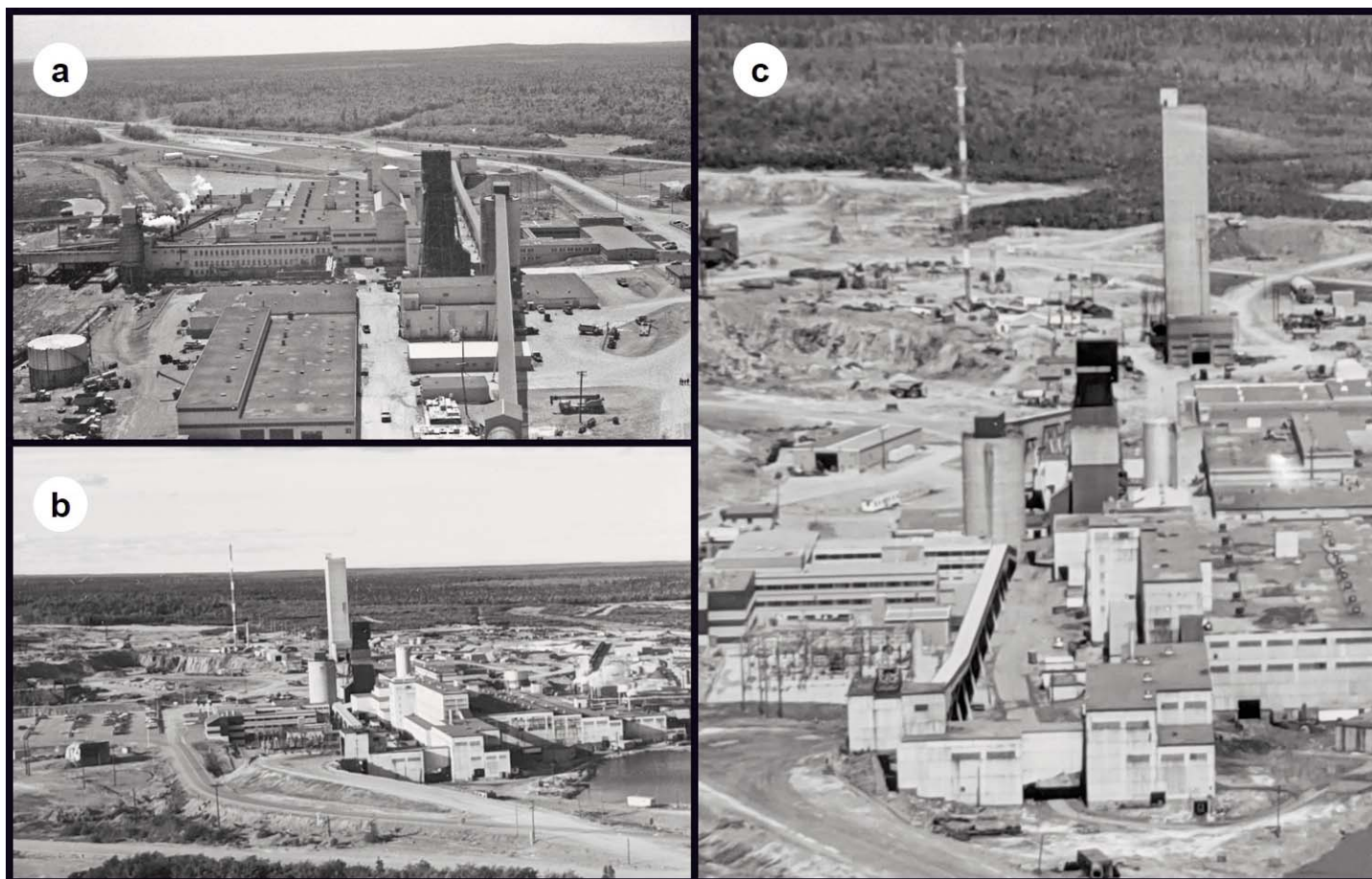


Figure 12. 1980s Brunswick No. 12: a) view from #3 headframe looking south over the mill and #2 headframe in the late 1970s (Brunswick Mining and Smelting archives); b) aerial view looking north at the mill (foreground), #2 headframe (dark grey) and #3 headframe (light grey) with the ventilation stack (striped) and the nearby open pit in 1983 (BMS archives); c) close-up aerial view looking north at the mill (foreground), #2 headframe (dark grey) and #3 headframe (light grey), with the ventilation stack (striped) and the nearby open pit in 1987 (BMS archives).

45 m area of bedrock beneath 5 to 6 m of till, from which Stratabound mined an 11,000-tonne bulk sample in 1990. The ore was trucked to the Heath Steele mill and processed successfully in September of that year (Whaley 1992). Between then and 1992, Stratabound mined another 28,000 tonnes (Fig. 15b) that was milled at Heath Steele (Luff 1995).

In 1995, Breakwater Resources Ltd. announced a metallurgical breakthrough, namely introduction of new mills (designed at the Mt. Isa Mine in Australia) capable of processing fine-grained ores, which would enable the company to reopen the Caribou mine. Reopening plans included the mining and processing of ore from the nearby Restigouche deposit, which was purchased from Marshall Minerals Corporation, following a positive feasibility study and testing of Restigouche ore. In 1996, Breakwater Resources, through its subsidiary East West Caribou Mining Ltd., received regulatory approval to mine the Restigouche deposit. Both the Caribou and Restigouche mines began production in 1997 (Figs. 15c, 16a, b), with the first ore going through the Caribou mill in July, at a combined rate of 3000 t/d. Production ceased in August 1998, when both mines went into care and maintenance mode.

At Brunswick, a new high-density, sludge-water treatment plant was completed at the No. 12 mine by 1994 (Jarratt 2012). In 1995, reclamation work at the No. 6 mine was completed, including installation of three drainage trenches (Fig. 16c) to capture run off from the waste-rock piles, which were contoured and seeded, and construction of an 8.5 km pipeline and pump station to transfer pit water to No. 12 for treatment (R. Schwenger written comm. 2017). In 1999, the underground ore handling and ventilation systems at the No. 12 mine were upgraded to support new mining areas in the south end of the orebody, and process changes were made to the grinding and flotation circuits to enhance metallurgical recovery.

At Heath Steele, a new water-treatment plant and buffer-storage pond were completed in 1997 (R. Schwenger written comm. 2017). Acid generating waste rock was removed from the vicinity of the B-Zone mine and from the haulage road to the B-Zone in 1998–99, and in November 1999 the Heath Steele mine and mill were closed (Figs. 11d, 16d).

