Cold Regions Science and Technology 85 (2013) 1–14

Contents lists available at SciVerse ScienceDirect

Cold Regions Science and Technology

journal homepage: www.elsevier.com/locate/coldregions

Invited Review Paper

The Arctic Islands Adventure and Panarctic Oils Ltd.

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A R T I C L E I N F O

Article history:
Received 12 May 2012
Accepted 19 June 2012

Keywords:
Arctic
Arctic Islands
Oil and gas exploration
Ice
Ice structures
Drilling

A B S T R A C T

The story of oil and gas exploration in the Arctic Islands of Canada and in the Sverdrup Basin of that region is largely the story of Panarctic Oils Limited. Panarctic was incorporated May 27, 1966 by Federal Letters Patent and operations started in 1968 with the first seismic work. J.C. Sproule of Calgary was a major force behind its formation. Panarctic was an industry/government consortium established to explore for oil and gas in the Canadian Arctic Islands, with up to 37 participating companies. Panarctic drilled 150 wells over an area measuring some 850 by 1200 km. The most northerly well was located approximately 80°45′ N on Ellesmere Island and the most southerly well was at 72°40′ N on Prince of Wales Island. 38 of these wells were drilled offshore from floating ice platforms in water depths of up to 550 m. 500 km^3 (17.5 trillion ft^3) of natural gas reserves was discovered over this period and small oil reserves were discovered at Bent Horn. All of the offshore wells attempted were drilled, logged and tested as planned, a proof of the viability of using ice as a support for drilling. In spite of large distances, extreme weather and permafrost, the operations were successful and had no lasting effect on the environment. This paper summarizes the significant achievements over Panarctic's history from inception to 1986 when operations ceased.

Contents

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doi:10.1016/j.coldregions.2012.06.008

1. Introduction

Panarctic Oils Ltd. was an industry/government consortium established to explore for oil and gas in the Canadian Arctic Islands, with up to 37 participating companies. Panarctic drilled 150 wells over an area measuring some 850 by 1200 km. The most northerly well was located approximately 80°45′ N on Ellesmere Island and the most southerly well was at 72°40′ N on Prince of Wales Island. 38 of these wells were drilled offshore from floating ice platforms in water depths of up to 600 m. In conjunction with Panarctic's operation, the Polar Gas Pipeline Project planned several proposed pipeline routes to transport natural gas from the islands, across the Northwest Territories and Nunavut, to markets in the south. Later, The Arctic Pilot Project proposed to transport 250MMSCFD of gas from Melville Island in the Canadian Arctic to markets in Eastern Canada. To do this the gas was to be pipelined from the Drake Point gas field to Bridport Inlet on the South Coast of Melville Island where it would be liquefied and loaded on ice-breaking LNG carriers for transportation to a regasification terminal in Eastern Canada (Milne, 1979).

Weather, particularly frigid temperatures, high winds and blowing snow causing poor or no visibility and distance were of course significant challenges. Transportation of drilling rigs and supplies between wellsites (some of which could be on separate islands) was a major effort and required careful planning and disciplined execution with constant communication (Baudais et al., 1976; Franklin, 1983). White outs, or arctic snow storms caused by blowing ground snow, often stopped operations for several days. Not only was travel and work impossible at these times, but there was also considerable digging out at the end of the storm before normal work could proceed.

Communications during the earliest times of operation consisted of HF radio transmission directly from the drilling rigs to head office in Calgary. This worked much of the time and succeeded in providing vital communication. However, for a significant part of the time the HF link was interrupted by atmospheric magnetic storms which are more prevalent in polar regions. At times a week would go by without drilling reports. Those reports that got out came out in paper form by airplane on a crew change. VHF radio was used in air to ground communications and in hand held radios on the wellsite which had limited range.

In 1974 Panarctic was the first Canadian commercial user of satellite earth stations for telephone and teleprint communications. The satellite system provided by Telsat Canada provided a dependable and effective link between Rea Point and Calgary. In 1982 the introduction of computer-based data service by HF radio between outpost sites and Rea Point further enhanced communications between head office and the work sites. VHF line of site communication via aircraft was sometimes used to relay reports to Rea Point during HF blackouts.

Panarctic drilled its first exploratory well in 1969 with a drilling rig flown from Yellowknife. In total, Panarctic drilled 112 onshore wells, using conventional land rigs. Transportation of the rigs and supplies was accomplished either by aircraft or overland by vehicles such as trucks and/or tracked or rubber tired all-terrain vehicles. Panarctic has also drilled 38 offshore wells using modified land rigs. The rigs were supported by floating ice platforms constructed with thickened sea ice in water depths ranging from 55 m to 550 m (Baudais et al., 1976; Hood et al., 1976; Masterson et al., 1987). Fig. 1 shows the wellsites.

Well costs were relatively low for a frontier area, an onshore well being drilled to a depth of 3000 m for $11–12 million. An offshore well of similar depth could be drilled for $22–23 million and in the early days (1969 to mid 1970s) wells were drilled for $2 to $4 million, a cost comparable to deeper wells in the south. Later wells cost more because of several factors, including increased depth of the wells necessitating larger and more sophisticated rigs and because the operation included more stringent health and safety measures and more sophisticated and costly camps and related support.

Additional 37 wells were drilled by other operators in the Arctic Islands. The first well drilled in the Arctic Archipelago, Dome et al. Winter Harbour #1 was drilled in the winter of 1961–62 to 3828 m using a rig which was transported by ship.

A background on the Arctic Islands and its Sverdrup Basin geology is given in Meneley (2006). Fig. 2 shows the main geological provinces of the Arctic Islands and the Sverdrup Basin therein where Panarctic concentrated its efforts. Figs. 3 and 4 provide additional information on the drilling and discovery history in the Sverdrup Basin and on total wells drilled in northern Canada by year.

