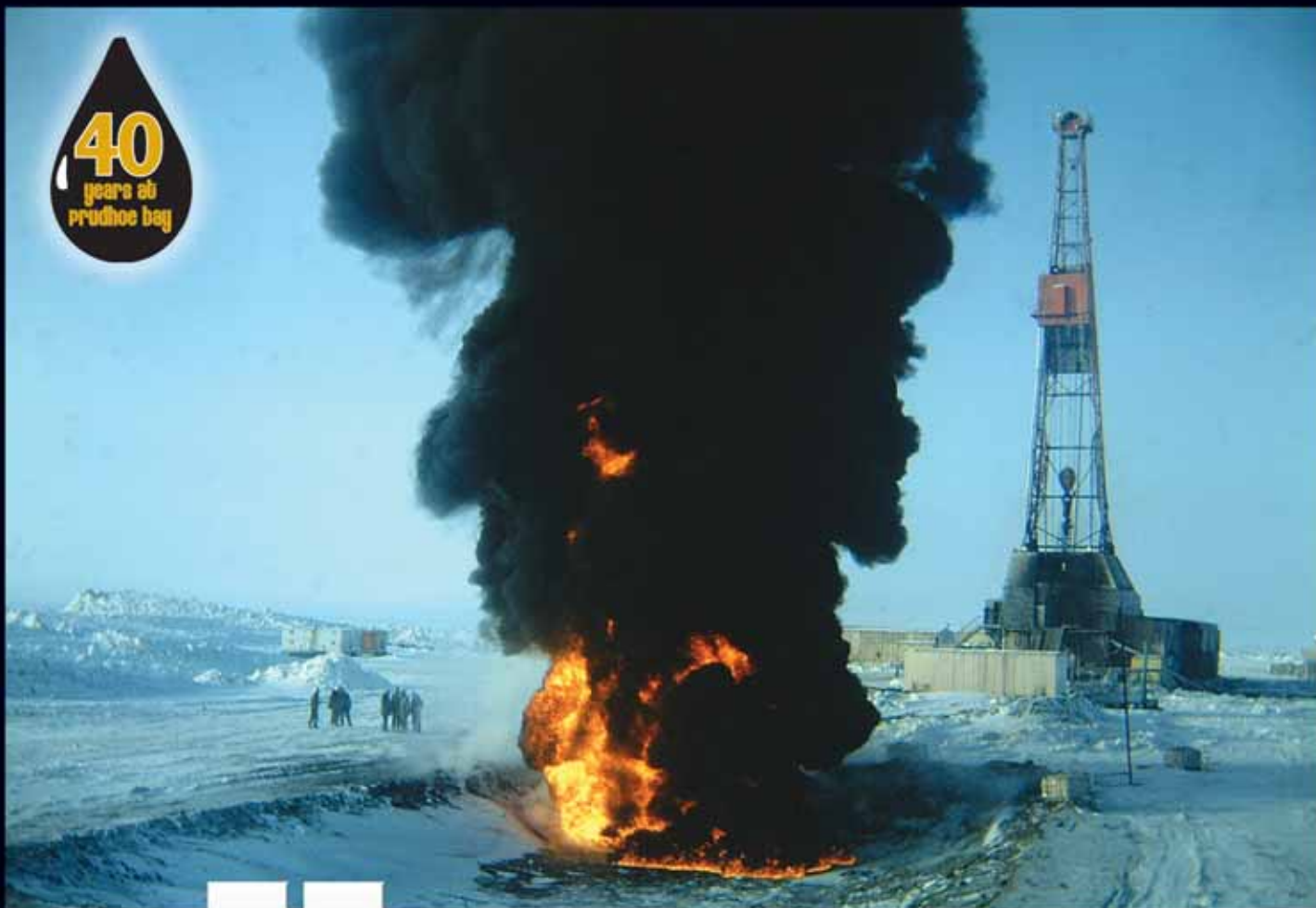


40
years at
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40 years at Prudhoe Bay



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*Main cover photo by Gil Mull.
Cover design by Steven Merritt*

*Printed by Journal Graphics,
Portland, Oregon*



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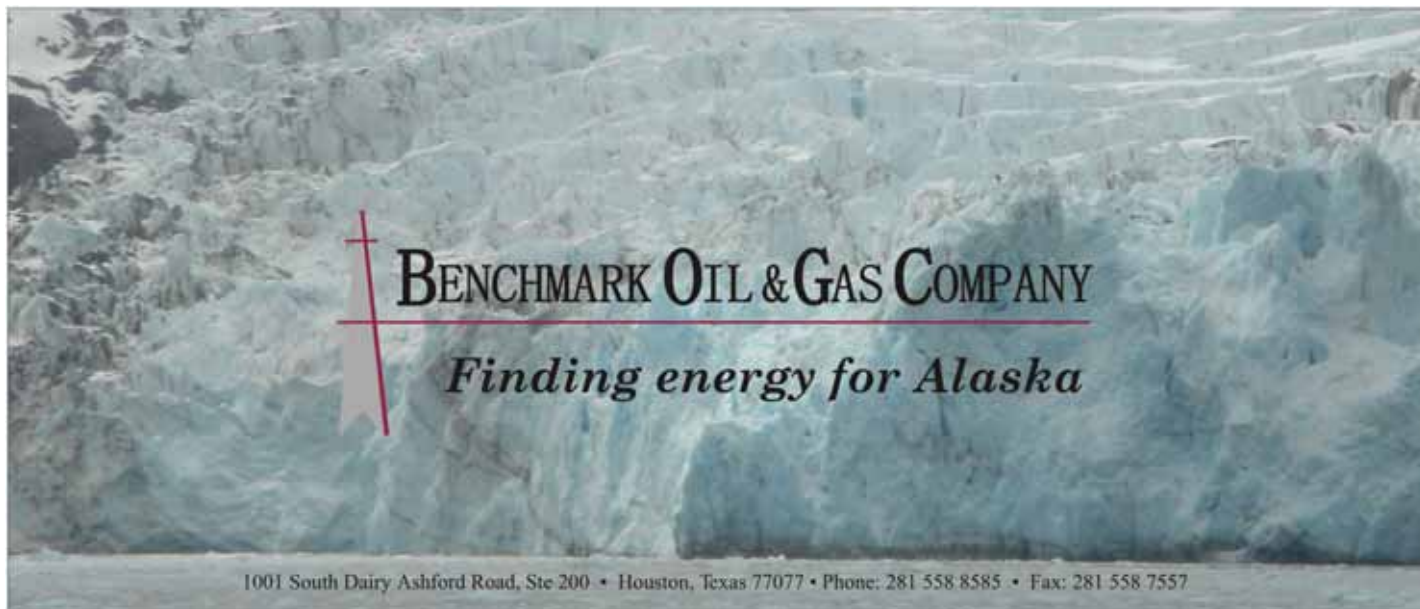
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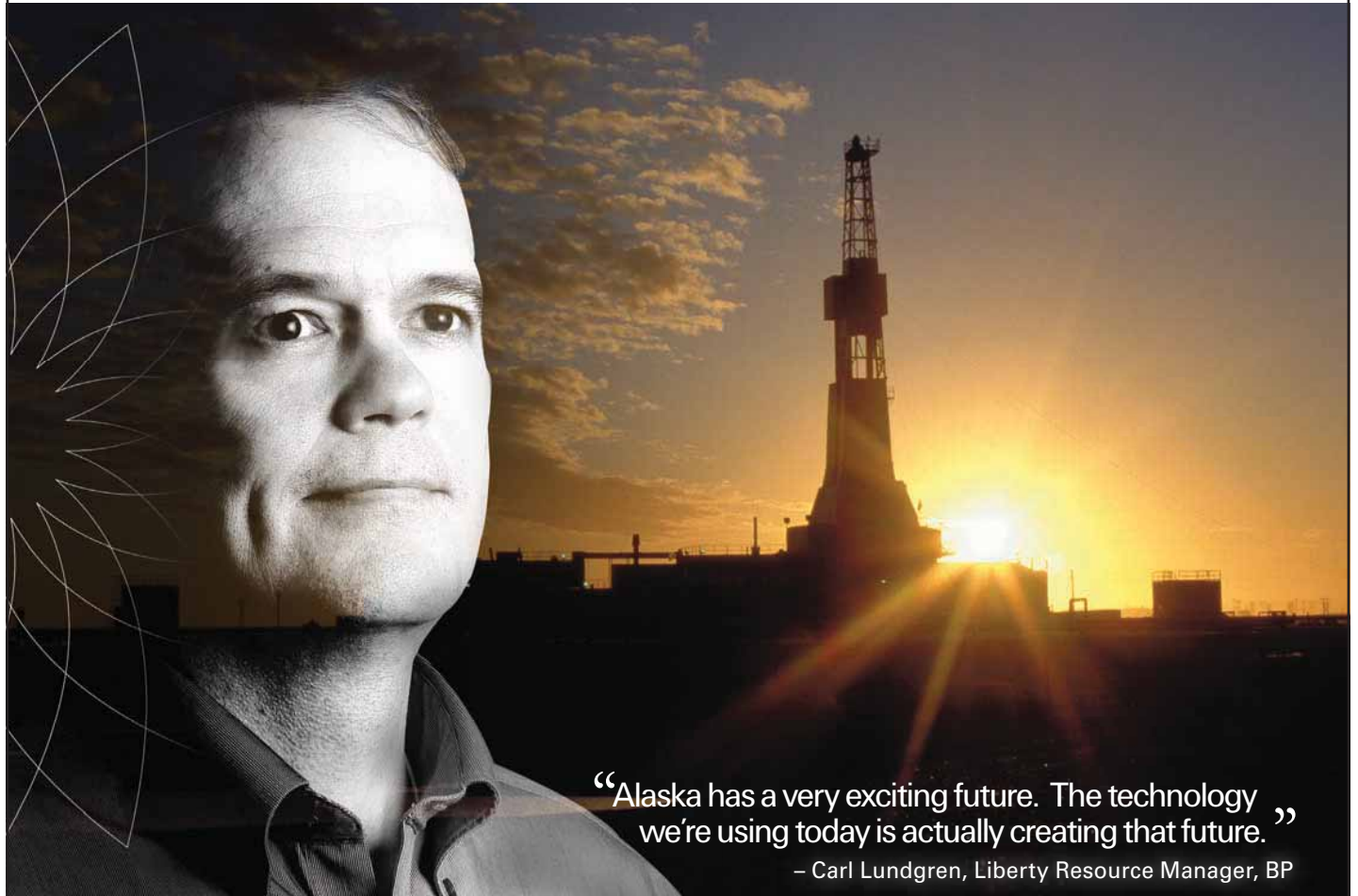
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Company invested in North Slope exploration from the Foothills to the Arctic coast, while others scoffed at area's oil potential



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Special thanks

Editor's Note: Petroleum News owes a tremendous debt of gratitude to retired geologist C.G. "Gil" Mull who helped make this publication possible.

Mull worked alongside other pioneers of 1960s North Slope exploration and was one of several geologists who actually "sat" on Prudhoe Bay State No. 1, the discovery well in 1967 and 1968.

For the past 40 years, Mull has dedicated himself to the study of the geology of Northern Alaska, working for several oil companies, the U.S. Geological Survey, the Alaska Division of Oil and Gas and the Alaska Division of Geological and Geophysical Surveys.

Described by his colleagues as "a walking encyclopedia" of knowledge of Alaska geology, Mull has made contributions that span three generations and numerous industry plays.

A remarkably prolific photographer, Mull has shared his valuable collection of early North Slope photographs with Petroleum News for this publication. Many of the photographs, observations and even articles within these pages are products of Gil's unflagging enthusiasm and dedication to telling the true story of the Prudhoe Bay oil field's discovery and its development.

Thank you, Gil.



C.G. "Gil" Mull at Drill Stem test No. 5. Photo was taken by Bob Jacobs, Interior Airways

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Oil field discovery of the century

Publication strives to recognize people, events that shaped Prudhoe Bay, making petroleum production in Alaska's Arctic a reality

Forty years ago, Prudhoe Bay, North America's largest oil field, was discovered on the windswept coast of Alaska's North Slope. The field, located some 400 miles from the nearest city, Fairbanks, brought worldwide attention to the new and thinly populated state, and thrust it into the forefront of United States oil and gas production.

In "Harnessing a Giant: 40 Years at Prudhoe Bay," Petroleum News has sought to direct much-deserved attention to people and images of that long ago era. We hope to share their stories and photographs in commemorating the 40-year anniversary of the field's discovery and to highlight the importance of its subsequent development and the implications of that development on Alaska, the nation and the world.

Intense scrutiny during the past two generations has centered on construction and operation of the 800-mile trans-Alaska oil pipeline, which transports hydrocarbons from Prudhoe Bay and other North Slope fields to an ice-free port in Valdez. But relatively little attention has focused on the dynamic era that set the stage for the discovery of the Prudhoe Bay field.

Indeed, monuments have been erected to immortalize builders of the pipeline, and yet most people struggle to

name even one member of the Atlantic Richfield Co. team that discovered Prudhoe Bay, the largest oil field in the Western Hemisphere and a major source of U.S. energy for more than 30 years.

How did the discovery of Prudhoe Bay come about? What events led up to this world-changing moment? Who were the key figures in this early period of Alaska's history? And what stories should be immortalized in the saga of the field's discovery and development?

Prudhoe Bay, estimated to contain as much as 15 billion barrels of recoverable crude and nearly 26 trillion cubic feet of natural gas, has transformed the petroleum industry, including the companies that found the field and others that profited from its development as well as subsequent discovery and development of other North Slope fields.

In Alaska, the importance of the Prudhoe Bay field cannot be overstated. Taxes and royalties on the field's petroleum output have accounted for the lion's share of the State of Alaska's public revenue for decades. Even today, 31 years after the startup of the trans-Alaska oil pipeline and first production from the



ROSE RAGSDALE

huge Arctic reservoir, the field still accounts for more than 70 percent of Alaska's total unrestricted revenues, and nearly half of the state's gross state product.

Moreover, Prudhoe Bay's bounty has enabled Alaska policymakers to create the Alaska Permanent Fund, a one-of-a-kind mega savings account currently valued at nearly \$40 billion. From this pot of money, every Alaskan has received a dividend every year since 1980, averaging more than \$1,000 each.

The Prudhoe Bay field is also the backbone of a state economy made robust by oil and gas investment that is directly responsible for thousands of high-paying jobs and tens of thousands of support and service industry positions.

Looking to the future, the impact of the 1968 discovery will continue to be felt by Alaskans and, indeed the nation, for generations to come as industry moves forward with development of giant heavy oil accumulations above and near the Prudhoe Bay field and the field's vast quantities of natural gas. A pipeline carrying 4.5 billion cubic feet per day of natural gas to markets in the Lower 48 states via Canada and to population centers in Southcentral Alaska is on the horizon, and some forecasters predict its completion by 2020 or sooner.

—Rose Ragdsdale, editor

Three Generations of Experience....



From left, Tim Wood, Steve Stuart, & Owen Boyle

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Alaskans remember Prudhoe Bay

By Nancy Pounds

Most Alaskans don't remember what Alaska's economy looked like before the discovery and development of Prudhoe Bay.

Only 14 percent of about 670,000 Alaskans today lived in the state in 1968, the year of the Prudhoe Bay discovery, according to Scott Goldsmith, economics professor at the University of Alaska Anchorage's Institute of Social and Economic Research.

So nearly nine out of every 10 residents today know little about Alaska prior to major development on the North Slope, he said. Goldsmith compared 1968 and 2008 in a recent report called, "How North Slope oil has transformed Alaska's economy."

A few longtime Alaskans, participants and decision-makers during Alaska's major economic changes, recently recalled events of the era.

Roger Herrera

In the late 1960s, a British Petroleum geologist Roger Herrera walked the North Slope foothills and interpreted seismic data. He had joined the international oil producer in 1960.

Herrera saw firsthand the changes for BP and Alaska resulting from oil development on the North Slope.

The Prudhoe Bay find was important on many levels, he said.

BP's early North Slope research focused on the Colville River area, west of

Prudhoe Bay. Geologists gathered data from that area, finding dry holes, even at their best looking above-ground site, Herrera said. It was a big disappointment.

"That's the reason they didn't drill (Prudhoe Bay) first even though they were the biggest landowner. They were licking their wounds," he said.

Also, corporate officials were unwilling to spend more money and take high risks in Alaska.

In 1968, geologists at Atlantic Richfield uncovered promising geological data in the Prudhoe Bay area, and ARCO officials proposed a deal for BP's Prudhoe Bay land, he said. BP then swiftly pursued its own successful Prudhoe Bay research.

The next step to reap the benefit of Prudhoe Bay was construction of the trans-Alaska oil pipeline. "We now had \$50 billion in hardware to build," Herrera said.

"Everyone says the pipeline was the biggest construction project at the time," said Herrera, a retired BP executive who now does consulting work. "But obviously the development of infrastructure at Prudhoe Bay was equally significant. They went hand in hand."

Development on the North Slope proved to be unique, unlike BP's work in the Middle East, he said. The company had to confront permafrost, eight-month-long winters and moving huge quantities of oil, he said. "It was a brand new clean slate,"

see **HERRERA** page 12



ROGER HERRERA

JUDY PATRICK



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Roger Herrera, a young geologist in the 1960s, fished during a break in a North Slope stream.

COURTESY ROGER HERRERA

Early days on the North Slope



Natural oil seeps near Cape Simpson, southeast of Barrow, visible for centuries, were first visited by Natives who collected the surface crude for heating fuel. The seeps first sparked the interest of western explorers in the early 20th Century.

C.G. "GIL" MULL

Oil development spans more than 100 years

Prudhoe Bay field discovery follows decades of exploration and production by geologists, others, on and off the Arctic Slope

By Rose Ragsdale
For Petroleum News

Discovery of the giant Prudhoe Bay oil field in 1968 near the shore of the Beaufort Sea sparked a new era in petroleum exploration and production in North America and changed Alaska forever.

But before geologists narrowed their search to the central North Slope in the mid-1960s, the Arctic Slope of Alaska, that area of coastal plain and foothills north of the Brooks Mountain Range, had been a focus of at least modest geological inquiry for at least 75 years.

Indeed, Alaska oil and gas exploration dates back more than 100 years to wilderness locations rimming the Gulf of Alaska, Cook Inlet and the Alaska Peninsula. Discoveries include the Katalla oil field near Prince William Sound and the town of Cordova in the late 1800s and the Swanson River oil field in the Kenai National Wildlife Refuge in 1957. In fact, at the time of the Prudhoe Bay oil field dis-



Geologist Ernest de Koven Leffingwell spent seven years surveying the Arctic coastline and mapping the geology of the northeastern Brooks Range from 1906 to 1914.

covery in 1968, Cook Inlet oil production was nearing its zenith.

Petroleum development in northern Alaska probably began when Inupiat travelers along the coast discovered natural oil seeps near Cape Simpson, 50 miles southeast of Barrow and 150 miles northwest of Prudhoe Bay, and at Angun (Ungoon) Point, 30 miles southeast of the village of

Kaktovik on Barter Island, within what today is the Arctic National Wildlife Refuge.

Residents of the area traveled to these seeps to cut out blocks of oil-soaked tundra to take back to their homes to use as fuel. These deposits were generally unknown to the outside world until the early 1900s.

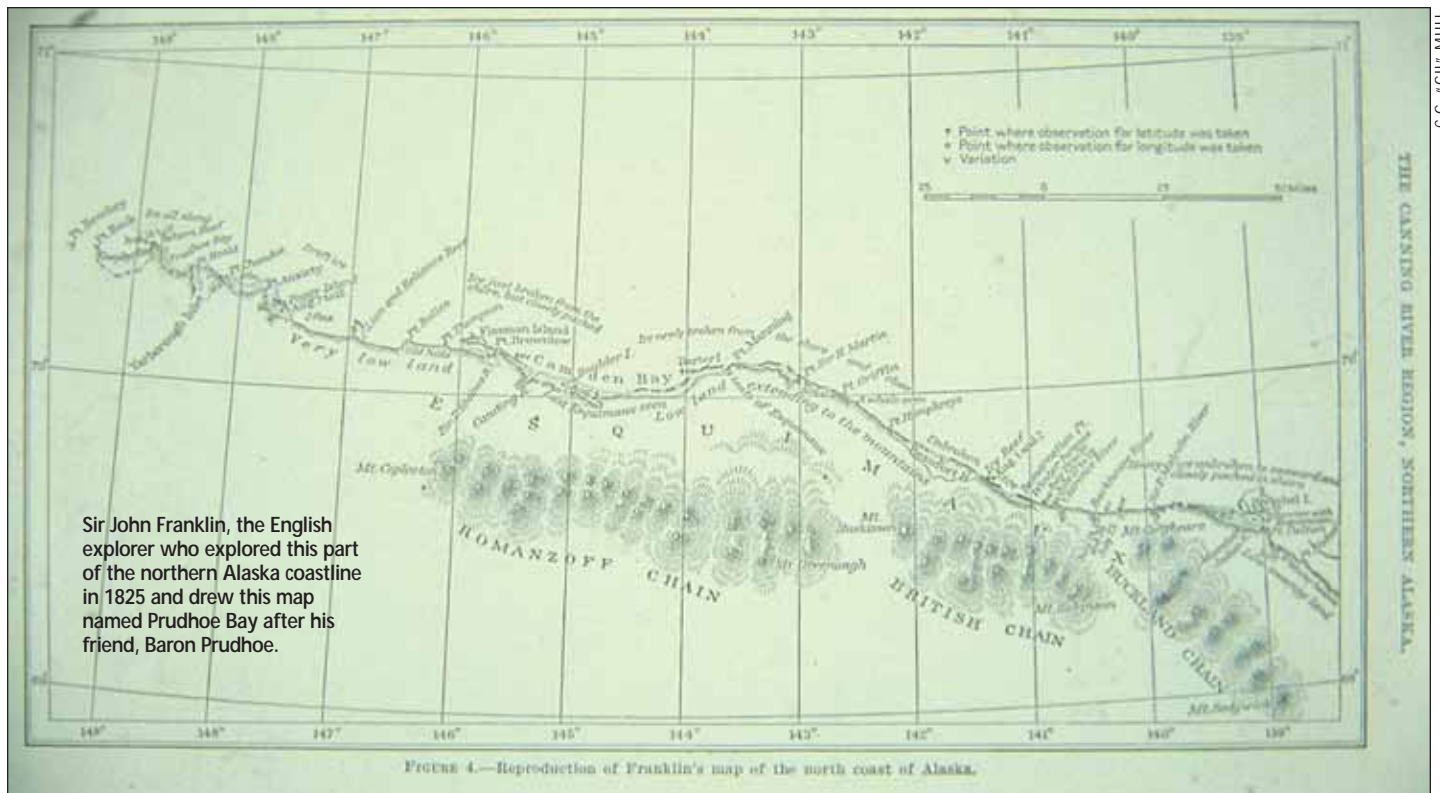
Teacher stakes first claim

The first wildcatter to stake a claim on the North Slope of Alaska was William Van Valin, a U.S. Bureau of Education teacher from the Arctic village of Wainwright. Van Valin had heard stories of an oil lake on the Arctic coast near Cape Simpson southeast of Barrow, so in the summer of 1914 he traveled more than 500 miles to the east side of Smith Bay.

Van Valin's claim included seeps about a mile inland from Smith Bay.

The U.S. government became aware of the oil seeps when Ernest de Koven Leffingwell, a geologist on a privately funded expedition, spent seven years from

COURTESY C.G. "GIL" MULL



Sir John Franklin, the English explorer who explored this part of the northern Alaska coastline in 1825 and drew this map named Prudhoe Bay after his friend, Baron Prudhoe.

1906 to 1914 mapping the geology of what is now the Arctic National Wildlife Refuge and surveying the Arctic coastline. Leffingwell reported what he had learned from locals and sent samples to Alfred H. Brooks, head of the Alaska section of the U.S. Geological Survey, who included the information in a 1909 USGS annual report. In this report, Brooks surmised that there might be a petroleum field in northern Alaska, but thought that it would be of no value owing to the remoteness of the area.

In 1921, Standard Oil Co. of California and General Petroleum Co. sent represen-

tatives to examine the seepages at Cape Simpson. They found two flows, but commercial development did not follow because of more accessible finds in other parts of the country, particularly in California.

"Leffingwell's final report on the Canning River region, published by the USGS in 1919, had even more details about the seeps at Cape Simpson — which was undoubtedly the reason Standard Oil and General Petroleum sent people to look at them," according to geologist Gil Mull.

By 1921, prospecting permits were filed

under the mining laws.

In 1923 during President Warren G. Harding's administration, large areas surrounding the seeps at Cape Simpson and extending south of the crest of the Brooks Range were withdrawn from oil and gas or mineral leasing to become the Naval Petroleum Reserve No. 4 (now National Petroleum Reserve-Alaska) and USGS had begun sending expeditions to the area. During this era following World War I, the Navy had become increasingly aware of its dependence upon oil to fuel its fleet and was concerned about future supplies. ♦

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HERRERA

which caused much nail-biting by BP employees, Herrera said.

"It turned out to be much more expensive" than originally anticipated, he said.

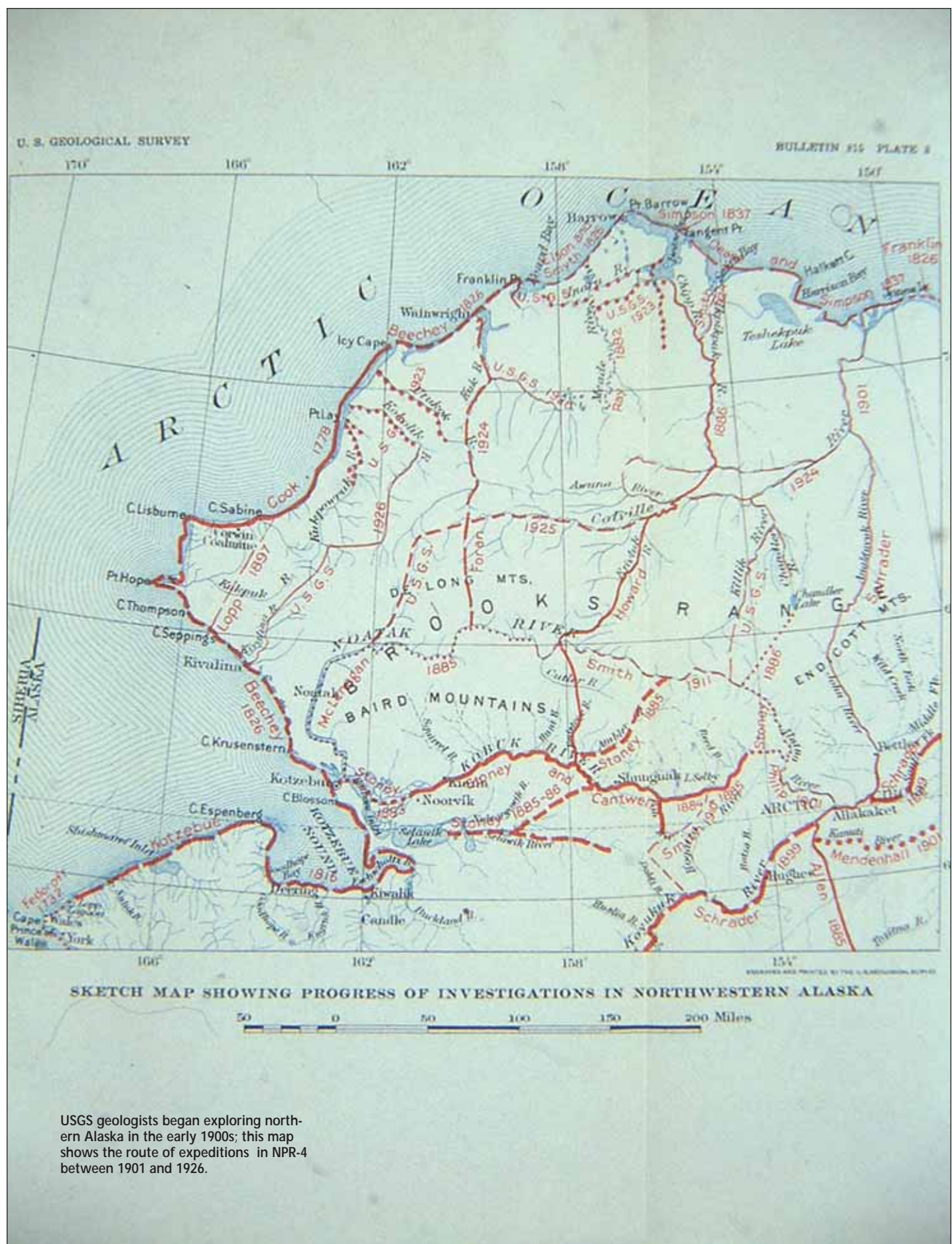
Landownership issues caused delays from 1969 to 1975 and escalated costs, he said.

"BP was radically affected. The cost of it was going to be gigantic," Herrera said.

BP had signed an alliance with Sohio, requiring Sohio to fund Prudhoe Bay development and earn a progressive interest in Prudhoe Bay ownership, he said. The cost of the project almost bankrupted Sohio.

"BP escaped that because of the side deal with Sohio," he said.

The Prudhoe Bay find added significantly to BP's world oil reserves. "Prudhoe reserves filled that void in world oil reserves. It was a lifesaver for them." ♦





Natural oil seeps like this one at Cape Simpson stirred the interest of the U.S. Navy in the 1920s when potential oil reserves became vital to national security.

C.G. "GIL" MULL

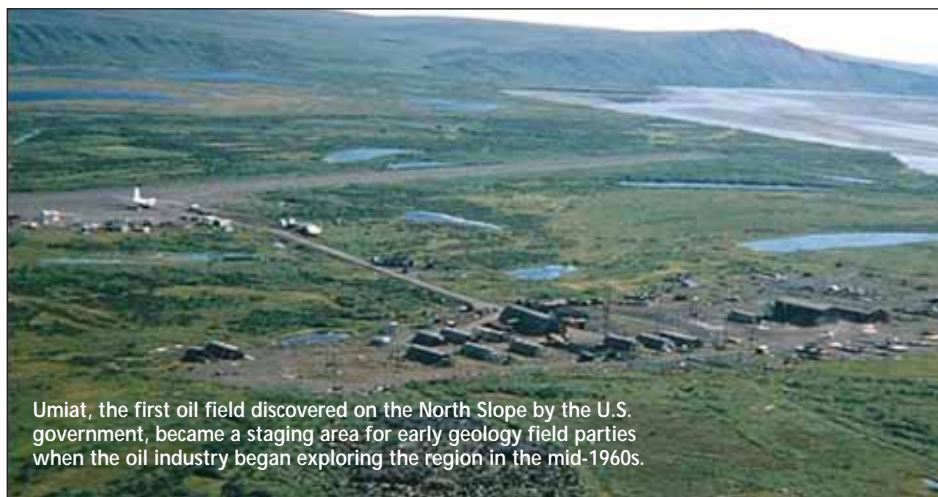
Navy targeted Arctic reserve in 1920s

Presidential order establishes expanse of tundra the size of West Virginia as area designated for petroleum exploration

By Rose Ragsdale
For Petroleum News

By executive order, President Warren G. Harding created the Naval Petroleum Reserve No. 4 (now National Petroleum Reserve-Alaska), in 1923, setting aside nearly 24 million acres, or about 38,000 square miles of the Arctic Slope of Alaska for future petroleum needs of the U.S. government.

NPR-4 amounted to about half the area of the entire Arctic Slope north of the Brooks Range, which was now off-limits to commercial production. The reserve included Cape Simpson and extended to the Colville River on the east and south to the crest of the Brooks Range. For a period of four years following the establishment of NPR-4, the U.S. Geological Survey sent a series of geological field parties to explore the area and begin initial exploration of the new petroleum reserve. These field parties were headed by some famous names in the USGS — John Mertie, Jim Gilluly, and P. S. Smith, who later became the director of the USGS.



Umiat, the first oil field discovered on the North Slope by the U.S. government, became a staging area for early geology field parties when the oil industry began exploring the region in the mid-1960s.

C.G. "GIL" MULL

(See attached map.)

Test drilling and other exploratory work by the U.S. Navy and the U.S. Geological Survey during the next 30 years, though not extensive, produced no commercially significant discoveries.

In 1943 during World War II, the entire North Slope was withdrawn from public entry under Public Land Order 82, and the Navy, again with the USGS, initiated a

major exploration program that lasted nearly a decade.

Marvin Mangus, a USGS geologist who worked on the North Slope for nine field seasons from 1947 to 1958 and later for Atlantic Refining Co. and then Atlantic Richfield Co., said USGS mounted expedition after expedition to explore the area.

"I first went up there in 1947. ... We made maps; we set up all the geological

nomenclature and the geologic history of the North Slope. The Navy in 1923 set aside that petroleum reserve ... because it looked excellent for petroleum production. At that time, the U.S. Navy drilled about 23 holes looking for oil.

"Unfortunately, we did not do too well. We found a field at Umiat; that field had estimated reserves of about 30 million to 100 million barrels of oil. At the time, a 6-inch pipeline from Umiat to Fairbanks would have cost \$2 million, so it was not considered commercial by any means. What (the Navy) needed was one well to produce 3,000 barrels a day to make it commercial on the North Slope.

"Some 50 years ago, it was so far different than how we do things today, so that it's hard to compare," Mangus observed.

Between 1945 and 1952, the government conducted 45 shallow core tests and drilled 36 test wells within and immediately adjacent to NPR-4. The results included one oil field, Umiat, and two small gas fields, Gubik and Barrow; three prospective gas fields, Meade, Square Lake and Wolf Creek; and two minor oil deposits near Cape Simpson and at Fish Creek.

Uncle Sam departs

By 1953, the federal government effectively ended 30 years of exploration activity in NPR-4 having spent an estimated \$50 million to \$60 million in an unsuccessful effort to find worthwhile petroleum resources.

"Being that there were no big finds found in the oil wells there, they shut it down (in 1953)," Mangus recalled. "They ran out of money; and Congress wouldn't appropriate any more."

After the close of the NPR-4 program in 1953, the USGS continued mapping the geology and studying the stratigraphy of the Brooks Range and adjacent areas as part of its long-range objectives.

In 1958, the federal government opened parts of the North Slope outside NPR-4 to simultaneous filing of oil and gas leasing, and several major oil companies began conducting extensive geophysical and geologic studies throughout northern Alaska.

This development would turn out to be more than important for the future of the oil companies, according to geologist Gil Mull.

That September, after a 60-day simultaneous filing period, the Bureau of Land Management held a drawing from the

7,500 offers it received to lease the 4 million acres in the offering. This was the first sizable area to become available from lands withdrawn 15 years earlier during World War II.

During the summer of 1958, Sinclair Oil Corp. began surface geologic work on the North Slope with a field party based at Umiat for the three-month season.

British Petroleum, interested in reducing its dependence on the Middle East, formed a partnership with Sinclair Oil and Gas Co. to explore the North Slope of Alaska.

Ongoing interest evident

In December 1960, the federal government established the Arctic National Wildlife Range covering nearly 19 million acres from the Canning River east to the Canadian border and including the Brooks Range on the south to the Beaufort Sea on the north.

The creation of the wildlife range and the continued existence of NPR-4 limited industry entry to just the acreage lying between the Colville and Canning rivers.

In a 1964 simultaneous filing, Richfield Oil Co. acquired a large number of leases and bought leases from others. As a

result, Richfield acquired more land than any other company.

In 1976 Congress placed NPR-4 under the management of the U.S. Department of the Interior and renamed it the National Petroleum Reserve-Alaska, or NPR-A, in the Naval Petroleum Reserves Production Act.

During 1975 and 1976, the federal government still demonstrated its ongoing interest in exploring the North Slope with an extensive program of seismic surveys and exploration. Five or six wild-cat wells were drilled in the Foothills province of the North Slope and one at Cape Halkett in NPR-4 by the U.S. Navy.

All of these tests were dry holes, but they did have some significant shows of gas, with minor oil shows and provided a large amount of additional data on the geology of NPR-4. Areas believed to contain multiple oil and/or gas reservoirs on the continental shelf northeast of the Point Barrow-Cape Simpson; in the Beaufort Sea, from Prudhoe Bay to the Canadian border; and the coastal plain area north of the Sadlerochit and Romanzof Mountains to the Arctic Ocean within the Arctic National Wildlife Range (changed to Refuge in 1980.) ♦

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Mangus laid groundwork for oil discovery

Retired geologist was among the few who surveyed and mapped the Arctic coastal plain from Barrow to the Northwest Territories

By Rose Ragsdale
For Petroleum News

Marvin Mangus first came to Alaska's North Slope in 1947 with the U.S. Geological Survey and spent nine field seasons mapping the geology of the area, from the Brooks Range to the Arctic Ocean and from the U.S. border with Canada in the east to Cape Simpson near Barrow in the west.

Mangus, who grew up in Western Pennsylvania, earned bachelor's and masters degrees in geology from Pennsylvania State University, before pursuing a career in petroleum geology.

"I'd always wanted to do field work in Alaska, so I put in my resume with the Survey in 1946 and was hired in 1947 to put in the Navy oil unit," Mangus recalled in a recent interview.



MARVIN MANGUS

During this period, longtime USGS geologist George Gryc led one of the first field parties for the Survey on the North Slope, then known as the Arctic coastal plain, Mangus said.

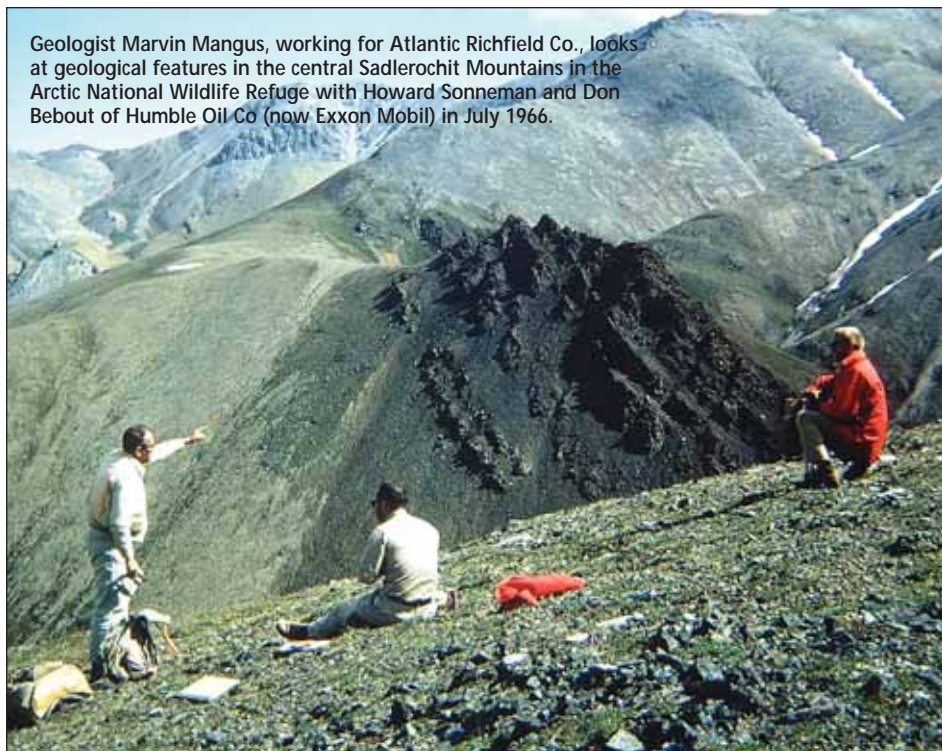
"We knew the area had one of the largest and thickest suites of Cretaceous rocks, comparable to the Rocky Mountains foothills," Mangus said.