Post-2000 Development

Since 2000, mine closure and reclamation have been as prevalent as mine development in the BMC. A new mining opera-



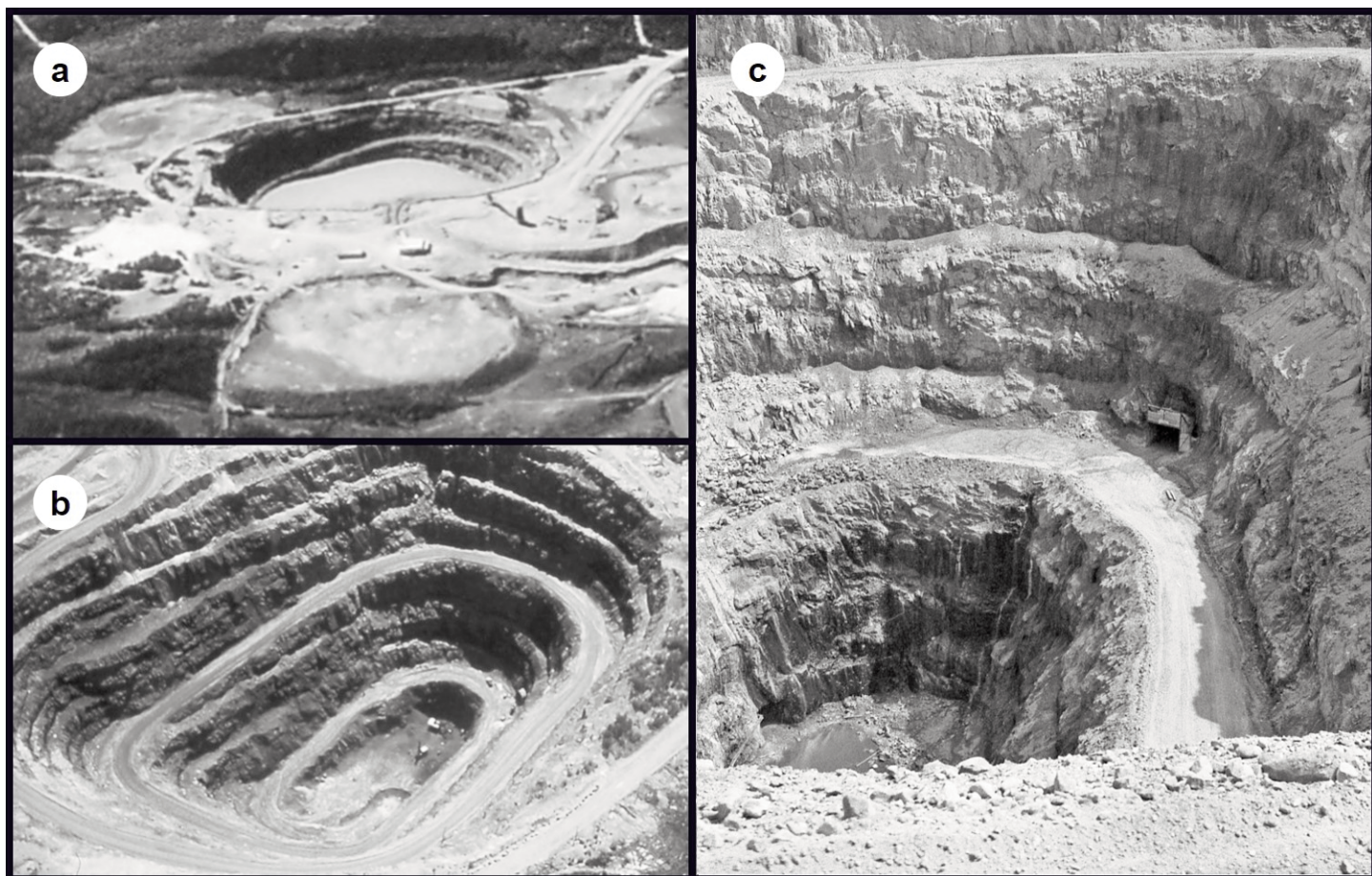


Figure 13. 1980s Brunswick No. 6: a) aerial view looking west of No. 6 pit (flooded) in 1989, with waste-rock piles at bottom center and top left (New Brunswick Natural Resources and Energy Development archives); b) aerial view looking southerly into No. 6 pit circa 1980 (Brunswick Mining and Smelting archives); c) ground view looking southerly into No. 6 pit, circa 1980 (courtesy of Ronald Jessulat).

tion was established at the Halfmile Lake deposit (Table 1, Fig. 1) and further developments occurred at Brunswick No. 12, Caribou, and CNE. Reclamation work occurred at Heath Steele and Brunswick.

In 2008, Kria Resources entered an agreement with Xstrata Canada Corporation – Xstrata Zinc Canada Division (now Glencore Canada), whereby Kria had the right to gain 100% interest in the Halfmile Lake and Stratmat deposits for \$18 million (US) and by issuing units worth \$7 million (CAD) (www.trevali.com). On April 7, 2011, Trevali Resources Corporation merged with Kria Resources Ltd. and changed its name to ‘Trevali Mining Corporation’. In August of that year, construction of a portal and underground ramp (Fig. 17a) to the upper part of the Halfmile Lake orebody began. The mine permitting did not allow ore processing on site, or permanent storage of waste rock on surface; it also limited surface storage of ore, directing all run off away from the Northwest Miramichi River. All site discharge was controlled and there was a commitment to meet strict Canadian Council of Ministers of the Environment (CCME) guidelines using state of the art Veolia water treatment. (J. Griggs written comm. 2017). In the first seven months of 2012, approximately 100,000 tonnes were mined (on a trial basis) from the Upper Zone of the

deposit; the ore was trucked to the Brunswick No. 12 mill for toll processing, which was considered a technical success (www.trevali.com). However, since then, the mine has been on care and maintenance mode while Trevali focuses on its Caribou operation.

In 2003, new technology was implemented at Brunswick No. 12 that significantly lengthened the life of the mine. The introduction of paste backfill (80% tailings with water and cement) in 1998 allowed re-entry to the long-abandoned upper part of the orebody (‘425 Main Ore Zone’); permitted mining without having to leave pillars of ore; reduced rock stress, and quenched oxidation of waste sulphides (Jarratt 2012). The fire (oxidizing sulphides) that had burned in that part of the orebody since 1970 was finally extinguished by 2005, and the 23 m exhaust stack that was used to vent SO₂ gas was dismantled (compare Figs. 12c and 17b). In July 2005, Brunswick’s owner, Noranda, acquired the remaining shares of Falconbridge Ltd., a Toronto-based mining company, and changed its name to ‘Falconbridge Limited’, but in 2006 Xstrata Zinc, an Anglo-Swiss multinational mining company, purchased Falconbridge (Jarratt 2012) and the name changed to ‘Xstrata Canada Corporation – Xstrata Zinc Canada Division’. Xstrata closed the Brunswick No. 12 mine on April 30, 2013, but not before pro-