Figs. 5 and 6, taken from the Glenbow Archives (http://ww2.glenbow.org/search/archivesPhotosResults.aspx?AC=GET_RECORD&XC=/search/archivesPhotosResults.aspx&BU=&TN=IMAGEBAN&SN=AUTO12682&SE=330&RN=0&MR=10&TR=0&TX=1000&ES=0&CS=0&XP=&RF=WebResults&EF=&DF=WebResultsDetails&RL=0&EL=0&DL=0&NP=255&ID=&MF=WPEngMsg.ini&MQ=&TI=0&DT=&ST=0&IR=35337&NR=0&NB=0&SV=0&BG=&FG=&QS=&OEX=ISO-8859-1&OEH=ISO-8859-1), show Panarctic's camp at Sherard Bay which in summer provided an alternate landing strip to Rea Point since initially it did not have a serviceable year-round airstrip capable of accommodating heavy aircraft. There was a serviceable year round Twin Otter strip at Rea Point so sea lifted supplies could be moved to and from Rea Point by Twin Otter and then to the rig sites (Drake and Hecla) by helicopter (Fig. 12).

2. Seismic operation

Exploration for petroleum in the Arctic Islands required the acquisition of seismic data over vast areas of the land and ocean. Aboriginal Affairs and Northern Development Canada, n.d. (see reference) has listed figures for this area, shown in Table 1.

Of the 44,242 km of seismic line run in the islands, Panarctic ran a total of 35,000 km with approximately 16,000 km being run over the offshore ice pack in late winter or spring. Shot holes were drilled through the ice, mostly at intervals of 67 m or 220 feet and 134 m or 440 feet. Between 1971 and 1980, the ice thickness at each of these holes was measured and logged. 83,606 measurements of thickness were recorded and this data was assembled into statistical reports by Vernon Wetzel of Sun Oil in Calgary. Fig. 8 summarizes the data, a unique and valuable set of ice thickness information.

3. Sealift

The majority of the equipment, including drilling rigs, supplies, and fuel required to drill wells at remote sites in the islands, was sealifted into Rea Point annually (Baudais and Franklin, 1986). A short two week window in late August/early September provided open water or pack ice conditions. Oceangoing freighters and tankers with Lloyds 100 A-I ice class hulls normally were loaded in Montreal and traveled to Rea Point via the east coast of Labrador and Baffin Island, Lancaster Sound, Barrow Strait and Byam Channel. The ships were usually escorted by a Canadian Coast Guard ice breaker. The freighters were commonly in the 1750 to 8000 tonne range and the tankers in the 16,000 to 36,000 tonne range.

At Rea Point, the freighters were positioned parallel to the beach, approximately 10 m offshore and tied off. A small barge was placed between the ship and shoreline and earth ramps were pushed up to the barge. Unloading then proceeded using the ship's cranes to the barge. Forklifts and conventional trucks were then used to move materials to storage yards in Rea Point. For fuel transfer, the tanker normally nosed in to the beach and maintained its position with thrusters or main propulsion. Floating hoses were pulled out to the tanker from shore and the ship's pumps were used to pump the fuel 2.75 km, through a 254 mm pipeline, to an eight million liter steel tank near the camp.

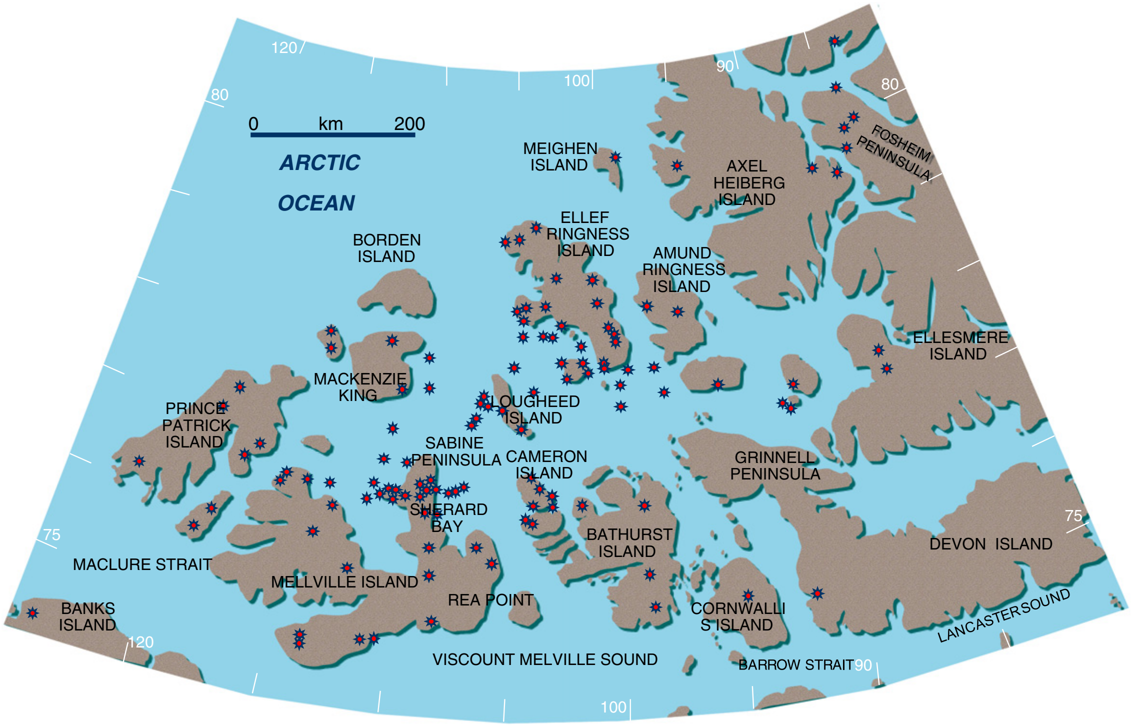

Fig. 1. Arctic Islands map.

The Rea Point base camp is shown in Figs. 9 and 10. Dense, wind drifted snow was a continual challenge and caused untold hours of man and machine effort to dig out and remove it from runways, yards and roads. The annual sealift with the ship "at dock" is shown in Fig. 11.

Table 2 contains a summary of tonnage, fuel volumes and number of wells drilled in the last 5 years of Panarctic's operations.

When a new rig was not required until the following January or February to drill an offshore well, the high cost components, commonly comprising the high weight/low bulk items, were trucked from Edmonton to Hay River or Yellowknife and flown by Hercules directly to the wellsites.

4. Onshore wells

Normally onshore wells were drilled in the fall since the cost of an onshore well might increase by $0.8 to $1.0 million or 7% to 8% of its total cost if it were drilled over the summer. The reason for the increase in cost consisted of the need to completely stockpile a summer location with supplies before the surface melted and became untrafficable. After this all crew, perishable food and supplies that were not stockpiled could only be moved in or out by helicopter.