Mangus said the Navy had built and maintained a small camp with a full-time cook at Umiat in the reserve. Ten to 50 USGS geologists did field surveying each season, depending on annual congressional appropriation.

"We went into the Brooks Range because when we got out to Umiat, we started losing the outcrops. They had to use seismic north of there," he said.

Disappointed by the lack of big oil discoveries, the federal government backed away from Arctic exploration in 1953, shutting down the USGS exploration program when the agency ran out of fund-

Geologist Marvin Mangus, working for Atlantic Richfield Co., looks on at geological features in the central Sadlerochit Mountains in the Arctic National Wildlife Refuge with Howard Sonneman and Don Bebout of Humble Oil Co (now Exxon Mobil) in July 1966.



C.G. "GIL" MULL

ing and Congress wouldn't appropriate any more funds for the work.

A new era of exploration

In 1958, the industry took over where the government left off.

Before then, companies were not allowed to prospect north of the Brooks Range for hydrocarbons and minerals because it was set aside for the government in case of emergency, by Public Order No. 41.

The federal government rescinded that order in 1957 and 1958, and private industry moved in and started prospecting for oil.

By then, Mangus had left the USGS and gone to work for Philadelphia, Pa.-based Atlantic Refining Co. in Central America. He spent two years doing field work in Guatemala, before Atlantic transferred him to Calgary, Alberta in 1960.

Mangus then spent two field seasons mapping the Richardson and Western Mackenzie and Franklin mountains in

northern Canada.

"I did surface work in the northern Yukon Territory and Northwest Territories and found some big structures some 180 miles east of Umiat in what today is (the Arctic National Wildlife Refuge)," he recalled.

"We mapped all the way from Banks Island, Northwest Territories to Cape Lisburne and Point Lay. That's 1,200 miles. We would move camp by boat. We usually had two geologists, two field assistants and a cook. I wore out my knees scrambling around over the rocks," Mangus recalled.

"It all tied in very nicely. The area had the same outcroppings, and same age rocks as the Richardson Mountains and Mackenzie Mountains. At Norman Wells, NWT, we found unconformities and structural traps. Now they are doing quite well with gas fields up at Inuvik, NWT," he said.

"If you thought the North Slope was sparsely populated, you should have

gone to the Northwest Territories back then," he added.

In 1962, Mangus returned to Alaska as regional senior surface geologist in charge of the Arctic Slope of Alaska. His mission: to conduct Atlantic Refining's geological field program.

"We started mapping the North Slope from Umiat to the Canning River, which was the western boundary of ANWR. We did the geologic mapping in there. We compiled the maps, and then we came up with some recommendations for drilling wells, but we had to wait for the geologic seismic maps to come out because there were no outcroppings in the northern part of the coastal plain. We tied those maps together, which took a couple more years. Then in 1964, we worked the Brooks Range from Umiat to Feniak Lake.

"Everything was confidential. We didn't trade maps unless we were partners with a company. Even then there was some secrecy," he said.

Helicopters changed the game

During the 1950s and 1960s, helicopters transformed geological field work in the Arctic, providing a mode of transportation that made surveying and mapping a far more efficient process.

"In the Navy oil days, we walked and we moved camp by boat. There is no comparison to doing field work by boat," Mangus said.

"Helicopters are a much better way of getting around to look at the rocks in the field as long as you take notice. To really look at rocks, it is better to walk for a few years."

That's especially true for young geologists fresh out of school, he said. "Don't come right out of college and go only to the helicopters because you over fly and miss

a lot of pertinent ideas," he warned.

Mangus said everyone whom he worked with both at the USGS and in the oil industry were good geologists and hard workers. But a lot of them didn't come back after working one summer on the North Slope because of the harsh living conditions, especially for the USGS, he said.

"We never lost anyone in that rough country because you had to be very careful," Mangus recalled.

Though he did not use a helicopter to do field work until 1960, Mangus said he definitely recommends their use because of all the walking he had to do in Alaska and in Central America.

"You can't land helicopters in a lot of places. But another good thing about helicopters if you saw something late in the season, and you remember it four or five weeks later, you can go back and look, but if you're walking, or floating in boats, you sure as hell can't go back," he said. "You also can re-fly areas you've already worked. You can go back and check. You can't do that when you're walking."

Still, helicopters came with their own set of difficulties because landing areas on the North Slope are very nebulous, said Mangus, who was involved in five helicopter crashes in the latter part of his career.

The geologist's wife, Jane Mangus, recalled a night in the 1960s when her husband's colleague, John Sweet, came to her house and wanted to pray because Marvin's helicopter had gone down.

"Nobody was in it, and that made me feel like he might be alright," she said. "Marvin built an enormous bonfire and a commercial airplane saw it. So he was rescued."

Industry brought resources to field work

Working for industry



ROSE RAGSDALE

Marvin Mangus, an accomplished and celebrated artist, painted this memorable scene from a photograph of geology pioneer Alfred H. Brooks, for whom the Brooks Range was named, and a colleague, as they surveyed the Alaska Range in the early 20th century.

"THESE FRAGMENTARY DATA POINT TO THE CONCLUSION THAT THERE MAY BE A PETROLEUM FIELD IN THIS EXTREME NORTHERN PART OF ALASKA. WERE THE REGION NOT SO INACCESSIBLE, IT WOULD CERTAINLY BE WORTHWHILE TO INVESTIGATE THESE OCCURRENCES, BUT AS IT IS, EVEN IF PETROLEUM IS FOUND, IT COULD NOT BE BROUGHT TO A MARKET."

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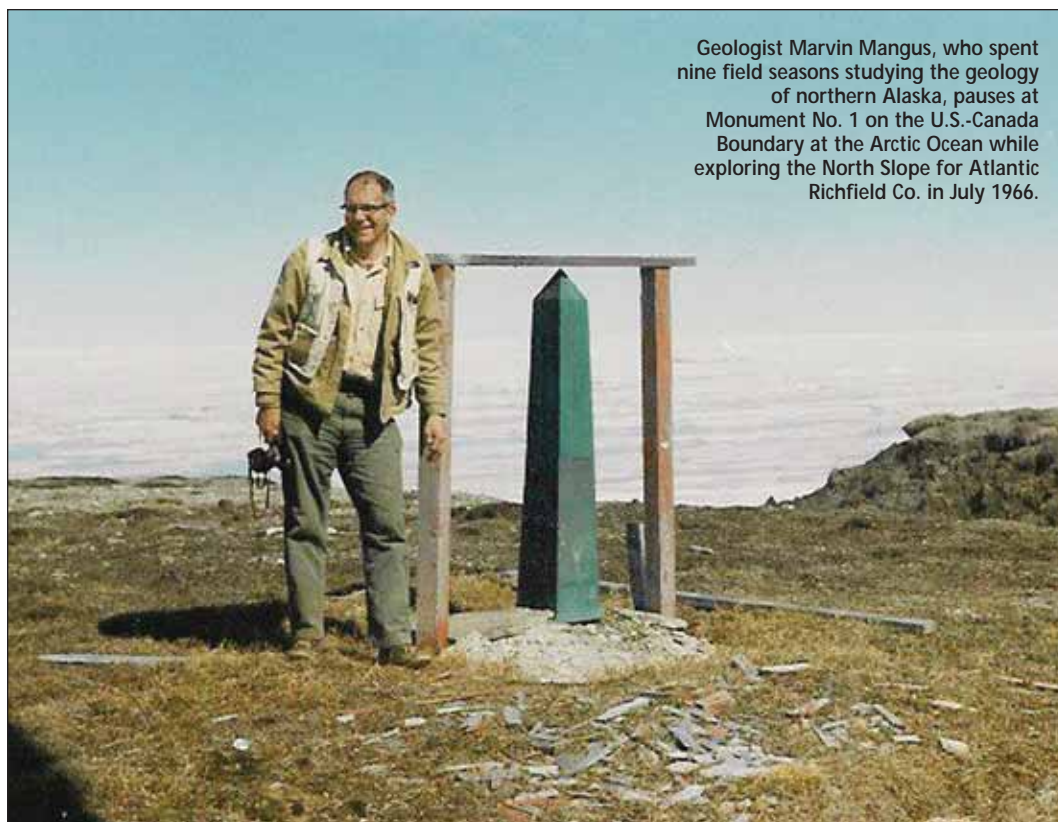
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offered other advantages, too.

"We had no supplies. With industry, we had a lot of things we didn't have with the USGS such as communications. We also had better tents, and we could carry a lot more field gear. If you go in and do a good job of reconnaissance, then you can go in and take a better look next year. With the helicopters, you can work the inner stream areas, while you were limited to within 15 miles of the river with the boats. Walking more than 30 miles in that country was something else. Walking was just tougher than hell," Mangus recalled.

However, the North Slope's barren landscape allows one to see long distances. Thus, outcrops were better exposed, and not hidden by vegetation, he said.

When Atlantic Refining and Richfield Oil Co. merged in early 1966, Mangus became senior field geologist for



Geologist Marvin Mangus, who spent nine field seasons studying the geology of northern Alaska, pauses at Monument No. 1 on the U.S.-Canada Boundary at the Arctic Ocean while exploring the North Slope for Atlantic Richfield Co. in July 1966.

C.G. "GIL" MULL

Atlantic Richfield Co. He shared an office with Humble Oil Co.'s geologist Gil Mull

since Richfield had partnered with ExxonMobil's predecessor company.

The newly combined ARCO had to take over the drilling operation and carry out all of Richfield's commitments. So ARCO drilled the Susie No. 1 well.

"We went down about 14,000 feet and it was dry," Mangus recalled. "By that time, government regulations came along and we had too much acreage and had to release some of it."

A convergence of ideas ensued involving joint fieldwork and mapping parties with Humble Oil, he said.

Up until that time, industry had spent \$250 million and come up with nothing but dry holes, Mangus said.

"We consolidated maps between the three organizations and came up with the big structure. We figured one more hole after Susie. Prudhoe Bay State No. 1 would probably have been the last hole if we hadn't found oil. We figured this would be a good place

because it was a sub-surface clay. We took it to management, and they said go ahead.

"We were all in favor of drilling it — Charlie Selman, head of geophysics; Rudy Berlin, Gil Mull, John Sweet and Harry Jamison," he recalled. "When we put it all together, from geophysics to geology, Prudhoe Bay State No. 1 was our discovery. We discovered it using geologic field work and seismic work."

"X" marks the spot

In August 1966, Mangus was chosen to travel to the North Slope and actually mark the surface location where Prudhoe Bay State Well No. 1 would be drilled.

"We put a 10-foot iron rod, painted international red, where the well was to be drilled. It was a joint effort to pick that location; I was just asked to mark it. I was the senior man, and they asked me.

"When we finally hit oil there, well, we were real

see page 20

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Pioneering geologist Marvin Mangus painted the Prudhoe Bay State No. 1 well in 1968, while "sitting" on the well during drilling.

ROSE RAGSDALE

excited because we knew it was really big," Mangus said. "We had to stop drilling in the spring of 1967 and that fall we went back. In December, we hit the oil but they did not call the official discovery date until February or March of 1968. You didn't want everyone to know. We didn't finish Prudhoe No. 1 until about June 1968."

The confirmation well also was drilled in June 1968.

"We used a different drill rig at Sag River State than at Prudhoe Bay. We used a Nabors Drilling rig for Sag River," Mangus recalled. "When we hit that, we couldn't believe it. It was just loaded with oil. That's the one that was estimated at (9 billion barrels). Sag River had no gas cap. It was all oil, and oil was worth a lot more than gas."

"We were just elated. We couldn't believe it. When you find the biggest oil reserve in North America, you are happy. Everyone gets into the act. Finding that was like finding a \$100 gold piece in your Christmas stocking instead of a lump of coal," he added.

Geologist captures beauty of the Arctic

Mangus, an accomplished and celebrated artist, captured many images of the dramatic Arctic landscape on canvas during his years of field work in the far North.

One memorable painting depicts the Loffland Bros. rig that drilled the Prudhoe Bay State No. 1 discovery well. Mangus painted it while sitting on the well as the well site geologist for ARCO.

"Every night I'd go out and look at the samples and gawk at the Northern Lights and come back inside and slap on a few more brush strokes," he recalled.

After the Prudhoe Bay field was discovered, Mangus stayed on with ARCO until 1969 when he formed a consulting firm with two geologists from Phillips Petroleum, he said.

"After I left ARCO, we tried to get a couple of the oil companies to pursue drilling at Alpine but had no luck," he said.

Mangus said his last mapping job for ARCO was a detailed study of the Sadlerochit Formation.

In addition to Prudhoe Bay, Mangus played a significant role in Pan American's Kavik gas discovery and mapped the Alaska Peninsula from Port Moller to Kamishak Bay, the Talkeetna Mountains and the Kandik and Copper River basins. ♦

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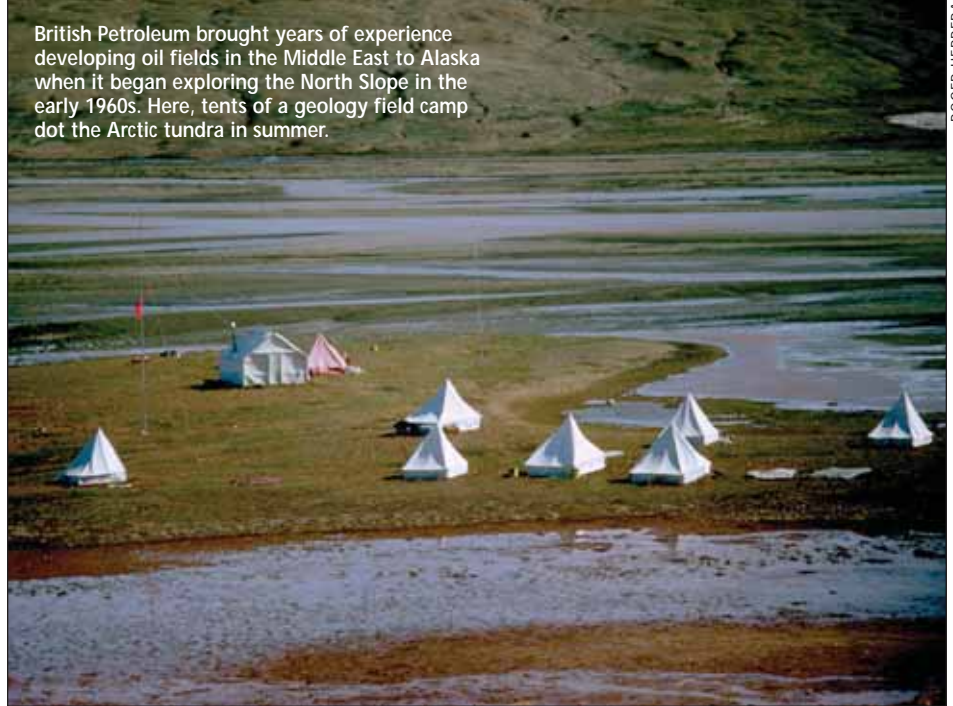
BP's long road to Alaska

British company prevailed over 10 years of international setbacks, obstacles on its way to becoming major U.S. oil producer

Petroleum News

As one of the seven major international oil companies, BP's strength had always been in the Middle East. Its vast reserves of oil in Iran, Kuwait and Iraq were greater than those of any other single company, over a fifth of the total reserves of the whole world in fact. This was strength but also a weakness, for while the other big companies were developing their marketing outlets throughout the world BP was content to rely mainly on its profitable oil production, selling any crude oil that it could not market itself to other companies who had the markets but not the production. As far back as the mid-1930s, BP had thought about entering the United States, the world's most lucrative oil market. Then after World War II, when BP decided it really did want to go into America, the big problem was Britain's

British Petroleum brought years of experience developing oil fields in the Middle East to Alaska when it began exploring the North Slope in the early 1960s. Here, tents of a geology field camp dot the Arctic tundra in summer.



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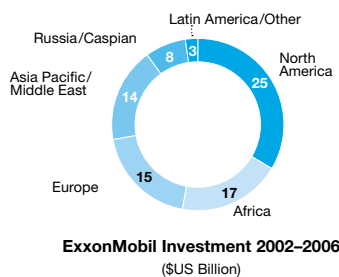


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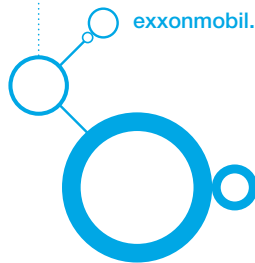


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adverse balance of payments and the corresponding shortage of dollars. It would have been an immensely costly investment either to buy up existing companies or to start from scratch with all the production and refining and marketing operations required. And BP was doing very well as the biggest producer of Middle East crude oil and possessor of the lion's share of its reserves.

In 1951, Iran suddenly nationalized her entire oil industry and BP was compelled to withdraw 50 years after first entering the country. It was the first major act in the tide of nationalism that was beginning to sweep across nations previously dominated by foreign industries.

The Iranians were unable technically to run such a complex industry, and during the ensuing legal battle, an embargo was placed on any country accepting Iranian oil. In 1954, BP returned to Iran to operate as the major partner in a consortium of American and European oil companies. But it had been a traumatic shock, joggling the company's management out of its rather complacent attitude toward marketing and proving the need to develop oil production in other parts of the world.

Some observers said it was the best thing that ever happened to BP, resulting in determined expansion in place of a tendency toward self-satisfied stagnation.

World survey identifies Alaska

Within weeks of being forced out of Iran, a group of BP geologists, led by Alwyne Thomas, C.A. O'Brien, Frank Slinger and Harry Warman, got together to prepare a world survey of oil prospects, based on their knowledge of the sedimentary basins in various regions. These were graded according to the likelihood of oil being present.

When the survey was completed in early 1952, Alaska was near the top of the list. The north of Alaska was included because of the oil and gas discoveries made there by the U.S. Geological Survey in the 1920s and during and after World War II. But the harsh arctic conditions as well as a shortage of exploration funding pushed Alaska to the bottom of the list. The closest BP got to the area was in 1953 when the company took over Canada's Triad oil company, operating in Alberta.

It was another political leader in the Middle East, the late President Nasser of Egypt, who provided the final impetus



Vital supplies like aircraft fuel, heating oil and diesel were stockpiled in barrels at various North Slope sites once exploration got under way in the mid-1960s. Companies barged in or flew in such supplies at the beginning of the season and meted them out to support the work of geological field parties.

for BP's entry into the United States. The Suez Canal crisis of 1956 convinced BP's board of directors that the company needed a substantial presence in North America's profitable and stable oil industry.

But the cost of entering the U.S. market directly was higher than ever. The British government owned 56 percent of BP at that time.

The answer seemed to be to find a company which was already marketing in the United States, but which was short of crude oil, and come to a joint agreement whereby BP would supply it with oil. BP developed such a relationship with Sinclair Oil Corp. But the BP-Sinclair agreement was frustrated from the outset. Shortly after the companies joined forces, the U.S. government, alarmed by the threat of low-cost foreign oil flooding the market, imposed at the beginning of 1959 rigid controls on crude oil imports. Only those companies with domestic production could import foreign oil. This rule effectively excluded BP.

Unable to market Middle Eastern oil in the United States, BP and Sinclair turned to the other part of their joint operation, which was to explore for new domestic sources of oil.

Geologists see similarities to Iran

By this time, Richfield Oil had made its discovery at Swanson River on the

Kenai Peninsula south of Anchorage in 1957. The U.S. Navy also had published the results of its oil exploration on the North Slope.

Sinclair suggested the possibility of looking for oil in Alaska, specifically the Cook Inlet Basin where many American oil companies had focused exploration. But BP, recalling its world survey in 1952, was more interested in the North Slope, where there was a better chance of finding a large field.

During a plane trip, BP geologist Peter Cox flew over the North Slope and went home impressed. "There is a similarity between the foothills of the Brooks range and the Zagros mountains in Iran," he told colleagues.

The North Slope, in fact, got its name from the way the foothills sloped gently toward the Arctic Ocean. It was similar in many geological respects to the deserts of the Middle East — except for the difference of about 150 degrees of temperature — and the annual 4 inches average of precipitation on the North Slope was even less than in most deserts.

Cox also reportedly told BP executive Robert Belgrave that the North Slope was one of the few places in the world where there might be a chance of finding a Kuwait-sized oil field.

Shortly afterward, Cox became a managing director at BP and in February 1959, it was he who accepted the rec-

ommendation of a report to London in which BP geologists wrote: "The areas of sedimentary basins are very large. That of the Arctic Slope measures 105,000 square miles, larger than our entire Iranian concession. ... It contains a wealth of drillable anticlines on the Iranian scale with lengths of the order of 20 miles. ... Overall, prospects are of a high order. ..."

But the tide of industry opinion was against the move. BP geologist Frank Rickwood, who later became head of BP Alaska in New York, recalled that he was always embarrassed when American companies said to him, "What in God's name are you doing in that wilderness?"

"I remember when the North Slope first came up, I had to send a girl down to find a map of Alaska to see where the bloody place was," he told author Bryan Cooper in the early 1970s.

The hunt begins

Being the only company interested in the North Slope turned out to be a big help to BP, enabling the company to pick up oil and gas leases cheaply in the foothills of the Brooks Range near the U.S. Navy's discoveries at Umiat and Gubik.

Secrecy was critical to the maneuver.

So, BP hired a retired Pan American Oil executive to apply for leases in its name at the land office in Fairbanks. The 70 separate forms, all in quintuplicate, were typed confidentially in a local bank. They were filed April 1, 1959.

The first step for BP and Sinclair was to conduct geological surveys on the North Slope.

In 1959, BP opened its first office in Alaska in downtown Anchorage and a year later, the company's first team of geologists arrived.

Geoff Larmanie, a BP geologist who became the company's area manager in Alaska, recalled those early days in Alaska – *The Last Frontier*, published in 1972.

"We started work in 1959 in the Richardson Mountains and went to the North Slope the following year. By 1966, we had covered it back to the Brooks Range. The geological work had to be done in summer because you've got to let the snow melt so that you can see the rocks. We gradually worked northwards as the snow melted, setting up camp alongside lakes so that our float planes could land. The weather was terrible sometimes. There were days when we were stuck in our tents, unable to fly, and had to keep warm by staying in our

sleeping bags all day. Because of the weather, flying in the mountains was very tricky. Fog and low clouds could suddenly seal off a whole valley. Everyone had to carry emergency rations and the orders were to stay put if you were cut off until you could be rescued. Shortage of water was a problem, strangely enough. People could become badly dehydrated if left out in the mountains with no rations.

"It could get pretty rough, especially in the mountains. There we'd sit, our heads in the sky, our backsides in the snow for days on end. Living cheek by jowl with people under these cramped conditions could result in certain psychological tribulations, when we might all run out of both work and reading matter.

"Usually the camp would wake up about six o'clock. Someone would make breakfast, then the first helicopter would be away with the first team — we normally worked in parties of two. It would come back for the second team, and so on, until we were all out scouting the hills and valleys."

Roger Herrera, now retired from BP, was a member of the company's first team of geologists in Alaska.

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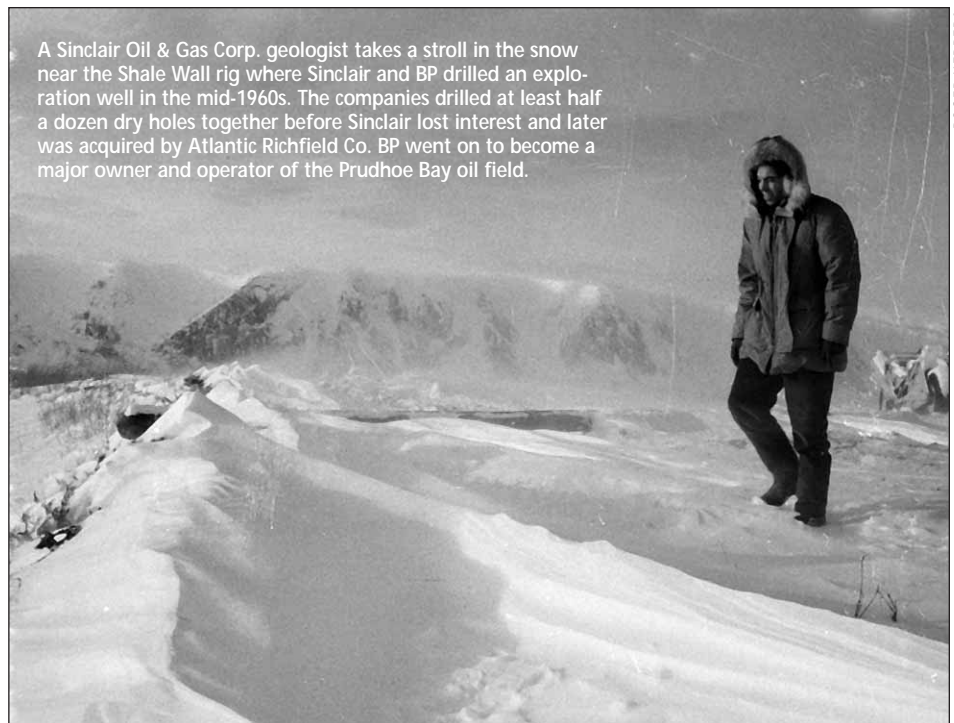
“There were very few maps available in 1960 for those parts of Alaska,” Herrera said. “Those that were available were of poor quality so we relied heavily on aerial photographs.”

Herrera said their assignment was to define the geologic structures more exactly and to identify more promising reservoir rocks and develop a picture of the regional, geologic trends. They lived in tents, moving by float plane from site to site and landing in the numerous small lakes that dot the Slope. Sometimes they would travel by helicopter.

“We’d go out in the morning to get rock samples, and since we had many miles to go, we only carried essentials — a map, compass, rock hammer, good hiking boots, plenty of mosquito repellent and, in the event of bad weather, patience,” Herrera said. “I recall many nights spent out on the tundra because the weather was too poor for pilots to fly.”

California production finances exploration

The costly Alaska exploration program was draining BP’s already lean financial resources, both in terms of cash flow and Britain’s balance of payments. It was



A Sinclair Oil & Gas Corp. geologist takes a stroll in the snow near the Shale Wall rig where Sinclair and BP drilled an exploration well in the mid-1960s. The companies drilled at least half a dozen dry holes together before Sinclair lost interest and later was acquired by Atlantic Richfield Co. BP went on to become a major owner and operator of the Prudhoe Bay oil field.

ROGER HERRERA

here that the Kern Oil properties in California that BP acquired in 1957 from Rio Tinto proved particularly valuable.

These wells, discovered and developed in the 1920s, did not flow under their own pressure and had to be

pumped at a rate of five to 10 barrels per day each. For each group of about six wells, a steam engine drove a huge flat wheel from which wire cables were attached to individual wells. As the wheel turned, the wires would jerk the

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pump at each well in succession and a slug of oil would emerge and trickle into a gutter dug in the ground. The oil was thick, almost solid, but was particularly useful in California for making asphalt, selling at a profit of about a dollar a barrel. Production had declined to almost zero and BP was seriously considering disposing of the properties.

Then Tidewater Oil Co., which also owned leases in the Kern River field, became interested in the possibilities of secondary recovery, which could greatly increase production. Tidewater negotiated an agreement with BP and took over operation of the field, paying BP a share of the profits. Enhanced recovery resulted in production increasing to the point where BP received \$2 million to \$3 million a year. It was this money that enabled the company to finance Alaska exploration, a program that cost \$3 million a year out of BP's total worldwide wildcat exploration budget of \$10 million.

Early drilling proves fruitless

When BP began seismic work on the North Slope in 1963, geophysicists had little or no experience in seismic reflec-

tion surveys in permafrost. With Slope permafrost thickness at some 2,000 feet, it was feared the readings would be severely distorted. New methods of interpreting seismic logs would prove beneficial in BP's early exploration efforts.

BP management in London accepted the team's recommendations to proceed with exploration drilling. By the end of 1963, BP and Sinclair had acquired options to lease about 150,000 acres.

Though BP was the first company to extensively explore the North Slope, Colorado Oil and Gas was the first to actually drill a well. The independent spudded a shallow well in July 1963 one mile from the Gubik gas field, using a small rig left behind by the U.S. Navy when it completed its exploration program in 1953. The well was only drilled to 2,000 feet and the company abandoned it as a dry hole and showed no further interest in the North Slope.

Since the area was isolated from the rest of the world, transporting drilling equipment there was a major logistical challenge. BP brought its first drilling rig by rail from Calgary, Alberta to the Hay River in the Northwest Territories,

then barged it down the Hay River into the Mackenzie River, to the Beaufort Sea coast, west to the Colville River and finally upriver.

With Canadian crews, BP drilled six wells fairly quickly under difficult and unfamiliar conditions. In addition to the thick permafrost, the mercury dipped so low that steel equipment fractured and normal lubricants solidified.

BP geologists had made a mistake about the foothill folds north of the Brooks Range. They looked promising, but did not go down to any depth. As a result, the company's drilling in the foothills of the Brooks Range and the Colville River delta proved to be unproductive — to the tune of \$30 million and nine dry holes. Dreams of an Eldorado in this northern frontier quickly faded.

"It's remarkable how little notice people take of you when you're drilling dry holes," said Mike Savage, a senior BP executive at a 1987 ceremony in Anchorage that commemorated the 10th year of Prudhoe Bay oil production. "The odds of success in an entire new exploration area were at least 20 to 1 against." ♦

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Remembering the unsung heroes

The seismic crews and interpreters who crisscrossed the vast tracts of frozen tundra in the mid-1960s deserve special recognition

By C.G. "Gil" Mull
For Petroleum News

Seismic crews who collected critical subsurface data and the specialists who interpreted this information are the unsung heroes who led to the discovery of the giant Prudhoe Bay oil field and most of the subsequent discoveries on the North Slope. Only in the Brooks Range foothills belt are outcrops continuous enough that anticlines and major faults can be mapped solely on the basis of surface data, but even there, seismic data is needed to resolve structural and some stratigraphic details in the subsurface. The small Umiat oil field, which was discovered by the U.S. Navy in the mid-1940s in the southeast corner of NPR-4, was found on the basis of surface mapping by



A seismic shot hole drill operates on the tundra during seismic surveys on the North Slope in the early 1960s.

United States Geological Survey and Navy geologists who mapped the structure on foot. They mapped the area after hearing of the small oil seeps at the base of Umiat Mountain from the nomadic Nunamiut

Eskimos who had long known of their presence. However, subsequent exploration programs by the Navy and the oil industry began with surface geological mapping and then quickly continued with acquisition of geophysical data.

After the federal government released the first North Slope lands to exploration in 1958, many companies, including British Petroleum, Sinclair Oil & Gas, and Richfield Oil, sent surface parties north to evaluate the lands. BP and Sinclair, in partnership, mobilized a United Geophysical Co. seismic crew in 1962, and then drilled several relatively shallow wells on foothills anticlines.

The 1963 Richfield surface field party also realized that seismic data would be needed to explore the lands beneath the coastal plain north of the foothills outcrop belt, and this resulted in Richfield's first seismic crew in the winter of 1963-64. This crew from United Geophysical was supervised by Charlie Selman, Richfield's district geophysicist in Anchorage, and shot three north-south reconnaissance lines from the foothills north onto the coastal plain.

In addition to the crews from United Geophysical, other oil companies, including Atlantic Refining, also had seismic crews from National Geophysical Co. and Western Geophysical Co. operating in the winter of 1963-64. In the spring of 1964, Richfield added a second seismic crew, contracted from Western Geophysical.

Yet a third crew, from United Geophysical, was mobilized in the winter of 1964-65 to provide coverage to the north on lands to be selected by the State of Alaska following a partnership agreement with Humble Oil in the fall of 1964. This crew shot the first lines across the Prudhoe Bay structure for Richfield-Humble, although other companies also saw the feature in their seismic data.

Map interpretations of the structure by geophysicists Paul Bolheimer, Rudy Berlin, and Pete Clara led to the final interpretation that was used for the 1965 state sale in which Richfield-Humble acquired its leases across the top of the Prudhoe Bay structure. ♦



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Young geologist changed Alaska history

Lands selection officer convinced state leaders to gain control of petroleum-rich North Slope acreage before Prudhoe Bay discovery

By Rose Ragsdale
For Petroleum News

Like so many other young adventurers, Tom Marshall came to Alaska in 1958 to homestead on federal lands.

Marshall, a young geologist from Wyoming, also was eager to get in on the ground floor of the Cook Inlet oil exploration boom touched off by the Swanson River discovery in 1957.

"I also wanted to see if Alaska was the magnificent place that my grandfather Marshall said it was," he told members of the Alaska Geological Society in April 2008. The elder Marshall had traveled to Alaska decades earlier as a member of the Royal Canadian Mounted Police.

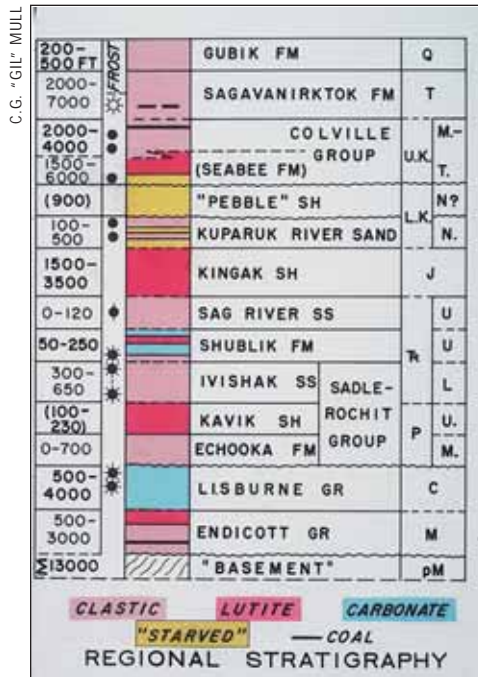
From his first days in Alaska, the younger Marshall recalls clearing land at a cost of about \$1,000 per acre.

"Homesteading was very hard on personal finances," he said in explaining his decision to accept a position with the very young Alaska state government as an assistant lands selection officer.

"It looked very appealing as a means to get me through the winter," he said.

Marshall, a University of Colorado-trained geologist, was asked to evaluate a federal opening for land selection on the North Slope in 1958.

Marshall said his principal source of information in preparing for the selections was professional papers published by the



A diagram illustrating the various sedimentary strata on the North Slope; large black dots indicate potential oil or gas reservoir units. Diagram by Irv Tailleux, US Geological Survey.

U.S. Geological Survey, which were crammed with lots of information about the Navy's exploration program in the 1940s and 1950s.

Similarities to Rocky Mountain areas

The federal government established the

Arctic National Wildlife Range (now the Arctic National Wildlife Refuge) in 1960.

A year later, Alaska, as part of its land entitlement under the Statehood Act, selected more than 1.8 million acres of the Arctic coastal plain bordering the Beaufort Sea between what is now the National Petroleum Reserve-Alaska and ANWR.

It was an area the federal geologists had declared impossible to survey and estimated it would take 100 years to accomplish the task.

Marshall, who had been promoted to state land selection officer, enthusiastically recommended the swampy lake-covered area, which contains no surface rock exposures, be included in the state's land selections because he found general geological similarities of the Arctic Slope to petroleum-bearing areas in the Rocky Mountains.

"Regional geology is what I used in my selection criteria because it had meaning to me. I transferred my Rocky Mountain oil and gas exploration experience," said Marshall. He also observed that the same USGS publications he studied were available to the Bureau of Land Management and the oil companies, "but they had their own ideas."

Ironically, the state Division of Lands polled seven companies and none of them recommended the Prudhoe Bay area for lease.

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The oil companies wanted to drill in the area around the Colville basin, not on the Arctic coast.

During his investigation, Marshall said he noticed the 2,000- to 2,500-foot Lisburne Limestone over a broad area with all sorts of porosity.

"It excited me because back in Wyoming, we had the geologic equivalent of the Lisburne Limestone in our Madison Limestone, which had been in many areas of Wyoming, including Casper where I lived for many for years," Marshall said.

He said the Lisburne Limestone was an unattainable 20,000 feet deep in the Colville Trough, and the limestone was probably at that latitude in the Umiat oil field.

"This was definitely considered an uneconomic depth," Marshall said. "But regional geology to me means there would be a rise from the Colville Trough up to the Barrow Canyon Arch on the Beaufort Sea shore. It would be a terrific gathering area for petroleum and maybe there would be a big oil field there."

Leaders believe in "big banana"

Marshall recalled that he might have gotten "a little overdramatic" when he told Alaska Natural Resources Commissioner Phil Holdsworth and state lands director Roscoe Bell that "there could be a big banana up there on the coast."

Marshall's selections were the first ever made by the state that had no known surface uses.

Luckily for Alaska, Holdsworth and Bell had faith in Marshall's judgment.

Other Alaska leaders were skeptical.

Marshall said he received calls from politicians in Juneau wanting to know what the basis was for "Arctic waste land selection."

Other taunts included "Marshall's ice box" and "Marshall's folly." Fellow home-steaders dubbed the land selections "worthless tundra."

Perhaps the cruelest taunt came later after some very disappointing dry holes were drilled on the Colville and at Union's Kookpuk well from those who had witnessed Marshall's earlier enthusiasm and who suggested that "there might be just the 'banana skin,' up there," Marshall recalled.

It turned out that selection of the coastal plain area offered an additional advantage because it eliminated potential future disputes between the state and federal governments over the definition of



Tom Marshall included the barren tundra where the Prudhoe Bay oil field lies in land selections for the State of Alaska four years before the discovery.

Others who participated in the Prudhoe Bay discovery say Marshall deserves considerable credit for the state owning the acreage where the Prudhoe Bay field is located.

navigable streams in upland areas. If the surrounding lands were state lands, it thus became unnecessary to define the limit of navigability of streams flowing into the Arctic Ocean.

The lands thus selected included Prudhoe Bay.

Trail leads to Prudhoe Bay

By October 1964, the state received tentative approval for its land selections from the federal government, and scheduled for December its first competitive oil and gas lease sale on the North Slope.

In this sale, the state took in a total of \$5.6 million in bonus bids for leases covering acreage in the Kuparuk-Ugnu area of the North Slope. Though it wasn't a huge sum, it was enough to cover the state's land selection filing fees and compensate for its loss of highway funds for the entire North Slope.

Marshall was ecstatic.

Richfield Oil Co. picked up more than 71,500 acres of land covering the crest of a subsurface geological structure on the shores of Prudhoe Bay in the July 1965 sale.

British Petroleum, following theories developed by its geologists, acquired nearly 82,000 acres lower down the flank of the Prudhoe Bay structure.

Nearly three years later, Atlantic

Richfield Co. announced discovery and confirmation of the Prudhoe Bay oil and gas field, which 40 years later, remains North America's largest petroleum reservoir. In a matter of months, "Marshall's folly" had changed the course of history, becoming the single-most important source of revenue for the State of Alaska.

Wrong theory, right location

Marshall, who retired from the state in 1978 as chief petroleum geologist for the Division of Oil and Gas, continues to work as a consulting geologist.