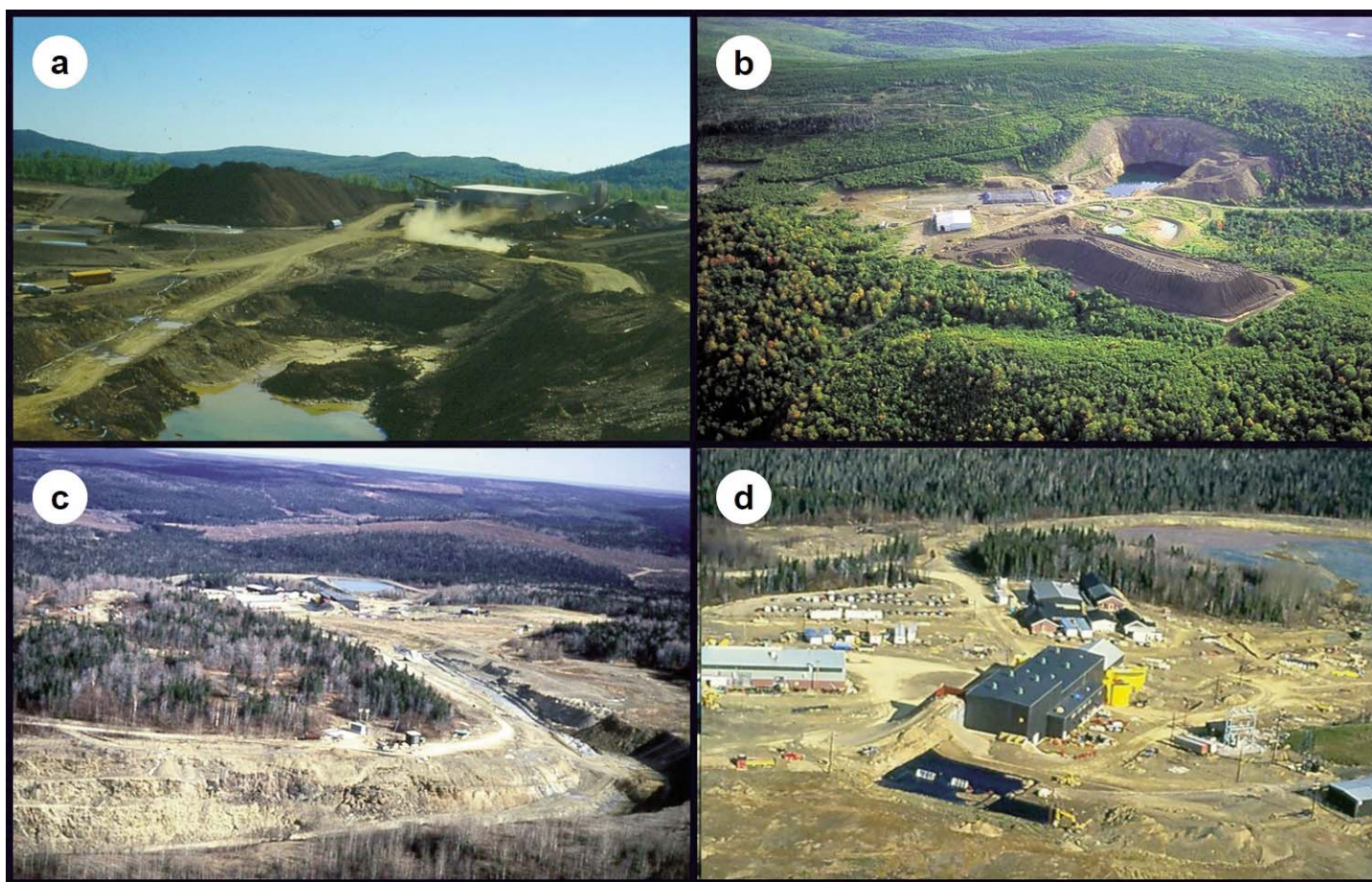


Figure 14. 1980s developments: a) Murray Brook open pit in 1989 with pit in the foreground and leach-plant in the background (to right) and gossan tailings (to left), looking northeast (New Brunswick Natural Resources and Energy Development archives); b) aerial view looking south of Murray Brook open pit (flooded) and gossan tailings pile in the foreground in 1997 (NBNRED archives); c) aerial view of Caribou mine site looking northeast, with open pit in the foreground and mine buildings in the background in 1988 (NBNRED archives); d) close-up of Caribou mine buildings looking north, with mill in the foreground and office in the background in 1988 (NBNRED archives).

cessing 62,720 tonnes of ore (between March 6 and April 12) from Stratabound Minerals Corporation's CNE open pit mine (Fig. 17c).

Between 2008 and 2017, reclamation work was done at the Brunswick No. 12 mine site (R. Schwenger written comm. 2017). Covering the slopes of the tailings began in 2008 and was completed in 2015. The covering of tailings benches started in 2011 and was completed in 2017. A south perimeter ditch was constructed in 2012; a north perimeter ditch was started in 2013 and completed in 2017. Demolition of the mine buildings began in 2014 and was complete by 2016. All openings to surface were capped and fenced in 2016. Reclamation of the mine site itself began in 2015 and was completed in 2018.

In August 2006, Blue Note Mining Inc. acquired an 80% interest in the Caribou and Restigouche mines from Breakwater Resources. Blue Note Caribou Mines Inc. invested approximately \$116 million to revive the two mines; operations started in July 2007 with commercial production declared at the start of 2008 (*The Northern Miner*, October 27, 2008). Operations achieved full capacity at 3000 tonnes daily, and recoveries exceeded 83% for zinc and 70% for lead. Restigouche ore (Fig. 17d) was hauled to Caribou and blended with Caribou ore in

the mill. Production ceased in late 2008 because of the global economic slowdown and the accompanying drop in metal prices. Following a legal battle, control of the Caribou deposit passed to Maple Minerals Corporation in April of 2011 (visit the New Brunswick Mineral Occurrence Database).

Between 2000 and 2007, demolition and reclamation work were completed at Heath Steele (R. Schwenger written comm. 2017). Demolition began in 2000 and was finished in 2001. During the same period, a dike was constructed around the Stratmat open-pit to increase its storage capacity; shafts at Heath Steele were capped; a pump station was constructed at the B-Zone mine; the main tailings dam and buffer pond dam were raised 0.6 m to increase their storage capacity, including constructing permanent and emergency spillways in the main dam. In 2005, dams on North Little River Lake and McCormack Reservoir were decommissioned, and a fish way was installed in South Little River Dam. In 2007, two pump stations were decommissioned, and one was upgraded; a collection ditch to the B-Zone open pit was constructed; the cave-in of a crown pillar at the B-Zone mine was filled and capped with clay, and finally, fences were constructed around all crown pillars.