The well location was surveyed, staked and the site visually marked with several empty gasoline drums. Then construction equipment and

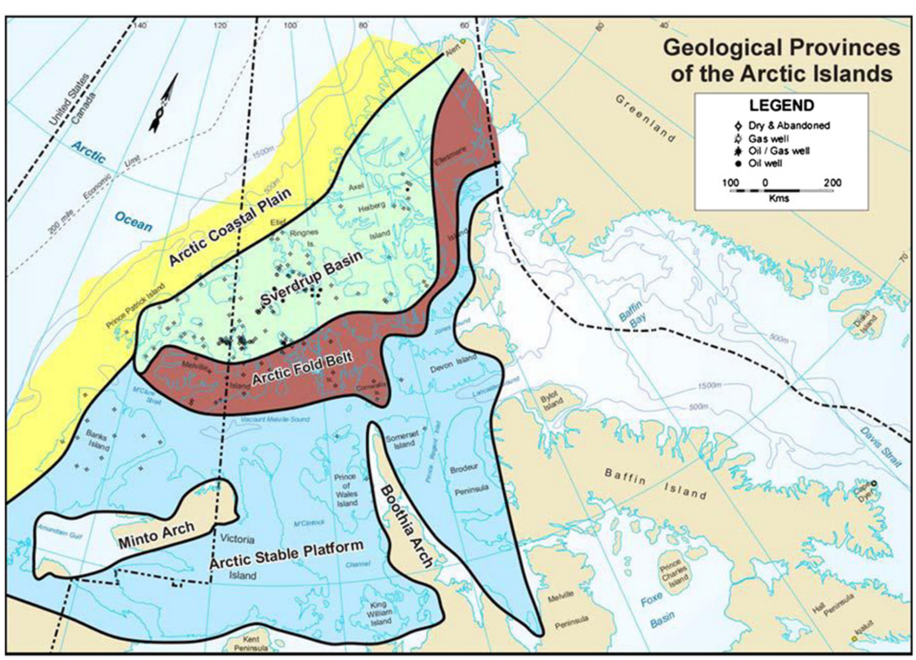

Fig. 2. Geological provinces of the Arctic Islands.

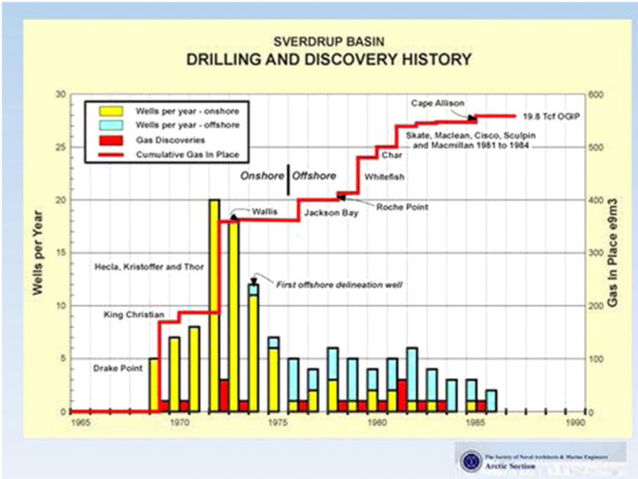

Fig. 3. Drilling and discovery history.

an advance camp were brought in by Cat train if the equipment was located on the same island and distances were under 200 km.

Fig. 12 shows a Sigorsky S61 helicopter which was used to deliver construction equipment and camps to sites at start-up. The S61 could carry a payload of approximately 3000 kg and would lift in a D-4 Cat with the blade removed. Fig. 13 shows an all-terrain Delta Commander, built by Foremost Industries of Calgary, which hauled loads to remote sites.

5. Airstrip preparation

A crew prepared a 400 m long × 25 m wide Twin Otter airstrip as close as possible to the wellsite. A Hercules airstrip was, where possible, an extension of the Twin Otter airstrip and had the dimensions of 60 m wide × 1800 m long. The airstrip was normally cleared free of deep snow with bulldozers and graders and then leveled as much as possible. 20–40 mm of snow left on the strip surface filled small depressions when the strip was dragged or graded. Soil disturbance was kept to a minimum for environmental reasons and also for practical operational reasons.

Subsequent trips with the Hercules brought in

- a 20–30 man advance camp
- larger generators
- incinerator
- aircraft refueling unit
- bladder type fuel storage tanks.

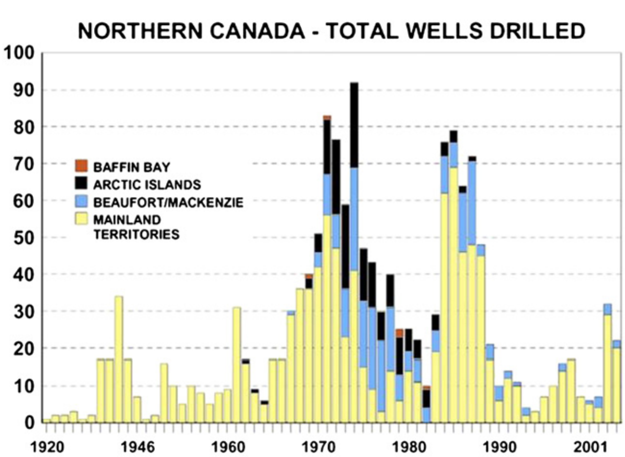

Fig. 4. Total wells drilled in northern Canada.

Fig. 5. Sherard Bay camp.

Trucks and heavy equipment were flown in to construct a pad for the drilling rig and a small self-propelled drilling rig and 25–50,000 kg of explosives were flown in to construct a mud disposal sump for the drilling operation.

6. Onshore rig move

An 80 man rig camp was the first item to be flown in to a rig site, the loads being sequenced to fly insulation and rig matting to the location on the first trips. Subsequent rig loads were then flown to the site in their proper sequence as rig up progressed. Good communications between supervisors at both ends of the move and load

Fig. 6. Sherard Bay camp.