"I don't want to sound too smart about the discovery, because frankly, I was dead wrong. I had read reports about the Sadlerochit Sandstone and the Ivishak Formation. They were described as being primarily quartzite, which has to be zero porosity. I couldn't see outcrops of these Ivishak Sands in the information I had about the region across the broad Slope, and it didn't seem to impress the USGS geologists who studied them in the Foothills area," he explained. "But as we know, the Prudhoe Bay discovery was primarily in the Ivishak sands of the Sadlerochit Formation, which I did not even consider. I thought it was going to be the Lisburne. Fortunately, it's in both of them. But the Lisburne is a far distant third or fourth largest reservoir on the North Slope."

Marshall's modesty notwithstanding, the significance of his contributions cannot be underestimated.

Doing his job as a state employee, Marshall essentially shaped a critical component of Alaska's destiny.

Others who participated in the Prudhoe Bay discovery say Marshall deserves considerable credit for the state owning the acreage where the Prudhoe Bay field is located.

"Tom Marshall deserves a monument for persisting in getting the state to select the acreage where the discovery of Prudhoe Bay was made. He fought tooth and nail from his appointment in 1960 until he convinced the governor in 1963 to make the selections on the North Slope," said John Sweet, Alaska district explorationist for Atlantic Richfield Co. at the time of the discovery.

The Alaska Legislature has honored Marshall for his work, and Sweet told the Alaska Geological Society in April that it should ask the geosciences department at the University of Alaska to name a permanent chair in honor of Tom Marshall.

"He deserves it," Sweet added. ♦

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Lease sales opened doors to prosperity

Making North Slope acreage available to industry for oil and gas leasing ushers in exciting new era of challenges, opportunities

By Rose Ragsdale
For Petroleum News

In 1960, the federal government established the Arctic National Wildlife Range (now the Arctic National Wildlife Refuge), covering the entire eastern end of the Arctic Slope and Brooks Range from the Canning River to the Alaska-Yukon border.

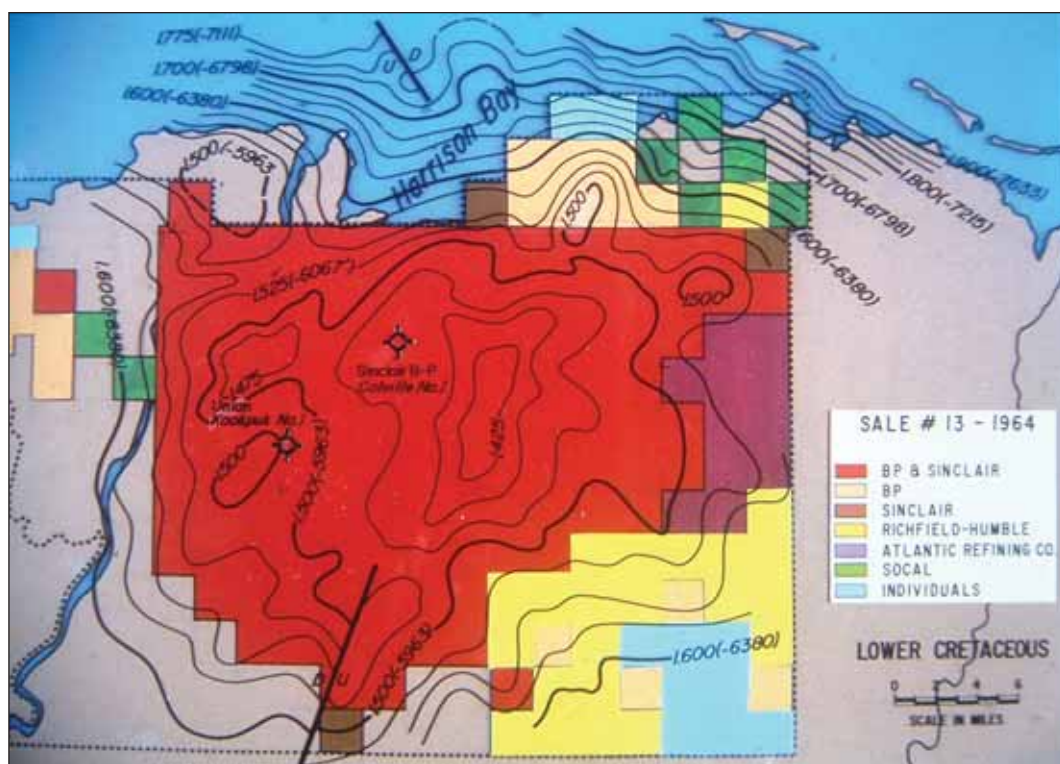
The State of Alaska, as part of its land entitlement under the Statehood Act, selected more than 1.8 million acres of the Arctic coastal plain bordering the Beaufort Sea between NPR-A and the wildlife range. This swampy lake-covered area contained no surface rock exposures but was recommended for selection by the state's only geologist, Tom Marshall, who recognized some general geological similarities of the Arctic Slope to petroleum-bearing areas in the Rocky Mountains.

Selection of the coastal plain area had an additional advantage because it eliminated potential future disputes between the state and federal governments over the definition of navigable streams in upland areas. If the surrounding lands were state lands, it became unnecessary to define the limit of navigability of streams flowing into the Arctic Ocean.

The lands thus selected included Prudhoe Bay, an obscure geographic feature named more than 130 years earlier by Arctic explorer Sir John Franklin for his friend, Capt. Algernon Percy, Baron of Prudhoe and later Fourth Duke of Northumberland in the first penetration by white men along the Arctic coast west of the Mackenzie River in Canada.

Alaska offers first North Slope acreage

In late 1964, the state received tentative approval for its land selections from the federal government, and in December held its first competitive oil and gas lease sale, Sale



A map showing the lease blocks acquired by various oil companies at the first sale of leases on the North Slope in December 1964. BP and Sinclair bought most of the leases on a large structure near the Colville River delta.

13, offering state-owned lands on the North Slope, near the mouth of the Colville River east of NPR-4. The sale also included some tracts in Cook Inlet and offshore Kodiak Island. Of the total \$5.5 million in bonuses that the state received from the sale, some \$4.3 million was from tracts on the North Slope. The highest amount per acre received by the state of Alaska was \$31.96 per acre on tracts U-3-5-42 and U-3-5-43 submitted by British Petroleum and Sinclair Oil and Gas Corp. (This sale did not include tracts above the Prudhoe Bay structure.)

In July 1965, Alaska held Sale 14 and took in a relatively modest amount in total bonuses. In this sale, tracts C14-123 and C14-124 both brought \$93.78 per acre, a record high. It was on these relatively expensive tracts that three years later, ARCO and Humble would drill Prudhoe Bay State Well No. 1 and make their historic discovery.

Richfield Oil and Humble Oil as partners acquired more than 71,500 acres of land in

Sale 14, covering the crest of a subsurface geological structure adjacent to Prudhoe Bay. At that time, the only information available was seismic data combined with geological predictions on the nature of the subsurface rock types projected from the outcrops in the Brooks Range, 80 to 130 miles to the south and east. The nearest exploratory well was in NPR-4, 75 miles west of Prudhoe Bay. British Petroleum, with lower bids, acquired nearly 82,000 acres located lower down the flank of the structure.

The bonuses paid by the oil industry for North Slope leases in these two sales held by the State of Alaska were said to have pleased then-Gov. William "Bill" Egan, who had taken the risk and allowed the industry to come in.

ARCO acquires critical offshore tracts

On Jan. 24, 1967, Alaska held Sale 18 in which 15 tracts mostly offshore in Prudhoe

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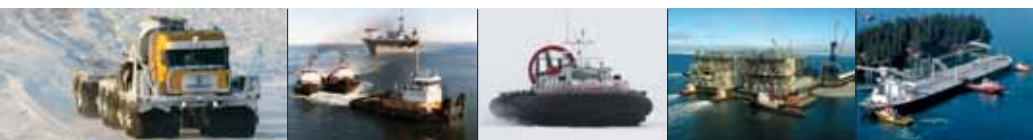
In the summer of 1975, Crowley Maritime Corporation was about to embark on the biggest sealift in history. It was also the year when Alaska would experience the worst arctic ice conditions of the century. 47 Crowley barges were being cautiously towed from Anchorage up to the North Slope for the Trans-Alaskan Pipeline project. Arctic ice usually retreats for six weeks every summer, but this year it never happened. The determined fleet was forced to a standstill. Finally, after two months of waiting, the ice flows momentarily retreated. The Crowley crews immediately forged ahead. When the ice began to close in once again, it took four tugs to force each barge through. It was slow, arduous

work, but all 160,000 tons of cargo made it safely to their destination.

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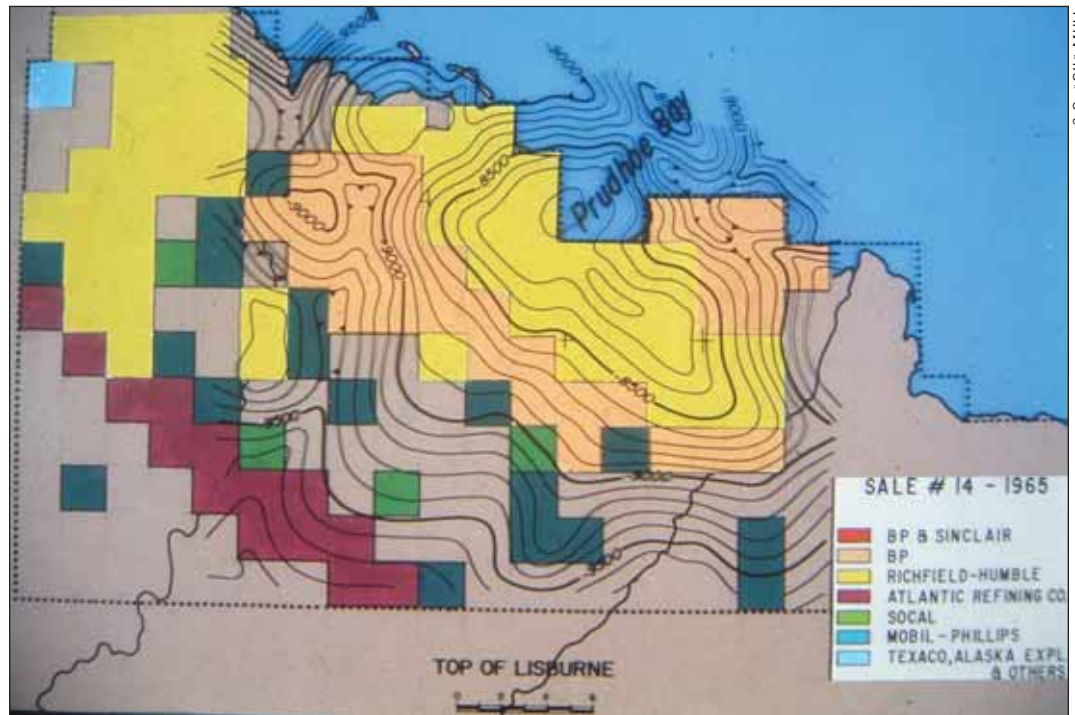


Bay were offered to industry along with acreage in the Katalla area near Prince William Sound.

A memo from Pedro Benton to Charles Herbert through Roscoe E. Bell on Dec. 16, 1966 held the following paragraph:

"The Arctic Slope area is the same area we recommended originally, which was approved by Mr. (Phil) Holdsworth. Almost all of the area is off-shore, however, according to the protraction diagrams, which check very closely with recent (Bureau of Land Management) surveys in the area, several of the tracts include small projections of uplands or small islands. I suggest we include these uplands parcels to maintain a solid and logical lease pattern."

Bids of only \$1 per acre by T. Miklautsch on C-18-1 and C18-2 were the only bids for these tracts and thus the high bids. Within a year, those two tracts would bring a tidy return on investment.



A map showing the leases acquired by various oil companies at the second sale of leases on the North Slope, in July 1965. At this sale, Richfield and Humble bought most of the leases on the crest of the Prudhoe Bay structure, BP acquired many leases on the flanks of the structure.

The only other bidders in the sale were British Petroleum and a partnership between Atlantic Richfield Co. and

Humble Oil Co.

On tracts C18-10 and C18-11, which adjoin two tracts that ARCO acquired in Sale 14, the

company bid a total of \$885,293. The next highest bid in the sale was a modest \$5,029, and BP did not even bid

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on C18-10 and C18-11.

C18-10 brought \$121 per acre, while C18-11 drew \$233 per acre from ARCO.

The highest bid from BP in the entire sale was \$53.77 per acre.

The lease sale that made Alaska rich

Some say that Sept. 10, 1969, was the day Alaska got rich. It was the day Alaska held its most famous and lucrative oil and gas lease sale, netting more than \$900 million in bonus bids for state coffers. (This was the first sale of North Slope lands after the Prudhoe Bay discovery.)

In the days leading up to the sale, oil industry scientists and executives from around the globe converged on Anchorage, crowding hotel lobbies and motels to overflowing.

Former ARCO Alaska President Harold Heinze recalled how he spent the days leading up to the sale helping to generate the information that would form the basis of the company's bids.

"I got a transfer to Alaska in February 1969. I was the youngest of the young. Very shortly I found myself in Dallas where I worked in a closet for most of the summer with one other engineer. We did the evaluation for ARCO of the 1969 sale. I had a chance to see things from the perspective of the lowest of the low. Because of the secrecy, we had to do everything ourselves, read all the charts and do all the interpretation ourselves. I coded all the stuff. ARCO already had a tremendous acreage position."

Heinze said amazing stories about the behavior of various sale participants surfaced.

"We heard that Hamilton Brothers got a train in Western Canada and they rode up and down the track and everybody involved in their bidding group had to stay on the train whenever it stopped," he said. "Several wells were drilled on the Slope that summer and people went to great lengths to find out about them."

Episodes of industry espionage became rampant. Company scouts would land and creep about the tundra with binoculars, Heinze said.

"There times when things got really bad, when there were three helicopters circling in a tight pattern around the drilling rigs. FAA traffic control was out of Fairbanks at that time, so it wasn't a good scene," Heinze recalled.

It was then that many of the company "scouts decided that it wasn't worth killing someone over the information" and settled down to "pretty civilized" behavior, he added.



"The day Alaska got rich." Gov. Keith Miller holds the microphone at the State of Alaska 23rd Oil and Gas Lease Sale in the Sydney Laurence Auditorium in Anchorage on Sept. 10, 1969. Alaska Department of Natural Resources Commissioner Tom Kelly stands at far right.

The world comes to Anchorage

In the days leading up to the sale, witnesses said big raw-boned Texans rubbed shoulders with nattily suited businessmen from Japan and smooth-talking executives from New York and London, all seeking a piece of the action in what had become the hottest oil play in the world.

Groups of company men — directors, accountants and geologists — huddled together in corners to plan their strategy, those already operating on the North Slope jealously guarding the geological information they had obtained, while others had to guess at what were the best locations and what they might have to bid to get them. Rumor and counter-rumor ran riot as industrial spies tried to break through the tight cordon of security around the North Slope drilling operations.

On offer were 451,000 acres of previously unleased land around Prudhoe Bay and the Colville River. It was the fourth time that the state had put up North Slope land for lease since selecting 2 million acres in 1964 of former federal land on the North Slope.

Though 37 wells had been drilled by 23 active rigs within the area and thousands of square miles of the region had been mapped by 24 different seismic crews, no company knew what the others might bid for leases offered, nor what it would have

to bid to prevail in getting the acreage it particularly wanted. The only thing for certain was bidding would be high.

For the State of Alaska, the stakes also were high. Of the bonuses collected from all 22 lease sales held during Alaska's 10-year history, including the three previous sales on the North Slope, the state had netted a total of \$97.6 million.

Speculation leading up to the sale suggested that Alaska could attract as much as \$1 billion in bonuses and trounce the previous U.S. record of \$603 million paid in 1968 for 363,000 acres off the California coast in the Santa Barbara Channel. But some Alaska officials played down the sale's prospects, talking in terms of an expected \$100 million in bonuses. Even that amount would have been welcome, considering that the state's total annual budget that year was \$150 million.

Drama, humor and huge bonuses

On the morning of Sept. 10, representatives of oil companies, state officials, investors and journalists filed into the 350-seat Sydney Laurence Auditorium. In the presence of armed guards and state troopers, bidders handed over sealed envelopes, each envelope marked with the number of the tract it concerned.

In an almost festive atmosphere, the sale began promptly at 8 a.m. The very first bid

opened brought gasps of astonishment, then wild cheering from the audience. This set the pattern for the rest of the day's excitement, witnesses said.

What immediately became apparent was that many companies formed new alliances to improve their chances of success in the sale. Gulf Oil joined BP, while Shell teamed with Texaco. Mobil, Phillips and Standard Oil of California also mostly bid together. Many smaller companies also banded together to improve their odds - Amerada-Hess and Getty Oil; Hamilton Brothers, Union and Pan American; Continental Oil, Sun Oil and Cities Service.

BP-Gulf bid \$15.5 million for one of six lots on the Colville River delta, 100 miles northwest of Prudhoe Bay, or more than \$6,000 per acre.

Excitement mounted when BP-Gulf won the second lot out of 21 separate bids, for an average of about \$8,000 per acre. The third parcel went even higher, selling for \$12,000 an acre. By the time the BP-Gulf partnership had swept the board, taking all six of the lots offered in the Colville River delta, the companies has offered a total of \$97.7 million in bonuses.

When the bidding moved to the leases that were available around Prudhoe Bay, prices went so high that even the BP-Gulf coup paled to relative insignificance. The most spectacular moment of the sale came when bids were opened for Tract 57, the closest parcel to the oil discoveries at Prudhoe Bay. Atlantic-Richfield Co. bid \$26 million. BP-Gulf bid \$47.2 million, which remained the high bid as offers of \$36.8 million and \$36.6 million were announced from the Hamilton group and Continental-Sun-Cities Service. The next bid, however, drew a roar of shouting and cheering from the crowd that shook the auditorium. The Mobil-Phillips-Standard group bid \$72.1 million. A moment later, the state

announced a bid of \$72.3 million, or \$28,233 an acre, from Amerada-Getty.

The audience stunned with sheer disbelief lapsed into a moment of total silence before erupting in pandemonium. Not only was it the highest bid ever offered in a U.S. lease sale, it also was incredibly close to the previous bid. Had there been a leak? Why had the Amerada group bid alone this time when most of the day, they had bid with Louisiana and Land Exploration, Marathon Oil and H.L. Hunt interests?

There had never been any doubt that Tract 57 contained oil. One estimate put its recoverable reserves at 200 million barrels.

Standard Oil had purchased seismic results from the area from BP and thus, had a good idea of the parcel's potential. Standard had been involved with Amerada Hess in joint bidding for Louisiana leases some months earlier, so each group was familiar with the other's way of thinking.

Observers theorized that they had placed a similar value on the oil, related it to their joint experience in the Louisiana sale and added a bit for luck. The resulting closeness of the bids likely was a coincidence.

"Some of the bids in the 1969 sale were squeaker close," Heinze said. "That's when you start checking your security."

In the end, the sale netted just over \$900 million, or an average of \$2,180 an acre. A plane had been chartered to transport the checks to the Bank of America in San Francisco, while bankers were on hand to cancel the checks from unsuccessful bidders.

Not all of the bids were record-breaking. One block, tract 36, was close to BP's discovery well and thought to have been really hot. Mobil-Phillips-Standard picked it up for \$18 million, double the only other significant bid from Humble.

The sale also had its moments of humor. Almost all of the tracts drew joke bids of a few cents an acre. On one whole parcel, in fact, the sole bid was \$1, entered by locals who were very upset when the offer was rejected.

The entry into the auditorium of a mysterious figure dressed as an Arab, complete with flowing robes, head-dress and dark glasses, caused a buzz of speculation that a rich Middle Eastern sheikh might be entering the fray — until it turned out that a local humorist had donned the disguise.

Natives protest state leases

Not everyone was delighted with the results of the sale. Some economists at the University of Alaska argued that the state had shortchanged itself by selling so much North Slope acreage so quickly.

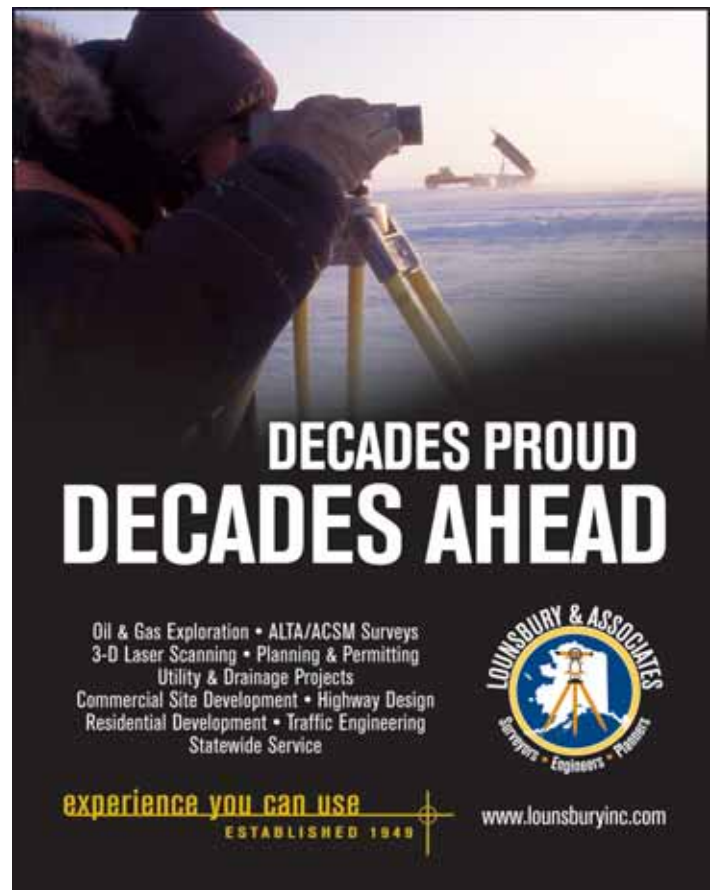
Edgar Paul Boyko, former Alaska Attorney General during the Hickel administration, also voiced doubts about the state's

early policies toward the oil industry.

"I'm not anti-oil company," Boyko said. "They are in business to get the most they can, and we need them here. But we must not let them develop our country on their terms."

After the big lease sale, Boyko tried to file an injunction against the state issuing some of the leases, but the effort failed.

Most Alaskans were delighted with the way the sale had gone and with the sudden windfall. However, a group of Alaska Natives and their supporters held a protest during the sale and occasionally interrupted the proceedings in the auditorium. While seemingly insignificant, the protest proved to be a symptom of deeper discontent among Alaska Natives, and portend of challenges yet to be faced and overcome in the future of North Slope oil development. What looked so promising in the fall of 1969, a year later was beset with problems and uncertainties. ♦



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Richfield, others go elephant hunting

Geologists pore over few North Slope outcroppings; California company's team gets excited about oily sands in two locations

By Rose Ragsdale
For Petroleum News

In the early 1960s, Richfield Oil Co., with other companies that were operators, participated in the discovery of oil and gas fields across Cook Inlet, racking up success after success with such finds as Middle Ground Shoal, Granite Point, McArthur River and North and South Cook Inlet.

Richfield's emphasis was on large promising structures beneath the Upper Cook Inlet, but the events taking place in the far north on some 88,000 square miles of nearly treeless tundra would have greater significance and far-reaching consequences for both Richfield and Alaska.

In the summers of 1963 and 1964, at least six oil industry helicopter-supported field parties were fanned out across the central and eastern North Slope and into ANWR. The abandoned Navy camp and airstrip at Umiat, located on the Colville River in NPR-4, served as a base of operations; at the time, this was the only improved airstrip on the North Slope other than the airstrips at Barrow and Kaktovik, which were too remote from the outcrop belt to be of use to industry geologists. Umiat was a beehive of activity. Wien Airlines had a station agent and several bush pilots based there, as well as three-day-a-week scheduled flights from Fairbanks on its route to Barrow. Aviation fuel was available for purchase, and a



Richfield Oil Co. geologists examine an outcrop in the foothills of the Brooks Mountain Range in the early 1960s. The California major poured resources into North Slope exploration, gambling that field parties supported by helicopters could find an elephant.

COURTESY OF BP EXPLORATION (ALASKA) INC.

catering company had opened a kitchen for meals.

Most of the companies started off in mid-June working out of Umiat; the helicopter of choice was the Bell 47G2, a small machine with a piston engine mounted behind a fish bowl-shaped bubble for a cockpit, and an open tail boom. The main rotor blade was wood, with a stainless steel leading edge and a steel spar down the center of the blade. The G2 held the pilot and two passengers, an extra 10 to 20 gallons of fuel in cans and a

small amount of field gear on the side racks. The ship could cruise at about 60 mph and without the extra fuel, had a range of about 2 1/2 hours of flying time. The limited fuel range meant that most field parties soon ran out of work that could be done within the fuel range from Umiat, thus after a week or so, most of the field parties then moved to widely dispersed tent camps located on river bars or lakes.

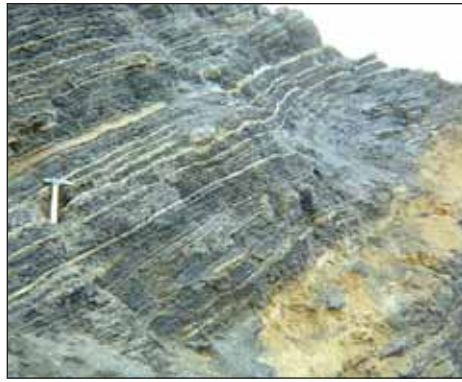
Richfield Oil's 1963 field operation was similar to that of many of the companies, with the exception that in addition to the helicopter, Richfield had chartered a single engine Cessna 180 to work with the field party for the summer. Early in the season the Cessna was equipped with wheel-skis so that it could operate on the frozen lakes as well as on the gravel strip at Umiat. In mid-June 1963, Richfield moved its camp to Peters Lake in ANWR; the 180 ferried camp equipment, a large amount of aviation gas, and passengers to the campsite on the lake shore. After camp was established, the plane was used to ferry fuel caches to other lakes, and fly back and forth to Umiat to mail in reports, ship rock samples, and pick up food ship-

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ments that came in on Wien Airlines. After the lake ice melted in early July, the plane was switched to floats and the pilot continued his routine, flying between the tent camp at Peters Lake, a subsequent camp at Cache One Lake near the Echooka River, and a small lake at Umiat.

Most of the tent camps consisted of a large wall tent as a cook tent, an office tent, and several sleeping tents. Most field parties consisted of four to six geologists, and the most important people in the camps were the pilots, helicopter mechanic, and of course the cook. A good cook was the key to a happy camp. Besides the pilot, the mechanic was the key to a safe operation — he spent most evenings working on the ship, inspecting, tuning, repairing, and balancing the rotor blades, which soaked up water during every rainstorm. Field operations consisted of flying the geologists, two at a time, out to creek or river bluffs or mountain top outcrops to walk traverses, describe the rocks, and map the geology on aerial photographs or topographic maps. At the end of a traverse or the end of the day, the helicopter pilot would return to ferry the crew to a different location or back to camp.

Though it was a big country and most of the field parties were camped in sepa-



This outcrop on the Sadlerochit River in the Arctic National Wildlife Refuge shows interbedded black shale with a high content of organic material and bentonite, or altered volcanic ash. It is in a formation called the Hue Shale, which is one of the rich oil source rocks on the North Slope and in ANWR. When Richfield Oil Co. geologists C.G. "Gil" Mull and Gar Pessel saw these rocks during the summer of 1963, they realized that there were good oil source rocks widespread on the North Slope.

rate locations and operating independently, it was not uncommon for two or three helicopters and field crews to end up on the same outcrops at the same time — all trying to be secretive and proprietary about what they were seeing and interpreting. Evenings in camp were spent compiling data and updating the mapping. And so it went for the summer — most of the field parties had 2 1/2- to 3-month

field seasons without break until the end of August, when they migrated back into Umiat.

Field party report makes impact

In 1963, Richfield sent geologists Garnett Pessel and Gil Mull, two youngsters with several years of experience, to the North Slope to build on the data acquired by field parties in 1959 and 1960 and U.S. Geological Survey reports from the 1940s and 1950s.

Late in the season after two months of exploring, Pessel wrote a letter to Ben Ryan, conveying their conclusions and describing an outcrop he had seen on the banks of the Sagavanirktok River.

At a banquet held by Gene Rutledge in 1988, in honor of the men featured in his book, "Prudhoe Bay Discovery," Charlie Selman, Richfield's division geophysicist, recalled events leading to the decision to continue exploring the North Slope.

"It was Cretaceous sand that just crumbled in your hand," Selman said. "He (Pessel) got all excited and wrote, 'If we can't find an oil field in something like this, I give up.'"

Selman added to Pessel's letter, recommending that Richfield send a seismic crew up north. Ryan attached a cover let-

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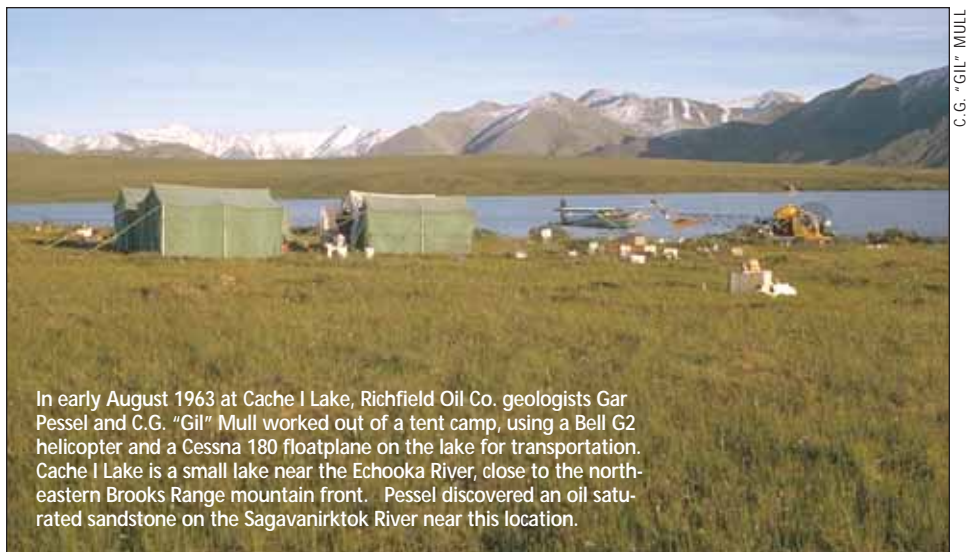
ter simply stating that he concurred with Pessel and Selman's recommendation and sent it to Harry Jamison, Richfield's Alaska district manager in Los Angeles.

"As luck would have it," said Selman, "a drilling operation had been canceled somewhere else, so ... Jamison got the funds to put a seismic crew on the North Slope."

Great deal for Humble

Despite Richfield's growing enthusiasm for North Slope exploration, limited budgets probably would have quashed the company's oil hunting efforts in the Arctic were it not for a strategic partnership it entered with Humble Refining Co. (predecessor to ExxonMobil) in preparation to bid on leases in the State of Alaska's first lease sale for North Slope acreage in December 1964. It was the first of many joint agreements between the two companies in the 1960s that led to an enduring and lucrative partnership on the North Slope.

"That partnership has to have been one of the all-time great deals for Humble (now ExxonMobil)," Mull said. "It bought into half of everything Richfield had done to that point (which included the preceding years of surface field mapping, two seasons of seismic data (winters of '63-'64 and '64-'65),



In early August 1963 at Cache I Lake, Richfield Oil Co. geologists Gar Pessel and C.G. "Gil" Mull worked out of a tent camp, using a Bell G2 helicopter and a Cessna 180 floatplane on the lake for transportation. Cache I Lake is a small lake near the Echooka River, close to the north-eastern Brooks Range mountain front. Pessel discovered an oil saturated sandstone on the Sagavanirktok River near this location.

C.G. "GIL" MULL

and a lot of federal leases Richfield had previously acquired) — all for \$1.5 million in cash and an obligation to pay for another \$3 million worth of seismic data. So for \$4.5 million, Humble got onto the North Slope after most of the other major oil companies already had surface mapping and seismic data and had already gotten a land position up there."

In the 1964 sale three other companies, Sinclair Oil & Gas Corp. — a predecessor of ARCO, its partner, British Petroleum, and

Atlantic Refining Co., another ARCO predecessor, acquired leases that were to become part of the Kuparuk River field.

Most of the 600,000 acres that the State of Alaska offered for bid in the Colville area, west of Prudhoe Bay, were purchased by Sinclair and BP. The bids averaged \$32 per acre.

The next lease sale, for Prudhoe Bay, was held just over six months later in July 1965. Richfield and Humble were determined to outbid BP for this acreage, wrote author

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Jack Roderick in *Crude Dreams*. Five people selected the tracts: Harry Jamison, Armand Spielman, Ben Ryan, George Shepphird and Charlie Selman, according to Roderick.

"Actual bids were worked up by the Los Angeles land group under Frank McPhillips."

"We decided we had to bid at least three times what BP bid in 1964 to get the tracts," Selman told Roderick.

It was a momentous decision that would lead the company to riches.

At \$94 per acre, Richfield outbid BP, Atlantic Refining, Chevron, Shell, Mobil and Phillips for the crestal tracts — those parcels located on the crest of the Prudhoe Bay structure.

"We bid higher on the crest and then lower on the flanks," according to Richfield geologist Harry Jamison. "That's exactly why we got the crest — the gas cap — and a portion of the oil. BP got the oil rim."

BP did end up with more than half the oil in the Prudhoe Bay field "by spreading its bids across the entire structure," said Roderick, who, at the time, was an individual investor in Alaska oil and gas leases.

Ironically, Humble wanted to put another \$1 million into the sale, but Richfield demurred. If Humble had prevailed, the partnership might have won the leases on

the Prudhoe structure's flank, too, which likely would have landed them ownership of virtually all of the Prudhoe Bay oil field, Mull told *Petroleum News*.

A third lease sale in 1967 covered offshore leases in Prudhoe Bay that were not included in the first sale of leases in the Prudhoe Bay area.

Richfield and Atlantic Refining join forces

Atlantic Refining also picked up 28 tracts in the July 1965 lease sale. Later that year, Atlantic purchased Richfield and the two companies merged in 1966 to become Atlantic Richfield Co., or ARCO. The two men who led the merger talks were Atlantic Chairman Robert O. Anderson and Richfield Chairman Charles S. Jones.

The two companies needed each other, according to Roderick's description in *Crude Dreams*. Richfield, he said, had come under scrutiny from the U.S. Justice Department because the company was partly owned by Sinclair and Cities Service Oil, and Atlantic hadn't been able to drill any wells on the North Slope.

Mull said the Justice Department was looking at Richfield for possible antitrust violations. "In fact, all three companies competed vigorously in many places," he said.

Richfield's merger with Atlantic made sense because Richfield "was somewhat cash poor," which is one of the reasons that Humble was able to buy in to Richfield's interests on the North Slope, Mull maintained. The merger of Richfield and Atlantic, Roderick said, "catapulted the new organization into seventh in size of all oil companies in the United States."

Frustration and hope

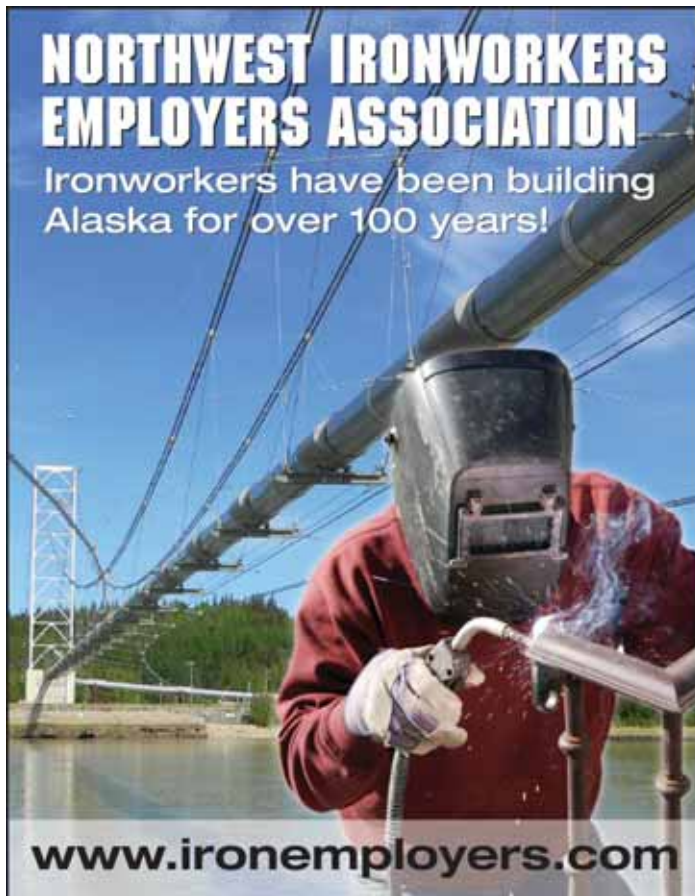
Richfield's Jamison was appointed as ARCO's first Alaska district manager after Anderson directed senior ARCO executive Mo Benson to put the smartest geologist he could find in charge of the Alaska exploration program.

The last half of the 1960s was both a frustrating and trying time for oil companies exploring northern Alaska.

For example, ARCO and Humble spent more than \$4.5 million (in 1968 dollars) on the Susie No. 1 well, just north of the Brooks Range foothills before finally abandoning the well on Jan. 9, 1967.

Still, from that great loss came one of the biggest triumphs in business history: The discovery of oil at Prudhoe Bay. ♦

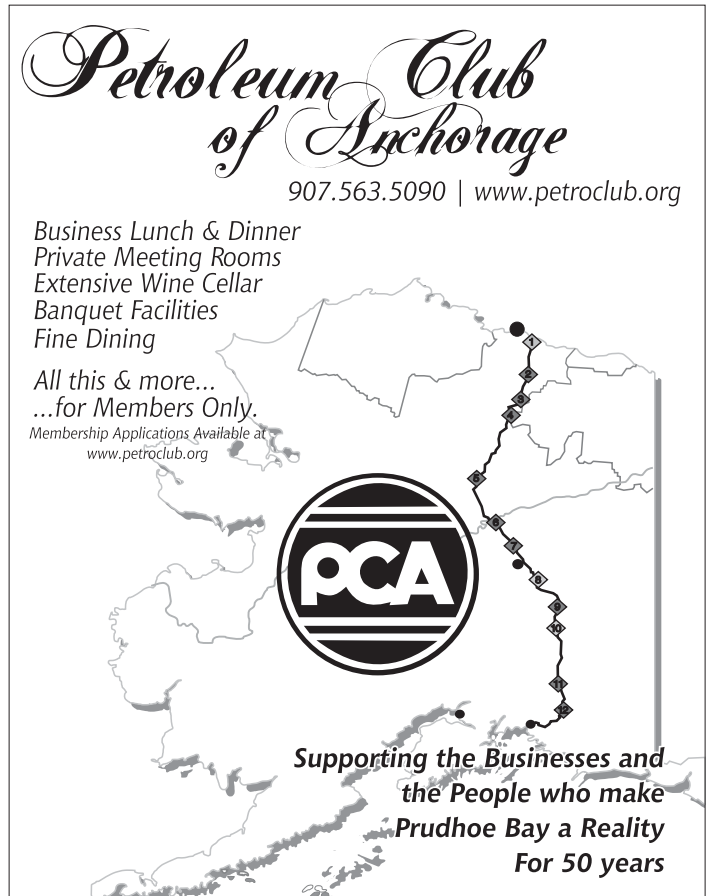
Former Richfield geologist Gil Mull contributed to this report.