Figure 15. 1990s developments: a) aerial view looking northeast of the flooded Stratmat Boundary (foreground) and N5 (background) open pits in 1997 (New Brunswick Natural Resources and Energy Development archives); b) view looking east of the partly flooded CNE open pit in 1991 (NBNRED archives); c) aerial view looking north of the Caribou mine site in 1997 (NBNRED archives).

Mine Production

The production history of the BMC is described in Luff (1995); an update is shown in Table 1. Twelve of the known 45 deposits in the BMC have been mined.

The Heath Steele deposit was the first producer, beginning in 1957, and was mined under a joint agreement between INCO and AMAX. The B zone (Fig. 11b) to the east and ACD zones (Fig. 11a) to the west provided most of the mill feed, with over 20 million tonnes being mined from the B zone and over 0.5 million tonnes from the ACD zones (Table 1). In addition, approximately 178,000 tonnes of gold–silver-bearing gossan from the ACD and B zones was processed at the Heath Steele mill between 1983 and 1984 (Luff 1995).

Other deposits were processed at the Heath Steele mill (Table 1). For example, the Wedge deposit, which was mined for copper by Cominco from 1962 to 1968, produced about 1.5 million tonnes, all of which was milled at Heath Steele. From 1989 to 1993, over one million tonnes were mined from the Stratmat Boundary and N-5 zones and processed there (Table 1). Finally, between 1990 and 1992, Stratabound Minerals extracted approximately 39,000 tonnes from the CNE deposit and trucked it to the Heath Steele mill. Total through-

put at the Heath Steele mill from all sources was over 26 million tonnes.

The Brunswick No. 12 deposit started production in 1964, followed in 1966 by the Brunswick No. 6 deposit. The No. 12 deposit is the ‘elephant’ of the BMC, with total production of nearly 137 million tonnes to the end of mine life in 2013 (Table 1). The combined production from the No. 6 and No. 12 deposits exceeded 149 million tonnes (Table 1). In addition, approximately 126,000 tonnes of ore, mined at Halfmile Lake by Trevali Mining Corporation in 2012 and approximately 63,000 tonnes of ore mined at CNE by Stratabound Minerals Corporation in 2013, were processed at the Brunswick mill (Table 1).

The first production from the Caribou deposit, roughly 340,000 tonnes, was from the supergene copper zone between 1970 and 1974 (Luff 1995). Between 1982 and 1983, approximately 60,000 tonnes of gold–silver-bearing gossan were processed at Caribou, making it the first heap leach gold recovery operation in Canada (Luff 1995). A test stope of the primary massive sulphide was mined at Caribou in 1983 and processed at Brunswick. Further underground production took place from 1988 to 1990 and was processed at the Cari-



Figure 16. 1990s developments: a) aerial view looking north of Restigouche open pit in 1997 (New Brunswick Natural Resources and Energy Development archives); b) ground view looking north of Restigouche pit face in 1997 (NBNRED archives); c) aerial view looking west of drainage trench at Brunswick No. 6 open pit in 1997 (NBNRED archives); d) view looking north of the gate to the Heath Steele mine site in 2003, with water-treatment ponds (foreground) and water-treatment plant in the background at left (NBNRED archives).

bou mill. In 1997, production resumed at Caribou and began at Restigouche by open pit. Production continued until July of 1998. The ore from the two deposits was blended and processed at the Caribou mill. Total combined lead–zinc production from these deposits to the end of 2018 was over five million tonnes (Table 1).

The Murray Brook deposit has also been mined (Table 1). Over one million tonnes of gossan was successfully vat-leached (indoors) for gold and silver between 1989 and 1993 and represented the first application of indoor leaching in Canada. Also, over 50 thousand tonnes of primary and secondary massive sulphides, rich in copper (2.5%), were mined at Murray Brook in 1992 and placed on an outdoor leach pad. A bio-assisted leach operation was attempted in the fall but was unsuccessful (Luff 1995).

IMPORTANCE OF THE BATHURST MINING CAMP

The Bathurst Mining Camp (BMC) was, and still is, important to New Brunswick and Canada for many reasons, encompassing such things as infrastructure, mining innovations, economic impact, social effects, and environmental initiatives. Details about each of these topics are provided below.

Infrastructure

Prior to the discovery of the BMC, access to remote parts of Gloucester and Northumberland counties was mainly by seasonal lumber roads or by canoe. When Heath Steele was being brought into production in the mid-1950s, the road from Newcastle (now Miramichi City) to Wayerton had to be extended northwestward to the mine site, including construction of a bridge, known as the ‘Miners Bridge’ over the Northwest Miramichi River (described in some detail by Gallagher 1999). A spur railway line from the main CNE track was also constructed from Bartibog Station to the Heath Steele mine site (Fig. 5a); the tracks were taken up after the mine closed in 1999, and the roadbed is now used as a snowmobile trail. Then in the early 1960s, when the Wedge mine was being readied for operation, the road was extended north from Heath Steele, across the Nepisiguit River, and northwest along the river to the mine site. This road included construction of a major bridge over the Nepisiguit River, referred to locally as the ‘Heath Steele Bridge’ (Fig. 18a). A bit later, when Brunswick No. 12 was being made ready for production a road (the ‘Mines Road’) was constructed from Big River, just south of Bathurst, to the mine site. A spur railroad line was also built