Fig. 7. Tracked camp for Big Indian Drilling Rig 3. On Ellef Ringnes Island near Kristoffer Bay. The rig drilled shallow holes to determine the depth of the permafrost. The depth varied from 200 m to 400 m.

sequence flexibility, governed by the rig up progress, minimized the number of times a load was handled.

Two special pieces of equipment were required

– A 25 metric tonne crane scale to weigh all loads before transport by the Hercules.

Table 1
Arctic Islands: Sverdrup and Franklinian basins.

Area	Arctic stable platform 780,000 km^2 (47% onshore) Arctic fold belt 240,000 km^2 (60% onshore) Sverdrup Basin 313,000 km^2 (46% onshore)
Discoveries	First discovery in 1969 (Panarctic Drake Point N-67; gas): 18 subsequent discoveries (8 gas; 7 oil and gas; 3 oil)
Discovered resources	Gas: 407 × 10^9 m^3 Oil: 66 × 10^6 m^3
Production	Gas: none Oil: Bent Horn 321,470 m^3 to the end of 1993
Total number of wells	177 (192 including delineation/development wells?)
Average well density	1 well per 1630 km^2 in the Sverdrup Basin, 1 per 7000 km^2 in the Arctic Islands region
Seismic coverage	44,242 km
Pipelines	None
Area under licence	13,000 km^2 (or 37,500 km^2 if restricted areas included)

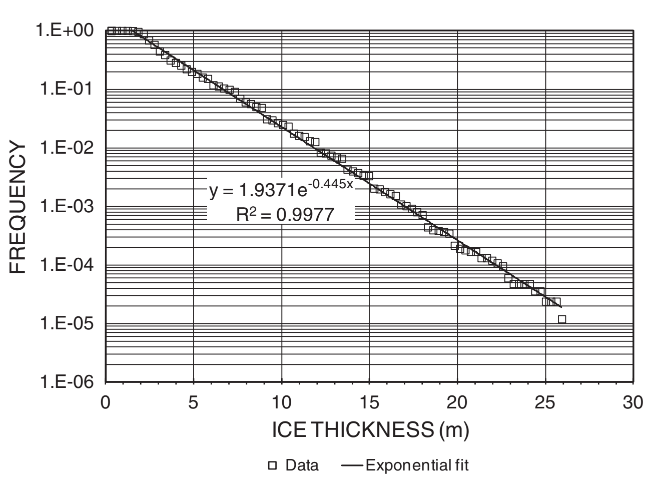

Fig. 8. Arctic Islands ice thickness exceedance plot — data from seismic programs.

Fig. 9. Rea Point base camp — Sabine Peninsula.

– a specially designed tandem low bed truck trailer with an overall width of 2.7 m and a deck approximately 1 m above ground level when loaded.

A summary of loads for establishing an onshore rig site is given in Table 3.

Fuel was flown from Rea Point by Hercules and stored in collapsible rubber bladders, shown in Fig. 15. A rig move normally took 12–25 days, depending on weather conditions and Hercules serviceability. Delays due to fog and blowing snow were common. Despite the extremely cold ambient temperatures, aircraft downtime for maintenance was minimal. A Hercules rig move would add $1.5–$1.8 million to the cost of a well. Fig. 14 shows a Hercules being loaded. Heavy oilfield trucks as shown in Fig. 16 were commonly used for and over ice transport. A typical land camp and rig are shown in Figs. 17 and 18. In Fig. 19 a blast is used to provide a pit for garbage burial in the permafrost. Fig. 20 shows a pickup truck negotiating a difficult near shore ice road. Fig. 21 depicts burning garbage in a permafrost pit. Large portable tent structures formed buildings and shelters as shown in Fig. 22.

7. Air support

Initially supplies such as fuel, food, repair parts and small equipment were flown into the wellsite from Rea Point by Twin Otter (Fig. 23). Crew changes were effected weekly by air and consisted of 25–35 people from each rig plus other personnel. When the airstrip was approved for the 727/737 jet aircraft, crew and supplies were flown directly to the wellsite from Edmonton (Figs. 24 and 25). These aircraft routinely landed on the ice at offshore wells.

A summary of freight and passenger northbound/southbound air transport is contained in Table 4.

Fig. 10. Where is my truck?

Fig. 11. Rea Point sealift.

8. Offshore wells

Offshore well locations were selected from seismic work conducted from the ice in late winter. In the following year, the proposed well location was surveyed when stable ice occurred in late October/early November. The wellsite was staked and a location for a future Hercules airstrip was selected. Preference was for smooth multi-year ice, but smooth first year ice was also suitable. Very rough multi-year ice could be used, however, the extra time required to level the ice surface made this the least desired choice.

Table 2
Tonnage and well summary.

Year	Total		Number of wells drilled
	Dry cargo	Total fuel	
	Tonnes	Liters × 10^6	
1980	4934	15.31	5
1981	5832	16.36	5
1982	10,131	7.85	5
1983	3403	16.21	4
1984	1110	9.59	4
1985	1036	12.15	3

Fig. 12. Sigorsky S61.

9. Ice movement

A critical component of establishing safe sites for offshore drilling was the determination of lateral movement of the floating ice during the time of drilling. Ice movement could not be larger than five percent of water depth during the drilling of a well. Before a site could be designated as safe for drilling, ice movements had to be measured in prior seasons. Initially this was done via shore based survey techniques using line-of-site and radar instrumentation. Acoustic methods using the seafloor as a reference were also tried. The methods were difficult to employ and often unreliable on a continuous basis. In the 1976–77 winter season, a new satellite surveying method developed by Shell Oil Company was adopted by Panarctic. This method involved positioning receivers on the ice and tracking changes in position using five Polar orbiting satellites, made commercially available at the time by the U.S. Navy. Each satellite individually passed over the Arctic Islands about every 2 h enabling position fixes to be made.

Fig. 13. Delta commander.

Table 3
Onshore well rig load summary.

	Item	Loads
1)	Advance camp	6
2)	Construction equipment	25
3)	Rig camp	20
4)	Drilling rig	82
5)	Mud, cement, casing (incl. contingency)	30
6)	Fuel — 2.05 × 106 l	90
	Total loads	253

Fig. 14. Loading a Hercules C130.

Fig. 15. Fuel storage bladders.

Fig. 16. Truck transport.