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A big tracked vehicle pulls seismic equipment along its designated path during a 1969 "shoot" on Alaska's North Slope. Cat trains were used in winter to transport equipment and seismic crews in the Arctic as early as the 1950s and on the North Slope, beginning with John C. "Tennessee" Miller's historic venture in 1964.

ATLANTIC RICHFIELD COMPANY COLLECTION, STATE OF ALASKA ARCHIVES

Prudhoe Bay or bust!

Accounts of cat trains, convoys and accidents illustrate just how harsh North Slope working conditions were in early days

By Rose Ragsdale
For Petroleum News

The 1964 cat train expedition from Fairbanks to the North Slope has the honor of being the first overland transport of seismic exploration equipment for hunting for oil on state lands. Other cat trains had made their way north in the mid-1950s in connection with the military Distant Early Warning Line operation west of Prudhoe Bay, but the cat train of 1964 was the first conducted for the oil industry.

Spearheaded by John C. "Tennessee" Miller, founder of the Frontier Companies of Alaska Inc., the 1964 operation stemmed from Miller's desire to prove that it was possible to transport men and equipment overland for oil industry work. In early 1964, Miller approached Charles Selman, then division geophysicist for Richfield Oil Co., with the idea of running a cat train to the Arctic coast.

Selman had one geophysical crew on the North Slope and wanted to set up another one. The crew would need a cook



The newly formed Atlantic Richfield Co. moves the Loffland Bros. drill rig from the Susie well north to drill Prudhoe Bay State No. 1 with a cat train in February 1967. Bob Jacobs, a pilot for Interior Airways, took the photo.

COURTESY OF C.G. "GIL" MULL

shack, bunkhouse and three D-7 Cats, or Caterpillar tractors, to plow the snow and pull all of the supplies on logging sleds.

Miller convinced Selman to use his cats on the condition that he loaded all the necessary equipment and supplies and that he ran the train all the way to Sagwon.

After several weeks spent organizing the expedition, Miller then spent two

weeks staging everything for the cat train at the Dunbar railroad siding near Fairbanks. Among the crew making the trip was land expert, cook and handyman Don Simasko.

Simasko headed back to Fairbanks to pick up supplies. There he learned a Cheechako's lesson.

"One time we had to go back to

Fairbanks and it was 65-70 below," Simasko said in an interview published in *Renergy* in 1984. "I was saying, 'Gosh, it isn't so bad. Back at Dunbar, it's only 38 below.' Everyone started laughing when they found out we had a mercury thermometer. You see, mercury freezes at 38 below. The thermometer was frozen solid. They told me to get an alcohol thermometer and then we found it was 68 below. So then we were cold!"

In addition to frigid temperatures, the cat train crew battled frequent equipment breakdowns, numerous mishaps, desperately inadequate clothing, poor morale, and dangerous river crossings to get to the North Slope via Anaktuvuk Pass.

The hardware hero of the cat train was Caterpillar Tractor Co.'s D7 model. Why?

It had the horsepower to pull the sleds and higher ground clearance than the D6 model. It also had an angle blade to move snow, good weight distribution in the tracks that could bridge the tundra and available parts, according to Boyd Brown, who managed the train crew from Livengood to the North Slope.

Further use on the North Slope enabled the D7 to prove itself. The heavier D8 made river crossings more hazardous, while the lighter D6 model was a little



Workers unload a D-7 Caterpillar tracked vehicle from an Alaska Airlines Hercules C-130 airplane in March 1968 after Atlantic Richfield Co. and Humble Oil Co. realized that had a discovery at Prudhoe Bay and would need a lot more equipment. Both vehicles were the work horses of the era, the D-7 because of its versatile size and durability and the C-130 because of its cargo capacity. Alaska Airlines was a major cargo hauler on the North Slope during the era.

More trains followed as conditions improved

After the discovery of the Prudhoe Bay field, the rush to get drilling equipment to the North Slope encompassed every mode of transportation, including cat trains and truck convoys.

In a 1970 interview with an internal British Petroleum publication, truck driver Burn Roper vividly described the weather conditions as ground-based crews scrambled to deliver BP's critically needed drilling equipment.

"We needed almost as much fuel to keep warm as to run the rigs," noted Roper. "The temperatures were something fierce, running down to minus 65 degrees Fahrenheit. At this temperature, steel was as brittle as candy; human flesh froze in 30 seconds. Engines had to be kept running round the clock — from fall to spring, they never stopped."

Roper drove a 20-ton transport truck in a convoy that in 1968 made the 11-day, 600-mile trip up the winter Arctic Ice Road from Fairbanks to the North Slope. This road was sometimes called the "Hickel Highway," named after then-Alaska Gov. Walter J. Hickel, who spurred the road's construction.

The Hickel Highway followed old Native trails and much of the route was bulldozed by Boyd Brown, Tennessee

Miller and others during the famous 1964 cat train, which transported seismic exploration equipment to the North Slope. No road was actually built — only a simple path cleared across the tundra.

"We had a tractor with us to pull us over the ice ledges we met along the way," Roper said. "These ice steps were more than two feet high. We had radios in our cabs, and though we were alone, we could talk to each other and to the convoy leader."

High rate of accidents

Still, the furious activity that immediately followed the discovery of Prudhoe Bay took its toll on human life. Thirty-two men were killed on the North Slope in 1969. Most of them were killed in 10 aircraft crashes, including a Hercules transporter lost with all of its crew. Three men were killed when a hovercraft crashed during an experiment, and two men walked into helicopter blades. Another was crushed between a forklift truck and its load. Two workers were drowned in the cement they were pouring to erect a building, and another was killed during a seismic survey.

In addition, there were many serious accidents on drilling rigs and the Arctic cold took a further toll in snow blindness and amputations due to frostbite. Oil drilling was a dangerous enterprise 40 years ago, and the harsh weather made the North Slope especially hazardous. ♦

BP EXPLORATION (ALASKA) INC.



British Petroleum used tracked vehicles like this one, beginning in the early 1960s, and throughout its early exploration of the North Slope. The company partnered with Sinclair Oil and Gas Co. in 1963 and drilled its first exploration wells (all dry holes) in the region in 1964.

small for pulling sleds, Brown said.

It took 40 days, though only 18 days were spent actually traveling. The rest of the time was spent making repairs and addressing other unforeseen setbacks. During the trip, the Good Friday earthquake devastated Southcentral Alaska and overshadowed their efforts.

But Miller's cat train succeeded in what it set out to do, blazing a trail for others to follow.

Atlantic Refining brought Mangus back

Company invested in North Slope exploration from the Foothills to the Arctic coast, while others scoffed at area's oil potential

Petroleum News

In 1963, Atlantic Refining Co. began to supplement what was known about the geology of the North Slope from work done years earlier by the U.S. Geological Survey when the federal government explored the National Petroleum Reserve-4.

Marvin Mangus, a former USGS geologist, returned to his former haunts as chief geologist for Atlantic Refining in charge of Alaska exploration.

But this time instead of a boat, Mangus conducted his field surveys with the aid of his fixed-wing and helicopter air support.

Geologists Don Jessup and Louis Cramer along with Bob Tabbert from the Geosciences group in Dallas assisted Mangus during that first summer. Elder Lebert was Mangus' faithful cook and camp hand for all the years he worked for Atlantic and ARCO.

In 1964, Gerald "Jake" Thomas served as Mangus' field assistant and in 1965, it was William C. Penttila and Richard Moore.

Post-merger collaboration

After the merger with Richfield, Gil Mull worked with Mangus, as did Hank Repp of Humble in 1966.

"In 1964, (we) shot our first line across the Prudhoe structure," Mangus said. "Lonnie Brantly and Jack Carlisle were making maps as the data arrived from the field crew."

Richfield was also shooting the area and had its own independent interpretation on which Prudhoe Bay leases would actually be acquired.

Concurrently, Larry Pipes on Atlantic Refining's Dallas staff was also making an interpretation. Atlantic had as partners for some of the geophysical work Pan American and Sun Oil, but the two companies lost interest and did not participate in bidding for leases at Sale 14 in July 1965 when the leases that Richfield and Humble ultimately became part of the Prudhoe Bay oil field, Mangus said.

If only he could eat his words

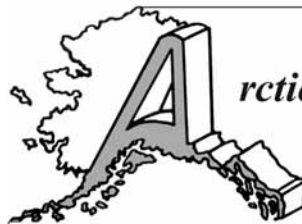
"I remember one day at lunch at the 'Bull' (community) table at the Petroleum

But this time instead of a boat, Mangus conducted his field surveys with the aid of his fixed-wing and helicopter air support.

Club," Mangus said. "A contemporary geologist with Union was deriding Atlantic Refining for exploring on the North Slope. He said with great sarcasm, 'Why, you would have to

find 500 million or 600 million barrels of oil.' His implication was that it would be impossible to find a field that large. How wrong he was about that."

On the other hand, statistics were on his side, Mangus observed. "With what was known and given the industry history and experience at that moment, it was very unlikely we would find something large enough to be commercial," he added. ♦



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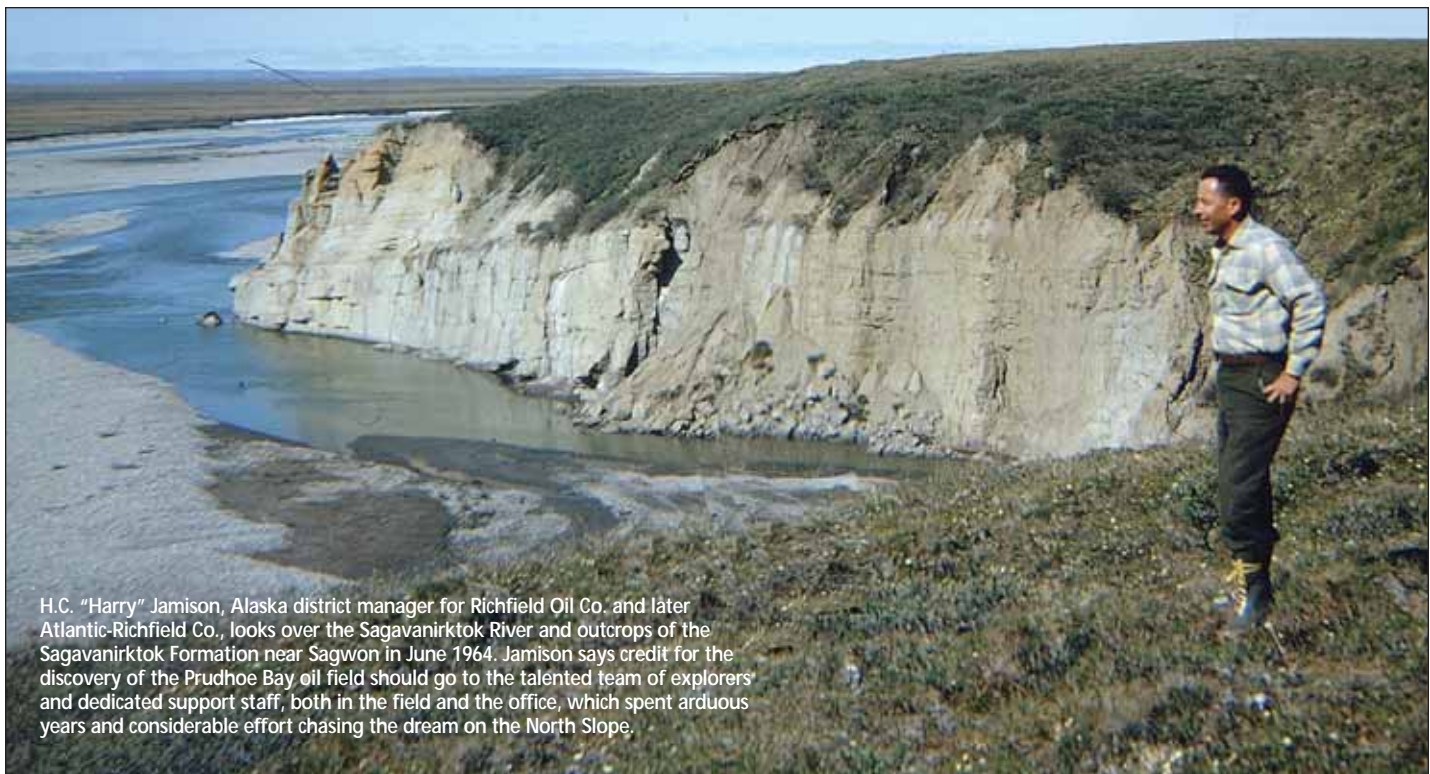
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C.G. "GIL" MULL

H.C. "Harry" Jamison, Alaska district manager for Richfield Oil Co. and later Atlantic-Richfield Co., looks over the Sagavanirktok River and outcrops of the Sagavanirktok Formation near Sagwon in June 1964. Jamison says credit for the discovery of the Prudhoe Bay oil field should go to the talented team of explorers and dedicated support staff, both in the field and the office, which spent arduous years and considerable effort chasing the dream on the North Slope.

Oil field discovery saga spawns MVP

Geologists, others say ARCO's Jamison is individual most responsible for California major's exploration success on North Slope

By Rose Ragsdale
For Petroleum News

If the discovery of the Prudhoe Bay oil field on Alaska's North Slope was a team effort, then H.C. "Harry" Jamison, a young, mid-career geologist out of California, was unquestionably that team's most valuable player.

"Without Harry Jamison, there is no question in my mind that Richfield Oil Co. and later Atlantic Richfield Co. would not have had its position at Prudhoe Bay. I consider Jamison the most important single individual in the position Richfield had at Prudhoe Bay," said C.G. "Gil" Mull, a field geologist who had worked for Richfield and later worked for Humble Oil & Refining Co. when the oil field was discovered in 1968.

In an exploration program, Mull said there is usually no way to say that any one person was responsible for a discovery — because these things are a team effort

involving a number of people and events over a period of time — all of which had to occur. "And in some ways the same thing was true for the Prudhoe Bay oil discovery. But, without Harry, a number of the critical events for Richfield would not have occurred. Richfield — and thus ARCO — would not have had its position at Prudhoe Bay had it not been for his push and managerial expertise," he explained.

Educated in California oil fields

Jamison, who attended high school in St. Louis and Beverly Hills, served in the U.S. Navy during World War II and saw combat in the Pacific as a second-class radio technician, had earned his geological credentials at the University of California, Los Angeles, and in Richfield Oil Co.'s Cuyama Valley oil field in central California.

Richfield hired Jamison two years after the 1948 discovery of the 400-million-barrel field during an intensive development pro-

gram that saw the young geologist "sitting" on 15 wells his second day on the job.

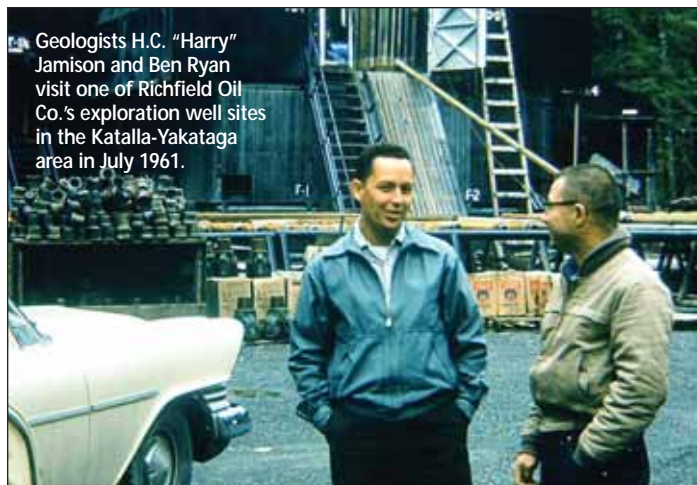
Jamison's boss on that first job in 1950 was an engineer named Mo Benson, who became a pivotal figure in his future in Alaska.

At first, Jamison spent three 24-hour days on the rig and six days "off" in the company's offices working eight-hour shifts. For 18 months, he held that position, working with petroleum engineers, roughnecks and toolpushers. He then spent six months doing subsurface work in the San Joaquin Valley.

"I was a total greenhorn," recalled Jamison recently. "I had never been on a rig before. It was a great education."

Richfield then transferred Jamison and his boss to a two-person office in Olympia, Wash. He spent three years there, including 18 months alone, studying the geology of Washington State.

"I did (plenty of) tough field geology,



Geologists H.C. "Harry" Jamison and Ben Ryan visit one of Richfield Oil Co.'s exploration well sites in the Katalla-Yakataga area in July 1961.

C.G. "GIL" MULL

mapping areas that had never been mapped before. By the time I finished, I had a lot of field experience. That's because the western part of the state was like a rainforest and as you go into the mountains, the Cascades, it's more like a high desert environment," he recalled.

Jamison returned to Los Angeles as an administrative geologist, where he worked for a couple of years before gaining another broadening position as administrative assistant to Mason Hill, Richfield's manager of exploration.

Jamison journeys to Alaska

It was 1960 before Jamison made his first trip to Alaska. He was asked to do troubleshooting on the Katalla-Yakataga project for Richfield with partners Sinclair and British Petroleum.

In early 1961, Richfield decided to reorganize its Alaska operation and put Jamison in charge as exploration supervisor for Alaska and the Pacific Northwest and posted his good friend Ben Ryan to Alaska as district geologist.

"Ben and I were very close. He worked with me in Cuyama for several months and we worked together in Bakersfield. I knew him to be blunt, forthright, and very honest in his opinions and a sound geologist of few words. So when he said something, I listened," Jamison said.

Richfield, a moderate-size

major integrated oil company, was working offshore in Cook Inlet. Besides its 1957 discovery of the Swanson River oil field on the Kenai Peninsula — the first commercial discovery in Alaska — the company had participated with other companies in several successes, including the Beluga River gas field.

Another critical piece of the puzzle fell into place some months later when Richfield's district geophysicist Charles "Charlie" Selman began to work directly with Jamison and Ryan.

"It was a very positive change. Charlie was a math major from Arkansas State, a good ole Southern boy and a damn good geophysicist. He understood the ramifications of physics but he was an excellent interpreter. Most people would be lost, but Charlie was able to convey what he did in maps and words," Jamison said.

Selman, Ryan and Jamison became the prime movers in Richfield's exploration program on the North Slope.

"Ben was close-mouthed, terse, factual and solid in contrast to Charlie, who could tell really good stories," Jamison recalled. "I think our friendship and ability to work together had a lot to do with what happened on the North Slope."

Spurred by the promise of more federal land becoming available for exploration, Richfield sent a geological field party to the North Slope in 1963.



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Earlier, Richfield has as many as eight geological field parties scattered across Alaska during the summers of 1958, 1959 and 1960. These field parties included two parties on the North Slope in both 1959 and 1960, which had given Richfield the general framework of the region's geology. Now the company needed to fill in the details between the Colville and Canning rivers, where BLM was promising to offer acreage in 1964.

"We wanted to zero in on that area, though it was expensive. But it was not as expensive as putting together a seismic crew," Jamison said.

Fateful summer field work

The results of the 1963 field work would reverberate through the years

Jamison, who visited Alaska every two or three weeks, sent two young geologists, C.G. "Gil" Mull and Gar Pessel, to the North Slope as co-leaders of the summer field party.

Excited by oil shows in sandy outcrops he and Mull ran across near the Sag River, Pessel penned a letter to his bosses, extolling the potential of the rocks they had seen.

When Ryan and Selman got the letter, they passed it along to Jamison with their endorsements.

When Jamison read Pessel's letter, he decided to attach a longer missive, outlining the company's options and recommending seismic coverage of the area. He also warned his bosses that if Richfield did not follow up on the field party's findings, the company "would be out in the cold."

"Both Ben and I knew Gil and Gar very well. They knew good rocks when they saw them, and if they had the guts to stand behind their observations, then we could stand behind them," Jamison said.

Richfield's managers had just begun to consider possibilities when Selman and Ryan phoned to alert them that a seismic crew would be available if the company moved quickly to secure their services.

Richfield managers become believers

Jamison encountered a certain amount of resistance in pushing for more investment in northern Alaska exploration among higher management at Richfield, not only at this point, but throughout his tenure as Alaska district manager, according to Mull.

Richfield's manager of exploration, Mason Hill, was traveling when Jamison got the call about the seismic crew, so he went to Frank McPhillips, the general manager of land and exploration, and Bill Travers, the



Charles "Charlie" Selman, Alaska district geophysicist for Richfield Oil Co., confers with Ben Ryan, Richfield's district geologist for Alaska, during a visit to the company's first seismic operation on the North Slope in December 1963.

executive vice president of exploration and production.

"My job was to convince them that this was an opportunity we could not afford to pass up," Jamison said.

Richfield hired the United crew.

"There is no doubt that was the turning point," Jamison recalled. "Without that decision, we would most certainly have become a minor player on the North Slope. This chain of events illustrates that no one person can take credit and say I found Prudhoe Bay."

Jamison said the teamwork aspect so pervades the story of Prudhoe Bay's discov-

ery that it may offer more profound insights into how organizations work.

"If a team works well together, sometimes you can come up with successful ideas that move from the bottom to the top. Any interruption or block along the way would have resulted in failure," he observed.

But failure wasn't in the tea leaves for Richfield.

Jamison said Richfield shot a line of seismic from the foothills to Prudhoe Bay, across the Prudhoe Bay structure. It also shot a closed anticline, and drilled the Susie State No. 1 well, trying to find the sand that Gar and Gil had been so enthusiastic about.

During this multiyear effort, costs began to mount and Richfield needed a partner.

Jamison said Hill suggested that Richfield approach Humble Oil & Refining Co. (predecessor to ExxonMobil), saying Humble would be a good partner.

Jamison called Humble and J.R. Jackson, Dean Morgridge and Ken Fuller came across the street to meet with Hill and Jamison.

"I showed them our seismic results, which at that time did not include data from the Prudhoe Bay area, and the samples that Gar and Gil had sent back from the Sag River. Those samples had 2 Darcies of per-



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meability. You could practically blow through them, and they had oil stain," Jamison recalled.

Persuaded, the Humble trio traveled east to company headquarters in Houston and recommended to their board of directors that Humble partner with Richfield and leave Richfield as operator of the North Slope venture.

Humble's board agreed.

"They paid us quite a bonus and became our 50 percent partner," Jamison said.

For that simple act of faith and a few million dollars, Humble (later Exxon) would reap billions.

Richfield merges with Atlantic Refining

Jamison continued to lead the charge as Richfield cleared more hurdles in the years leading up to the oil field's discovery. These included hiring a second seismic crew for the winter of 1964-65, acquiring more federal acreage from BLM, drilling the disappointing Susie well.

"Everybody had basically given up, going into the period in 1966 when Richfield was acquired by Atlantic Refining," he recalled. "We were shaking in our boots. I was really concerned. I had seven children."

After the merger, Jamison was again tapped to manage the Alaska district.

In addition to his reputation at Richfield, Jamison said he believes the impression he made on Louis Davis, Atlantic Richfield Co.'s vice president of exploration, during a three-hour, one-on-one meeting gave him a leg up in securing the appointment.

But it was his first boss, Benson, who made the final decision to re-appoint Jamison as Alaska district manager, after ARCO Chairman and CEO Robert O. Anderson told him to find the "brightest" person he could to run the Alaska operation.

As district manager, Jamison was the point person for merging the Richfield and Atlantic Refining organizations.

"That time was like walking on eggshells. It was tough, putting two groups together," he said.

Atlantic Refining was a larger organization with procedures in place, so "it was a steep learning curve for us Richfield guys," Jamison recalled.

Fortunately, Atlantic's people were just as enthusiastic about the North Slope's potential as Richfield's staff.

"We had good vibes between us. We had discovered the Trading Bay field in Cook Inlet that summer after the merger,"

Jamison said.

It was a Union Oil explorationist who told Jamison during a plane ride back to Los Angeles that "he would drink all the oil that anyone finds on the North Slope."

As outrageous as his attitude sounds today, it was understandable at the time.

"The general knowledge of logistics, drilling, expenditures, climate and weather of Alaska was virtually nil, even in Alaska," Jamison said. "Very few people, even residents of Fairbanks, had knowledge of the North Slope. It was really telling that once you flew over Bettles, you would not see a single light all the way north to the coast. If the Prudhoe Bay well hadn't come in or been encouraging, it would have written 'finit' to the (industry's North Slope exploration) effort at least for a number of years."

But Prudhoe Bay State No. 1 did find a big oil field, and the rest, as they say, is history.

After Prudhoe Bay

Jamison continued to serve as Alaska district manager for ARCO during the tumultuous months after the discovery in 1968 and 1969. He was then transferred to Dallas and became Alaska coordinator.

In 1970, Jamison was seconded to Alyeska Pipeline Service Co. for two years,



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where he worked to gain congressional passage of the Alaska Native Claims Settlement Act.

In 1973, he returned to Dallas to become vice president and chief geologist in ARCO's North American producing division. "I greatly enjoyed that job. We had lots of activity, good budgets and good people," he recalled.

In 1980, ARCO asked Jamison to take over as district manager for the Rocky Mountain District in Denver and to supervise exploration for the central and western United States. He said he found the hybrid job a challenge, especially trying to put together an exploration group by drawing on the resources of other districts.

Then in May 1981, he was promoted to senior vice president of Atlantic Richfield Co., and appointed president of a new company he was charged with creating — ARCO Exploration Co.

"I stayed for four years, and we found a number of modest-size oil fields scattered around the country," he said.

In 1985, the oil industry underwent a major retrenchment and Jamison was offered a golden parachute to retire at age 60 with the same benefits he would have enjoyed at age 65. He took the offer and immediately began working as a consultant.

That work continued for the next eight years and included a couple of special projects on the North Slope for the U.S. Department of Energy, Jamison said.

Jamison's role key to ARCO's success

Despite his quiet exit from ARCO many years later, Mull and others say Jamison remains the guiding force behind the fateful events that culminated with the giant oil field's discovery.

Mull lists Jamison's major contributions as follows:

- "It was Jamison who personally pushed to get the second Richfield surface geological mapping field party on the North Slope in 1963 — against some amount of resistance in the company, from people who thought that Cook Inlet was the only place to be working. And it was on that summer field party that we found two oil-saturated sandstone outcrops that had never previously been seen.

- "Harry then took the information about the oil-saturated sandstone that Gar Pessel found and other favorable indications, and at the proper time convinced high-level management that the company needed to have a seismic geophysical exploration crew that coming winter if we were going to be successful in exploration

on the North Slope.

- "Again, he did an admirable job of selling the idea to management at the proper time. It was that seismic crew that the following winter ran the first seismic survey for Richfield across the Prudhoe Bay structure and that influenced the bidding that Richfield and Humble did in the first Prudhoe Bay oil and gas lease sale, in which the two companies in partnership acquired the leases across the highest part of the Prudhoe Bay structure. (This was before the merger with Atlantic Refining Co.)

- "Harry also played a role in arriving at the successful bids that Richfield/Humble submitted for those leases. The Atlantic Refining Co. bids on the same tract were way, way low, and if it were not for the Richfield/Humble leases, the merged Atlantic Richfield Co. (ARCO) would not have had its large position in the field. Instead, British Petroleum and other companies would have had the majority of the field, and ARCO would have been a minor player in the area.

- "ARCO senior managers would have had nothing to sell when they sold ARCO, a profitable company out from under the employees in 2000, if it had not been for things that Harry Jamison did 40-plus years ago," Mull concludes. ♦

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Prudhoe Bay discovery: A retrospective

Richfield and then ARCO district manager takes a playful look back at the way it really happened and what might have been

Editor's Note: These remarks are excerpted from a paper written for the Alaska Geological Society Technical Conference, April 19, 2008

By Harry Jamison

First of all, let an old man of 83 years tell, for the first time, the unvarnished truth. I found it! I alone had the genius and persistence that led to success!

The problem is that it didn't happen like that. It was a team effort from the beginning.

It was my privilege to lead the exploration group within Richfield (Oil Co.) that did the geological field work, the recon and detailed seismic and the over-



H.C. "Harry" Jamison, Alaska district manager for Atlantic-Richfield Oil Co. when the Prudhoe Bay oil field was discovered in 1968, hikes through the rocks on a trip in southern Utah.

all stratigraphic and structural analyses that convinced us we had viable play. Fellows like Ben Ryan, Charlie Selman,

Armand Spielman, Leo Fay, Gar Pessel, Pete Clara, Rudy Berlin, Milt Norton, and yes, Gil Mull, all played vital roles.

Then there were fellows from Humble's (Los Angeles) office, who we convinced in 1964 to buy into a very risky program. J.R. Jackson, Dean Morgridge and Ken Fuller were the first believers.

After the merger with Atlantic Refining in 1966, I once again was privileged to lead the combined company office in Anchorage as district manager. This time we were drilling the Susie Unit No.1 with a Loffland Bros. rig that we flew to the North Slope in Hercules cargo planes on lease from the Air Force. The (Susie) well was dry. So we took the rig some 60 miles north over the tundra



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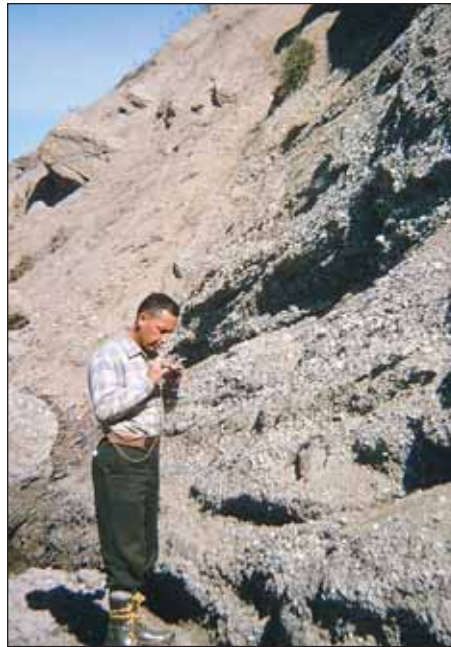
to PB in early 1967 and spudded the Prudhoe Bay State No. 1 well before breakup, only to shut down in early May.

We had great construction foremen, expeditors, drillers and tool-pushers under the overall supervision of my drilling and production superintendent Lee Wilson. Names like Benny Lauder milk, Joe Dunn, Wray Walker, Ernie Arp, Bill Congdon, Joe Mann, John Ruosi and Jim Keasler come to mind as well as our chief pilot, Marv Meyer, who ran our aircraft operation and Roland Champion, district landman.

The well was drilled, cored, tested and evaluated in an absolutely first-class fashion. These geologists and engineers who designed and carried out the program gave us the foundation for expansion on which to build the future development of the field.

John Sweet was my exploration manager and Don Jessup, Bill Pentilla, Marv Mangus, Woody Kingsbury and Jerry Rochon are a few key names.

Why do I get so specific as to name these Alaskans? To emphasize that it was a team effort and to give some degree of recognition to those who might not be remembered. Our ranks grow thinner, year by year.



H.C. "Harry" Jamison, Alaska district manager for Richfield Oil Co. and later Atlantic-Richfield Co., examines sandstone and conglomerate in the Tertiary Sagavanirktok Formation near Sagwon in June 1964.

Reality intrudes on rosy recollection

Man, was it exciting to drill into the Sadlerochit and the main Lisburne objective and have the great shows, cores and

tests immediately and know you've hit the big time jackpot!

What a rush! To have your company executives, the politicians and the press hailing you as the new heroes of prosperity for the company, Alaska and the nation. What an ego trip!


The problem is: It didn't happen like that.

In reality, it was a very slow, gradual awakening. We had shows all the way down the well. We had good, solid formation tests in the Sadlerochit and the Lisburne. We had test rates that were spectacular anywhere else. But were they good enough to make us believe we had a billion-barrel oil field? Not really.

We had a thick gas column on top of a relatively thin oil sand in the Sadlerochit.

Everyone knew what gas was worth in Alaska, especially on the North Slope.




Yes, there was excitement and enthusiasm within ARCO and certainly in the news media. But the Eureka moment did not arrive until we had drilled the confirmation well, Sag River State No. 1. That was in July 1968, about a month after the completion of the Prudhoe Bay well. The first drill test in Prudhoe Bay No. 1 was in December 1967 and the confir-



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mation well was drilled in July 1968.

That was really a gradual process, especially when you spend your time fending off constant inquiries about what you found and you really don't know the answer.

Discovery reflects hard work

My feelings then were two-fold.

First, I was very proud of my team and the accuracy of that interpretation that led us to the discovery, followed by a successful step-out seven miles from the discovery. None of us had ever heard of such a thing. It took a lot of science, engineering and management guts.

Secondly, I was ecstatic that we could at last be credited with real success, a commercial discovery on the North Slope of a world-class oil field. A lot of people then and later, for whatever reason, attributed the discovery to luck.

Of course, I knew we'd been lucky but that our luck was based on 10 years of exploration, land acquisition efforts, logistical operational know-how and management level support all the way to the top at both ARCO and Humble.

We gave ourselves the opportunity for serendipity through hard, intelligent, persevering work and guts and judgment and it paid off.



C.G. "GIL" MULL

H.C. "Harry" Jamison, Richfield Oil Co.'s exploration supervisor for Alaska confers with Ben Ryan, Richfield district geologist for Alaska, during a visit to the company's first seismic operation on the North Slope in December 1963

Discoverers bask in glory of find. Not!

After all that science and engineering and good luck, what resulted for us was a leisurely round of congratulatory banquets and awards ceremonies, big promotions and public adulation. It was fulfilling and satisfying to be part of it.

The problem is: It didn't happen like that.

What really happened was CHAOS.

It was like being caught completely unawares in a monstrous avalanche. We were deluged with orders, directives, requests, demands, obligations and bureaucratic nonsense.

First, we had to meet the immediate demand for action on the Slope, extension wells, air strip construction and controls, camp expansion, construction equipment, additional aircraft, fuel supplies, seismic crews, drilling rigs, security measures and a hundred other things. And we had to begin the series of findings for long-term development and production and pipeline segments.

What about housing several hundred, then several thousand workers? What about flying them in and out? What about finding them in the first place? You get the idea, hundreds of operational questions and problems were facing us every day.

Then we had the equally immediate need to vastly expand our staff in Anchorage in all disciplines. My bosses decided to provide me with managerial level help. So we added legal, business operations and employee relations departments and managers during the next few months. But no local help was forthcoming with government and public relations. We were left to our own devices and that was largely my bailiwick.

And we had visitors, did we ever have visitors!

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I know personally that anyone in ARCO at all, who had an excuse, had an urgent need to come to Alaska. Folks also needed to cross the Arctic Circle, to be in a photo at the discovery well or at least, the Sag River site, and have a personal visit with the district manager, me.

We had folks from Humble, including auditors, who wanted to know why I rented Cats from Tennessee Miller's Frontier Rock and Sand, rather than using company equipment (which we didn't have).

We had the board of directors from Union Oil, including Chairman Fred Hartley, who during the oil spill in Santa Barbara, was rumored to have said, "What's a few damn birds?"

And we had a delegation of about 50 from the United Nations in New York, accompanied by the president of ARCO, Thornton E. Bradshaw.

And we had enumerable members of the media, including Time, Oil & Gas Journal, Bakersfield Californian, Life, Oil World, Los Angeles Times, San Francisco Chronicle, National Geographic, Reader's Digest and many, many others.

Our first visitor, however, was Alaska Gov. Walter J. Hickel, who was accompanied by Phil Holdsworth and Roscoe Bell, and we had a group of Humble managers along. During the UN visit, one of the diplomats was a small, slender East Indian lady dressed in a bright orange sari. At the time, we were beginning construction of the base camp, which required drilling a large number of 18-inch-wide eight- and 10-foot-deep holes in the permafrost to set pilings and foundations for the camp modules.

The Indian lady was very active and curious, and I remember being petrified that she would wander off and fall into one of the piling holes and disappear.

Another incident occurred, when, contrary to all flight and ground control rules, John J. King [the independent oil man

who bought the rifle (Lee Harvey) Oswald used to kill Kennedy) landed on our airstrip at Sag River State. He debarked from the plane and was met by Bill Congdon, who was our rough and ready, surly and imposing tool-pusher.

King asked how far up the rig he and his party could go.

Bill growled, "You're there right now."

Congdon also told King he was on a private air strip without permission. John climbed back aboard and left with no further discussion.

Discovery still satisfying

Besides all the furor and frustration, there was a lot of satisfaction, too. After all, we'd found what was acknowledged as the largest oil field in North America and had done it in an efficient and professional manner.

Thirteen billion barrels of recoverable oil doesn't go unnoticed.

My impression at the time: It was a damn good job of exploration in a remote, forbidding, harsh part of Alaska. It was an adventure and a lot of fun. The folks I had the privilege to work with were and are my personal heroes.

To borrow a familiar, partial quote from Dickens: "It was the best of times ..." ♦



View of a test hole drilled through permafrost for oil drilling operations at Prudhoe Bay.

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Field discovery debate still rages

Finding the subsurface ocean of oil known as Prudhoe Bay involved two Arctic exploration wells and spanned more than a year

By Rose Ragsdale
For Petroleum News

Forty years after a team of explorers first drilled into North America's largest oil field, the actual date of discovery remains a subject of debate, even among the geologists, engineers and others who participated in the world-changing event.

The problem is that Prudhoe Bay's discovery, like most great endeavors, didn't happen in a moment of brilliant inspiration. Instead, it took months of gritty toil, frustration and uncertainty to unleash the elephant locked beneath Alaska's North Slope.

"It was about as exciting as watching a tree grow," recalled John Sweet, then district explorationist for Atlantic-Richfield Co.

Pivotal event in question

Sweet, who was an integral part of the Prudhoe Bay discovery team, said he is convinced the Prudhoe Bay oil field wasn't actually discovered until the Sag River No.1 well was drilled in the summer of 1968.

"The first well provided the leadership, but if that had been all we'd found, it would not have been commercial," Sweet told Petroleum News.

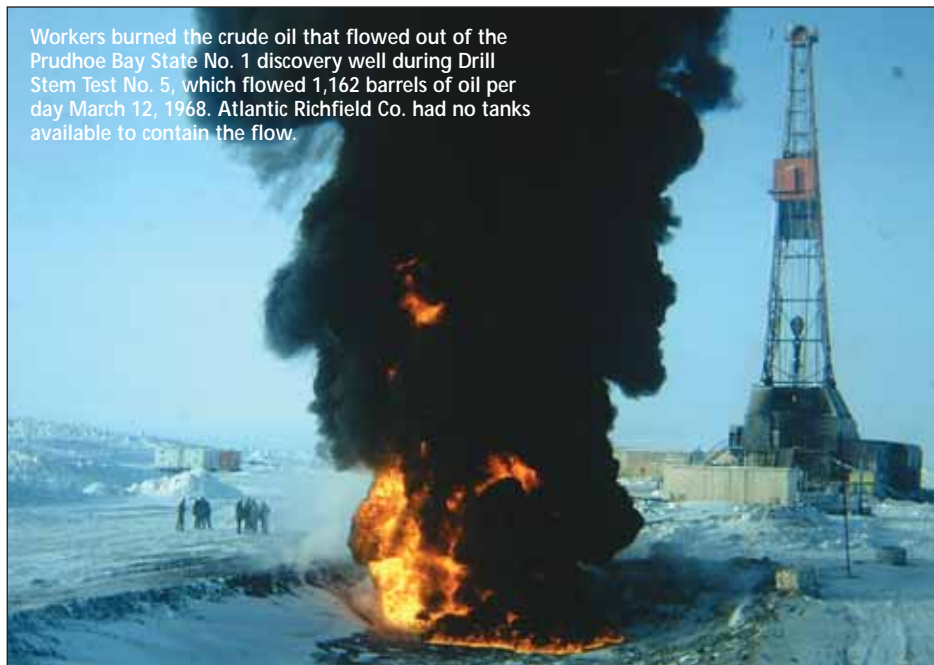
H.C. "Harry" Jamison, then ARCO's Alaska exploration manager, disagrees. Jamison, who led the Prudhoe Bay discovery team, said the oil field's date of discovery was the date the well was completed.