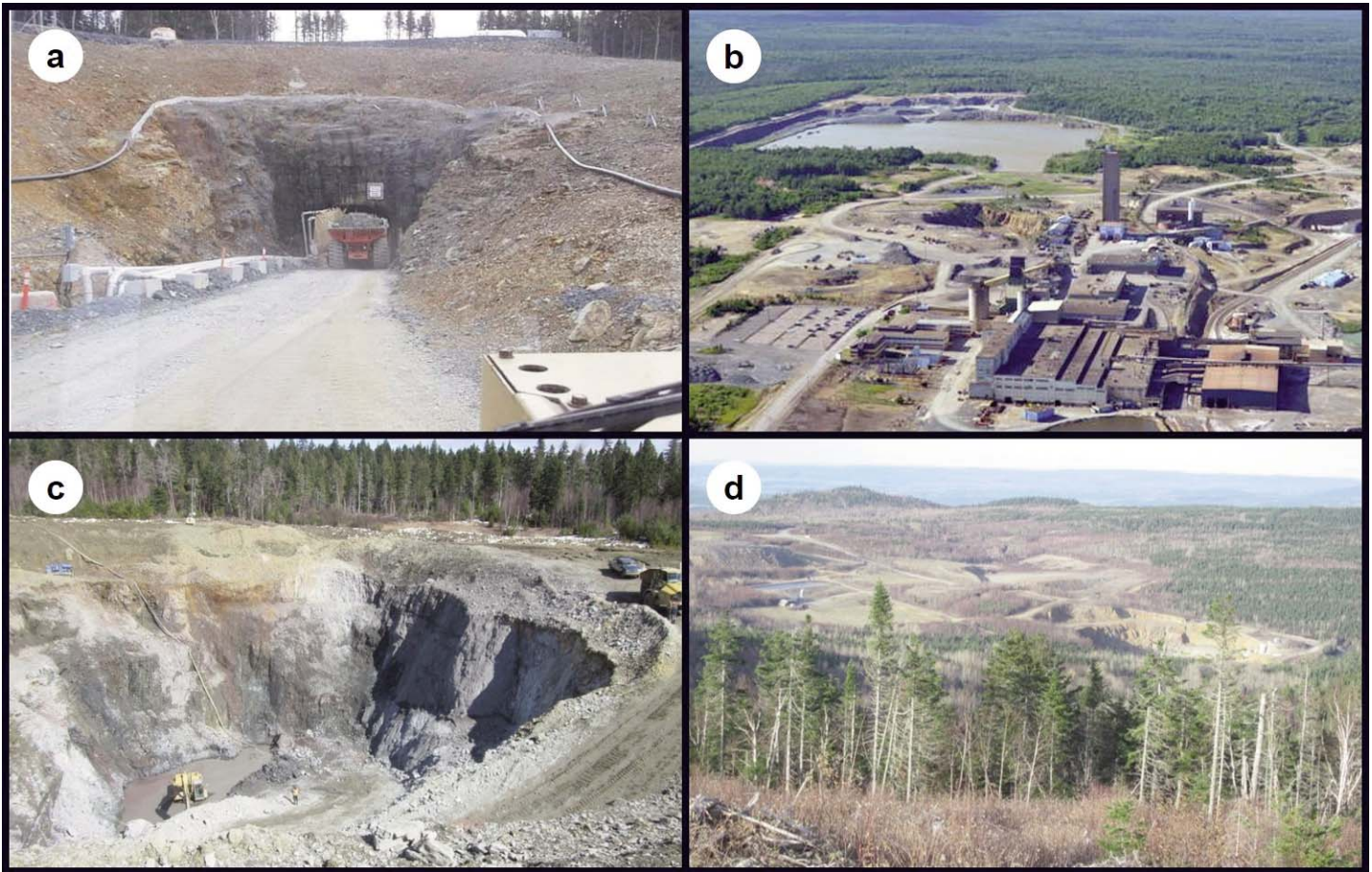


Figure 17. 2000s developments: a) portal to the Halfmile Lake decline in 2012 (New Brunswick Natural Resources and Energy Development archives); b) aerial view looking north of Brunswick No. 12 in 2010, showing the absence of the ventilation stack between the #3 headframe and the open pit, with the flooded rock-backfill quarry in the background (Bathurst Heritage Museum); c) open-pit at CNE in 2013 (NBNRED archives); d) Restigouche mine site looking northeast across the open pit (to the right) and waste rock piles (to the left) in 2012 (NBNRED archives).

from Nepisiguit Junction to the mine site. Furthermore, a smelter and deep-water port facilities were constructed at Belledune (Fig.18b) and are still there today, although the smelter closed at the end of 2019. Ultimately, the roads to Brunswick and Heath Steele were linked and are now known as provincial Highway 430.

Similarly, the southeastern part of Restigouche County was difficult to reach, even up to the 1980s, when the ‘Road to Resources’ was completed. However, it was development work at the Caribou mine site in the late 1950s and 1960s that led to construction of the road from South Tetagouche (just west of Bathurst) to Caribou Depot in 1965. In the early 1980s, the road was extended westward, past the Murray Brook and Restigouche deposits, to connect with a main lumber haulage road coming east from St. Quentin. Subsequently, it has been upgraded and it is now a paved provincial highway (Route 180) from Bathurst to St. Quentin. Finally, the lead smelter and the deep-water port at Belledune would not exist if not for the discovery of the BMC.

Mining Innovations

The BMC has been the site of multiple mining innovations.

Many of them pertain to Brunswick No. 12 and are described in papers that were published in the CIM Bulletin over the years. In fact, a 1971 issue of the CIM Bulletin (V. 64, no.713) was devoted to “The Brunswick Story”. Many innovations that occurred at Brunswick No. 12 are mentioned in Jarratt’s (2012) book. More specifically, the BMC was where:

- the first heap-leach gold operations in Canada, both indoor at Murray Brook and outdoor at Caribou, were conducted (Luff 1995);
- a state-of-the-art underground-seismic-monitoring network was installed in 1986 at Brunswick No. 12; it was upgraded in 1997; and was used until 2013 to guide mining activity and maintain safety (Simser and Falmagne 2004);
- a large-scale panel-distress blast was fired in 1999 to reduce ground stresses in a critically important part of the Brunswick No. 12 mine, which allowed more ore to be mined and thereby extended mine life (Andrieux et al. 2003);
- modified cone bolts and 00-gauge metal straps were employed at Brunswick No. 12 to control rock bursts (White and Rose 2012);