Fig. 17. King Christian Island 1974.

The method was accurate to plus or minus one meter. This technique was more economical than conventional surveying stations and more dependable than the acoustic systems. By early 1977, ice movement was being monitored at ten offshore stations. Ice movement at the rig site was also monitored continuously during drilling. Table 5 contains an example of measured ice motion from the W. Hecla P-62 ice platform well drilled in 1976.

10. Airstrip construction

A helicopter transportable 20 man construction camp and equipment was flown from a land based staging area. The camp could be

Fig. 18. Rig 17.

Fig. 19. Blasting a hole in the permafrost.

Fig. 20. A rough road.

set up on a minimum of 1.0 m of sea ice and some flooding might be necessary to build up or level the ice under the camp. Small tracked vehicles equipped with hydraulic ice drills and hydraulic driven flood

Fig. 21. Burning garbage in a pit.

Fig. 22. The “shop” at King Christian Island.

Fig. 23. Loading a Twin Otter.

pumps, small bulldozers equipped with rippers, forklifts, and tracked vehicles were delivered to the site using an S-61 helicopter. A Twin Otter airstrip was constructed as soon as possible after the camp was in place, either on level first year ice or on rough, hummocked multi-year ice. The flooding operation is shown in Fig. 26 and an “ice camp” is shown in Fig. 27.

Fig. 24. Boeing 727 landing.

Fig. 25. Lockheed Electra taking off.

Table 4
Summary of air freight and passenger transport.

Year	Number of flights	Northbound Freight (tonnes)	Southbound Freight (tonnes)	Northbound Number of passengers	Southbound Number of passengers
1980	117	938	458	4972	4902
1981	139	1335	505	6108	6079
1982	144	1282	519	6151	6089
1983	119	949	506	5136	4981
1984	88	728	330	3605	3579
1985	71	613	229	3007	2837

Rough hummocked ice posed a problem. The only effective tool for cutting down ice hummocks was a crawler tractor with ripper attachment. Blasting was tried but the results were slow and unpredictable. The first equipment shipped to a site having a newly constructed Hercules airstrip was usually a D-7 crawler with ripper and dozer and a grader, neither of which could be transported by helicopters available in the Arctic.

11. Airstrip and ice platform

Flooding of the ice platform for rig support proceeded immediately and simultaneously the Twin Otter airstrip was extended in length to a Hercules airstrip. On first year ice, where only flooding was required,

Table 5
Measured ice motion at W. Hecla P-62.

Date	Movement (m)	Drilling
1976-01-08		
1976-01-16	1.6	
1976-01-25	2.1	
1976-01-29	0.5	
1976-01-30	0.6	
1976-02-08	0.5	
1976-02-19	0.8	
1976-03-04	0.0	

Fig. 26. “Imp” flooding.

Fig. 27. Ice camp.

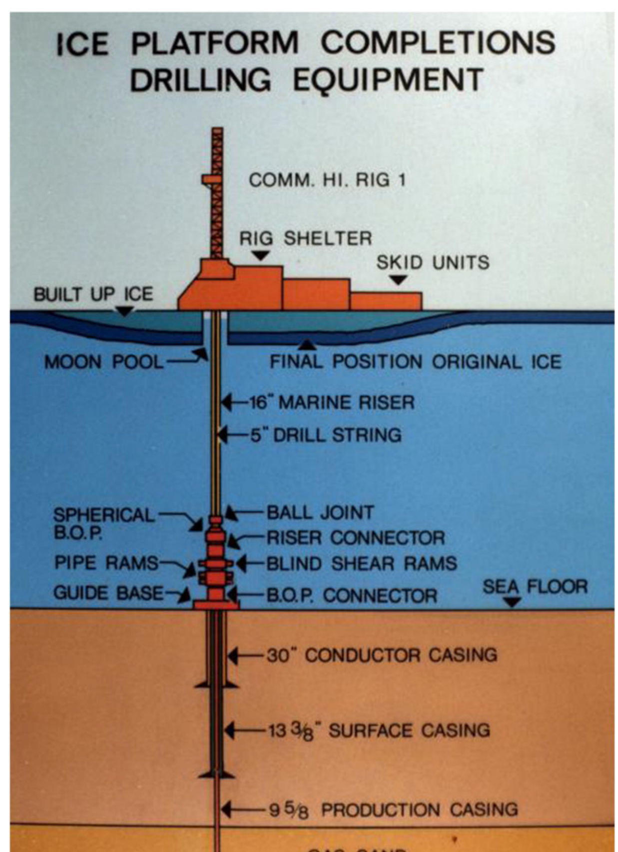

Fig. 28. Section of ice platform and drill assembly.

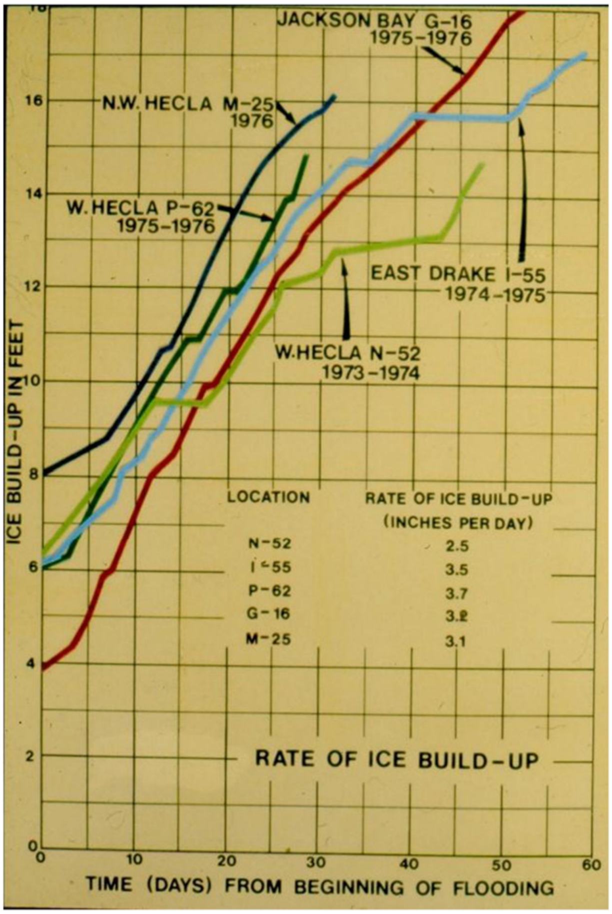

Fig. 29. Ice build-up record.

build-up rates at the airstrip averaged 30 mm/day. The final ice thickness was determined by criteria set out in the Ministry of Transport Specification. For Hercules L-100-30 and Boeing 737 aircraft the required ice thickness was 1.37 m (54 in.).