Alaska Oil and Gas Conservation Commission records show that date as June 24, 1968.

"I've worked all over the United States, and I've always heard that conventional wisdom is that the date of discovery is the date the well was completed," Jamison said. "Otherwise, you'll get dates all over the place. One guy will say, 'It was when we got first oil shows,' another one will say, 'It's when we first hit the Sadlerochit (formation), and another will say, 'No, it's when we drilled the Mississippian.' You get the idea."

People, in fact, can't even agree on the year in which the oil field was discovered. Some still say it happened in 1967, though

Workers burned the crude oil that flowed out of the Prudhoe Bay State No. 1 discovery well during Drill Stem Test No. 5, which flowed 1,162 barrels of oil per day March 12, 1968. Atlantic Richfield Co. had no tanks available to contain the flow.



C.G. "Gil" Mull

most people point to 1968.

Getting a decision to drill

The discovery chronology was complicated by many factors, including the harsh working environment and the constraints on drilling during the Arctic summers.

In retrospect, the Prudhoe Bay well has been described as a last ditch effort as the entire oil industry, smarting from the expense and disappointment of 14 dry holes, seemed ready to abandon the North Slope as a frontier for petroleum exploration.

ARCO and Humble Oil Co. pooled resources to drill the Prudhoe Bay State No. 1 well in April 1967, after the daunting failure of the Susie No. 1 well to the south and an impassioned plea to try again from then Gov. Walter J. Hickel.

C.G. "Gil" Mull, who "sat on the well" as a geologist for Humble Oil during the Prudhoe Bay field's discovery, said ARCO's exploration department unanimously voted to drill in the Prudhoe Bay structure.

Number-crunchers in the Dallas headquarters, however, were skeptical.

They reportedly asked Louis Davis, ARCO's vice president of exploration in North America, to commit to the well producing at least 500 barrels per day of crude before they would agree to the project.

Davis subsequently told colleagues that he had no idea what Prudhoe Bay State No. 1 would find, but he quickly assured the accountants that the well would produce at least 500 barrels per day.

E.M. "Mo" Benson Jr., who was Harry Jamison's boss and the ARCO executive who reported to CEO Robert O. Anderson on the North Slope project, told author Gene Rutledge in the 1980s that a major factor in convincing skeptics in Dallas was a provision in the contract that the company had negotiated for a rig to drill the Susie No.1 well.

Benson said the rig's owner, Loffland Bros., required ARCO to pay the cost of shipping it back to Fairbanks. He said ARCO President Thornton F. Bradshaw argued that since the rig was already on the North Slope, ARCO could essentially drill a second well for relatively little additional cost.

"According to Brad, he used that argument to support drilling the Prudhoe Bay

State No. 1 since, in effect, he considered it a free well as we would have had to spend the same money to fly the rig out in lieu of drilling," Benson said.

"Be that as it may, Bob Anderson's support never wavered. My personal role in the decision to drill Prudhoe Bay was purely in support of the exploration people who were enthusiastic about the prospect," he said.

Benson said the list of those who supported drilling at Prudhoe Bay included Rollin Eckis, former president and former exploration manager of Richfield, Mason Hill and the entire Alaska exploration staff of Richfield as well as the exploration staff of Atlantic Refining, including Julius Babisak, the exploration manager.

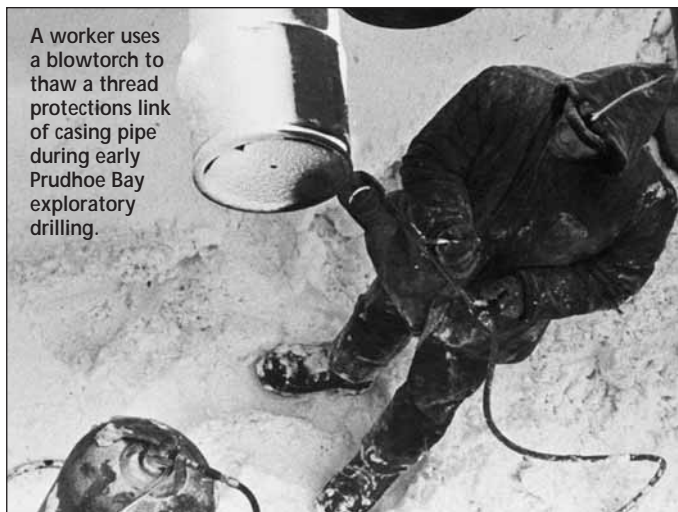
All of the persuasion apparently worked.

"The location of the Prudhoe Bay State No. 1 well and of the confirmation well, Sag River State No. 1 were picked by our explorationists, including Harry Jamison, a geologist and Alaska district manager of ARCO," Benson told Rutledge.

Benson said others involved in selection of the well sites included former Richfield Chairman Charles S. Jones, Ben Ryan, Charlie Selman, Bill Bishop and Bob Specht from the Richfield side and ARCO Vice President of Exploration Louis F. Davis, James A. Savage, chief geologist and John A. Thomas, chief geophysicist as well as Marvin Mangus, John Sweet and Don Jessup on the Atlantic Refining side.

The opinions of all of these professionals came together when drillers spudded the

ATLANTIC RICHFIELD COMPANY COLLECTION



A worker uses a blowtorch to thaw a thread protection link of casing pipe during early Prudhoe Bay exploratory drilling.

Prudhoe Bay State No. 1 well April 22, 1967. After a couple of weeks, ARCO shut down the well for the summer due to breakup conditions.

The explorers re-entered the well in November 1967, and soon had small oil shows in drill cuttings from thin sandstones in the upper part of the well in late November and early December 1967.

Early oil shows encouraging

"This, however, is not uncommon on the North Slope; almost all wells drilled there encounter some shows in the Cretaceous sandstones, thus seeing small oil shows in this part of the section was not particularly significant," Mull said.

On Dec. 8, 1967, a drill stem test run on an interval of thinly inter-bedded Cretaceous age sandstones and shale from 6,876 feet to 6,998 feet deep flowed with some natural gas and recovery of a few barrels of oil from the drill pipe, though no oil

flowed to the surface.

"This was an encouraging sign, but again not terribly significant, because other wells previously drilled on the North Slope also had recovered small amounts of oil from rocks of Cretaceous age — those deposited some 65 million to 140 million years ago," Mull said.

On Dec. 27, 1967, the explorers encountered strong gas shows during drill stem test No. 2 in the Triassic Ivishak Formation of the Sadlerochit Group, and the well flowed with a high volume of gas, which marked a significant gas discovery.

Mull said this was the first significant production of hydrocarbons from what has become the main reservoir of the Prudhoe Bay field, but no oil was encountered in this part of the section.

Eyewitnesses recall that the gas rushed out of the well roaring like a jet engine with such force that it shot 50 feet into a 35-knot wind.

After drilling resumed Feb. 1, 1968, oil shows were seen in the drilling mud and in cores from the lower 40 feet of sandstones in the Sadlerochit Formation, but were not evaluated until logs were run on Feb. 8, 1968.

"Evaluation of these logs along with the core data indicated that the formation had sufficient porosity and contained enough oil that it could be considered a discovery," Mull says.

Field discovery announced

ARCO sent out a news release Feb. 16,



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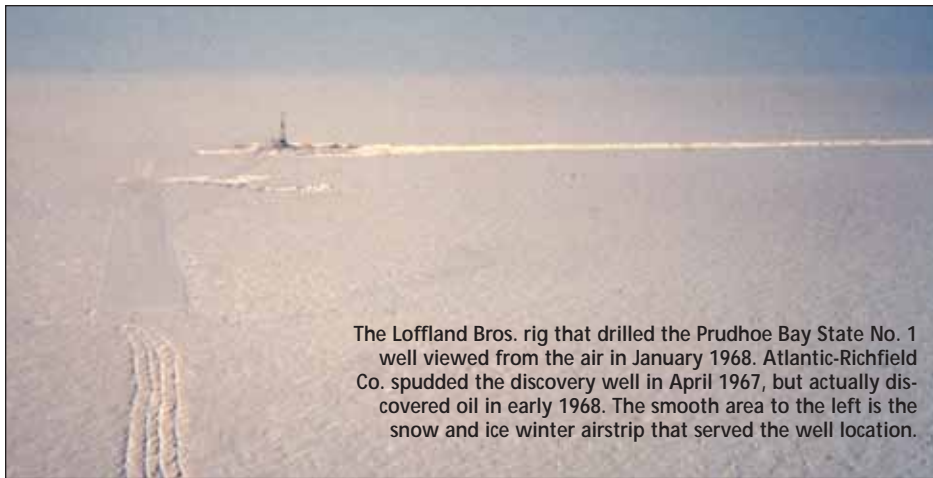


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The Loffland Bros. rig that drilled the Prudhoe Bay State No. 1 well viewed from the air in January 1968. Atlantic-Richfield Co. spudded the discovery well in April 1967, but actually discovered oil in early 1968. The smooth area to the left is the snow and ice winter airstrip that served the well location.

C.G. "GIL" MULL

1968, announcing the discovery of oil, though no flow tests had been conducted.

Two days later, the explorers conducted drill stem test No. 3 in the top of the Lisburne limestone. It flowed with a large amount of gas and an estimated 100 barrels per day of oil, but at least part of this oil and gas flow probably came from the overlying Sadlerochit Formation rather than the Lisburne, according to Mull.

The first actual measured oil flow from the Prudhoe Bay well came in Drill Stem Test No. 5 in the Lisburne on March 12, 1968. It measured the flow at 1,152 barrels per day of oil and produced headlines March 13, 1968.

"However, this oil was produced from Lisburne limestone and dolomite that underlies the sandstone and conglomerate of the Sadlerochit Formation, and showed that there are multiple reservoirs in the Prudhoe Bay area," Mull said. "This had the effect of increasing the likelihood that the Prudhoe Bay field could be economically viable."

By May 1968, several drill stem tests had measured the flow of oil from several intervals in the Sadlerochit Formation.

About a month later — June 25, 1968 — explorers drilling the Sag River State No. 1 well encountered oil in the Sadlerochit Formation, seven miles away and 400 feet deeper than crude found by Prudhoe Bay State No. 1.

On July 18, 1968, ARCO and Humble announced that the Prudhoe Bay field probably contained 5 billion to 10 billion barrels of recoverable oil.

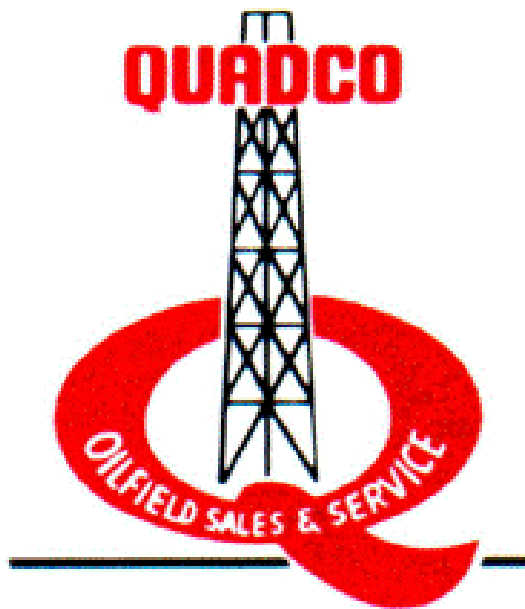
Support for winter discovery

So when was the Prudhoe Bay oil field discovered?

"As you can see, there was a succession of events that built to the realization that the Prudhoe Bay State No. 1 well was a commercial discovery," Mull said in a letter to author Gene Rutledge in 1998. "But, if I had to pick a date at which one could say that oil was discovered in the Prudhoe Bay field, I would pick Feb. 1, 1968, when the first oil saturated sandstone was encountered in what has become the main reservoir in the field."

Not so, says Marvin Mangus, ARCO's well geologist for Prudhoe Bay State No. 1.

"Oil was discovered at Prudhoe Bay in December 1967," Mangus told Petroleum News. "We decided not to make it known until we drilled the confirmation well. So, the top brass decided to hold off making the announcement until February 1968. But all of us on the well had decided that we



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had something. It should have been right around Christmas 1967.

"You just don't have oil shows that big unless it's really good. We felt that it was a discovery," Mangus said.

Frigid weather hampered progress

Garnett "Gar" Pessel, a geologist who worked in ARCO's geophysical department at the time on core samples coming in to Anchorage from Prudhoe Bay State No. 1, said one possible reason for the conflicting views on the discovery date was the huge amount of uncertainty that loomed over the operation that winter. Frigid temperatures caused equipment to malfunction and bogged down the pace of exploration.

"During the early testing, the engineers were unfamiliar with working in the cold. The equipment kept freezing up and giving bogus results, and the guys kept arguing about it," Pessel said. "But Don Jessup, the district geologist for ARCO kept looking at the cores and getting excited."

Sweet agrees that the cores looked promising. "I had never seen oil shows like that before in my whole career," he told members of the Alaska Geological Society at its annual technical conference in April 2008. Still, those tantalizing glimpses of something big did not an economic discovery make, according to Sweet.

Geologists aimed for Lisburne

Part of the problem was that the initial target for the Prudhoe Bay well was the Lisburne Formation. However, Richfield geologists had been eyeing the Sadlerochit Formation since doing field work in the Brooks Range in the early 1960s, Mull said.

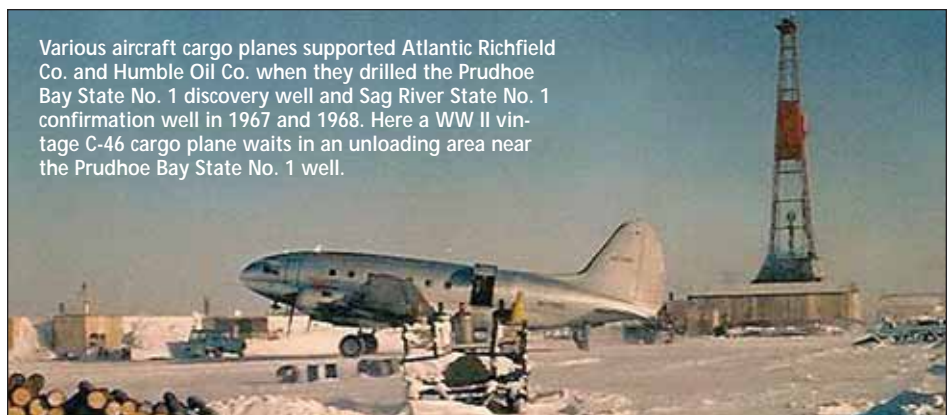
In fact, when Susie No. 1 reached its projected total depth in the Jurassic Kingak at 13,500 feet and ARCO and Humble's geologists flew to Barrow to telephone in their report, they made a pitch for "taking the Susie well on down another 2,000 feet or so to the Sadlerochit to see what it looked like," Mull said.

A lack of casing at the well site prompted company executives to "wisely" nix the idea, he said.

Dramatic breakthrough

At 8,700 feet, the drillers got 150 barrels per day of oil, but when they dipped below 9,500 feet, gas flowed for 3 minutes and oil at 1,152 barrels per day, Sweet said.

The period was frustrating because the oil shows were in shale with very little sandstone. After the drill bit penetrated other formations in the well, it reached the Sadlerochit formation at 8,200 feet.



Various aircraft cargo planes supported Atlantic Richfield Co. and Humble Oil Co. when they drilled the Prudhoe Bay State No. 1 discovery well and Sag River State No. 1 confirmation well in 1967 and 1968. Here a WW II vintage C-46 cargo plane waits in an unloading area near the Prudhoe Bay State No. 1 well.

C.G. "GIL" MULL

"The drill had been progressing at a foot an hour," Sweet recalled. "When it hit the Sadlerochit, the drill rate went ... to about a foot a minute. We ran a test and we had gas to surface at 1,250 Mcf/d.

"On Feb. 4, 1968, we reached ... part of the Sadlerochit and what came out was aggregate, loose sand and oil, some of which ran through the rig floor.

"I received a core analysis on Feb. 7, and it was one of the most dramatic things you'd ever want to see. With that we made the first reserve calculations," he said.

Incredible signs, caution

Sweet said those first calculations were based on reservoir characteristics such as porosity upward of 30 percent, permeability in Darcies up to 3 (when permeability in oil fields is usually expressed in millidarcies) and 65 percent oil saturation. Sweet's figures yielded 223 barrels per acre foot with 20 sections of proven, 17 sections of probable and 33 sections of possible crude reserves for a total of 2.3 billion barrels of oil. "That's the number we called in to Dallas," he said.

"In March 1968 what we had was an unbelievable reservoir, a little oil value but with good flow of oil and lots of gas. It was exciting but with many questions," he said. "Almost immediately, everybody's minds turned to a confirmation well. We had to determine the oil column, if any, the water table and the continuity of the reservoir and an all-season location, which required tons and tons of gravel."

Though the "Dallas people" pored over all the seismic maps, there was no drama and little politics involved in selecting the location of the confirmation well, Sweet said.

"It had to be a long step-out and near a source of gravel. That put the location near the Sag River where geologists determined there was lots of gravel," he explained.

The explorers spudded Sag River State

No. 1 May 3, 1968 and by July, ARCO and Humble geologists had tested the Sadlerochit Formation and confirmed the presence of the Prudhoe Bay oil field.

Mull said an interesting aspect of the Sag River well was the reservoir quality that the geologists saw in the cores. "Normally, a core that comes out of a core barrel consists of solid rock that you hope will have oil or gas in the pore spaces. But in one of the cores from the Sadlerochit in the Sag River No. 1 well, what came out was just a pile of loose sand, gravel and oil — which immediately ran down through the derrick floor into the cellar below.

In an effort to keep findings confidential, ARCO had erected a sheet on the rig to screen off the area where the geologists examined core samples from the drilling crew.

"What we were seeing in the samples was supposed to be a secret from the drilling crews, but they generally had a pretty good idea of what we were finding, and particularly so, after seeing that oil running through the derrick floor," Mull said.

On June 25, 1968, Atlantic Richfield Co. said in perhaps the most understated new release in oil company history: "The Sag River State No. 1 — a joint venture with Humble Oil & Refining Co. — has encountered oil in the same Triassic formation as the initial well."

Anderson, ARCO's CEO, said, "We believe this is a significant oil and gas discovery, the extent of which must await further testing and exploratory drilling."

Significant isn't even close to describing the find that would change the company's — and Alaska's — history forever. Just a month later, Anderson announced that the find was potentially "one of the largest petroleum accumulations known to the world today."

Says Sweet: "The statistical chance that the Sadlerochit (formation) would occur in conjunction with the Prudhoe Bay structure boggles the mind." ♦

Hickel had role in Prudhoe Bay's destiny

Former governor had uncanny interactions through two decades that contributed to the oil field's discovery and development

By Rose Ragsdale
For Petroleum News

Former Gov. Walter "Wally" Hickel tells a great story about the Prudhoe Bay oil field discovery.

"I flew to the Slope to meet with (Atlantic Richfield Co.) Alaska district manager Harry Jamison," Hickel told a group of geologists in April 2008. "He shocked me by telling me that they (ARCO) were going to pull out. I told Harry, 'You drill or I will.' They did and the rest is history."

Forty years later, the tale is so engaging that people chuckle when they hear it, and some may wonder if the 89-year-old retired politician embroiders around the facts a bit.

After all, Hickel couldn't really have done the things he says he did, right? Wrong.

Not only did Hickel play a crucial role in several important events leading up to the 1967 discovery, he also predicted the oil find and went on to influence national policy on oil development in the Alaska Arctic as U.S. Interior Secretary under President Richard M. Nixon.



Alaska Gov. Walter J. Hickel, also a former U.S. Interior Secretary under President Richard Nixon, played a key role in events leading up to the Prudhoe Bay oil field discovery.

Hickel's involvement with North Slope events began as early as 1952 when he read a report in The Anchorage Times that Congress was going to give Alaska 3 million acres.

Hickel, a young housing contractor in Anchorage, thought that was a paltry amount. So he traveled to Washington, D.C. on his own dime and ended up actually talking briefly with President Harry Truman.

Hickel also visited then U.S. Senate Majority Leader Robert Taft, R-Indiana, and made the case for statehood for Alaska.

JUDY PATRICK

When asked by Taft how much land Alaska would need as a young state, Hickel said he had no idea how many acres there were in Alaska, let alone how much the would-be state should have, so he just blurted out "100 million acres."

When he later learned that Alaska had 365 million acres, Hickel said he should have asked for half of that amount.

Six years later, Congress granted Alaska statehood with 103 million acres of land.

40 billion barrels of oil

Hickel's next brush with Prudhoe Bay's destiny came when Atlantic Richfield Co.'s Alaska district manager Harry Jamison called him in 1966 when he was governor of Alaska to plead the case for the state offering acreage adjacent to the Prudhoe Bay structure for oil and gas leasing.

ARCO reasoned that it could never drill a well in the structure with open leases, but if all of the structure was leased, even if other companies owned the acreage, exploration could go forward.

Hickel agreed and seven critical tracts were leased in a state sale in January 1967. While other companies pulled out after drilling dry hole after dry hole in the



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mid-1960s, ARCO moved a rig north and prepared to drill a well in the Prudhoe Bay structure.

"Once we asked the governor to put up those tracts, to me that was a clear signal," Jamison recalled in a recent interview. "You don't renege on that obligation. Though it wasn't a legal obligation, it was a moral one."

For Hickel, the next brush with Prudhoe Bay's fate came when he visited the discovery well site in the spring of 1968.

"Our first visitor was Alaska Gov. Walter J. Hickel, who was accompanied by (then Natural Resources Commissioner) Phil Holdsworth, (Oil & Gas Director) Roscoe Bell and (state geologist) Tom Marshall, and we had a group of Humble Oil managers along," Jamison recalled. "It was early May 1967 and breakup was in full tide. We had to shut down the rig that day. I can verify that Wally, standing there in melting slush and water, actu-

ally did say he was convinced there were 40 billion barrels of oil at Prudhoe Bay.

(To date, the Prudhoe Bay area has yielded more than 15 billion barrels of crude and still holds at least another 5 billion barrels, plus billions more in heavy oil and about 30 trillion cubic feet of natural gas.)

"I've often wondered with clairvoyance like that why Wally stuck with politics," Jamison quipped.

Hickel said Prudhoe Bay not only changed things in Alaska and America, the oil field also changed things in the world.

These days the former governor says he often finds himself at odds with the oil industry. He says company executives have a responsibility to their shareholders, but "those who helped make this state are dedicated to Alaska first."

Adds Hickel: "It's been an exciting ride." ♦

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BP's trail to Prudhoe Bay

Petroleum News

While its drilling program in the foothills was under way, BP and Sinclair carried on surveying to the north along the coastal plain of the North Slope. These were all seismic surveys, for there were no rocks or outcrops available for geological examination.

The U.S. Navy had established that oil-bearing sands existed at Point Barrow, but the question was, did they continue all along the coast?

In 1963 a brilliant young geologist, Jim Spence, came out to BP's Los Angeles office as chief geologist for the Alaska operation. Using seismic results from surveys in the winter of 1963-64, Spence and the exploration team were able to define for the first time two arches on the coast, an enormous buried dome near the Colville River Delta and a smaller faulted structure at Prudhoe Bay, further to the east. It was felt that Prudhoe was more likely to contain oil than Colville because of a tilt and then a reverse tilt, which had led to the oil migrating eastwards.

British Petroleum drilled Put River No. 1, its own Prudhoe Bay confirmation well, during the winter of 1968-1969 and announced a discovery March 13, 1969.



BP EXPLORATION (ALASKA) INC.

But both were good prospects and in September 1964, BP approached the Alaska government, requesting that all the state selected lands covering Colville and Prudhoe be put up for competitive bidding. In December 1964, the state decided to place half of the requested leases on the auction block and chose Colville instead of Prudhoe Bay for the honor.

In July 1965, while BP was making plans to bring a Canadian rig across from Umiat to drill at Colville, the state put up the first acreage at Prudhoe Bay for leasing. By this time, the American companies,

especially Richfield Oil Co., Humble Oil Co., Atlantic Refining Co. and Pan American, had begun to take notice of BP and Sinclair's efforts on the North Slope. They had all carried out geophysical surveys of their own in the area.

Sinclair bows out

Just before the Prudhoe lease sale, Sinclair decided to withdraw from the project. The company had never favored the North Slope program, but had been persuaded by BP's better-than-average record of oil discovery.

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Without Sinclair's support and despite a very limited budget, BP forged ahead on its own, bidding against the far greater resources of the American competitors. Deciding there was a chance the oil-bearing sands were thin on top and thicker on the flanks of the Prudhoe structure, the British company spread its bids to include those leases which seemed to be around the outer edge, acquiring 32 blocks for \$1.44 million, or an average of \$16 an acre.

Richfield and Humble pursued the 40 square miles on the crest, some of which they acquired for \$93 dollars an acre, out-bidding BP's \$47 per acre, Mobil and Phillip's \$12 per acre and a \$6 per acre bid from Atlantic Refining.

In 1966, BP got another disappointment when it drilled another well on the crest of the Colville structure and found only small quantities of oil.

With dollars running short, BP sought and found another partner in Union Oil Co. and began drilling a second well, Kookpuk No. 1, on farmed-out acreage in the central part of the Colville.

Atlantic Refining, meanwhile, merged with Richfield Oil and regained a dominant position on the North Slope. The newly formed company, still in partnership with Humble, decided to go ahead with a previously planned wildcat well between the Tooklik and Sagavanirktok rivers. Drilling began in March 1966.

In January 1967, the State of Alaska held another competitive lease sale with 38,000 acres of Prudhoe Bay tracts offered, compared with 403,000 acres in the 1965 lease sale.

This time, both Sinclair and Union Oil declined an invitation from BP to join in the bidding, and the company once again waded into the fray alone and with only a \$250,000 budget. By carefully spreading its bids and going for acreage where others were unlikely to offer competing bids, BP

was able to pick up six more blocks for \$44,000 each, or an average of \$17 an acre.

BP finally gives up

Shortly after the lease sale, ARCO's Susie well came up dry, and a few weeks later, the second Colville well, being drilled by Union Oil, also proved to be a failure. At that point, even BP's determination wavered. Over five years, the company had drilled or invested in eight wells drilled on the North Slope and spent \$30 million with nothing to show for its efforts.

The British company decided to cut its losses and leave the Slope. It stacked the drilling rig at Pingo Beach in preparation for shipment elsewhere, closed its offices in Anchorage and Los Angeles, disbanded the staff and stored the scientific records it had accumulated.

A few months later in March 1968, ARCO announced its discovery at Prudhoe Bay. By June, the company had confirmed its find seven miles to the southwest with the Sag River State No. 1 well, using the Canadian rig that BP had relinquished and stacked at Pingo Beach.

Rejecting offers by ARCO to take over all the Prudhoe acreage, BP decided to return to the Slope to carry out its own drilling operations. It meant a frantic rush to find a rig and assemble all the necessary equipment. With no roads to and on the North Slope, there were only three possible routes – to fly everything in from Fairbanks, which was prohibitively expensive; or to ship by barge along the Mackenzie River from Canada or by way of the Aleutians and the Bering Straits. In either of the two sea routes there were only six weeks of summer when the pack ice in the Arctic Ocean melted enough to allow the barges to reach the North Slope.

It was too late in the year to use the

Mackenzie River route, which BP had pioneered. No one had ever tried such a large commercial shipment through the Bering Straits, but the company believed it was the only possible way.

With only days notice, BP acquired a rig that had been drilling in Tyonek and had it barged, along with 4,500 tons of related equipment, through the Beaufort Sea to Foggy Island, a few miles east of Prudhoe Bay in mid-August, just before encroaching ice made the Beaufort Sea impassable.

BP confirms Prudhoe Bay

When winter freeze-up came in November, BP unloaded the barges and hauled the rig and other equipment to a site on the banks of the Putuligayuk River five miles from the coast and three miles south of ARCO's Prudhoe Bay State No. 1 discovery well.

BP geologist Geoff Larmanie told *Crude Dreams* author Jack Roderick that Put River No. 1 was designed to be located outside the edge of the gas and in the oil leg of the Prudhoe Bay structure.

"BP wanted to determine the thickness of the Prudhoe column at Put River and to then use this information to re-evaluate its seismic data," Larmanie said.


On March 13, 1969, BP made brief announcements in London and New York: "Oil had been discovered in porous sandstone below 8,000 feet," with an oil-column thickness greater than that at Prudhoe Bay. It was a major extension of the Prudhoe Bay discovery, like the Sag River State No. 1 well.


The announcement proved to be extremely significant. BP had acquired enough leases in preceding years to lay claim to about 60 percent of the entire Prudhoe Bay oil field.

After further drilling and analysis, BP announced six months later that an independent review of eight of its Prudhoe Bay wells indicated that nearly 5 billion barrels of recoverable oil lay under its leases, valued at \$15 billion (in 1969 dollars), excluding the cost of its production.

The entire Prudhoe Bay field was estimated to contain 9.6 billion barrels of recoverable oil and 26 trillion cubic feet of natural gas, making it a super-giant field of Middle East proportions.

With improved technology and additional investments, Prudhoe Bay's recoverable oil reserve figure has climbed steadily over the past three decades and has been revised upward to exceed 13 billion barrels. ♦



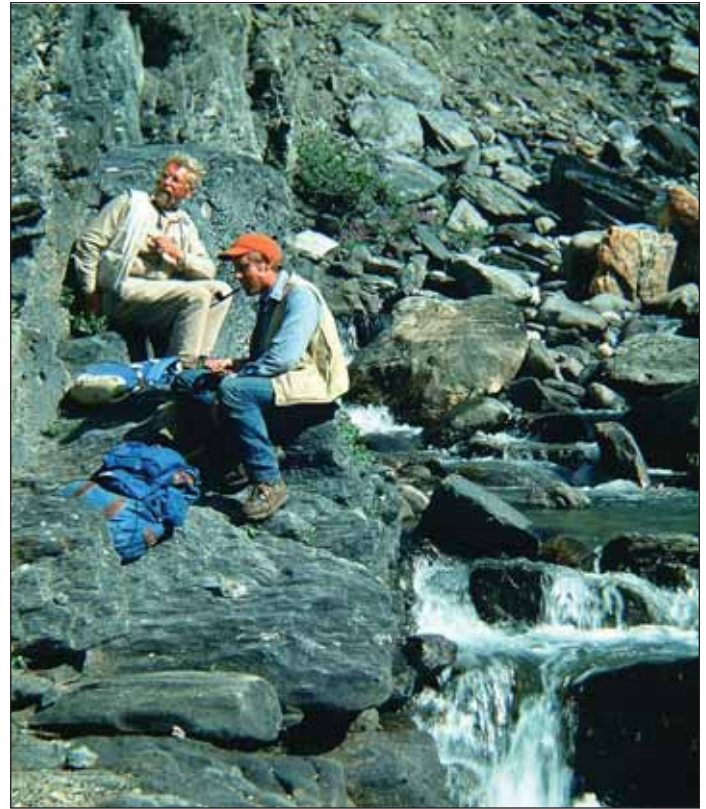
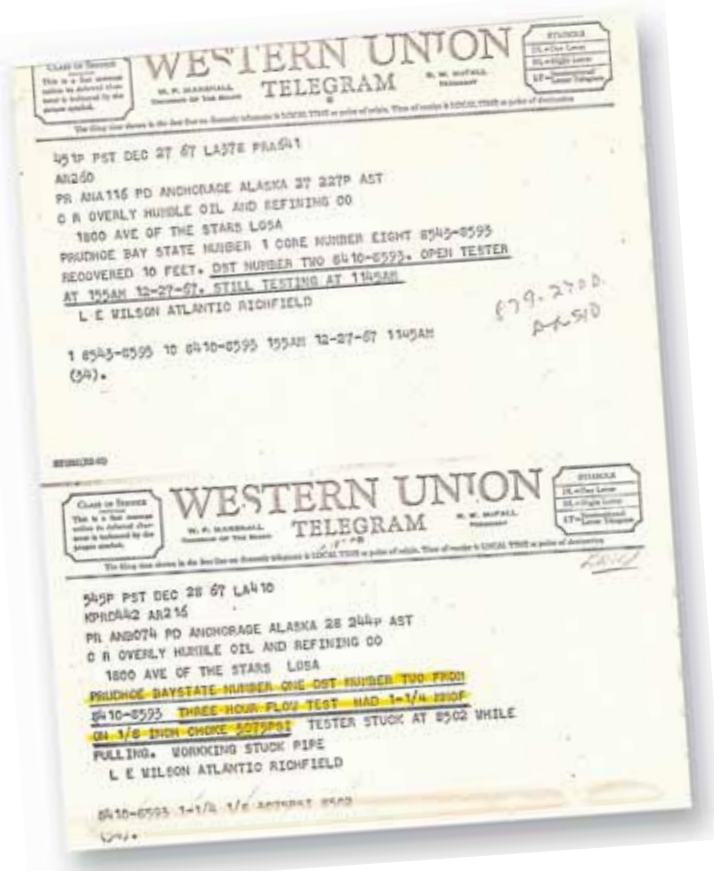

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Indelible imagery: 40 years at Prudhoe Bay



Photos by C.G. "Gil" Mull



Top: A tent camp and Bell G2 helicopter used by Richfield Oil Co. geologists in their search for oil on the North Slope during a mid-summer snowstorm.

Center left: Telegrams sent by Atlantic Richfield Co., informing Humble Oil Co. executives in Los Angeles of developments during the drilling of the Prudhoe Bay State No. 1 discovery well in late December 1967.

Center right: Geologists Bill Brosgé of the U.S. Geological Survey and Gar Pessel take a break beside a rocky stream in the foothills of the Brooks Mountain Range during field work in the 1960s.

Bottom left: The first Richfield Oil Co. seismic crew moves camp during the winter of December 1963.

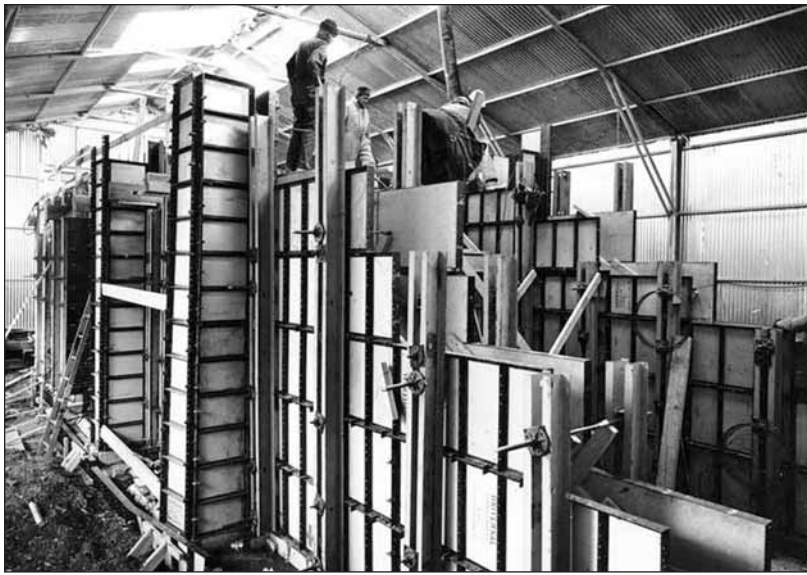
Indelible imagery: 40 years at Prudhoe Bay



C.G. "GIL" MULL

The pilot of this Interior Airways C46 aircraft misjudged the thickness of the ice on No Luck Lake in the western Brooks Range in early June 1968. Though the airline planned to return and fish out the plane, the exploration boom that followed the discovery of Prudhoe Bay so intensified the demand for air cargo services that the lake ice melted before the company could return to get the plane back onto the ice.

STEVE MCCUTCHEON/STATE OF ALASKA ARCHIVES



Above: View of construction crew building a draw-down box while working indoors during construction of Pump Station 1 and trans-Alaska oil pipeline at Prudhoe Bay April 20, 1975. Center right: The fabrication of modules in Alaska for North Slope oil fields - an outgrowth of development at Prudhoe Bay — provided a significant stimulus to the state's economy



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TRANS-ALASKA PIPELINE CONSTRUCTION COLLECTION, 1976-1977



TRANS-ALASKA PIPELINE CONSTRUCTION COLLECTION, 1976-1977

Left: A section of pipe is lowered into a ditch in the Brooks Mountain Range, about 175 miles south of Prudhoe Bay. Above: British Petroleum Board operator Jim Blythe communicates with the Trans-Alaska Pipeline System Operations Control Center in Valdez during the Prudhoe Bay production startup in 1977.



PRUDHOE BAY | CELEBRATING YEARS

40



EXTRAORDINARY PROSPECTS

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Talk far from cheap in early days

Once laid-back geologists wrestled with ways to keep exploration communications secure during, after Prudhoe Bay field discovery

By Rose Ragsdale
For Petroleum News

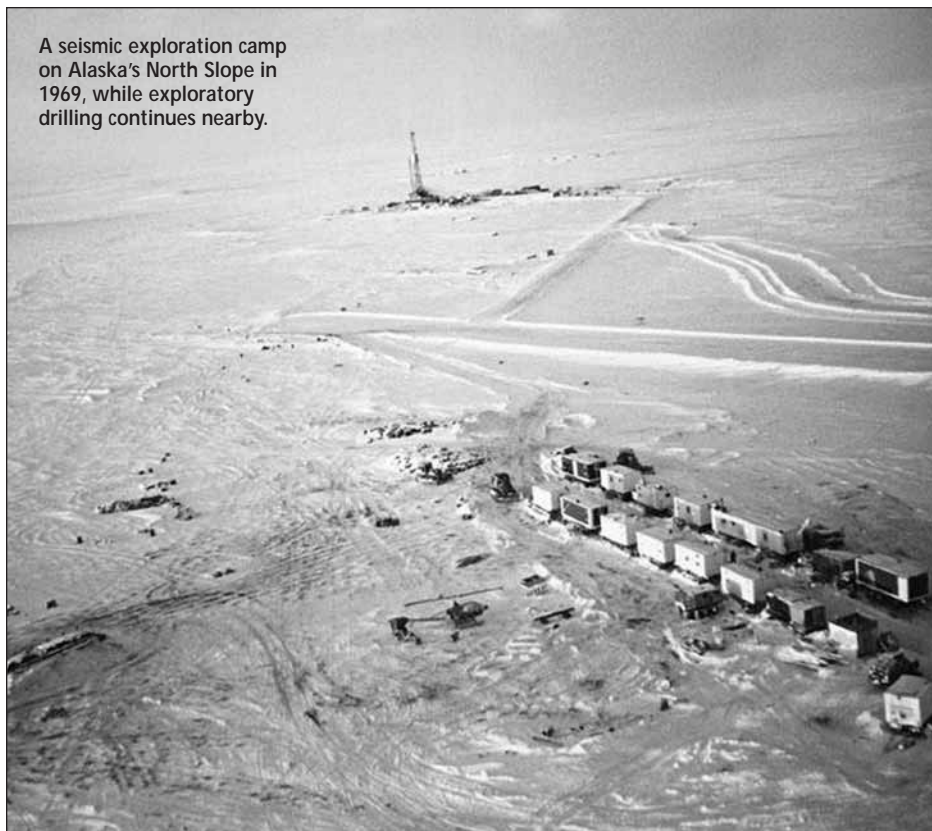
Before the Prudhoe Bay oil field was discovered in 1968, communications on the North Slope was a hit and miss proposition, say geologists who worked on projects there.