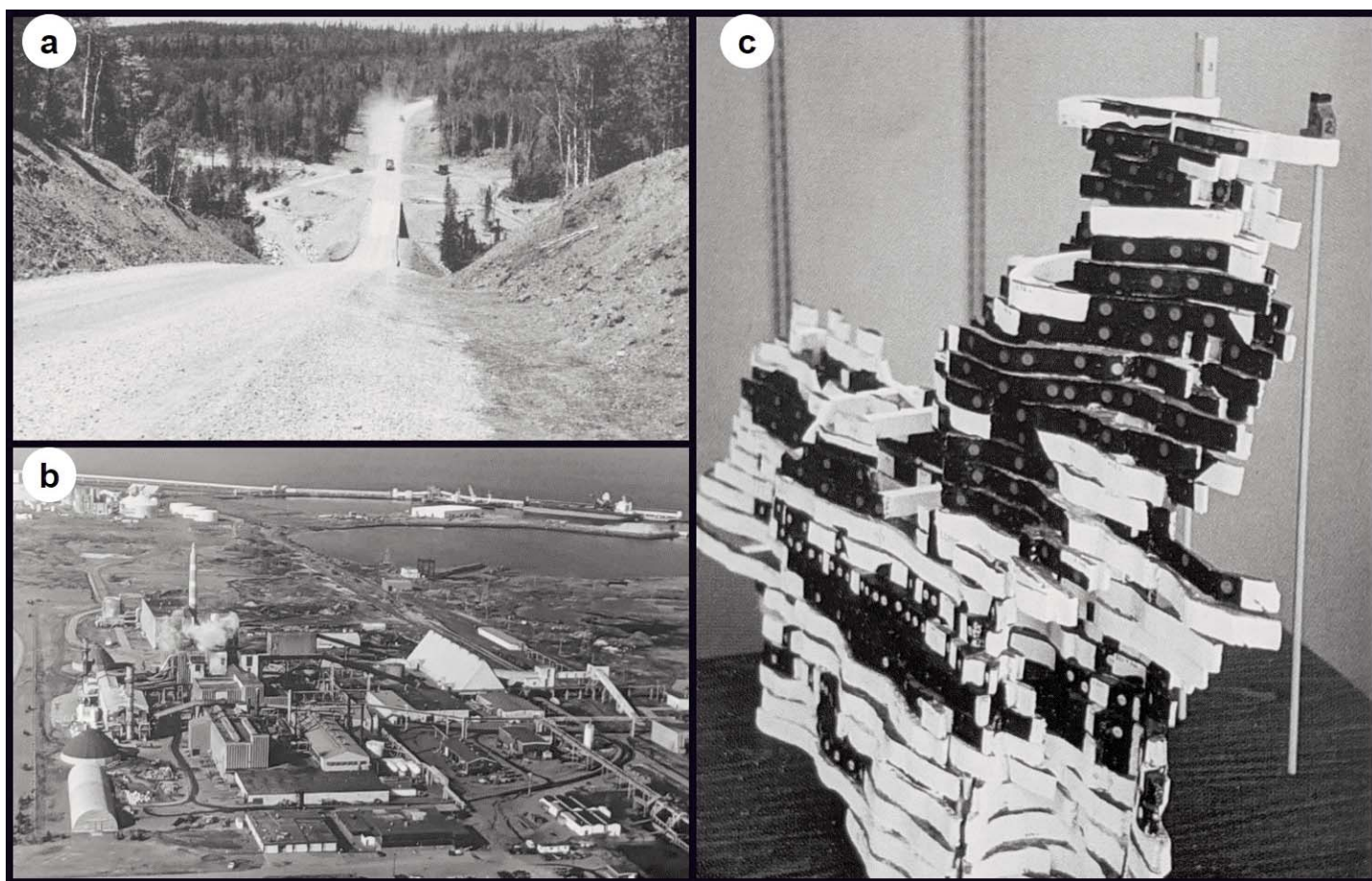


Figure 18. Other photos: a) road and bridge ('Heath Steele Bridge') over Nepisiguit River circa 1962, looking north (Our Miramichi Heritage Family archives); b) aerial view looking northwest at the Belledune smelter with the docks for the Port of Belledune in the background in 2000 (Bathurst Heritage Museum); c) a 3D model, created by Rhéal Godin, of the Brunswick No. 12 orebody in the mid-1990s, showing the #2 and #3 headframes (top), the #2 shaft and the various levels in the mine; black areas are mined-out stopes and white areas are unmined (from Gallagher 1997).

- the 'Mechanic's Stethoscope', a diagnostic software tool for underground vehicle maintenance, was developed and successfully employed at Brunswick No. 12 (Fauteux et al. 1995);
- the remotely controlled 'Weasel drill' was developed in 1992 for use in open stopes (Jarratt 2012) and beginning in 1997 was manufactured commercially by Marcotte Mining Machinery Services of Sudbury, Ontario, for other mining operations (Gallagher 1997);
- a 3D scale model (Fig. 18c) of the orebody that dwarfed Toronto's CN Tower was constructed in the mid-1990s by an employee, Rhéal Godin, to help develop a computerized model of the No. 12 mine, and so visitors could better visualize the underground extent of the mine workings (Gallagher 1997);
- an underground incentives program, the 'Brunswick Incentive System', was developed in 1972 and used for many years to keep Brunswick Mining near the top of the list of producers in terms of productivity and near the bottom, with respect to labour and bonus costs (Baker 1995);
- paste backfill was commissioned at Brunswick No. 12 in 1998 (Bernier et al. 1999), and implemented in 2000

(Cormier 2010), leading to increased ore recovery, improved safety and reduced mining costs;

- studies were done on composite soil covers (Bell et al. 1995) and the geochemistry of mine tailings (Blowes et al. 1992) at Heath Steele;
- studies were done on grinding media (Petruk and Hughson 1977; Cooper et al. 1994), mineral liberation (Petruk and Schnarr 1981), and flotation practices (McTavish 1980; Cooper et al. 2004) to enhance metal recoveries at Brunswick and Heath Steele (Chen and Petruk 1980);
- a method was developed to neutralize thiosalts, which form during the milling process and contribute to acid mine drainage (AMD), in wastewater from the Brunswick mill (Cormier 2010);
- and innovative mills designed at the Mt. Isa mine, Australia, were first used in Canada at the Caribou Mine by Breakwater Resources in the late 1990s.

Economic Impact

The economic impact of the mining industry for northern New Brunswick (and Canada) has been immense. During its lifetime, the Brunswick No. 12 mine alone produced over 136



million tonnes of ore grading 3.44% Pb, 8.74% Zn, 0.37% Cu, and 102.2 g/t Ag. The total value of metals recovered, in today's prices, is over \$46 billion of new wealth that was injected into the economy. This figure does not account for production from Heath Steele or the other metal mines in the BMC. Additionally, 100s of \$1000s per year have been injected into the regional economy from exploration expenditures for over 60 years. Furthermore, additional monies were injected into the economy by suppliers and service providers to the mining operations, such as the Brunswick Smelter at Belledune.

Social Effects

The discovery of the BMC started a transformational change in the social fabric of Bathurst and its surrounding communities. What had been a largely poor, rural society, mostly dependent upon the fishing and forestry industries, was faced with an influx of people and a new economic reality in the 1950s. Initially most of the miners and explorationists were from away, but over time local people were trained to do the well-paid jobs and were employed in the mines and exploration crews, as well as the smelter. The living standard in Bathurst and the surrounding communities improved, local businesses flourished, and Bathurst became a city in 1966, two years after Brunswick No. 12 went into production. The new opportunities, new wealth, and training provided by the mineral industry changed the social fabric of northern New Brunswick. Untold numbers of engineers, geologists, miners, and prospectors 'cut their teeth' in the BMC, and many of them have gone on to make their mark in other parts of Canada and the world.

Over the years, Brunswick Mining and Smelting Corporation contributed to virtually every non-profit organization and charity in the Bathurst area and beyond, encompassing such things as health, safety, education, sports, arts, culture, and the environment. For example, the list of recipient organizations for a two-year period (2010–2012) numbers 192 (Jarratt 2012).

Environmental Initiatives

Several environmental measures were initiated in the BMC. One of the results of the underground fire that began at Brunswick No. 12 in 1970, was a change in safety regulations; specifically, anyone working underground was required to be clean shaven and carry a portable respirator, in case SO₂ gas escaped from the fire zone into other parts of the mine. Ultimately, this regulation has been applied to all underground mines in Canada.