12. Rig mobilization and storage

The same procedures and equipment for land drilling were used for moving the rig to the ice platform. Once at site, the loads had to be stored on the surrounding ice with proper spacing to ensure that overstressing of the ice did not occur (Masterson, 2009). This was also true for the fuel storage in the rubber bladders and the area around the fuel storage was kept clean of snow to enable early detection of any leaks.

13. Rig design

The original rigs which were sent to the Arctic were an adaptation of conventional rigs designed for southern Canada oilfields, making rig up slow and transportation inefficient. Drifting snow accumulated on the open loads increasing their weight (see Fig. 10 and discussion). As a result, a modular design was adopted wherein a large number of components or combination of components were installed in totally enclosed Hercules sized modules. These could be heated immediately after being positioned in the rig complex and could be stored indefinitely without accumulating snow after the rig was dismantled. On a typical Arctic rig, 34 of the 82 rig loads were totally enclosed modules. The rig matting used under arctic rigs was designed for Hercules aircraft and was used as skids to transport miscellaneous rig components which could not be incorporated into modules.

14. Ice platform drilling

38 wells were drilled from thickened floating ice platforms between 1974 and 1986, this method of drilling being more cost effective than any competitive offshore drilling method. All planned wells were drilled, logged and tested successfully. Water depths ranged between 60 and 600 m. Lateral ice motion during drilling had to be 5% of water depth or less, thus ice motion was continuously measured and reported. The maximum flexural tensile stress in the ice platform under the rig was limited to 550 kPa to avoid failure of the ice or excessive creep deflection over time (Masterson, 2009).

Conventional land drilling rigs weighing up to 1200 tonnes were used to drill the wells. Well duration, including rig-up, drilling, logging and testing, was limited to about 90 days to meet the same season relief well capability which was a regulatory requirement.

Thickening of the natural ice was accomplished initially by flooding using electrical submersible pumps mounted in insulated wells. The ice was thickened from its initial 1.0 m thickness to a final thickness of 6 m yet little surface relief was evident as the ice sank under its own weight to reach its normal freeboard level. Flooding extended well past the design area to provide a tapered edge or transition thickness to the ice platform which would minimize any undue stress in the surrounding ice. The surrounding ice was subject to high load traffic during rig up and drilling operations after construction was finished and this extra flooding procedure ensured the safety of personnel and equipment in the immediate area around the platform.

Fig. 30. Flooding an ice platform.

Fig. 31. Ice platform site.

Average ice build-up rates of 80 to 95 mm/day were regularly achieved. Later, spraying with high pressure pumps – 1400 kPa (200 psi) – was introduced, thus increasing the build-up rate and nearly doubling it to 136 mm/day (Masterson et al., 1987). There was some compromise in strength of the ice but there was a net gain in drilling time of a week to 10 days.

Fig. 28 contains a section of a floating ice platform which was 5 to 6 m thick and supported rigs weighing up to 1200 tonnes including the subsea riser system. Fig. 29 shows the progress of ice build-up over time by flooding. The flooding and platform arrangement are shown in Fig. 30. Flooding occurred in December and early January when there was total darkness for 24 h. An aerial view of an ice platform site is shown in Fig. 31.

15. Moonpools

On first year ice the moonpool through which the well would be drilled consisted of a vertical rectangular shaft 4 m by 3 m constructed by bolting wood planks to corner bracing as shown in Fig. 30. The planks were added as required as the platform was flooded and insulated with urethane foam on the outside. The vertical structure would sink into the ocean as the platform was constructed. The top of the shaft would end up being at final constructed ice surface on platform completion. After rig up the water inside this insulated shaft was thawed out using the drilling rig boilers so that the underwater drilling equipment could be easily lowered through it to the ocean floor.

On thick multi-year ice installation of the moon pool was more difficult. A hole usually 1 m larger than the moonpool liner in both dimensions was cut out of the ice to a depth of 4 to 5 m using conventional chainsaws operated by construction personnel. Larger equipment was usually unavailable at this time since the Hercules airstrip was still under construction. The hole was cut down to a depth where the ice