"There were no phone links and our only communication with the office was by single side band radio, on an open public frequency — which meant that anyone could listen to what we were saying. Plus, depending upon the sunspot activity, there were times in which radio signals just were not good enough to get a message through," said C.G. "Gil" Mull, who served as well-site geologist for Humble Oil Co. on the Prudhoe Bay State No. 1 well.

In the beginning, Mull said, security and secrecy was not a particularly high priority.

On the Susie well and during the first months of drilling at Prudhoe Bay, "the drilling reports were sent most of the time in just plain language, although occasionally, we would try to use a simple code system. Each morning we would send, or try to send, to both ARCO and Humble offices the morning drilling report from the company tool pusher, the geological report with sample descriptions from the well site geologists, and something about what the plans were.

A seismic exploration camp on Alaska's North Slope in 1969, while exploratory drilling continues nearby.



ATLANTIC RICHFIELD COMPANY COLLECTION, UNIVERSITY OF ALASKA FAIRBANKS ARCHIVES

Because it was a really remote location, and management in town realized that communications were difficult, they generally relied on the expertise of the company tool pusher and well site geologists to run things, and generally figured that

no report from the rig meant that things were probably going OK at the drill site and the radio signals were out.

"They definitely did not try to run things from the office," he said.

"Sometimes, when we could not get through on the single side band radio, there was a ham radio operator in camp who could raise someone on one of the short-wave frequencies that he operated on. Thus, on some occasions, the offices got collect phone calls from strangers somewhere Outside, from whoever the ham operator could raise, relaying our morning reports," Mull recalled.

Discovery brings whirlwind

All this changed virtually overnight with the discovery at Prudhoe Bay.

After the first successful drill stem tests when everyone began to realize for certain that it was not going to be a rou-

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tine well, nothing of any consequence went out over the radio.

From then on, each morning right after breakfast, there was a plane warmed up, and one or another of the well-site geologists hopped aboard the plane to travel to the nearest phone, in either Fairbanks or Barrow, depending on the weather, to phone in the daily drilling and geological reports to the district offices of both ARCO and Humble, and to mail in a hard copy of the reports.

"As a result, I, or one of the other well site geologists, had a daily round trip commute of close to a thousand miles, just to make a couple phone calls and mail two or three letters," Mull said. "Normally, we would be back to the rig by early afternoon and back to running samples. This was the normal routine, unless something special was going on, such as running wire line logs, cutting cores or testing, in which case the well site geologist would not want to be away from the rig."

This system continued throughout the drilling of the Sag River No. 1 confirmation well.

Finally, a telephone relay system was set up, and from then on, messages went back and forth by a secure telephone relay system. And, of course with this, the independence of the crews at the well site began to diminish considerably as management in town assumed much greater control of operations, Mull added.

BP taps linguistic diversity

At BP, British geologists borrowed a page from the annals of World War II history and set up a system of code-talking to maintain secure communications to and from its exploration well site.

BP geologist Geoff Larmanie told Crude Dreams author Jack Roderick about the unusual method the British oil company devised to solve the communications conundrum in the earliest days after the Prudhoe Bay oil field discovery.

"As drilling continued throughout the winter, communications security was a problem. People at the well had to communicate with company officials in Anchorage, but without others listening in," Larmanie said.

"Everyone was sharing these terrible radio frequencies. We had a very good radio man in London who knew the international system ... frequencies, the VHF and rural problems, but we didn't have (Federal Communications Commission) authority to use the fre-

quencies. So, as we were getting closer to the target at Put River No. 1, we were sending information out in sealed bags — airlifted, hand-carried stuff."

Then BP came up with another way to communicate. Two Welsh-speaking geologists on the company's exploration team, one based at the drilling rig and the other at the Anchorage office, began to exchange messages in the lyrical speech of their native Wales.

"Welshmen Harvey Jones and Ron Walters conducted a conversation in their native language transferring all the Put River information from the rig to Anchorage," Larmanie recalled. ♦



A sign tells the story of the Sag River State No. 1 well drilled by Atlantic Richfield Co. and Humble Oil Co. in 1968 that confirmed the Prudhoe Bay oil field discovery.

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Innovator from the first

Richfield tackled challenges that it faced exploring for petroleum in Alaska by using latest technology to get the job done

By C.G. "Gil" Mull
For Petroleum News

Thinking about the legacy of Richfield Oil Co., it seems to me that it was characterized by a tradition of innovation in Alaska. For example, the discovery well at Swanson River in 1957 was drilled on an anticline that was discovered by a seismic survey — but a survey that was done with seismic equipment that was transported by helicopter.

I don't know for certain, but I have a hunch that that might have been the first time that a seismic survey was conducted in Alaska using a helicopter to move equipment to otherwise inaccessible areas. The area selected for the seismic survey was based on some cool deductions made by Richfield geologist Frank Tolman from aerial photos of the Kenai Lowlands that showed what appeared to be an anomalous stream drainage pattern. This pattern suggested the presence of a topographic high area. In the early days in California, a number of oil fields had been found on anticlines that formed topographic high areas. I suspect that other people had used aerial photographs to do geology



GIL MULL



A July 23, 1957 news article with the headline "Richfield Hits Oil" in the Anchorage Daily Times proclaims the discovery of the Swanson River oil field on the Kenai Peninsula that kicked off the Alaska oil boom, over 10 years before the Prudhoe Bay discovery.

in Alaska before, but at the time ... it was pretty bold to go out to expend the money to run a seismic survey by helicopter based on not much more than photo geology and the knowledge that there were oil seeps clear on the other side of Cook Inlet.

In addition, my understanding is that the total seismic survey was an extremely loose survey that consisted only of scat-

tered shots to provide strike and dip control and did not have the sort of conventional lines that would normally have been shot before a well was programmed. The seismic survey confirmed Tolman's deduction, and the first well drilled on the high was the Swanson River discovery. In other words, it was a pretty bold step on the part of Richfield management to drill a well on

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Workers flared the first gas flow from the Ivishak (Sadlerochit) Formation reservoir during Drill Stem Test No. 2 of the Prudhoe Bay State No. 1 well on Dec. 27, 1967. No oil flowed to the surface during the test, but natural gas flowed from the well with a rumble and roar that sounded like a jet plane overhead.



C. G. "GIL" MULL

Another definite first was the mobilization of an entire drilling rig and camp by air. No one had ever thought of doing all that by air before.

such meager data — most companies would not have been so bold. But it worked.

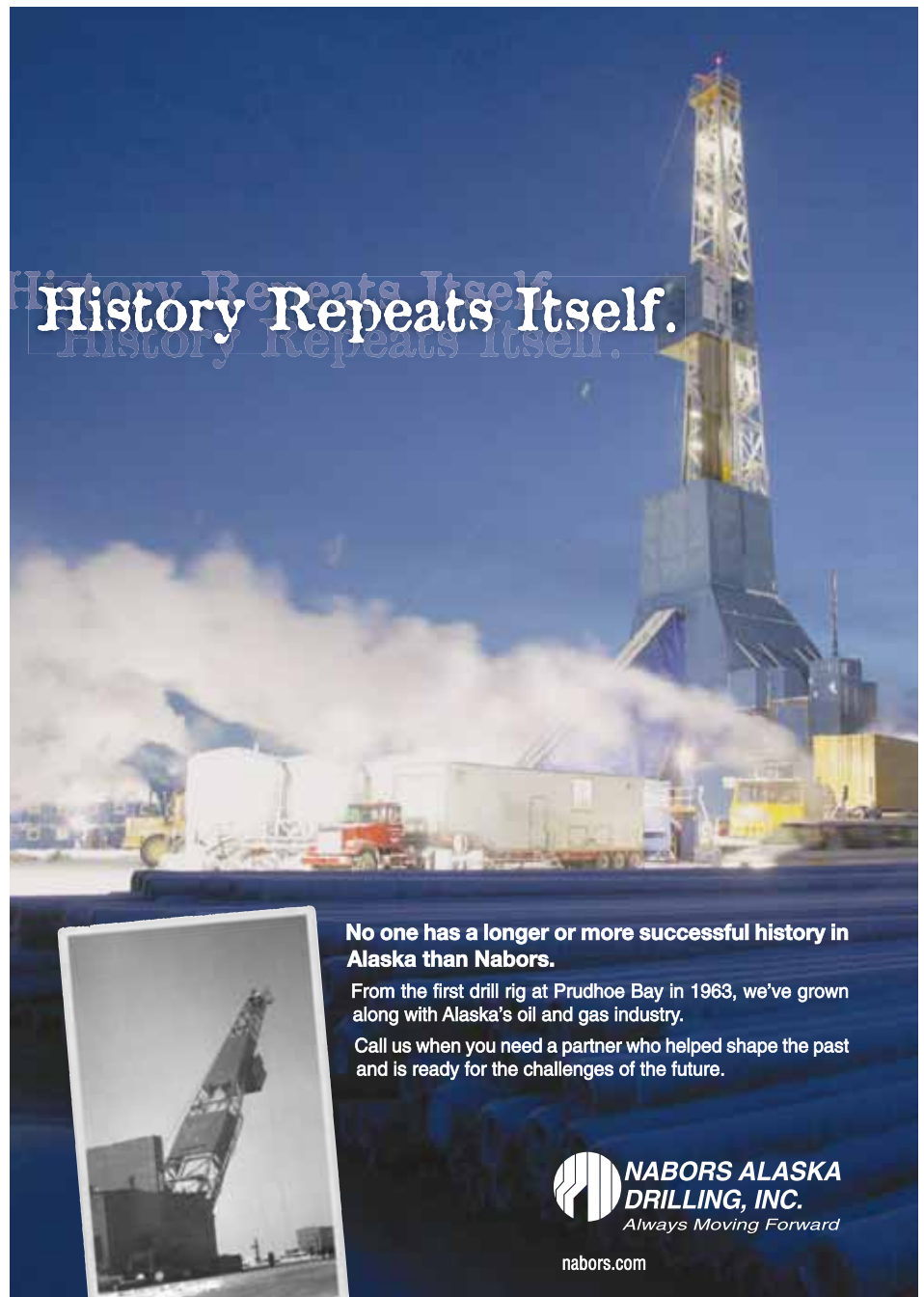
An offshore well that Richfield drilled in the early 1960s at Wide Bay on the Alaska Peninsula was drilled from a platform on pilings. I am sure this also was a first for Alaska — also using a technique developed in California many years back.

Another definite first was the mobilization of an entire drilling rig and camp by air. No one had ever thought of doing all that by air before. All the previous drilling rigs on the North Slope were taken up by barge and moved cross country by land during the winter.

Flying the rig up to the North Slope was a Richfield innovation that took a fair amount of doing, because first the permission to use a C-130 Hercules had to be obtained from the Defense Department — it had previously been strictly a military plane.

So the whole operation went in by air to Sagwon in something over 80 trips from Fairbanks using the C-130 leased from Lockheed, and some other cargo planes.

Another aspect of Richfield's successful operations was its reliance on the recommendations of its younger employees. It was not overloaded with layers of management, thus, the opinions and recommendations from the working stiffs in the trenches often went straight to the top as was evident in the use Harry Jamison made of the information from the surface geological party. ♦




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Two Alaska Airlines C-130 Hercules cargo planes at the Prudhoe Bay No. 1 well site during massive mobilization of equipment in late March 1968.



C. G. "GIL" MULL

Oil rush lifts aviation fortunes

Exploration boom takes off with history-making airlifts to North Slope

By Rose Ragsdale
For Petroleum News

The immense size of the North Slope and its challenging terrain and uncharted waters left the oil hunters with but two options: learn to fly or find a good pilot.

Wien Alaska Airlines, Interior Airways, Alaska Airlines and Economy Rotor Aids, predecessor to Era Aviation, among others eagerly accepted missions from exploration teams, geologists and scouts. A thriving aviation service industry developed, equipped with everything from Piper Cubs, Cessna 180s and Widgeons to World War II-era C46s and Hercules C-130s and helicopters.

Jim Magoffin, founder of Interior Airways, energetically whittled a niche for his company in the Arctic oil fields by scouting out a strategic location on the banks of the Sagavanirktok River and setting up a prosperous airport called Sag No. 1. The airport, adopting the name Sagwon from Texas and Oklahoma pilots slurring the name, became a self-supporting service center in the Arctic and served a never-ending stream of aircraft. Interior Airways flourished in a market heavily dominated by Wien.

ARCO drafts C-130

The Susie No. 1 well, the famous dry hole that Richfield completed before turning to the Prudhoe Bay structure, has another often overlooked distinction. It was the first wildcat well where the industry took on



Oil companies used various aircraft in the early days of summer field work to ferry personnel and supplies across the North Slope; this aircraft is an amphibious DeHavilland Widgeon at Elusive Lake in the Brooks Range.

C. G. "GIL" MULL

the challenge of moving a 2,000-ton drilling rig and necessary equipment and supplies over difficult terrain to a remote and desolate place more than 50 miles from the nearest navigable water.

Mo Benson, general manager of production operations for Richfield Oil Co. at the time, looked at all options before deciding that the best approach would be to fly the rig to the location.

There was only one drawback. Only one airplane could fly the rig intact to the slope – the Lockheed Hercules C-130 – that had

been used by Richfield in March 1965 to transport 18 loads of cargo to Sagwon, a gravel airstrip on the North Slope about 80 miles south of the coastline. That job had included moving one 24-ton D-8 Caterpillar with a blade.

The price wasn't cheap. Richfield would pay \$100,000 to use the aircraft for exactly 21 days, beginning Jan. 21, 1966. No extensions would be allowed, no matter what the reason. Richfield also had to agree to cover the cost of sending Alaska Airlines pilots to the African country then called Rhodesia,

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where the Herc was hauling copper on a demonstration basis, to get type-rated.

BP chartered C-130s, too

The Lockheed Hercules C-130 soon gained a reputation for being one of the most highly desired planes for use on Alaska's North Slope.

By the end of 1968, there were 11 Lockheed Hercules C-130 aircraft operating from Fairbanks to the North Slope, routinely carrying 24-ton loads at a cost of \$4,500 per trip.

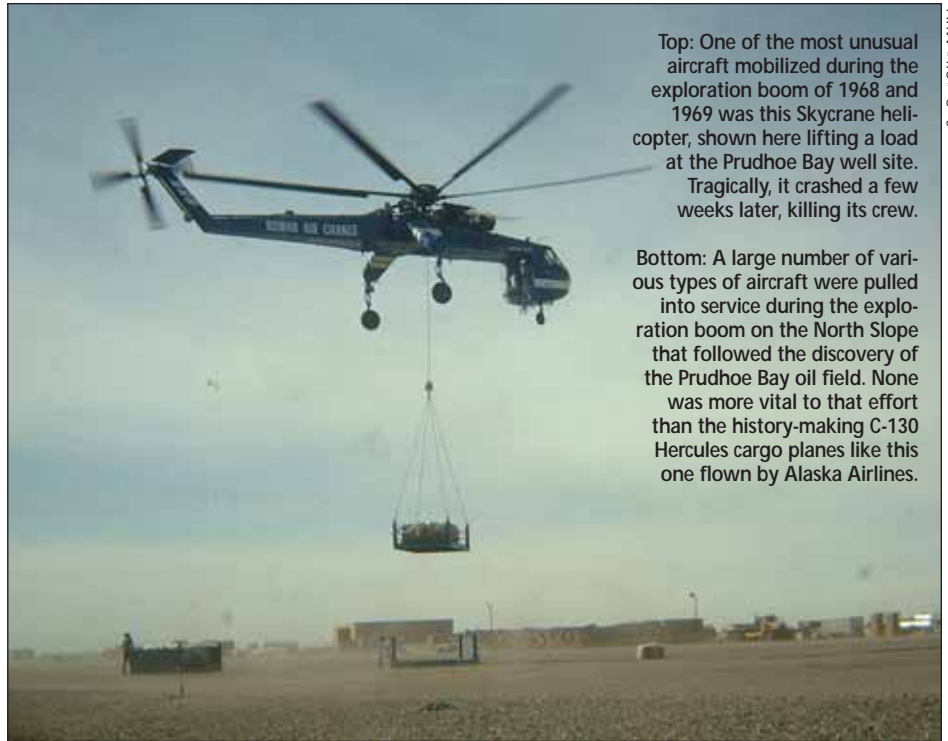
BP called on the C-130 transport planes to fly in drilling rigs to the Slope for its early drilling at Prudhoe Bay. The airlift involved five chartered C-130s, each costing \$250,000 a month, plus three Super Constellation aircraft.

John Matyr, then general manager and vice president of BP Alaska, described the difficulty of these early logistics: "I recall those great Hercules thundering through the winter night and the great flurries of snow whirling up along the lights burning at the side of the ice runway," he said. "It was the most difficult operation that I've ever been associated with," adds Matyr, a veteran of Kuwait, New Guinea, Trinidad and Libya oil fields as well as gold mines in southern India.

Aviation heyday

The Fairbanks airport swarmed with an amazing variety of planes, including Dakotas and 737s, as one of the biggest civilian airlifts in history got under way.

Harsh winter conditions made the going rough for many, yet the planes kept flying and the work got done.



Top: One of the most unusual aircraft mobilized during the exploration boom of 1968 and 1969 was this Skycrane helicopter, shown here lifting a load at the Prudhoe Bay well site. Tragically, it crashed a few weeks later, killing its crew.

Bottom: A large number of various types of aircraft were pulled into service during the exploration boom on the North Slope that followed the discovery of the Prudhoe Bay oil field. None was more vital to that effort than the history-making C-130 Hercules cargo planes like this one flown by Alaska Airlines.



One inexperienced pilot, who flew a light plane from Fairbanks during sub-zero temperatures, was foolish enough to switch

off his engine as he came to the end of his taxiing. It took three days to get it started again.

In all, aircraft transported more than 135,000 tons of freight to the Slope during a 12-month period and shuttled some 50,000 passengers to more than 20 different drilling sites. With not enough aircraft to go around, some oil companies had to charter their own, mostly DC-7s.

On the North Slope, the most expensive operation was ARCO's use of a giant Sikorsky Skycrane helicopter to move entire rigs, broken down into 20-ton loads from one site to the next. ♦

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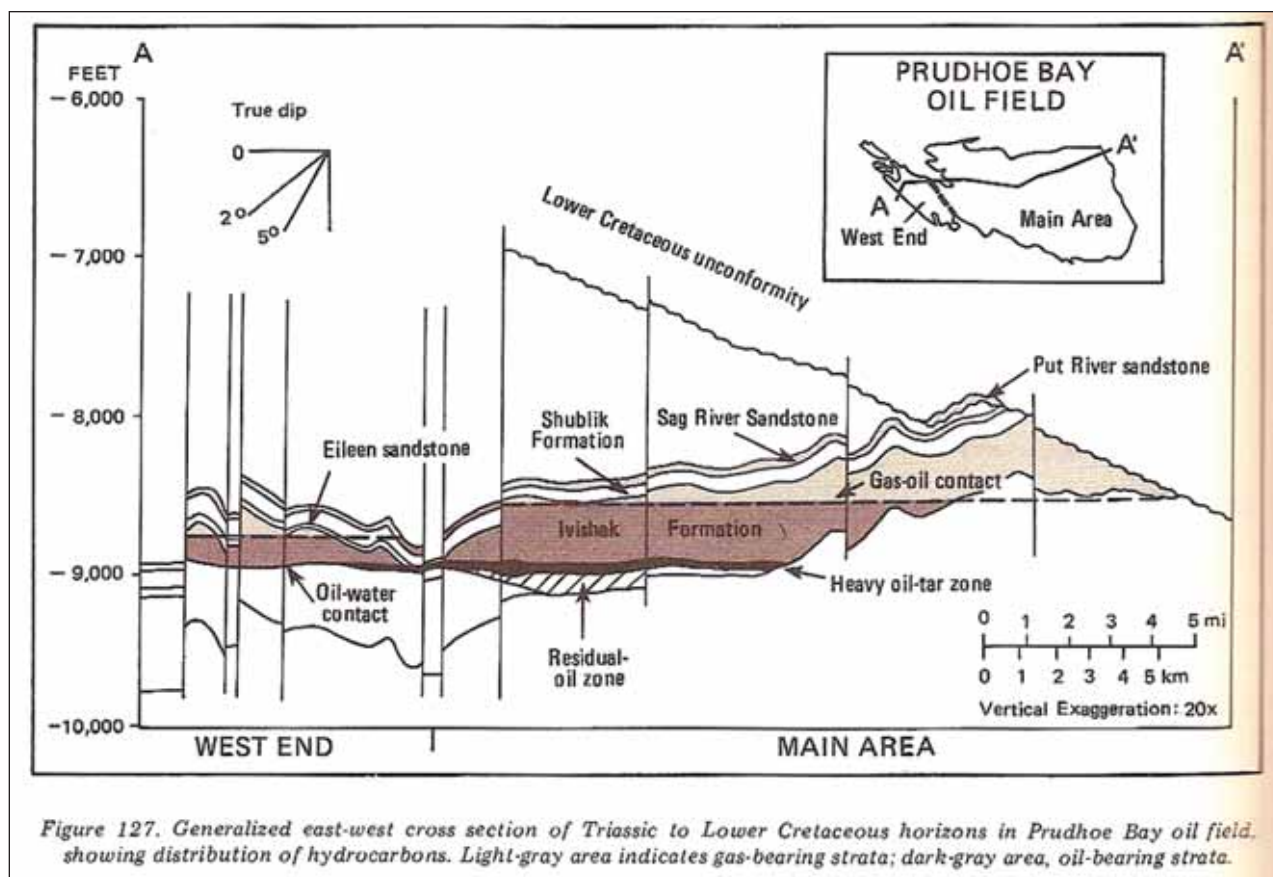
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Picture of field emerges

Long summer of drilling in 1969 reveals impressive, complex subsurface geology

Petroleum News

As drilling gathered pace through the summer of 1969, most of it within a 10-mile radius of Prudhoe Bay, the oil companies began to build up a clearer geological picture of what they had found.

The whole Prudhoe Bay field lies within an area roughly 45 miles long, from west to east, along the coast and 18 miles wide. It is one of a series of broad anticlines underlying the North Slope and known collectively as the Barrow Arch. There are four main oil and gas bearing reservoirs in formations of lower Cretaceous to Mississippian ages, between 120 million to 220 million to about 350 million years old that partly underlie each other and are sealed by a stratigraphic unconformity that is overlain by a cap-rock plunging from west to east.

The shallowest is the Kuparuk River Formation, some six miles to the north-

The whole Prudhoe Bay field lies within an area roughly 45 miles long, from west to east, along the coast and 18 miles wide. It is one of a series of broad anticlines underlying the North Slope and known collectively as the Barrow Arch.

west of the western end of the Prudhoe Bay field. It is up to 800 feet thick, below a depth of 6,765 feet, and extends over an area of about 128,000 acres. The Kuparuk field produces about 150,000 barrels a day and remains the second-largest oil field in North America.

Next is the most important and biggest formation, the multi-pool Prudhoe Bay group, formed in undulating sandstone up to 600 feet thick below a depth of 8,110 feet, and covering some 368,640 acres. Today, this field has produced more than 13 billion barrels of oil and ultimate recovery is estimated to exceed 15 billion barrels.

Slightly to the east is a deeper reservoir, formed in what has been classified as

Lisburne limestone, up to 1,700 feet thick below a depth of 8,758 feet and covering 181,750 acres.

And still farther to the northeast is the deepest reservoir in the area — the Kekiktuk Conglomerate, which forms the reservoir in the Endicott oil field.

Geologists subsequently identified other crude reservoirs in roughly the same area, including the vast, much shallower heavy oil pools of West Sak and Ugnu.

Of the 23 wells that had been completed by the end of the summer of 1969, nine had been drilled by BP, seven by ARCO-Humble, four by Mobil-Phillips, two by Standard Oil of California and one by Hamilton Brothers. Only two failed to find any oil or gas — one each drilled by BP and ARCO — though not all would necessarily prove to be commercial. Seven wells encountered two of the reservoirs and one, Socal's Kavearak Point wildcat, found oil in all three reservoirs. ♦

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Alaskans remember Prudhoe Bay

By Nancy Pounds

Most Alaskans don't remember what Alaska's economy looked like before the discovery and development of Prudhoe Bay. Only 14 percent of about 670,000 Alaskans today lived in the state in 1968, the year of the Prudhoe Bay discovery, according to Scott Goldsmith, economics professor at the University of Alaska Anchorage's Institute of Social and Economic Research. So nearly nine out of every 10 residents today know little about Alaska prior to major development on the North Slope, he said. Goldsmith compared 1968 and 2008 in a recent report called, "How North Slope oil has transformed Alaska's economy." A few longtime Alaskans, participants and decision-makers during Alaska's major economic changes, recently recalled events of the era.

Vic Fischer

An economic analysis in 1970 or 1971 — before construction of the pipeline — showed the possible financial strength of the work. Three economists from UAA's ISER compiled the report, and their predictions were fulfilled and even eclipsed.

It was a first look at the "phenomenal amounts of money the state was about to get because of the pipeline," remembered Vic Fischer, one of the report authors. He served in the territorial Legislature from 1957 to 1959 and was elected to the State Senate in 1980 and 1982.

The discovery at Prudhoe Bay was "a great day" for Alaska, he said in a recent interview

"The Prudhoe Bay discovery was very exciting event for everyone in Alaska," Fischer said. "It proved we would have a new resource coming on line that would provide significant economic progress for the state."

The most important aspect was the scale of development that occurred on the North Slope because of Prudhoe Bay. The pipeline report projected the future revenue stream the state would receive, but could not factor in the way oil prices soared in subsequent years, Fischer said.

Fischer had compiled a report in 1959, the year of statehood, concluding that state government services would exceed state income at then-current levels. "We became a state among great euphoria of great things going to happen," he said.

The 1964 Good Friday earthquake in Anchorage brought a temporary surge of federal dollars, but state government budgets were strained.

As Prudhoe Bay was developed, Anchorage's population grew, and political



VIC FISCHER

and demographical aspects changed, he said.

What would Alaska be like without oil today? The state would have a much smaller economy with fewer people, Fischer said.

"It would be a different Alaska," he said.

There would be no Permanent Fund dividend, which plays a role in the economy and helps lower-income Alaskans, he said. Also, the dividend helps Alaskans psychologically — people get to share in the state's oil wealth, he said.

Editor's Note: Victor Fischer has studied and taken part in Alaska government and politics for over 50 years. Educated at the University of Wisconsin, MIT and Harvard University, Fischer was a territorial legislator; a delegate to Alaska's constitutional convention, and later a state senator. A former director of the University of Alaska Institute for Social and Economic Research, he is currently engaged in state policy, local government, and Alaska-Russia issues.

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BP, ARCO prepare to tame an elephant

Initial development of the Prudhoe Bay field relies on seasoned workers, innovative logistics and historic equipment sealifts

Petroleum News

As the dust settled after the Prudhoe Bay oil field was discovered in 1968, BP began development drilling, using Nabors 18-E and Brinkerhoff Rig 36.

Everett Potter, then a drilling consultant for BP, said rig technology has come a long way since those days.

"We used to tear the rigs down to the ground to move them by truck from one well location to another," he recalled. "A rig move could take as long as seven days, especially during the winter months. Now, some of the rigs can be moved in half a day, and wheel-mounted rigs can simply be rolled to other locations."

Modern cantilevered rigs can be moved from one well location on a pad to another location in just a matter of hours.

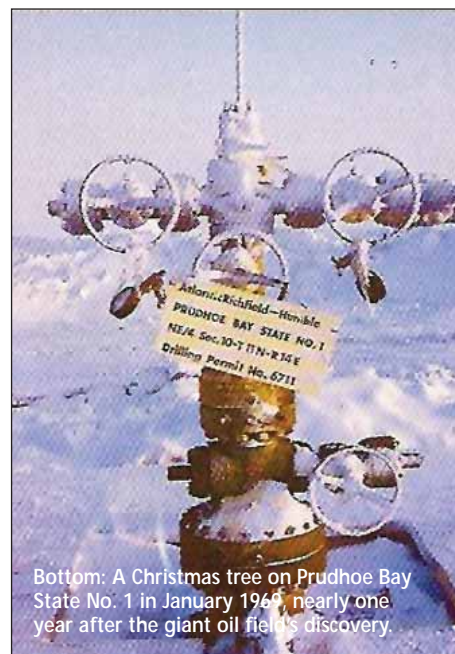
Brian Rose, a drilling superintendent for BP, joined the company in 1974 and became drilling foreman on the rigs.

"I got off the plane at Deadhorse and it was about minus 20 degrees (Fahrenheit) with a 30-mile-per-hour wind. A guy name Swede Swenson, a drilling foreman, picked me up at the airport in a yellow station wagon. I remember thinking to myself, "what have you gone and done now."

BP would operate the western side of the Prudhoe Bay field, or western operating area, or WOA, and ARCO would operate the eastern side, or EOA. The plan called for the six facilities to handle up to 1.8 million barrels per day of oil.

Unprecedented sealift shipments

The first sealift to Prudhoe Bay occurred in the summer of 1969, when about 70,000 tons of stores and equipment were barged from Seattle. The 1970 barge sealift was the largest in the North Slope's history — when 70 barges containing more than 175,000 tons of equipment journeyed



Bottom: A Christmas tree on Prudhoe Bay State No. 1 in January 1969, nearly one year after the giant oil field's discovery.

BILL SIMMS

north through difficult ice conditions.

From 1974 on, sealift shipments to Prudhoe Bay would contain oil production modules, buildings, modularized camps and other support facilities from the U.S. West Coast. The barge shipments were managed by Seattle-based Crowley Maritime Inc.

The first sealift also brought large modules for BP's three gathering centers, which would separate gas and water from produced oil; ARCO would have three similar facilities, called flow stations, on its side of the field.

Massive capital investment in the '70s

By 1975, two of BP's gathering centers were in place — each capable of handling about 300,000 barrels of oil per day.

During this period, a gravel "spine" road was built from east to west through the heart of the oil field, using gravel from approved material sites. Later, extensions and fingers off this road would access the many gravel "pads" from which development wells would be drilled. Pads were assigned letters on the western or BP-Sohio side of the oil field and numbers on the eastern, or ARCO side.

While initial facilities were being

installed, expansions to those facilities were already being designed by BP in San Francisco.

During the mid-1970s, when major capital expansions reached a crescendo on both sides of the Prudhoe Bay field, area-wide population peaked at about 8,000.

BP's first camp, Mukluk Camp, consisted of a few trailer units. The company's permanent base camp was shipped in modular form from Seattle to Prudhoe Bay in mid-1973 on eight barges. The following year, the first phase of the Central Power Station arrived, which consisted of two turbine generators and a control rooms. The Prudhoe Unit agreed to locate it on the western side of the field — making it a BP-Sohio-run facility.

Later sealift shipments would bring the other three phases, which included five more Frame-5 turbine generators, which were fueled by natural gas produced in the Prudhoe Bay field. Today, the CPS has a maximum output capacity of 160 megawatts, making it the second-largest single power station in Alaska.

The CPS provides all power for Prudhoe Unit oil production operations. Diesel generators throughout the field provide a back-up to provide life support, such as heating and emergency lights.

According to Jim Barrett, a supervisor at the station in the mid-1970s, the facility put out about two megawatts during its first year of operation.

In 1976, the three-story BP-Sohio center, sometimes called the BP Hilton, was expanded from 90,000 to 137,400 square feet, providing living and working room to accommodate about 264 people. BP also built two 500-worker camps for contractors developing the field.

Bill Lorenz, a BP North Slope construction veteran of about 25 years, said when Prudhoe facilities were first being installed, he couldn't foresee what they would eventually look like or how big they would become.

"Most of the production modules and buildings were designed by BP and Ralph M. Parsons Inc. of Pasadena, and came from the U.S. West Coast as increments," he said. "They were like jigsaw pieces of a bigger whole that we never saw until it was completed."

"The initial gathering centers were almost 'pass-through' facilities compared to today's multi-faceted complexes, and about one-third the size," recalls Fritz Wiese, who spent many years on the North Slope as BP production manager. ♦



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Engineer recalls Prudhoe Bay early days

Oil companies relied on cadre of talented individuals and contractors to design and build unprecedented Arctic infrastructure

By Rose Ragsdale
For Petroleum News

From the start, developing the Prudhoe Bay oil field was a gargantuan task.

In the words of O.C. Simpson, "It was a time of impossible demands and incredible feats."

But Atlantic Richfield Co. and British Petroleum, the two oil companies designated to operate North America's largest oil field, elected to start small, hiring a few very capable and clever people to oversee the effort.

Bob Bell was one such individual. Hired as a facility engineer by ARCO in 1974, Bell said he took the job to help keep his struggling surveying business afloat. While his partner, John Herring, continued to serve their clients, Bell worked for ARCO and split his salary with Herring.

Bell was one of three people who comprised the entire Prudhoe Bay facilities group for the company.

"Joe Dan Ash, a document control clerk and I were in charge of constructing the Prudhoe Bay facilities for ARCO," recalled Bell in a recent interview.

Bell worked directly with the big engineering firms that designed the field, Ralph M. Parsons and Bechtel Inc., and hired construction contractors to build the facilities and infrastructure. These contractors included such firms as Alaska General, Frontier Construction, Haskell Amelco, S.S. Muellins and H.C. Price.

Among the memorable early projects that Bell's group tackled: Installing multiplates in the Put River; building roads across the field; and constructing the West Dock causeway. The causeway is a gravel embankment that juts into the Beaufort Sea and enables the off-loading of cargo that otherwise could not be delivered to the Arctic oil field.

Bell said the pace of the work was so pressured in the early days of development by weather, the short summer sea-

son and other uncertainties that construction often outpaced design.

"We'd finish a section of roadway and the engineers wouldn't have designs ready for the next section," he recalled. "We would build a mile of road, praying our work would be close to the designs, and a week later, we'd get the drawings."

An especially harrowing point came during the first phase of constructing the West Dock causeway, while a barge waited to unload production modules for the field, Bell remembered.

"When we put that last gravel in, two days later the ice came back. We were

FORREST CRANE



BOB BELL

stopped. We couldn't go any further," he said.

Bell made a phone call to his boss, Hoyt Jarvis, and was told, "I don't care if you have to spend a million dollars, get those modules off that barge."

"The ice was 6 feet thick. We used a ditch witch to cut out a 10-foot section of the ice at a

time. As soon as we'd get a section of ice out, we would dump gravel in the hole we made. In this way, we continued to build the causeway," Bell said. "We worked through Christmas Day."

The prospect of the work continuing through Christmas upset the workers

see **BELL** page 83

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Owners work to unitize Prudhoe Bay

State-approved agreement creates participating areas for oil, gas; divides field

Petroleum News

The State of Alaska required that the Prudhoe Bay oil field be developed as a unit, and not individually by the companies holding leases. The 16 initial owners agreed to two operators carrying out the development: BP-Sohio for the western side and ARCO the eastern side.

The agreement was very unusual because it formed two separate participating areas within the Prudhoe field, one for oil and one for gas. Also, two companies being chosen to be field operators was an unusual arrangement. Ordinarily, one company chosen as field operator would be considered the most efficient procedure.

The separate gas and oil rim participating areas came about because the upper portion of the reservoir where

How to value the gas became a big issue in the lengthy, complex unit negotiations.

most of the natural gas is located, the gas cap, was not directly above the part of the reservoir where the oil was located. The gas cap was partially offset, toward the northeast, compared to the lower part of the reservoir that held the oil.

In many reservoirs, the gas cap would be directly above the oil pool, so leases covering a field would have similar shares of the gas and oil reserves. But because Prudhoe's gas was not directly above the oil reservoir, and because the reservoir was so large, the location of the various lease holdings resulted in widely differing ownership percentages of the gas and the oil among the field's owners.

Valuing natural gas

Many of ARCO's and Exxon's leases were over the gas cap, in the northeast, while most of BP's leases were over the oil rim. As a consequence, ARCO and Exxon had most of the gas with BP having more than half of the oil. This wouldn't have posed a problem if the gas could have been immediately marketed so that a commercial value would be put on the gas along with the oil. But because it was not economical to build a pipeline to carry the gas to market, no commercial sales of gas were possible and the parties could not agree upon a value for the gas.