Originally, the lead smelter at Belledune was supposed to be built on the east side of Bathurst Harbour at Daly Point, where land (mostly marshland) had been purchased for this purpose in the early 1960s. The land remained undeveloped until 1988, when Brunswick decided to turn Daly Point into a nature preserve, with the cooperation of the City of Bathurst and the NBNRED. In September of 1989, the Daly Point Nature Reserve officially opened as a joint venture between Brunswick and NBNRED (Jarratt 2012). A wildlife interpretation centre, parking lot, footpaths, boardwalks, and an observation tower were constructed, complete with bilingual signage, to enhance the area. In October of 2002, Brunswick offi-

cially signed over Daly Point to the City of Bathurst. Today, Daly Point is a popular tourist attraction, with 20,000 visitors annually, and it also serves to educate the public about the coastal wetland environment.

Acid mine drainage (AMD) is a common problem at most base-metal mines because sulphide minerals are unstable in the surface environment, where they react with oxygen. In the presence of water, oxidizing sulphides produce sulphuric acid, iron oxides (rust) and they release water soluble metals into the environment, which are harmful to aquatic life, unless the acid is neutralized naturally by limestone host rocks, or deliberately by adding lime. Since limestone host rocks are extremely rare in the BMC, AMD is a problem, which Brunswick discovered in 1969 at its No. 6 mine site, when spring run-off from the waste piles ran into Knights Brook and ultimately killed fish in the Nepisiguit River. To resolve this issue, Brunswick began to collect and treat AMD from both the No. 6 and No. 12 sites after that incident.

At Brunswick No. 12, the treatment consisted of mixing lime with the AMD, which was then sent to settling ponds where approximately 98% of the solids settled to the bottom as a sludge phase, and the remaining water was released to the environment. However, the water quality was not always acceptable, so a new wastewater treatment plant was commissioned in 1993 and went into operation in 1994 (Jarratt 2012). Initially, this plant did not treat water from Brunswick No. 6, which had its own liming station that treated AMD from the waste piles, and then pumped the treated water into the mined-out pit. By the late 1990s, however, the pit was nearly full, so a pipeline and pump station were constructed to send water from No. 6 to the No. 12 site for treatment. Drainage trenches from the waste piles at No. 6 to the pit were constructed and the liming station was removed.

However, the wastewater treatment plant did not resolve the thiosalt problem that is created by the milling process. Thiosalts are partially oxidized sulphur compounds that are not neutralized by lime, but become oxidized after release into the surface environment, where they lead to acidification of down-stream waters. To minimize the amount of wastewater (and thiosalts) released to the environment, Brunswick established recycling loops in the mill. However, the water reclamation system had limited storage capacity until after 2000, when paste backfill was implemented at Brunswick No. 12. This made the rock quarry, which had provided conventional backfill for the mine (Fig. 17b), redundant, so it became a big (500 x 500 x 20 m) storage reservoir for the reclamation system. This enabled the mill to increase the recycling rate from 48% to 64%, while reducing the freshwater withdrawal rate from the Nepisiguit River by 20% (Cormier 2010). One unforeseen effect was a dramatic increase in the concentrations of sulphates and thiosalts in the reclamation quarry over time. Sulphate-reducing bacteria proliferated and generated copious quantities of H₂S (rotten egg gas). In order to reduce the odour of H₂S (and other reduced sulphur compounds) generated in the reclaim quarry, AMD water from the No. 6 pipeline was re-directed to the reclamation quarry in 2009. As a result, the rotten-egg odour was immediately reduced and eventually

eliminated, the pH hovered around 7 (neutral), and the concentrations of sulphates and thiosalts both declined (Cormier 2010).

Also, in the late 1990s, a new wastewater treatment plant was constructed at the Heath Steele Mine to control AMD from that site. Since active mining had ceased by then, there was no thiosalt problem to deal with there.

Brunswick (and Noranda Research) had a long history with the Nepisiguit Salmon Association (NSA), which was formed in 1976 by a small group of local anglers who wanted to rebuild the Atlantic Salmon population in the Nepisiguit River. In 1981, only 312 grilse and salmon returned to the counting fence near the mouth of the River, so the NSA decided to start its own salmon enhancement program, with the blessing of the Federal Department of Fisheries and Oceans. Since 1981, nearly \$2.5 million has been spent on this program, with money mainly coming from Brunswick, the Environmental Trust Fund, and the Wildlife Trust Fund. In 1985, the NSA began pioneering studies with Noranda Research to develop and install streamside-incubation boxes for salmon eggs; survival rates of over 90% were achieved. By 1988, the salmon population in the Nepisiguit River had increased significantly; a total of 4,268 grilse and salmon passed through the counting fence that year. After 2009, NB Power and the Atlantic Salmon Conservation Foundation also became contributing sponsors to the NSA. Today, the Nepisiguit River is one of the premier salmon rivers of New Brunswick (Jarratt 2012).