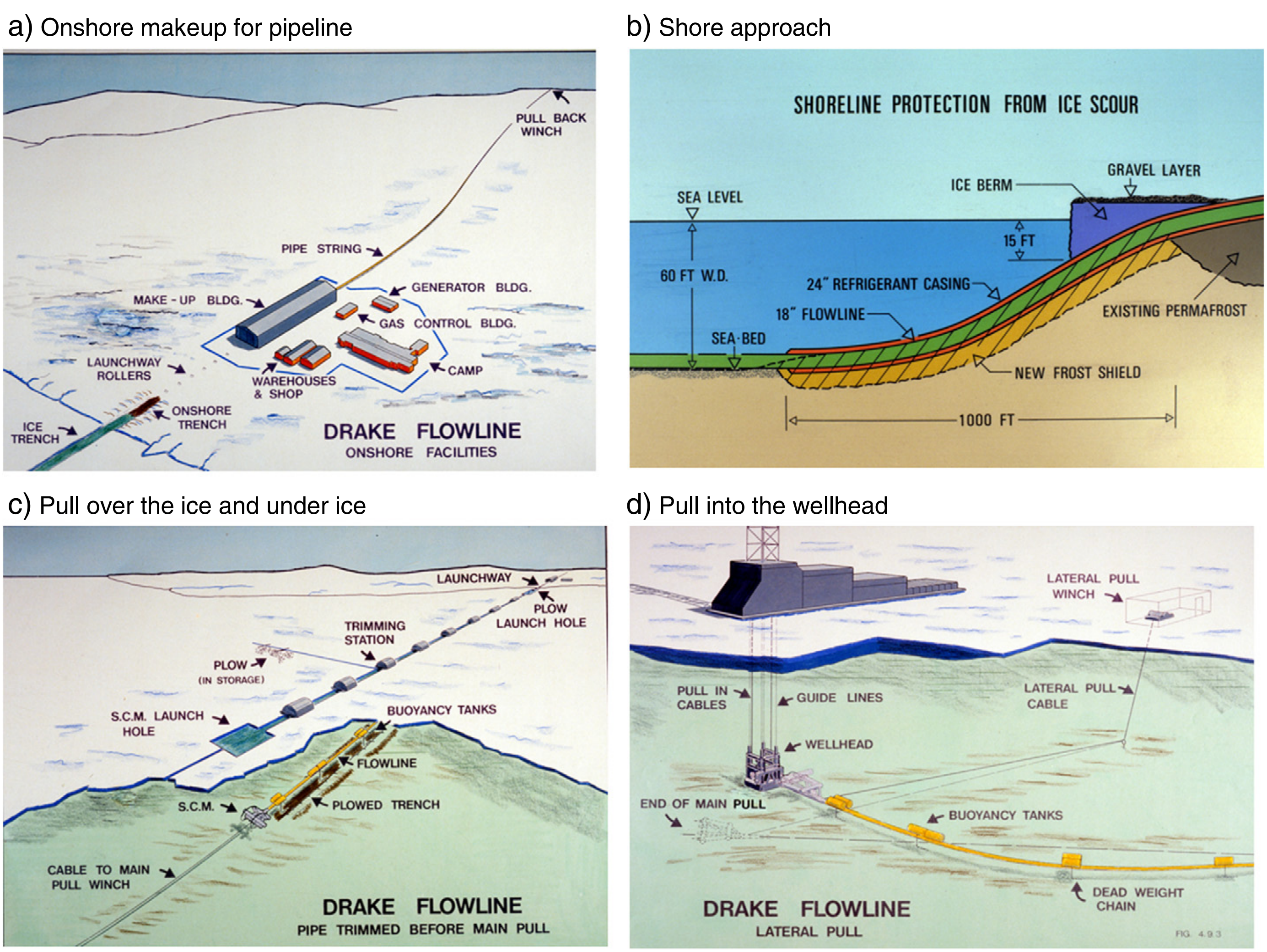

Fig. 32. (a) Onshore makeup for pipeline. (b) Shore approach. (c) Pull over the ice and under ice. (d) Pull into the wellhead.

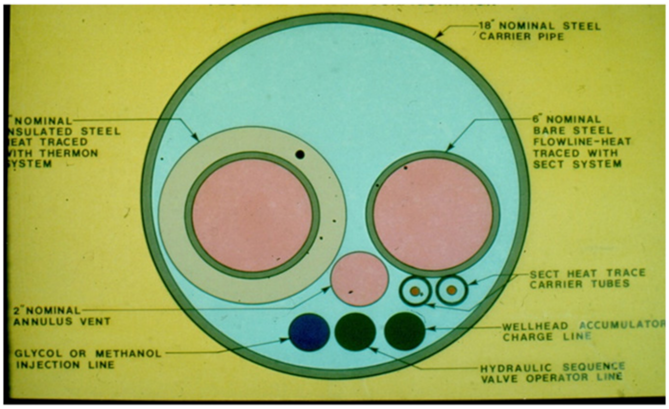

Fig. 33. Flow bundle.

Fig. 35. Lowering pipe through the ice.

thickness on the bottom could withstand the stress induced by the water pressure under it and the moonpool liner planking was constructed in this hole. The space between the ice and the plank liner was then flooded and allowed to freeze for several weeks to ensure solid ice around its perimeter. If water froze inside the moonpool, this was of no consequence as the drilling rig would use steam to clear the required opening later.

16. Ice platform Q.A.

A program of Q.A. (quality assurance) and monitoring during construction and drilling was rigorously followed. During construction the following were monitored

- ice build-up
- pumping hours and rates
- total platform thickness
- ice temperature and strength
- weather information.

Daily reports with all collected data were radioed to Rea Point and then faxed south via a satellite link established in 1975. Personnel on site conducting the monitoring were also responsible for operating the pumps thus making the most efficient use possible of manpower. Basic Q.A. information was also relayed to National Research Council in Ottawa who were the technical experts for the Government of Canada.

17. Monitoring during drilling

During drilling and testing of the well, monitoring consisted of:

- vertical deflection of the ice at the rig and along a profile of stations away from the load
- the rate of vertical deflection with time had to be constant or decreasing and the total deflection had to be less than the total freeboard of the ice platform
- ice temperature and properties
- watching for drilling procedures which would compromise the integrity of the ice platform.

Sometimes warm waste water was improperly disposed of near the moonpool, endangering the foundation of the main rig substructure. The moonpool itself was a wooden cribbing with insulation to minimize heating/melting of the ice. Fresh, cold sea water was circulated in the moonpool and heat removal from the ice was effected using coiled tubing and a heat exchanger.

18. Drake offshore trial gas production

In 1978 Panarctic drilled a production well at Drake Point (Drake F-76) and connected a pipeline to shore to conduct a trial gas production (Hood et al., 1981; Palmer et al., 1979). The well was 1200 m offshore in 55 m of water. Conventional Arctic Island offshore drilling was employed using a Hercules transportable rig founded on a floating ice platform. Two 152 mm flowlines, both heat traced, one insulated and

Fig. 34. Removing ice blocks.

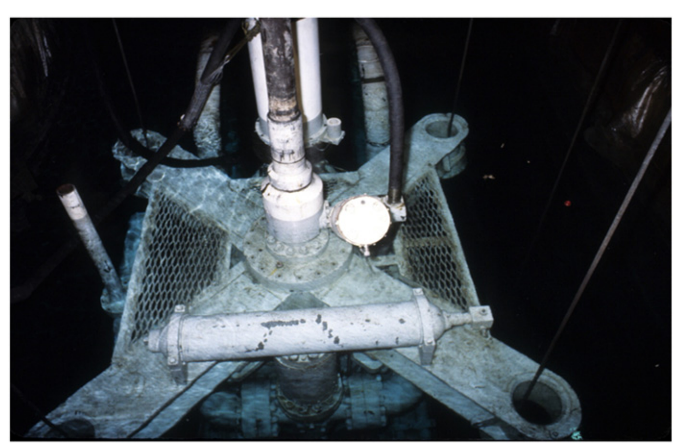

Fig. 36. Lowering the wellhead.