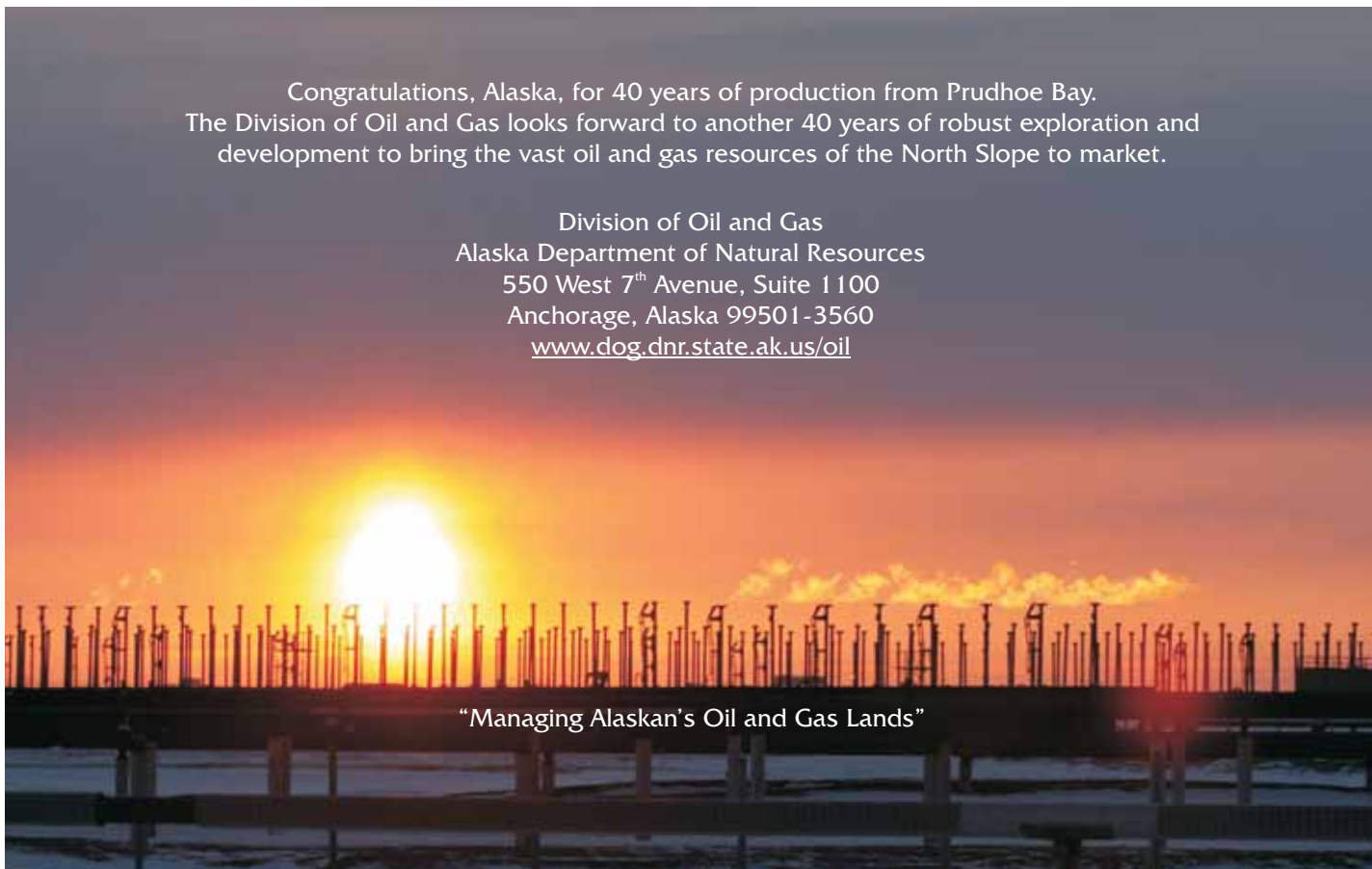
How to value the gas became a big issue in the lengthy, complex unit negotiations. John Reeder, a former chief counsel with BP, now retired, recalls that the deci-

see UNITIZATION page 84

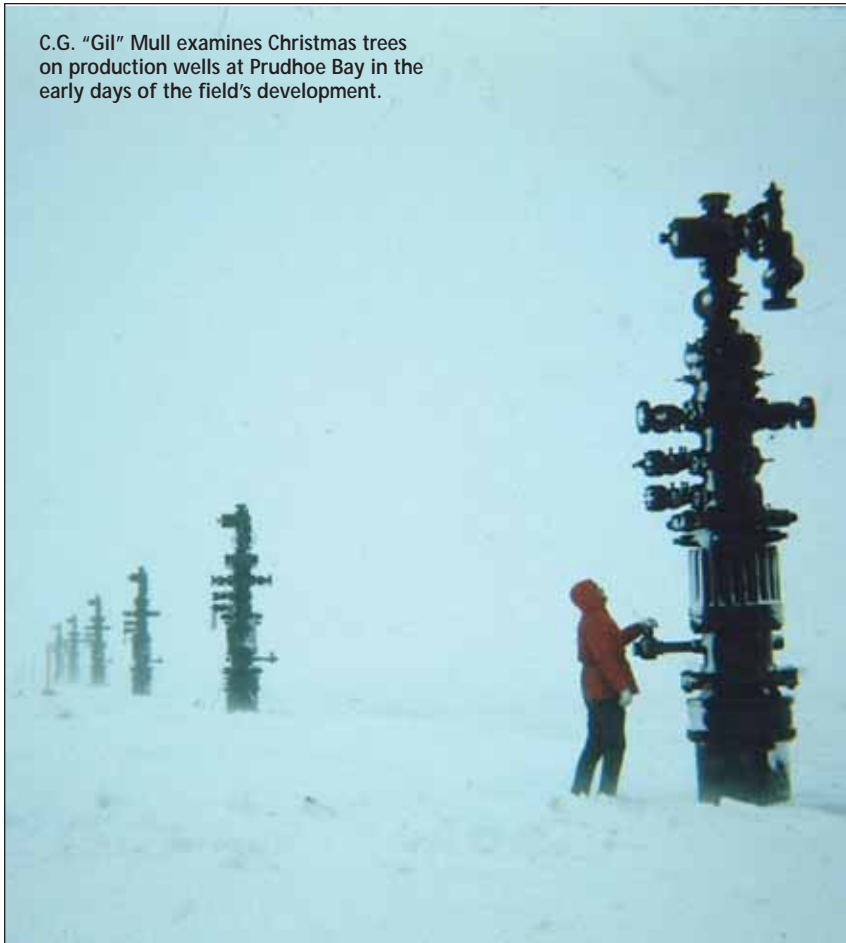
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C.G. "Gil" Mull examines Christmas trees on production wells at Prudhoe Bay in the early days of the field's development.



COURTESY OF GIL MULL

continued from page 81

BELL

union, and just before the holiday, Bell said he got a call from the union's business agent, saying he wanted to visit the North Slope to inspect the trucks that ARCO's contractors were using.

Bell said he understood that this was a ploy for the union to get the workers off on Christmas and Christmas Eve by finding something wrong with the truck fleet.

Bell said he told Tennessee Miller of Frontier about the proposed visit, and Miller volunteered to give the business agent a tour.

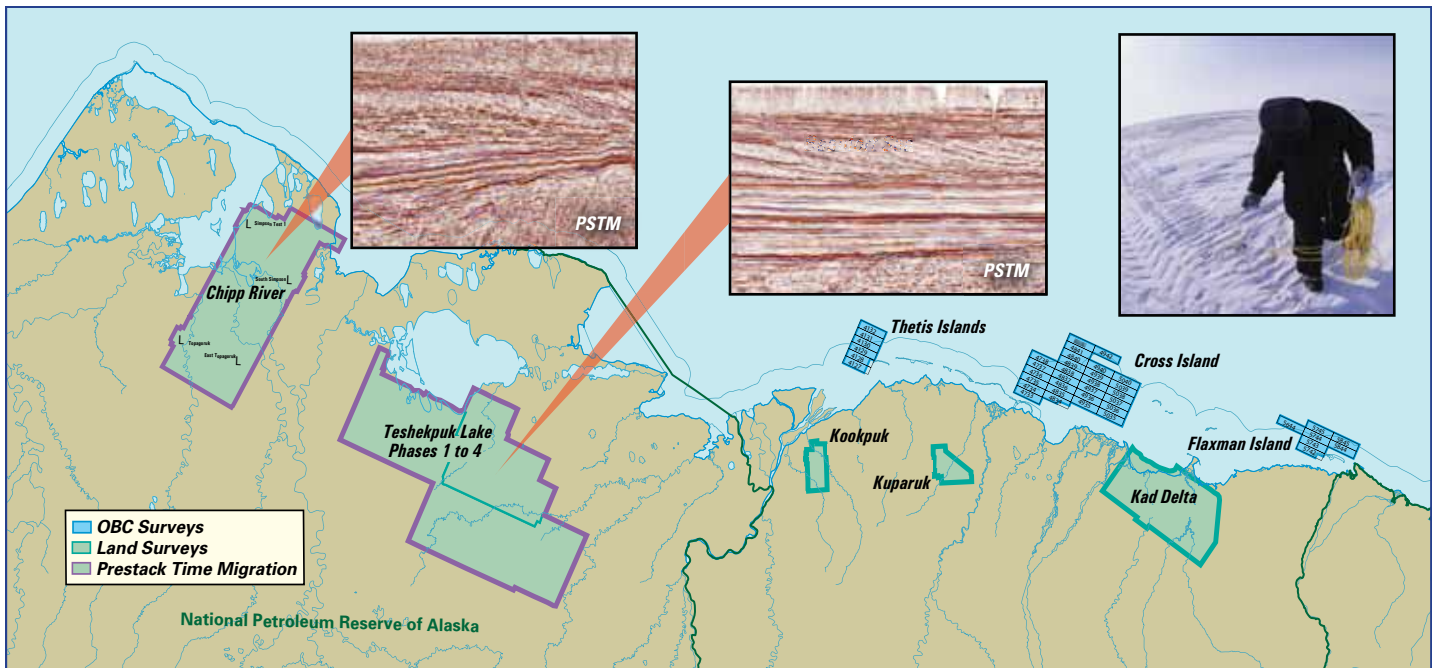
Then Bell told Miller that someone would need to pick the business agent up at the local airport.

Miller replied, "I'm the guy who will show them around, but I ain't no taxicab driver."

After that, Bell said he heard nothing else from the union about shutting down for Christmas.

During his tenure with ARCO, Bell said his group supervised the building of the main construction camp, all the production pads in the field, bridges over the Sag River and most of the roads.

Bell left ARCO in 1976, after two years, to concentrate on his business. Today, he is sole proprietor of Bell & Associates, one of the largest survey firms in Alaska with 100 employees. ♦



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UNITIZATION

sion to form two participating areas, one solely for gas, effectively put the decision off to the future, when a gas pipeline or some other way of marketing the gas would be available.

It also allowed the costs and benefits of production to be allocated among the oil and gas rim owners. For example, under the unit agreement, natural condensate — natural gas that became liquid at the surface — was allocated to gas cap owners. But because it was produced with the oil, most costs were borne by

the oil interest owners.

As these liquids were produced and shipped to markets along with crude oil through the trans-Alaska pipeline, the unit agreement provided the formula as to how revenues and cost would be allocated among the oil and gas cap owners.

The decision to have two operating companies was made partly for the same reason, so that the major gas cap owners, ARCO and Exxon, would be, in essence, represented by ARCO as one of the field operators.

BP wanted adequate manpower

Another reason, Reeder said, was that

at the time BP and Sohio felt they might not have adequate staff available in the United States to operate a very large field like Prudhoe on their own.

BP had experience running large fields in the Middle East, but at that time BP was heavily committed to North Sea development. Sohio was primarily a marketing company, although the company did have a small amount of U.S. production. Having two field operators was a way to bring the full range of expertise among the major owners into the operating organizations.

Reeder feels the arrangement of separate oil and gas participating areas worked well in the early years of the field's life.

But as Prudhoe Bay entered its more mature phase, with oil production declining and more liquid hydrocarbons being produced as condensate or natural gas liquids, it became more efficient to finally unify the gas and oil under a common operation. This is why the alignment of BP, Phillips and Exxon interests in the Prudhoe field made sense.

George Abraham, a retired BP executive with more than 30 years oil industry experience, was among a small group who worked on the Prudhoe Bay Unit Operating Agreement. Others included John Reeder, David Lybarger, David Pritchard, George N. Nelson, David Walker, Richard Newton and Glen Taylor.

"The basic reason for 'unitizing' the Prudhoe field was to optimize recovery and equitably divide costs among working interest owners and avoid duplication of facilities," Abraham recalled. "By limiting surface facilities you would also minimize possible environmental impacts."

The document covered how interest owners would divide expenses and how oil produced would be shared in proportion to each company's equity interest in the field. Abraham said the agreement was the most complex document he ever worked on.

"We started in 1975 but made the biggest push from January to April 1977, prior to field startup. We held our 15-hour, seven-day-a-week marathon sessions in San Francisco.

"As far as I know, the Prudhoe Unit was the largest oil field ever unitized," he added. "We had 16 interest owners involved. The sheer size of the Prudhoe field and the allocation of reserves in the oil rim/gas cap made the task more difficult. We finally ended up with two volumes containing 1,200 pages." ♦



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Oilfield veteran led construction

Prudhoe Bay's first North Slope coordinator remembers challenges of building field's petroleum production, processing facilities

By Rose Ragsdale
For Petroleum News

When Atlantic Richfield Co. took on the task of building production facilities to process the billions of barrels of oil it discovered at Prudhoe Bay, the Los Angeles-based major set out to recruit the best facilities engineers it could find.

That search brought to the company's attention Landon Kelly, an oilfield services veteran who had left ARCO a few years earlier to run his own consulting business in the Rocky Mountains before joining a partner to design and build offshore platforms in Cook Inlet.

Kelly reported for duty at North America's largest oil field in January 1969, just six months after the Prudhoe Bay discovery had been confirmed. Though he had spent 20 years drilling oil wells and building and operating oil-field production and distribution facilities from Canada to the Gulf of Mexico, Kelly had zero experience working in the Arctic, one of the harshest and most remote environments in the world.

"I was one of the first operating guys up there for ARCO," the Anchorage resident recalled recently.

One of two production engineers who shared the job of North Slope coordinator, Kelly was charged with ensuring that all of the varied drilling, production and construction activities under way in the eastern half of the field ran smoothly.

In that position, Kelly said he watched a functioning oil field, day by day, rise from the tundra and inch closer to startup.

"If anybody had a problem, they'd let me know about it, whether it was injuries or bears, whatever," Kelly said.

Experience and common sense

This responsibility sometimes led to dramatic confrontations, he said.

For example, when a worker was seriously injured, Kelly waylaid a commercial airplane sitting on the ground at the Sagwon airport and asked the pilot to delay takeoff so the plane could transport the



COURTESY OF LANDON KELLY

Landon Kelly, one of Atlantic Richfield Co.'s first North Slope coordinators, and Prudhoe Bay well superintendent Bill Congdon, right, discuss the company's early progress in developing the giant oil field with a visiting ARCO board member, PepsiCo co-founder and CEO Don Kendall.

Kelly reported for duty at North America's largest oil field in January 1969, just six months after the Prudhoe Bay discovery had been confirmed. Though he had spent 20 years drilling oil wells and building and operating oil-field production and distribution facilities from Canada to the Gulf of Mexico, Kelly had zero experience working in the Arctic, one of the harshest and most remote environments in the world.

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LONDON KELLY

A view of the Prudhoe Bay oil field and the trans-Alaska oil pipeline during their early development and construction.

injured man to the hospital in Fairbanks.

"I asked the pilot to wait and he said, 'No.' Well, I parked a bulldozer in front of the plane," Kelly recalled. "The pilot threatened to call the police, and I told him to get after it."

Five minutes after the standoff began, it was over. Emergency workers trundled the injured man aboard the plane and the aircraft took off.

Life on the Slope in those days, before the oil producers and contractors established formal policies and procedures, was full of instances where Kelly had to make snap decisions based on his judgment and common sense.

Kelly said he watched ARCO build a top-ping plant early on because the company knew it had a big field that would have a considerable thirst for fuel.

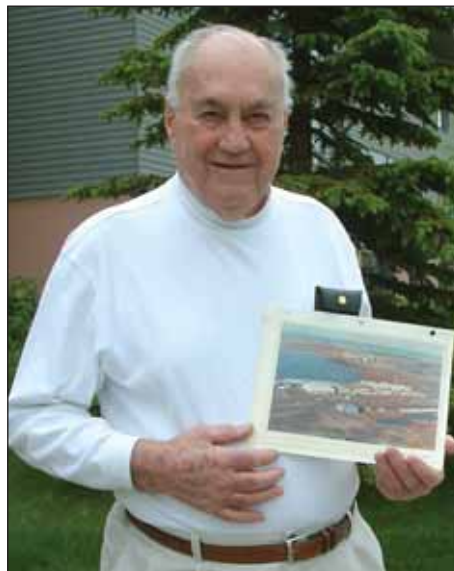
He said he also helped with construction of a pipeline test loop, which gathered data that ultimately affected the design of the trans-Alaska oil pipeline.

"We found that a core of oil would move through the lines with friction and that we could keep the oil moving even in the coldest temperatures," Kelly said.

He said this early period was dominated by politics, and it took ARCO four years to secure an operating permit for the field's processing facilities.

But by the time ARCO won the permit, the module that engineers had originally designed for the field's flow stations seemed inadequate.

"By that time, we had quite a bit more



ROSE RAGSDALE

Today, Landon Kelly fondly recalls his first job for Atlantic Richfield Co. on Alaska's North Slope, helping to manage construction of Prudhoe Bay oil field production facilities.

information, so we made the decision to start over," Kelly said.

The coordinator was asked to help with module design and selection of equipment.

"We started from scratch working with a design team in Los Angeles," Kelly recalled. "As we developed the design, we would make sure we could operate it safely and efficiently and that we could maintain it."

This process led to a rather unusual arrangement in which Kelly commuted between the North Slope and Los Angeles for three years.

"I'd spend all week in Los Angeles, come home on Fridays and meet with the operations people — the president of ARCO Alaska Inc., the head of engineering and the engineering staff," Kelly said. "When I returned to LA on Monday, I would have a pocket full of decisions."

Attention to detail

In this manner, ARCO worked its way through design, construction and commissioning of its production facilities.

During the construction phase, Kelly said he asked the operations staff to work at night, fine-tuning and testing the processing facilities while the construction workers slept.

"Every night, between 10 p.m. and 2 a.m., I'd go 'piddlin'," Kelly said.

"Piddlin" was Kelly's word for walking around the facilities, casually observing and visiting with operations staff while they were working.

He said the practice paid off when ARCO's production facilities did not miss a beat at startup in 1977, and "unlike, the other side of the field, was able to supply its full quota of output to Pump Station 1 of the trans-Alaska oil pipeline from Day 1 without interruption."

Once Prudhoe Bay was up and running, ARCO invited Kelly to bring the expertise he'd acquired to bear on the company's next North Slope challenge, designing and building production facilities for the Kuparuk River field, North America's second-largest oil field. ♦



1957

The Swanson River oilfield on the Kenai Peninsula becomes the first major commercial oil discovery in Alaska.



1968

The Prudhoe Bay oilfield is discovered. Its discovery well proves the commercial viability of the largest oilfield ever found in North America.



1969

The Kenai Liquefied Natural Gas Plant began operating after ConocoPhillips made natural gas discoveries in the Cook Inlet region, making it the only plant in North America that exports LNG.



1977

The Trans Alaska Pipeline System begins carrying Alaska oil 800 miles from Prudhoe Bay to the port of Valdez.

1981

The Kuparuk oilfield, the second largest in North America, begins production.



2000

ConocoPhillips starts up the Alpine oilfield, creating a reduced industry footprint of just two-tenths of one percent of the field's surface area.



2001

The first double-hulled tanker, the Polar Endeavor, arrives in Alaska — a new generation of oil tankers.

2004

ConocoPhillips announces the first Alpine satellite fields.



2008

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ARCO hires naturalist to study wildlife

Early 10-year commission establishes high standards for environmental protection in Prudhoe Bay, North Slope oil fields

By Rose Ragsdale
For Petroleum News

When oil was discovered at Prudhoe Bay in 1968, very little was known

about the North Slope, except that its tundra and permafrost would pose considerable problems in developing the field and in getting the oil to market.

Atlantic Richfield Co. hired a Canadian

scientist, Angus Gavin, to conduct a 10-year comprehensive baseline study from 1969 to 1978 to determine Prudhoe Bay's ecological values. Objectives of the study included evaluating the effects of oil field development on the environment; inventorying caribou, waterfowl and sea birds and other wildlife using this region of the Slope and evaluating the effects of oil field development on their numbers, distribution and migrations; and conducting a baseline study of all offshore islands.

Gavin came to Canada as a young zoologist from Scotland to work for Hudson's Bay Co. in Canada. For six years, he was assigned to the Western Arctic where his only means of communication with the outside was a once-a-year supply boat.

Gavin's primary function was to check and report on populations of fur-bearing animals in that remote region, in order to give Hudson's Bay's home office an estimate of the coming year's harvest.

But Gavin was many other things to the Canadian Natives that he befriended — doctor, teacher and counselor. During his Arctic years, he also compiled an English-Eskimo dictionary, which is still in use today.

Gavin also was the first to locate the breeding grounds of the elusive Ross' goose.

In the early 1940s Gavin spent two years gathering information for the province of Alberta on waterfowl and other wildlife in the Athabasca Delta area. Then, in 1945, he joined Ducks Unlimited, Canada, a conservation group, as provincial manager for Saskatchewan.

Gavin remained with Ducks Unlimited for 24 years, the final two decades as general manager for all of Canada. In 1969, he retired.

Conservationist comes to Alaska

But Gavin's retirement ended almost before it began.

ARCO Chairman and CEO Robert O. Anderson persuaded the naturalist to survey, study and report on wildlife and the environment of Alaska's North Slope.



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The Atlantic Richfield base camp in the early days at Prudhoe Bay in the 1970s.



FRANK H. WHALEY, ANCHORAGE MUSEUM ARCHIVES

At a time when the environmental movement was a fledgling concept and virtually unknown in Alaska, Kelly said ARCO tried really hard to protect the environment through Gavin's work.

Equally important, Gavin was to recommend ways to minimize the negative impact of oilfield operations there.

When Gavin first went to the North Slope in 1969, very little of substance was known about the area's wildlife and environment. Through his work, this quickly changed.

"Every time we wanted to build something, Angus would inspect the area," recalled Landon Kelly, one of the first operations managers appointed to lead development of the Prudhoe Bay oil field. "He would then tell us if we had to (avoid) any wildlife or nests with the construction."

At a time when the environmental movement was a fledgling concept and virtually unknown in Alaska, Kelly said ARCO tried really hard to protect the environment through Gavin's work.

When the zoologist completed his extensive 10 years of studies in 1978, Gavin summarized his findings as follows:

"Although the development of an oil field at Prudhoe Bay and the building of a pipeline to Valdez, together with all the other attendant activities, have at times disrupted and disturbed some of the wildlife within the area, this should not have any lasting or detrimental effects.

"With major construction work over for the present, more normal conditions now prevail, although our surveys over the years have shown that most species of wildlife adapt quite readily to changing environmental conditions." ♦

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A trench digger hews a trough in rock, ice and permafrost for a gas line to power pumps used to push crude oil through the trans-Alaska oil pipeline from the Prudhoe Bay oil field to Pump Station 4 in northern Alaska in the mid-1970s.

STEVE MCCUTCHEON TRANS-ALASKA PIPELINE SYSTEM CONSTRUCTION COLLECTION, ANCHORAGE MUSEUM ARCHIVES

Producers weigh many marketing options

Alternatives for getting Prudhoe Bay oil to market narrowed to choice between trans-Alaska and trans-Canada overland pipelines

Petroleum News

After the oil was discovered, the big problem facing the oil companies was how to get the oil to market. Markets within the United States, already dependent on foreign imports because domestic production could not meet demand, were located mainly on the East Coast, the Midwest and the West Coast.

Developers could envision only two

possible ways of transporting North Slope oil to market, by sea through the Bering Strait or overland by pipeline. The former would mean opening up the legendary Northwest Passage as a regular shipping route. If it could be done, it would mean tankers, or oil-carrying submarines could supply oil to East Coast markets. An overland pipeline could supply either the Midwest through a 2,900-mile line across Canada or the West

Coast through an 800-mile line to an ice-free port in southern Alaska where tankers could be loaded for ocean transport.

Several interesting proposals emerged from the discussion. One was moving the oil by sea to the East Coast via ice-strengthened tanker, notably Esso's tanker SS Manhattan in the U.S. merchant fleet. The project would cost an estimated \$50 million and was spon-

sored by Humble Oil and supported by BP and Atlantic Richfield.

While other vessels had made the transit earlier, the 150,000 deadweight-ton Manhattan was the first commercial vessel to make the passage. Its partial double-hull construction was designed to break through the Arctic ice packs on its voyage through the Northwest Passage and across the Canadian and Alaska Arctic.

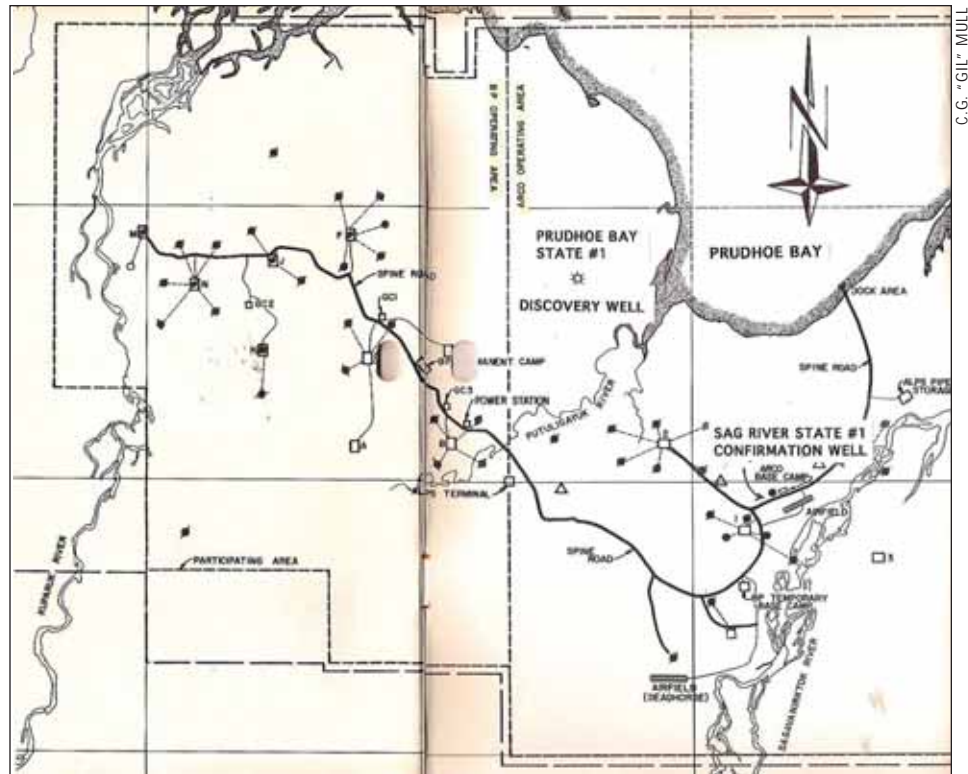
The tanker made a much-publicized 10,000-mile round trip in the fall of 1969 and another the following spring. However, this form of transportation was not adopted because it was concluded that transporting oil via tanker in the Arctic was not commercially viable on a year-round basis due to unpredictable, offshore ice conditions, which made it unreliable for year-round loading.

Other ideas explored

A proposal by General Dynamics called for a fleet of submarine, nuclear-powered tankers.

The Canadian Institute of Guided Ground Transport produced a study "Railway to the Arctic," which concluded that a 1,240-mile, double-track railway from Prudhoe Bay to existing pipeline facilities near the Alberta border would be technically feasible and financially attractive.

Tanker aircraft, dirigibles and other airships also had their supporters, but the most frequently suggested alternative to



A 1971 map of the Prudhoe Bay oil field showing locations of wells, and production and processing facilities.

been made.

Studies, however, indicated that a trans-Alaska pipeline was the most economical option.

The position of Alyeska Pipeline Service Co. on a trans-Canadian line was made clear in March 1972 when it pointed out that the trans-Alaska line would cross fewer permafrost areas than any

Canadian alternative, that it would result in less disruption of terrain and require the crossing of fewer streams and rivers, that it would be half as long, and that it would be built sooner at half the cost.

Trans-Alaska pipeline

Alyeska President Edward Patton told a U.S. House of Representatives subcommittee in April 1973: "If the trans-Alaska

line is completed in 1977, it will have taken nine years from commencement of planning to completion. A trans-Canada line, which would be twice as long merely for the first leg to Edmonton, is at the same stage in the planning process as was the Alaska line in 1969. Giving consideration to the magnitude of the project, and the potential for delay by opponents, it is most

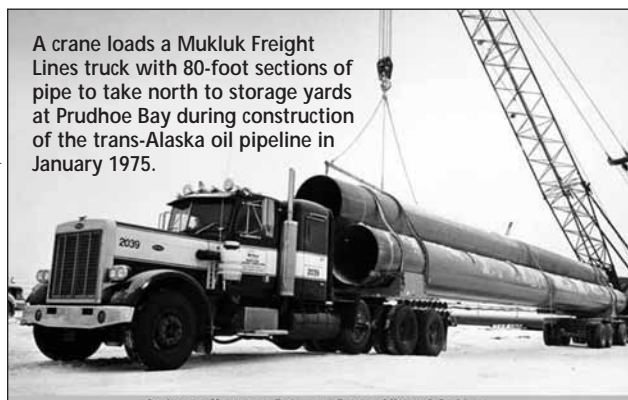
likely that a trans-Canada oil pipeline could not be operational before 1983."

Patton added that the resulting delay would add hundreds of millions of dollars to the nation's resource bill and some \$3 billion annually to the balance of payment deficit.

Because of the obvious economic benefits to the state and local communities, there was strong support within Alaska for an all-Alaska route. Alaska's Gov. Keith Miller and other influential Alaskans agreed with the proposal for a terminal to be built at Valdez.

When it came apparent that the trans-Alaska route had won out over other alternatives, the companies focused their energies on developing a viable pipeline system. The proposed 48-inch line, capable of carrying oil at a rate of 2 million barrels per day was initially estimated to cost \$900 million. The final cost eventually topped \$9 billion.

Various estimates were made of the cost of producing the oil at Prudhoe Bay. Arlon Tussing of the Federal Field Committee for Development Planning in Alaska estimated the wellhead cost, including discovery, development and production, at 24-54 cents a barrel based on 10 billion barrels in recoverable reserves. That compared with about 80 cents to \$1.25 per barrel in wellhead cost for Cook Inlet oil. ♦



the Prudhoe-Valdez line was another pipeline from the North Slope into Canada via the Mackenzie River Valley to Alberta. From there it would be linked to the existing pipeline system, allowing Alaska crude to be piped directly to Chicago and the Great Lakes industrial belt. The pipeline would also carry Canadian crude from the Mackenzie delta, where some significant oil discoveries had

Pipeline tops for moving oil to market

Companies organize unprecedented engineering feat to overcome technical challenges of transporting Prudhoe Bay crude to tidewater

Petroleum News

Even while Put River No. 1 was being drilled, the three companies most concerned with Prudhoe Bay at that time — British Petroleum, Atlantic Richfield and Humble (predecessor to ExxonMobil) — initiated a full-scale study of all possible alternative routes for moving the oil off the North Slope.

In October 1968, BP, ARCO and Humble formed a joint venture to organize, design and build a pipeline to transport Prudhoe Bay oil to market. The new enterprise was called Trans-Alaska Pipeline System, or TAPS.

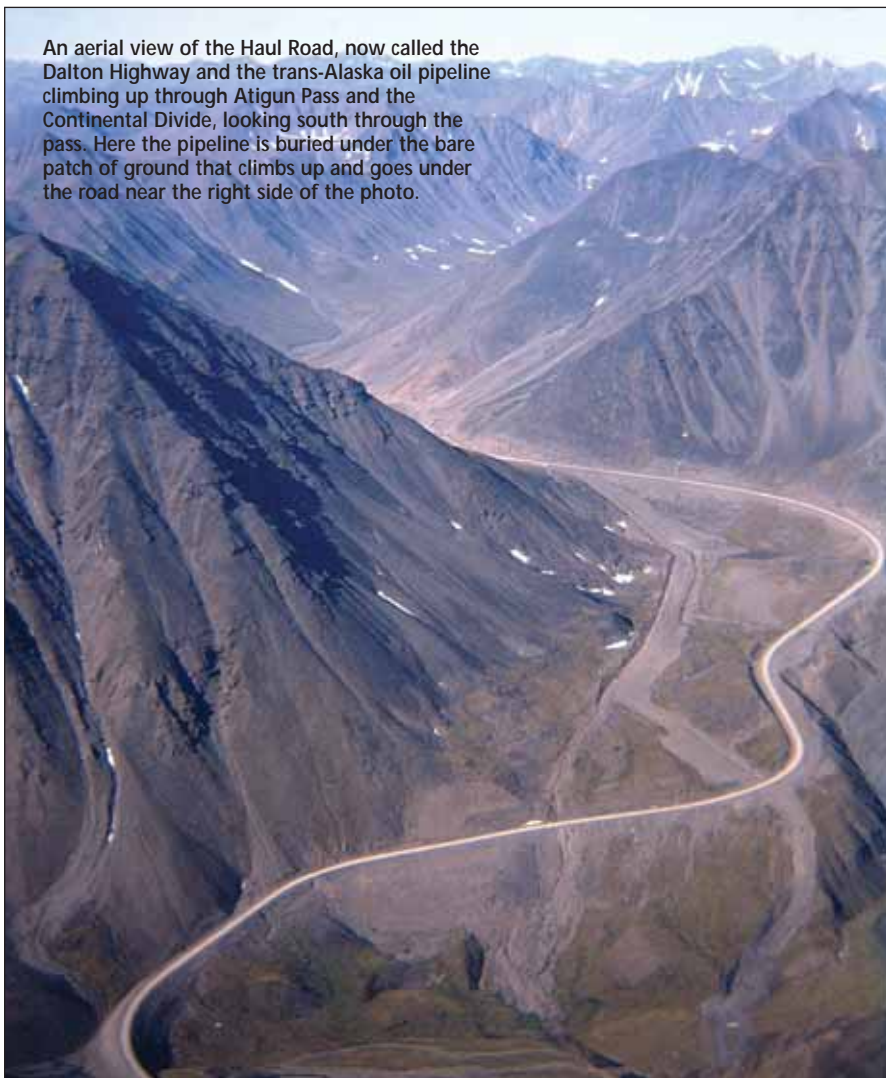
ARCO and BP each initially held a 37.5 percent interest in the line and Humble held a 25 percent share. Those ownership interests changed over the next 40 years. Today, BP owns 50.3 percent, while ConocoPhillips holds 28.1 percent and ExxonMobil retains a 20.3 percent stake.

In 1968, the big three soon-to-become producers extended an invitation to other companies that might wish to transport oil from the North Slope in the future. This led to four other companies — Mobil Alaska Pipeline Co., Amerada Hess Pipeline Co., Phillips Alaska Pipeline Corp. and Unocal Pipeline Co. — joining TAPS.

Trans-Alaska pipeline chosen to move oil

In February 1969 TAPS announced plans to build a trans-Alaska crude oil pipeline south from Prudhoe Bay to the nearest ice-free

An aerial view of the Haul Road, now called the Dalton Highway and the trans-Alaska oil pipeline climbing up through Atigun Pass and the Continental Divide, looking south through the pass. Here the pipeline is buried under the bare patch of ground that climbs up and goes under the road near the right side of the photo.



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An aerial view of Pump Station 4 of the Trans-Alaska Pipeline System and the Haul Road at the Brooks Range mountain front, looking north out onto the foothills. Galbraith Lake is in the upper center of the shot.

C.G. "GIL" MULL

port. TAPS aimed to build a 789-mile (revised later to 798 miles), 48-inch diameter pipeline from Prudhoe to the port of Valdez on Prince William Sound on Alaska's southern coast. The initial estimated cost of the project was \$900 million - the most expensive ever proposed by private industry at the time. Inflation and environmental considerations eventually drove the final cost to more than 10 times that amount.

Route feasibility studies indicated that an obscure pass through the Brooks Range was the best route for the pipeline. The pass had never been named. "Early on," Mull said, "the companies referred to it as Dietrich Pass," but

later it was officially named Atigun Pass.

"All of us working on the Slope at the time just assumed the line would go through Anaktuvuk Pass," he said.

Though Atigun was higher than Anaktuvuk Pass, an alignment of the route linking these principal points — Atigun Pass, Rampart Canyon and Valdez — was selected. Criteria included keeping the pipeline profile within the limits of past experience in relation to mountain crossings. This involved intensive studies to ensure the pipeline was not pressured past design specifications; minimizing the length of the line; ensuring that the line could be buried for the greatest possible distance; minimizing the

distance it would have to run in high ice-content permafrost areas; bypassing identifiable geologic hazards; avoiding terrain and soil conditions which could present undue construction difficulties, minimizing alignments requiring large amounts of grading, such as side-hill construction; bypassing population centers; and wherever possible, avoiding sites of antiquities and important fish spawning or wildlife areas.

Soil conditions along the route, which could influence the pipeline's alignment or mode of construction, were studied in considerable detail. More than 3,000 bore holes were drilled from Valdez to Prudhoe Bay, from which more than

30,000 core samples were taken.

Pre-construction costs of the Alyeska pipeline totaled more than \$100 million. The bulk of that was in soil investigations, in determining methods of pipe support, in testing the pipe itself, which came from three companies in Japan, and in compiling environmental baseline data.

The size and scale of the project was daunting. The pipeline would cross the Denali fault line on the north side of the Alaska Range, an area known to be seismically active, and 600 streams and rivers.

Three mountain ranges also would be crossed by the pipeline – the Brooks, Alaska and Chugach mountains. The point of highest elevation is 4,739 feet at Atigun Pass in the Brooks Range. The steepest grade is 55 degrees at Thompson Pass in the Chugach Range.

Unprecedented technical challenge

Designing the pipeline was an unprecedented engineering challenge. Thousands of bore-hole core samples were analyzed. Seismic experts at the U.S. Geological Survey in Menlo Park, Calif., reviewed reams of data to assess earthquake risk. Extensive stress analyses on the pipe were conducted.

Several factors made the design of the line unprecedented in terms of complexity.

The 48-inch pipeline system had to be able to achieve a throughput of 1.5 million barrels per day. It had to be built to address three different soil conditions – normal soil where the pipeline could be buried in a conventional manner; discontinuous permafrost where the pipeline could be buried if adequately insulated; and continuous permafrost where the pipeline would have to rest on an elevated pipe rack, or vertical support members, whose pilings were constantly cooled to prevent heating and thawing of the permafrost.

The 48-inch diameter mainline pipe was delivered to Alaska in the early 1970s from three companies in Japan – Sumitomo Metal Industries, Yawata Iron and Steel, and Nippon Kokan. The 69,000 lengths of pipe were stockpiled at large sites in Valdez, Fairbanks and Prudhoe Bay. Total pipe cost about \$120 million.

The pipe had to be strong with wall thicknesses of 0.462 and 0.562 inches and specified minimum yield strengths of 60,000-70,000 pounds per square inch. These specifications would meet or exceed the requirements for safety and



An aerial view of the bridge built over the Yukon River for the trans-Alaska oil pipeline and Haul Road crossing during its construction in the summer of 1975, with big barges and construction cranes in the center of the river.

special low temperature considerations as well as all U.S. government and American Petroleum Institute standards.

The pipeline system had to be built to withstand the combined stress of internal pressure of thermal, bending and seismic forces.

At river crossings and in certain flood plains, it required anti-corrosive coating and an outside layer of concrete to anchor it to stream bottoms. All buried sections required anti-corrosion coating and cathodic protection with sacrificial zinc anodes to prevent chemical and electrolytic corrosion of the pipeline.

Above-ground sections (about half the line) required thermal insulation to slow the drop in oil temperature in the event of a pipeline shutdown.

Geotechnical, geological, civil and Arctic engineering, stress analysis, thermal engineering, agronomics, hydraulics, mechanical and welding engineering were all required. This wide-ranging array of engineering disciplines produced the most detailed design of any pipeline ever constructed. Also significant was that it was constructed within a short period of time — a mere three years. ♦

Fast and furious construction

Prudhoe Bay owners tackle pre-pipeline preparations at record-setting pace; Haul Road completed in less than six months

Petroleum News

In order to begin construction on the pipeline, Alyeska Pipeline Service Co. needed to put in a road to service its construction. The road would start at the Yukon River, at the end of the 53-mile Elliott Highway from Fairbanks to Livengood, and continue north some 360 miles to the North Slope.

Anticipating an earlier passage of a the Trans-Alaska Pipeline System right-of-way permit, tons of road-building equipment and camp units were distributed along the proposed route of the haul road beginning in 1969-70. One of the main obstacles on the route was the Yukon River, so ice roads were constructed each winter to keep material supplies moving north.