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REFERENCES

- Andrieux, P.P., Brummer, R.K., Liu, Q., Simser, B.P., and Mortazavi, A., 2003, Large-scale panel distress blast at Brunswick mine: *Canadian Mining and Metallurgical Bulletin*, v. 96, no. 1075, p. 78–87.
- Baker, R.W., 1995, Underground incentives - their development, application and effect at Brunswick No. 12 mine, Bathurst, New Brunswick: *Canadian Mining and Metallurgical Bulletin*, v. 87, no. 985, p. 73–76.
- Belland, M., 1992, The birth of the Bathurst Mining Camp: a development history of the Austin Brook iron mine and the No. 6 base metal deposit: *New Brunswick Department of Natural Resources and Energy, Mineral Resources Popular Geology Paper* 92–1, 56 p.
- Bell, A.V., Riley, M.D., and Yanful, E.K., 1995, Evaluation of a composite soil cover to control acid waste rockpile drainage: *Canadian Mining and Metallurgical Bulletin*, v. 88, no. 995, p. 41–46.
- Bernier, L.R., Li, M.G., and Moerman, A., 1999, Effects of tailings and binder geochemistry on the physical strength of paste backfill, in: Goldsack, D., Belzile, N., Yearwood, P., and Hall, G., eds., *Proceedings of Mining and the Environment II: Laurentian University*, Sudbury, ON, p. 1113–1122.
- Blowes, D.W., Jambor, J.L., Appleyard, E.C., Reardon, E.J., and Cherry, J.A., 1992, Temporal observations of the geochemistry and mineralogy of a sulfide-rich mine tailings impoundment, Heath Steele Mines, New Brunswick: *Exploration and Mining Geology*, v.1, p. 251–264.
- Boyle, D.R., 2003, Preglacial weathering of massive sulfide deposits in the Bathurst Mining Camp: economic geology, geochemistry, and exploration applications: *Economic Geology Monograph* 11, p. 689–721.
- Chen, T.T., and Petruk, W., 1980, Mineralogy and characteristics that affect recoveries of metals and trace elements from the ore at Heath Steele Mines, New Brunswick: *Canadian Mining and Metallurgical Bulletin*, v. 73, no. 823, p. 167–179.
- Cooper, M., Bazin, C., and Grant, R., 1994, Grinding media evaluation at Brunswick Mining: *Canadian Mining and Metallurgical Bulletin*, v. 88, no. 987, p. 29–31.
- Cooper, M., Scott, D., Dahlke, R., Finch, J.A., and Gomez, C.O., 2004, Impact of air distribution profile on banks in a Zn cleaning circuit: *Canadian Mining and Metallurgical Bulletin*, v. 97, no. 1083, p. 1–6.
- Cormier, J., 2010, Acid mine drainage as a sustainable solution to eliminate risk and reduce costs, in: *The Organizing Committee of the 14th International Conference on Tailings and Mine Waste*, editor, *Tailings and Mine Waste 2010*: Taylor and Francis, London, UK.
- Davies, J.F., Gibson, H.L., and Whitehead, R.E.S., editors, 1992, *Exploration and Mining Geology*, Special Issue, v. 1, p. 93–207.
- Douglas, R.P., 1965, The Wedge mine – Newcastle–Bathurst area: *Canadian Mining and Metallurgical Bulletin*, v. 58, no. 635, p. 290–296.
- Dufresne, N., 1981, The evolution of mining methods used at Brunswick Mining and Smelting: *Canadian Mining and Metallurgical Bulletin*, v. 74, no. 825, p. 101–109.
- Fauteux, L., Dasys, A., Gaultier, P., and Johnson, R., 1995, Mechanic's stethoscope: a technology transfer model: *Canadian Mining and Metallurgical Bulletin*, v. 88, no. 994, p. 47–50.
- Gallagher, D., editor, 1997, *Noranda Mining and Exploration: New Brunswick Divisions Magazine*, May, 11 p.
- Gallagher, D., 1999, Heath Steele: Noranda Inc., Bathurst, NB, 87 p.
- Goodfellow, W.D., McCutcheon, S.R., and Peter, J.M., editors, 2003, *Massive sulfide deposits of the Bathurst Mining Camp, New Brunswick, and northern Maine: Economic Geology Monograph* 11, 930 p.
- Grebenc, F.J., and Welwood, R.J.R., 1971, *The Brunswick Story: Brunswick Mining Operations*: *Canadian Mining and Metallurgical Bulletin*, v. 64, no. 713, p. 37–43.
- Jarratt, M., editor, 2012, *Brunswick Mine, The End of an Era: Xstrata Zinc Canada*, Bathurst, NB, 195 p.
- Jensen, T., Blakley, I.T., Jacquemin, T., and Woods, S.C., 2018, Technical report on the Caribou Mine, Bathurst, New Brunswick, Canada: Roscoe Postle Associates Inc., prepared for Trevali Mining Corporation, 238 p. Available from: https://www.sedar.com/search/search_en.htm.
- Kenny, J.L., 1997, A new dependency: state, local capital, and the development of New Brunswick's base metal industry, 1960–70: *The Canadian Historical Review*, v. 78, p. 1–39, <https://doi.org/10.3138/CHR.78.1.1>.
- Lentz, D.R., editor, 2006, *Volcanic-hosted massive sulfide deposits and their geological settings in the Bathurst Mining Camp, New Brunswick: Exploration and Mining Geology, Special Issue*, v. 15, p. 1–261.
- Luff, W.M., 1995, A history of mining in the Bathurst area, northern New Brunswick, Canada: *Canadian Mining and Metallurgical Bulletin*, v. 88, no. 994, p. 63–68.
- McTavish, S., 1980, Flotation practices at Brunswick Mining: *Canadian Mining and Metallurgical Bulletin*, v. 73, no. 821, p.115–120.
- McCutcheon, S.R., and Walker, J.A., 2019, Great mining camps of Canada 7. The Bathurst Mining Camp Part 1: Geology and exploration history: *Geoscience Canada*, v. 46, p. 137–154, <https://doi.org/10.12789/geocanj.2019.46.150>.
- McCutcheon, S.R., Luff, W.M., and Boyle, R.W., 2003, The Bathurst Mining Camp, New Brunswick, Canada: History of discovery and evolution of geologic models: *Economic Geology Monograph* 11, p. 17–35.
- Petruk, W., and Hughson, M.R., 1977, Image analysis evaluation of the effect of grinding media on selective flotation of two zinc–lead–copper ores: *Canadian Mining and Metallurgical Bulletin*, v. 70, no. 782, p. 128–135.
- Petruk, W., and Schnarr, J.R., 1981, An evaluation of the recovery of free and unliberated mineral grains, metals and trace elements in the concentrator of Brunswick Mining and Smelting Corporation Ltd.: *Canadian Mining and Metallurgical Bulletin*, v. 74, no. 833, p. 132–159.
- Pollock, J.C., 2019, Great mining camps of Canada 6. Geology and history of the Wabana Iron Mines, Bell Island, Newfoundland: *Geoscience Canada*, v. 46, p. 69–83, <https://doi.org/10.12789/geocanj.2019.46.148>.
- Sim, R.C., and Davis, B.M., 2008, Technical report Chester copper property New Brunswick, Canada: First Narrows Resources Corporation, Technical Report NI 43–101 June 3, 2008, 88 p. Available from: https://www.sedar.com/search/search_en.htm.
- Simser, B., and Falmagne, V., 2004, Seismic source parameters used to monitor rock-mass response at Brunswick mine: *Canadian Mining and Metallurgical Bulletin*, v. 97, no. 1080, p.58–63.
- Whaley, K.D.A., 1992, The Captain North Extension (CNE) Zn–Pb–Ag deposit,



Bathurst District, New Brunswick: Exploration and Mining Geology, v. 1, p. 143–150.

White, R., and Rose, B., 2012, Rockburst support in high stress areas at Brunswick Mines (Presentation): Xstrata Zinc Canada, Sudbury, ON. Available from <https://www.workplacesafetynorth.ca/sites/default/files/resources/Rockburst%20Support%20in%20High%20Stress%20Areas%20at%20Brunswick%20Mines.pdf>.

Zhang, Y.H., Arsereau, G., Holland, L., and Barrett, J., 2014, Technical Report on

preliminary economic assessment for the Caribou massive sulphide zinc–lead–silver project, Bathurst, New Brunswick, Canada: SRK Consulting (Canada) Inc., prepared for Trevali Mining Corporation, 169 p. Available from: <https://secure.kaiserresearch.com/i/jk/tr16/TRTV20140513.pdf>.

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