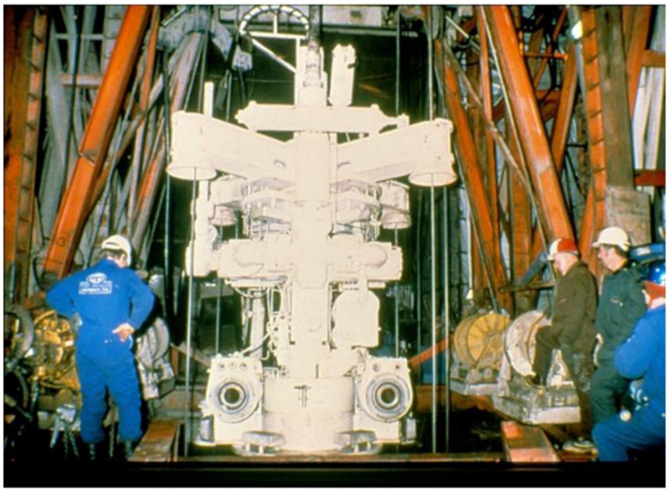

Fig. 37. Wellhead inside the rig.

one not insulated in a bundle were installed. Maximum natural gas flow of 20 m^3/s at 10 MPa pressure was achieved during the flow test.

Fig. 32a, b, c, d illustrates the sequence of the project. Fig. 32a shows the make-up shop and the pipeline ready for pull-out to the offshore production well. The flow bundle section is shown in Fig. 33. Fig. 32b shows the shore approach including burial of the pipe in this region and the permanent ice berm provided to protect the pipe from scour by thick multi-year ice (Palmer et al., 1979). Fig. 32c illustrates pulling the pipe over the ice and lowering it to the seabed through a trench cut in the ice (see also Figs. 34 and 35). Fig. 32d illustrates the connection of the pipeline to the wellhead using a lateral pull method (Hood et al., 1981).

The wellhead, shown in Figs. 36 and 37, was designed to be deployable through a limited size moonpool penetrating the floating ice platform supporting the drilling rig. An aerial view of the covered pipeline onshore and the permanent ice berm covered with gravel is shown in Fig. 38.

19. Drake flow test

After rig release April 28, 1978 further tests were performed to determine

- hydrate formation characteristics
- performance of the insulated and un-insulated lines
- experiment with alcohol injection rates and locations.

The extended production test was terminated May 14, 1978. Afterwards, the well was placed on a continuous low production rate to provide fuel for the test facility and camp. The well was shut in on November 28, 1978 after seven months of operation and in 1995 the well was plugged and abandoned.

20. Bent Horn oil production

Early in 1974 Panarctic discovered the Bent Horn oil field on Cameron Island. The field is a small one, containing about 12 million barrels. In 1985 the first shipment of 100,000 barrels was made by an ice-breaking tanker to a refinery in Montreal. These shipments continued until 1997 when they were discontinued. A total of 2.8 million barrels of oil was produced during this time. The produced oil was stored near shore in a tank as shown in Fig. 39. In late summer the M.V. Arctic arrived and anchored near shore. A flexible hose was strung from the tank to the ship and oil was pumped aboard. This procedure was repeated annually without incident. In some years more than one load of crude oil was shipped south.

21. Conclusion

Exploring for oil and gas in the Canadian Arctic Islands presents enormous physical, logistical and organizational challenges. Exploration began in 1961 and continued until 1986. Panarctic Oils Ltd, an industry/government consortium, was formed in 1966 to pool resources for this challenging and expensive undertaking.

Panarctic's effort formed the principal one, and they drilled 150 wells, 38 of them being offshore from floating ice platforms thickened to between 5 and 6 m. Conventional land rigs were used to drill both the onshore and offshore wells. Rig design was modularized to improve efficiency.

Panarctic collected 35,000 km of seismic line data during the time it operated, 16,000 km of this being from the offshore ice pack. Ice thickness was measured at shot holes drilled through the ice and 83,606 thickness measurements were obtained between 1971 and 1980.

Transportation over large distances under hostile weather conditions was effected using aircraft and overland and over ice vehicles, both standard trucks and all terrain vehicles. Supply of rigs, equipment and bulk material from the south occurred using sealift and Hercules C-130 transport. Crew changes were accomplished by Lockheed Electra and 727/737 aircraft. These aircraft landed on land strips or offshore on strips prepared on the sea ice. Hercules aircraft brought rigs and supplies to the remote locations. 253 loads were required. Helicopters, such as the Sigorsky S61, ferried construction equipment and camps to sites at start-up.

Communications and reporting via HF radio to the south was often challenging and intermittent. In 1975 a satellite link from the Rea Point base camp was established which provided a much more reliable flow of information. Radio communication between Rea Point and the rig sites was often interrupted by magnetic storms in the spring.

Fig. 38. Drake flowline and berm at shore.

Fig. 39. Ship loading at Bent Horn from storage tank.

Well costs were relatively low for a frontier area. An onshore well could be drilled to a depth of 3000 m for $11 to $12 million. An offshore well of similar depth would cost $22 to $23 million. Early wells were drilled for $2 to $4 million. Later wells cost more because of several factors, including increased depth of the wells necessitating larger and more sophisticated rigs and because the operation included more stringent health and safety measures and more sophisticated and costly camps and related support.

Drilling offshore from ice platforms required continuous quality assurance during construction and performance monitoring during drilling. Basic information was relayed south and to NRC in Ottawa as part of the daily construction and drilling reporting.

A trial gas production was completed at Drake F-76 in 1978. An offshore well was drilled from a floating ice platform and a pipeline was connected from shore to the well using the sea ice as a support. Two 152 mm flowlines, both heat traced, one insulated and one not insulated in a bundle were installed. Maximum flow of 10 m^3/s at 10 MPa pressure was achieved during the flow test. The well was shut in in November 1978 and was plugged and abandoned in 1995.

Panarctic discovered a small oil field at Bent Horn on Cameron Island in 1974, and between 1985 and 1997 2.8 million barrels of oil were tankered south during the late summer/early fall period.

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