With receipt of the right-of-way permit in 1974, the project moved into high gear. The logistics of the northward flow that began in the winter of 1974 would dwarf heroic episodes of the past like the Berlin airlift and some great overland efforts in Alaska itself, such as the Gold Rush in the 1890s; and some military movements during World War II.

In 83 days, from late January to mid-April 1974, a force that at one point numbered 680 workers moved some 34,000 tons of machinery and materials into northern Alaska. This took 671 aircraft flights – a large number of those C-130 Hercules cargo aircraft – and 1,285 trips by truck. Seven mothballed construction camps were opened and enlarged, and five new camps were built. Five temporary airstrips were built over the snow and ice, to be replaced in spring by a permanent gravel-based runway at each camp. Crews kept at it around the clock in temperatures that dropped as low as minus 68 degrees Fahrenheit.

Michael Baker Jr. Inc. was selected to

A truck headed south on the 400-mile Haul Road, now named the Dalton Highway, that runs from Fairbanks to Prudhoe Bay in the early 1970s. An 8-inch gas pipeline is being constructed beside the road to supply fuel for Pump Stations 2, 3, and 4.



STEVE MCCUTCHEON TRANS-ALASKA PIPELINE SYSTEM CONSTRUCTION COLLECTION, ANCHORAGE MUSEUM ARCHIVES

perform planning and civil engineering for the road project, which included the first permanent bridge across the Yukon River. A joint venture, Manson-Osberg-Ghemm won the construction contract for the \$30 million, 2,295-foot bridge, which was completed in 1975.

Road construction expedited

Haul Road construction officially began in April 1974, and at the peak of the effort, Alyeska and its contractors deployed more than 3,400 workers along the 400-mile route. The road was divided into eight sections, and each section was

built north and south from a center point until they all connected. Four execution contractors selected for the work were joint ventures Green Associated and General Alaska-Stewart along with Morrison-Knudsen Co. Inc. and Burgess Construction Co. Each of the contractors built two sections of the road.

Supply flights during the winter had just been the beginning. Now a squadron of more than 60 aircraft, ranging from helicopters to big, fixed-wing transports and air tankers, crisscrossed the skies over northern Alaska in support of the road-building effort. More than 127,000 flights were logged, an average of 700 flights per day. Suppliers flew in 8.5 million gallons of fuel to power construction equipment and camps. Another 160,000 tons of supplies and material were transported by air. By early summer, barges were bringing in materials by sea directly to Prudhoe Bay.

Alyeska picked Bechtel Inc. of San Francisco as Construction Management Contractor or CMC for construction of the road, 29 camps and the pipeline. The following year, Alyeska became

CMC for the pipeline portion of the work, which included nearly 800 miles of 48-inch-diameter mainline pipe installation, 12 pump stations and a marine terminal in Valdez.

Trucks carried more than 31 million cubic yards of rock to bring the 28-foot-wide road up to state secondary road standards. Work on the 360-mile-long gravel roadway, later named the Dalton Highway, was completed Sept. 29, 1974, only 154 days after construction startup. The 3-million-manhour, single-summer project was unprecedented in Alaska history. ♦

Pipeline startup brings oil to market

Producers wade through sea of challenges to build trans-Alaska oil transportation system

Petroleum News

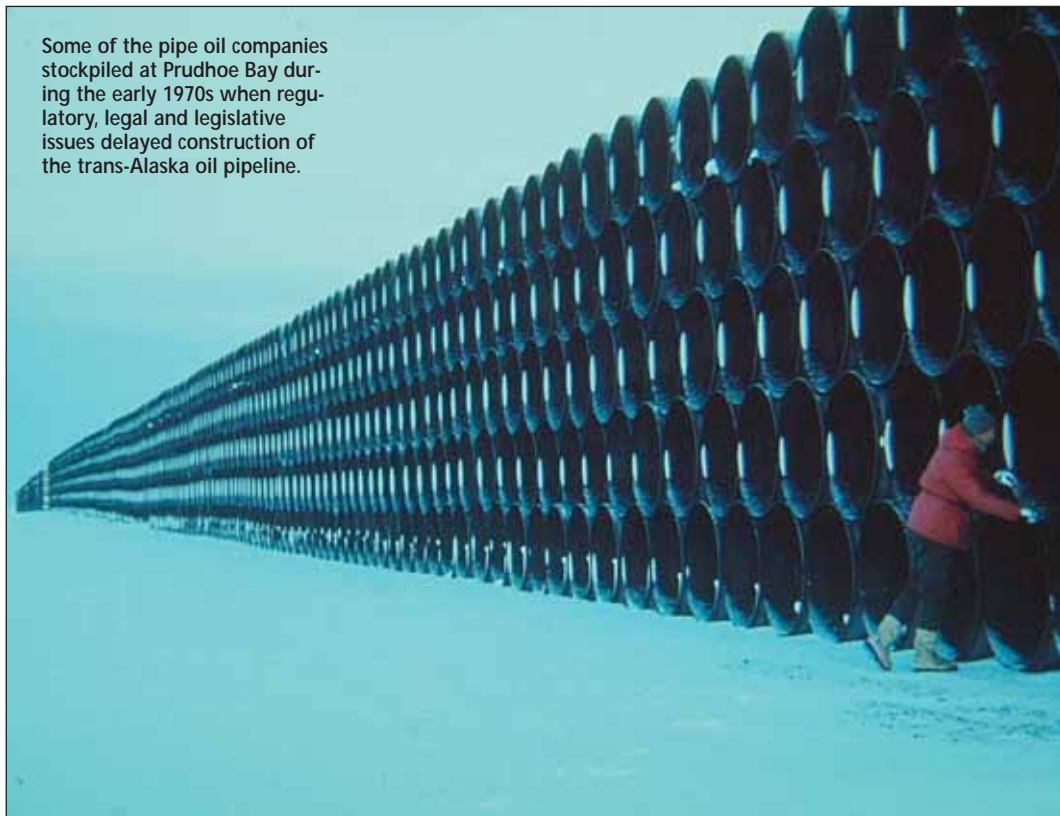
The year 1973 brought the Arab Oil Embargo and saw the creation of the term "oil crisis" in the minds of Americans and the nationalization of oil holdings by several Third World countries, including ARCO's holdings in Libya.

ARCO President Thornton F. Bradshaw told a Congressional committee on March 27, 1973, that "each day's delay in bringing Alaska oil to U.S. markets results in a balance of payments loss to the United States of about \$5 million."

By the 1980s, he said, this loss would amount to \$10 million per day. He also told the Senate Interior Committee that the first decade of operation of the pipeline would have a cumulative benefit of between \$20 billion to \$25 billion on U.S. balance of trade payments.

Addressing the environmental issues surrounding the proposed pipeline, Bradshaw said, "We have spent tens of millions of dollars in design to meet the stringent challenges of the Alaskan wilder-

Some of the pipe oil companies stockpiled at Prudhoe Bay during the early 1970s when regulatory, legal and legislative issues delayed construction of the trans-Alaska oil pipeline.



C.G. "GIL" MULL

ness. The trans-Alaska pipeline will be easily the safest and best-engineered pipeline in the world."

Pipeline right-of-way becomes law

President Richard M. Nixon signed the measure

into law on Nov. 16, 1973, and on Jan. 23, 1974, the U.S. Secretary of the Interior signed the primary federal right-of-way permit for construction of the \$9 billion, 800-mile, trans-Alaska oil pipeline. Called the most massive construction project ever undertaken by private industry, the trans-Alaska pipeline system was designed to pump up to 1.5 million barrels per day of crude across three mountain ranges and some 600 rivers and streams.

Alaska residents, particularly in Fairbanks, were cautious in their enthusiasm when Nixon signed the pipeline legislation because many of their businesses had barely survived the expected boom of 1969, which collapsed

when plans to build the pipeline were put on hold by the federal government.

World-class construction begins

Prior to actual pipeline construction, a service road was built from Livengood to the North Slope, a distance of some 360 miles, or about 581 kilometers. It took more than 31 million cubic yards of gravel to build the road.

First pipe laid for line

The first pipe for the trans-Alaska oil pipeline was installed at the Tonsina River on March 27, 1975. There were 29 temporary camps from Pump Station 1 to the marine terminal in Valdez. Each camp was self-sufficient

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and housed between a few and several thousand workers. The entire pipeline work force peaked at 28,000 in October 1975. Minority hire ranged between 14 percent and 19 percent and anywhere from one in 20 to one in 11 workers were women.

Average pay for working 12 hour days, seven days a week, was \$1,000 per week. Skilled laborers such as welders earned considerably more. Even with the high wages of the time, the turnover rate was about 20 percent.

In Fairbanks at the main transportation hub for the project, telephone lines were constantly jammed; grocery stores struggled to keep shelves stocked; and a cab-over camper in a pickup truck rented out for \$500 a month.

To a lesser extent, Anchorage and Valdez felt similar effects.

The Valdez terminal was a massive project. It covers more than 1,000 acres and was designed with four tanker-loading berths and tankage to hold a total of 9 million barrels of crude oil. The facility also processes oil ballast water taken out of tanker ships as they are loaded with North Slope crude oil. Hydrocarbon vapors are vented from the storage tanks as the level of crude oil fluctuates. The cost of the terminal was about \$1.4 billion.

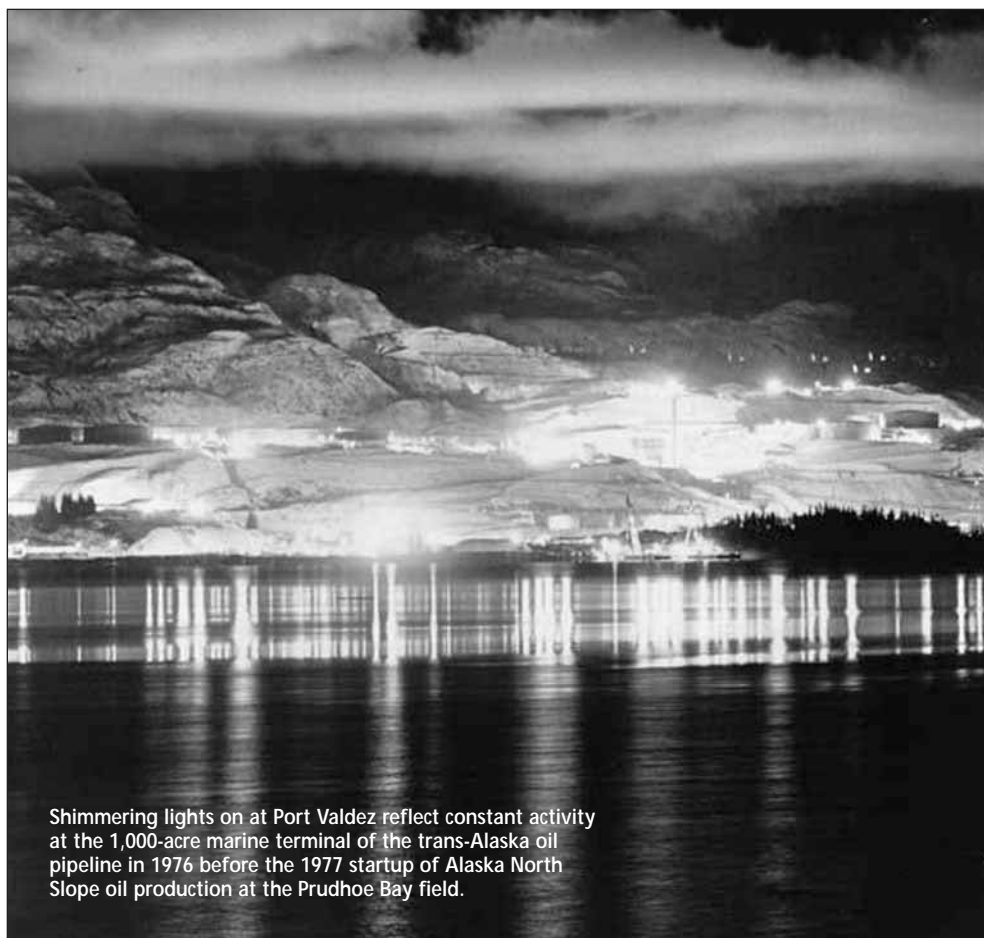
Oil flows into TAPS

Officials hoped to have oil flowing through the pipeline by July 1, 1977. Ten days ahead of schedule, the first oil flowed into the trans-Alaska oil pipeline on June 20, 1977, at 10:05 a.m. The oil moved at about 5 miles per hour through 10 pump stations, taking six days to reach Valdez. At that point, it was stored in 510,000-barrel tanks and then was taken by oil tankers to refineries in the Lower 48.

To date, the trans-Alaska pipeline system has safely transported nearly 13 billion barrels of crude from the North Slope to Valdez, oil that has accounted for 20 percent of U.S. oil production at Prudhoe Bay's peak of output and a substantial portion of domestic output for most of the past 31 years. ♦



Drilling rig crews have played a vital role in development of the giant Prudhoe Bay oil field throughout its 40-year history. Here roughnecks connect pipe string during delineation drilling at Prudhoe Bay in 1969. Extreme weather conditions in the Arctic mandate that the drill floor be enclosed and heated.



Shimmering lights on at Port Valdez reflect constant activity at the 1,000-acre marine terminal of the trans-Alaska oil pipeline in 1976 before the 1977 startup of Alaska North Slope oil production at the Prudhoe Bay field.



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Alaskans remember Prudhoe Bay

By Nancy Pounds

Most Alaskans don't remember what Alaska's economy looked like before the discovery and development of Prudhoe Bay. Only 14 percent of about 670,000 Alaskans today lived in the state in 1968, the year of the Prudhoe Bay discovery, according to Scott Goldsmith, economics professor at the University of Alaska Anchorage's Institute of Social and Economic Research. So nearly nine out of every 10 residents today know little about Alaska prior to major development on the North Slope, he said. Goldsmith compared 1968 and 2008 in a recent report called, "How North Slope oil has transformed Alaska's economy." A few longtime Alaskans, participants and decision-makers during Alaska's major economic changes, recently recalled events of the era.

Arliss Sturgulewski

Arliss Sturgulewski attended the oil lease sale in 1969 that brought \$900 million to the state.

"We just thought we were very rich," she recalled recently.

Sturgulewski, who came to Alaska in 1952, has seen many changes in the state. She served in the Alaska Legislature from 1978 to 1992.

"It was a really transitional time for Alaska," Sturgulewski said.

At the time of the Prudhoe Bay discovery, the state needed to build roads and other infrastructure, she said.

"We had some very big land issues to resolve," she added.



ARLISS STURGULEWSKI

Prudhoe Bay's oil development was the impetus and made the decisions come faster, she said.

"It was a tumultuous time," she said.

Alaska's economy has changed in the last 40 years, due to factors other than oil such as growth from fisheries, military spending and air cargo among others. But the oil industry has been important.

"Without question oil was a driver of good-paying jobs," she said.

She remembered the economic crash of 1986, but noted that growth since has been more controllable, and the state's economy

is more diversified.

"Without question oil has been a big factor in the state's economy," she said.

Editor's Note: Arliss Sturgulewski is

She remembered the economic crash of 1986, but noted that growth since has been more controllable, and the state's economy is more diversified.

"Without question oil has been a big factor in the state's economy," she said.

one of Alaska's reigning public stateswomen. Educated at the University of Washington, she retired in 1992 after 14 years in the Alaska Legislature and twice running as the GOP gubernatorial candidate. She has continued in public service as a major force in policy initiatives aimed at improving economic, educational and social opportunities for Alaskans. ♦

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Making the most of maturity

Major Prudhoe Bay oil field developments

PFX-1, PFX-2, PFX-3 (Flow line expansions)

Early 1980s expansion of oil flow line connections from well pads to gathering centers, PFX facilitated the tie-in of production manifolding at each well pad.

Wellpad Manifolding (WPM)

Routing oil from wells to common flow-lines through a manifold rather than sending it to gathering centers through individual lines.

Produced Water Expansion (PWX)

Multi-phased project begun in 1982 which expanded water-handling capacity throughout the Prudhoe Bay field and provided water treatment facilities to further strip oil from produced water. It also provided a distribution system to wellpads for injection to facilitate secondary recovery.

Low Pressure Separation (LPS)

Multi-phased project initiated in 1982 which greatly increased the productivity of Prudhoe Bay wells by allowing gas to enter separation facilities at a lower pressure. Cost exceeded \$700 million in 1982 dollars.

Gas lift (GLT)

Substantially increased gas-lift compression and distribution system at Prudhoe Bay in 1984 and supported well productivity processes.

The Seawater Treatment Plant at the end of the West Dock Causeway on the North Slope is an important component of processing facilities for the Prudhoe Bay oil field. Oil producers have used seawater in developing increasingly sophisticated enhanced oil recovery techniques that are vital in the ongoing development of oil reserves on the North Slope.



BP EXPLORATION (ALASKA) INC.

Field-wide Waterflood

Prudhoe Bay pressure maintenance program in 1984 which included seawater injection into the reservoir. Scope of the \$2 billion program included distribution system, seawater treatment plant (barged from Korea) and pumping systems at Gathering Center 1 and Flow Station 1.

Large-Scale Enhanced Oil Recovery (EOR)

Begun in 1986, involved injecting miscible injectant (MI) throughout the reservoir to aid recovery. Through construction of the Central Gas Facility (CGF) in 1987, more MI and natural gas liquids (NGLs) were

produced.

Eileen West End (EWE)

A Prudhoe Bay field extension in 1988. Facilities were mini-modules built in Alaska and trucked to the North Slope, and tied back into main Prudhoe infrastructure.

Gas Handling Expansion (GHX) Phases I and II

A project to handle increasing quantities of natural gas produced with the oil stream in 1990. A second phase was completed in 1995 at a cost of \$1.4 billion.

Source: BP Exploration (Alaska) Inc.

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The Central Gas Facility, foreground, and Central Compression Plant at Prudhoe Bay represent the largest natural gas plant complex in the world. The oil industry has invested more than \$40 billion in Alaska since the 1970s, and billions more will be required to keep oil production levels steady in the coming years. While natural gas promises to become an important future source of North Slope petroleum production, the producers also are focused on finding more oil in smaller accumulations. Five Prudhoe Bay satellite oil fields currently produce about 45,000 barrels per day and help offset the giant oil field's decline.

Mid-life transition for a giant

40 years after discovery the Prudhoe Bay field continues to produce oil while looking forward to future natural gas sales

By Alan Bailey
Petroleum News

At a time when daily oil production from the giant Prudhoe Bay on Alaska's North Slope has declined from a peak of about 1.6 million barrels in 1987 to about 400,000 barrels, it is tempting to think of the field as being in terminal decline.

Not so, BP's Greater Prudhoe Bay Waterflood Resource Manager Scott Digert told the 2008 Alaska Geological Society Technical Conference on April 17, 2008. The AGS conference was celebrating the 40th anniversary of the discovery of Prudhoe Bay.

"This is a very exciting time to be working on Prudhoe," Digert said.

Digert also reminded the audience that, despite major discoveries in places like the Gulf of Mexico, Prudhoe Bay remains the top producing oil field in the United States.

And the field has exceeded all expectations for oil production — originally, estimated recoverable oil reserves were 9.6 billion barrels.

"As we stand today we're at 11.7 (billion barrels) and counting," Digert said.

Moreover, Prudhoe Bay and the associated trans-Alaska oil pipeline have proved to be the anchor for about 25 producing North Slope fields.

"If it weren't for Prudhoe and TAPS none of those fields would be in production either," Digert said.

Ivishak reservoir

The Prudhoe Bay reservoir occupies an area of about 254 square miles. The main section of the reservoir lies in the Triassic Ivishak formation, consisting of sandstone and coarse pebbly rocks called conglomerates, laid down by an ancient river and river delta system, Digert said. In fact, information about the subsurface rocks obtained from the 2,500 or so well penetrations in the reservoir has enabled a detailed reconstruction of the geography of the ancient landscape.

The Ivishak is a massive 450-foot thick rock unit. And a separate 35-foot shallow marine sandstone layer known as the Sag River formation creates a second, much smaller reservoir above the main reservoir. The reservoir strata have been bent into an arch-shaped anticline, cut off at the top by a major geologic discontinuity termed the

lower Cretaceous unconformity — the oil and gas lie trapped against that unconformity.

To plan field development, petroleum engineers subdivide the Ivishak reservoir into four stratified zones, Digert explained. Differences in the grain sizes between the rocks in the different zones cause major differences in the permeability, or ability to flow fluids, within the zones. Zone 3, for example, consists of massively coarse conglomerates formed when the ancient delta was at its maximum extent. The conglomerates allow fluids to flow particularly easily — Digert recalled seeing 50,000 barrels of water per day being injected into just one foot of these rocks.

Layers of impervious shales are interstratified with the sandstones and conglomerates. The shales inhibit the vertical movement of fluids within the reservoir, but can be used to support the transmission of pressure across the reservoir to enhance oil recovery, Digert said.

Gas cap and oil rim

When discovered 40 years ago, the Prudhoe Bay field contained a huge gas cap sitting in the reservoir on top of an equally

huge oil rim. A thin tarry zone of heavy, impermeable oil marked the base of the oil rim and separated the oil from underlying water, Digert said.

At field startup in 1977, pressure in the gas cap forced oil up through the producing oil wells. Gas produced through the wells was injected back into the gas cap to maintain reservoir pressure. And in the part of the oil pool where the pressure from the gas cap transmits into the oil, gravity also causes the oil to flow down the gently sloping reservoir rock layer toward the production wells. This gravity flow effect gave rise to the term "gravity drainage area" to describe this part of the oil pool.

The lower section of the oil pool is too distant from the gas cap to be in significant pressure communication with the gas.

"We don't see that same gas-cap drive — the gas can't expand directly into those areas," Digert said.

Consequently, massive volumes of water have been injected into the periphery of the oil pool to maintain reservoir pressure in this waterflood area of the reservoir. Waterflood started in 1981, Digert said.

So, the basic mechanism for production at Prudhoe Bay involves the driving of oil under pressure up production wells by continuously cycling vast quantities of gas from the reservoir back into the top of the

gas cap, while simultaneously pumping equally vast quantities of water into the peripheral part of the reservoir.

Between 1990 and 1995 the gas cycling process necessitated a progressive expansion of the gas injection capabilities in the field, with gas production starting at around 4 billion standard cubic feet per day and eventually topping out at 8.5 billion standard cubic feet per day. The central gas facility at Prudhoe Bay is now the largest plant of its kind in the world and compresses the gas to about 4,000 pounds per square inch for injection into the reservoir.

Waterflood

Water for the waterflood operations consists in part of water separated from the produced oil. However, a major component of the injected water consists of seawater that has been processed through a seawater treatment plant. Initially, water was injected at the rate of about 500,000 barrels per day, but that rate has now increased to about 1 million barrels per day, Digert said.

Fluids flowing from the production wells pass through six flow stations and are separated into water, crude oil and gas, Digert said. The separated water is used in the waterflood operation, while the crude

oil transits through pipelines to the trans-Alaska oil pipeline for export from the field.

The gas is piped to a major facility that chills the gas to minus 40 degrees Fahrenheit. The chilling causes the heavier hydrocarbons such as propane, butane and pentane to drop out of the gas as natural gas liquids.

Some of the natural gas liquids are mixed with the crude oil for export. In all, more than 500 million barrels of natural gas liquids, or NGLs, have been shipped to market via the trans-Alaska oil pipeline. Much of the NGLs, however, are used for enhanced oil recovery operations both at Prudhoe Bay and in the nearby Kuparuk River field.

All but about 500 million cubic feet per day of the dry natural gas from which the natural gas liquids have been extracted goes to the compressors in the gas plant, for re-injection into the reservoir, Digert said. The gas that is not compressed is used as the primary fuel source for North Slope operations, with the bulk of this fuel gas being used to drive the huge gas compressors.

But because of factors such as the use of gas for fuel, more material leaves the Prudhoe Bay reservoir than is pumped back in, Digert explained. As a consequence, the gas pressure declined significantly over the years after the field went into production. In 2002, to stem this pressure decline, BP started injecting water as well as gas into the gas cap.

Further enhanced recovery

In addition to upping the gas and water injection capacity to maximize field production, several state-of-the-art enhanced oil recovery techniques have come into play to extend oil recovery from the field way beyond the initial recovery estimate of 9.6 billion barrels.

In what is known as tertiary extended oil recovery, a solvent known as miscible injectant removes some of the residual oil left behind after a waterflood operation. Miscible injectant consists of a mixture of natural gas and some of the natural gas liquids obtained from the gas chilling plant.

When the miscible injectant is swept through a waterflood area of the reservoir, lighter elements of the residual oil left behind from the waterflood operation tend to adhere to elements of the miscible injectant, Digert explained. As a consequence the fluid recovered from the reservoir becomes richer in oil components than the miscible injectant fluid that is

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injected into the reservoir, he said.

In 1999 the massive \$80 million MIX module was barged to the North Slope to expand the field's miscible injectant usage.

The use of 400 million cubic feet to 500 million cubic feet per day of miscible injectant is increasing oil production by about 50,000 barrels per day, Digert said.

Meanwhile, the multi-year use of gas injection and waterflood has resulted in some fragmentation of the oil, gas and water pools within the Prudhoe Bay reservoir. For example, the relatively gentle slope of just two to three degrees of the reservoir strata has allowed gas from the gas cap to flow under the impervious shale layers to leave small, disconnected pools of oil above the shales, Digert said.

"The gas tends to run under some of these continuous shales," Digert said.

State-of-the-art, high-tech drilling techniques have proved critical in extending field life by enabling access to these small, disconnected pools.

"So these are the targets that we're still drilling for today," Digert said.

One technique involves the use of sidetrack drilling, the drilling of new low-angle or horizontal well bores out from an existing steep well penetration, to thread directly through the isolated pockets of oil.

And what people refer to as quaternary

extended oil recovery, a technique called miscible injectant sidetrack, or MIST, uses miscible injectant in combination with a specially shaped sidetrack well to target remnant oil pools in worked-out waterflood zones. Essentially, a sidetrack well is designed to wrap horizontally around an existing injector well at a distance of about 1,000 feet. Bubbles of miscible injectant released into the reservoir at different points on the horizontal sidetrack then expand and herd the residual oil toward production wells.

Future gas sales

Despite all of these ingenious ways of producing yet more oil from Prudhoe Bay, the field continues along a slow path of declining production. However, the really big prize in the future is gas production from the field — the field originally contained equal volumes of oil and gas, Digert said. There is probably about another 2 billion barrels of viable oil production left in the field, but the field could produce gas equivalent in energy to about another 4 billion barrels of oil, he said.

The gas treatment plant for gas export would be sited next to the existing central gas facility, Digert said. Exporting gas from the field rather than re-injecting it would reduce the potential ultimate oil produc-

tion because of a loss of gas pressure. However, the volume of the resulting gas sales would more than offset the loss of oil, Digert said.

"Our game now is going to be continued reservoir management strategies. ... We have an enormous opportunity to optimize (oil) production and maximize that production ahead of gas sales," Digert said.

And there is also the prospect of continued future oil production in the Prudhoe Bay unit from horizons above the Prudhoe Bay field, such as viscous oil from West Sak (also known by BP as Schrader Bluff).

Meantime, the production of Prudhoe Bay oil is already accompanied by the production of huge volumes of gas for fuel use and recycling.

"In our gravity drainage area they're starting to look like gas wells with a little bit of oil, more than oil wells with a little bit of gas. It's mostly gas coming out," Digert said.

But Digert feels optimistic about Prudhoe's future.

"We've had massive development of a massive field," Digert said. "We think we're very well positioned for the next 40 years ... both in oil and then the gas sales that will follow." ♦

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Alaskans remember Prudhoe Bay

By Nancy Pounds

Most Alaskans don't remember what Alaska's economy looked like before the discovery and development of Prudhoe Bay. Only 14 percent of about 670,000 Alaskans today lived in the state in 1968, the year of the Prudhoe Bay discovery, according to Scott Goldsmith, economics professor at the University of Alaska Anchorage's Institute of Social and Economic Research. So nearly nine out of every 10 residents today know little about Alaska prior to major development on the North Slope, he said. Goldsmith compared 1968 and 2008 in a recent report called, "How North Slope oil has transformed Alaska's economy." A few longtime Alaskans, participants and decision-makers during Alaska's major economic changes, recently recalled events of the era.

Gov. Jay Hammond

Nearly all Alaskans receive the Permanent Fund dividend, an ongoing economic legacy from an investment fund created with oil revenue from the Prudhoe Bay oil field and other North Slope development.

Former governor Jay Hammond, who died in 2005, is considered author of the fund. The Alaska Permanent Fund has a history of controversy yet its "no-small-change" annual dividend has repercussions for retailers, banks and other businesses.

Hammond arrived in Alaska in 1946 and worked as a bush pilot, commercial fisherman, trapper and wilderness guide before entering politics.

Hammond was a member of the state House of Representatives from 1959 to 1965, then a state senator from 1967 to 1972. He was mayor of the Bristol Bay Borough from 1972 to 1974. And he served as governor from 1974 to 1982 — intense years of the state's oil rush.

"You might question his policies, but

you could never doubt his love for Alaska," Arliss Sturgulewski said.

Hammond speaks from his 1994 autobiography, "Tales of Alaska's Bush Rat Governor."

"To the United States, with its insatiable appetites, Prudhoe Bay's billions of barrels of oil (were) heralded as but one more fat item on the energy menu. But to Alaskans, it was seen as the end of dark poverty and the dawn of prosperity," he wrote. "As Alaskans eagerly awaited the 'boom' after so many decades of 'bust,' thousands from elsewhere began flooding the Greatland, detonating a population boom of their own."



GOV. JAY HAMMOND

Hammond pushed the proposed dividend for several years amid controversy and many changes. In his book, he described his view of its economic significance.

"The dividend is capitalism that works for Alaska. In a state where locals traditionally watch in frustration as most resource wealth goes Outside, the dividend's grassroots 'trickle up' distribution now accounts for the largest new capital

"The dividend is capitalism that works for Alaska. In a state where locals traditionally watch in frustration as most resource wealth goes Outside, the dividend's grassroots 'trickle up' distribution now accounts for the largest new capital infusion into Alaska's local economies each year," Hammond wrote.



Gov. Hammond in the 1970s

infusion into Alaska's local economies each year," Hammond wrote.

Editor's Note: Jay Hammond served Alaska as governor from 1974 to 1982, the years during which Alaska built an incredible oil pipeline, banked a large amount of the oil lease revenues, as well as created the Alaska Permanent Fund Dividend Program.

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Looking ahead to heavy oil



BP EXPLORATION (ALASKA) INC.



This mobile gripper is equipment being used by BP Exploration (Alaska) Inc. in a new cold weather technology aimed at developing heavy oil accumulations with the smallest environmental footprint possible on the North Slope. More than 20 billion barrels of viscous oil deposits remain in place near the Prudhoe Bay oil field. BP, ConocoPhillips and ExxonMobil have spent more than \$1 billion developing the viscous oil resource. Five Prudhoe Bay satellite oil fields produce about 45,000 barrels per day and help offset the giant oil field's declining production.

Moving ANS syrup

BP's initial test of producing Ugnu heavy oil at Milne Point succeeds

By Alan Bailey
Petroleum News

BP Exploration (Alaska) Inc. reached a major milestone in its heavy oil program in September 2008 when a special test well on Milne Point's S-pad succeeded in producing a mixture of sand and oil at a peak rate of 120 barrels per day. The company had lowered a pump into the well to extract oil with the consistency of chocolate syrup from the Ugnu formation, 4,200 feet below the surface. By the end of the test on Sept. 15, about 700 barrels of the oil had been mixed with conventional Milne Point crude and passed down the trans-Alaska pipeline, according to BP spokesman Steve Rinehart.

"The well brought oil and sand to the surface," Rinehart said. "It did it reliably, sustainably."

This initial test was part of a phase one testing project that continues into 2009, Eric West, BP's heavy oil project manager, told a media tour of the Milne Point test facility Aug. 18.

If the phase one testing demonstrates the technical feasibility of heavy oil produc-

tion, the project will move into a second phase of testing, to evaluate whether heavy oil production at Milne Point will prove economically viable, said Max Easley, Alaska Consolidated Team business unit leader.

20 billion barrels

And, with an estimated 20 billion barrels of heavy oil in place in the central North Slope, the stakes couldn't be higher.

"If we only get 10 percent of it, that's a lot of oil," West said.

The oil in the Prudhoe Bay region has migrated into various reservoirs at different depths. But bacteria that become particularly active in the temperature conditions at depths of around 4,000 feet eat out the lighter hydrocarbons, West said. That results in a residue of heavy oil in relatively shallow reservoirs far above the conventional light oil reservoirs of the North Slope oil fields.

Methane waste from the bacterial action bubbles toward the surface and becomes trapped around the base of the permafrost as gas hydrate, West said.

About three years ago BP decided to embark on a project to try to develop the heavy oil while there is still significant pro-

duction of light oil from the North Slope. The light oil is needed to thin the heavy oil so that the resultant fluid can flow down the trans-Alaska pipeline, West explained.

"We need the light oil to blend it with, so it's the perfect time in the North Slope's life," Easley said.

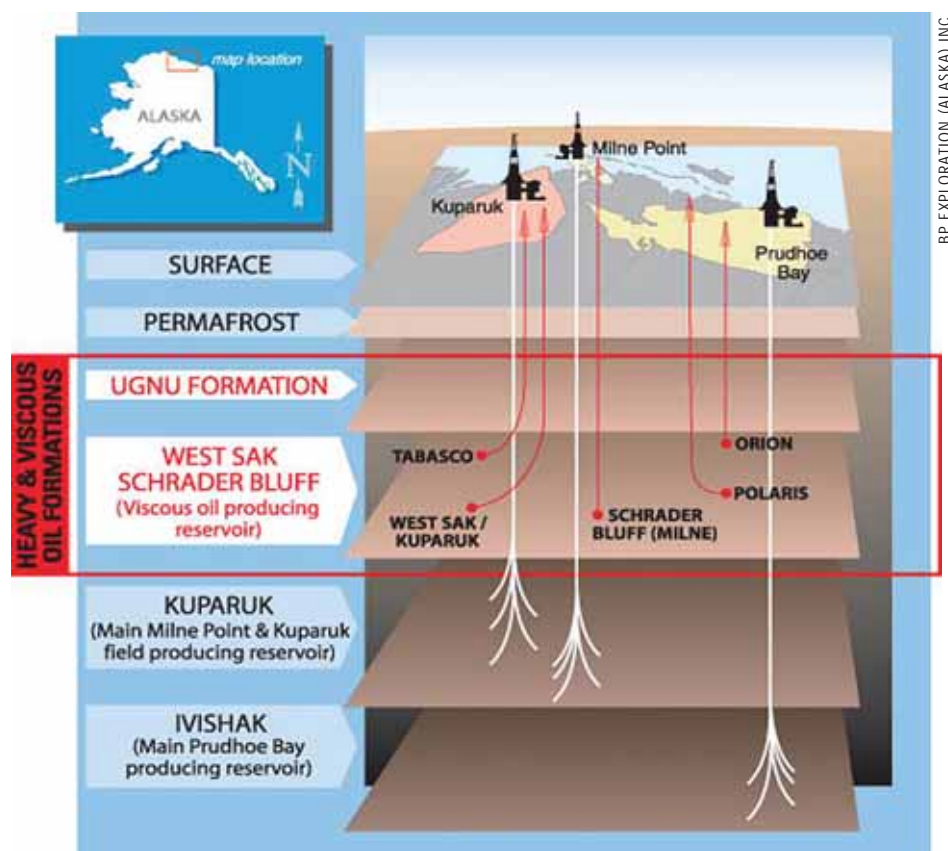
Were BP to stick to the conventional concept of waiting for depletion of the North Slope light oil before producing the heavy oil, the company would have to resort to an expensive technique such as hydrogen cracking to create a light enough fluid for export by pipeline, West said.

Which way?

But which of the many possible ways of producing that residue of heavy oil is likely to work?

The most widely publicized methods consist of either the surface mining of oil sands or the application of heat to the underground reservoirs, West said. However, in Canada, the epicenter of heavy oil development, techniques for cold heavy oil extraction have also been developed, he said.

BP has a policy of not mining for heavy oil, West said. But the choice between hot



Drilling advances such as extended reach directional, and multi-lateral and horizontal drilling techniques make it possible to reach untapped parts of reservoirs and viscous oil deposits, once considered uneconomic. At least 90 percent of the wells now drilled at Prudhoe Bay and other North Slope fields use this technology, which helps to boost production by tapping into oil deposits once thought out of reach.

and cold in-situ production depends on the nature of the oil reservoir and the characteristics of the oil, he said. On the North Slope much of the Kuparuk unit area heavy oil appears most suitable for hot extraction, while in the Prudhoe Bay and Milne Point units cold techniques seem more appropriated.

West also said that cold techniques create a smaller carbon footprint than hot techniques.

The particular technique that BP has chosen to try at Milne Point is called cold heavy oil production with sand, or CHOPS, a technique that has seen several commercial developments in Alberta.

In this technique, which depends on an unconsolidated sand reservoir, the production well has large perforations and no screen for keeping the sand out of the well. Sand is produced along with the oil and is subsequently separated from the oil at the surface by heating the oil/sand mixture in a tank.

"You're actually producing a bit of the reservoir into the wellbore," West said. "That is totally contrary to light oil reservoirs where you always want to keep the sand out."

Downhole pump

A key part of the well technology is the downhole pump, known as a progressive cavity pump, consisting of a long augur-like rotor that spins at high speed inside an enveloping tube. The rotating augur screw will draw material up the well, while being less susceptible to wear than a piston-based pump design.

Because the sand in the well would tend to cause a downhole electric motor to overheat, the pump's motor drive is placed at the surface and is connected to the pump rotor by means of a long rotating rod that extends through the well inner casing. A huge spool called a mobile gripper unit feeds the drive rod down into the well casing.

The pump should cause a pressure drawdown or drop of around 1,000 pounds per square inch or more at the bottom of the well.

"We're going to put really significant drawdown against these open perms," West said. "And that's going to induce the formation to produce into the well."

Once a well goes into operation, initial sand production should be high, perhaps 40 percent of the total production volume, said Grant Encelewski, operations lead tech for the BP heavy oil team. Then, after a system of fissures and wormholes in the reser-

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voir has opened up and somewhat stabilized, sand production will drop to 10 percent or less, with a corresponding increase in oil production.

"We define success, not so much as oil, but as being able to bring sand to the surface in a sustainable manner," West said. "... If we can do that we know we're going to have a project, because the oil will come with it."

And that's exactly what happened in the initial test, with sand production declining from about 50 percent of the oil/sand mixture to about 80 percent as the overall production rate ramped up.

The initial testing used adapted conventional oilfield equipment to process the material drawn from the well. But the next test will involve the installation of a long-term test kit consisting of processing equipment purpose built for handling heavy oil. Sand separated from the oil will be disposed through the Prudhoe Bay grind and inject facility. (The facility pulverizes all solid well drilling wastes and re-injects them into confined formations deep in the earth.)

The testing will also involve drilling three new wells and the total cost of the phase one project will be \$68 million.

Phase two will involve an additional extension to S-pad, the drilling of four more

wells and possibly the installation of additional well test facilities. Phase two is likely to cost about as much as phase one.

"We're going to put over \$100 million into this, before we even know if this is a business opportunity," West said.

Several hurdles

Phase two could culminate in a development decision, but for a viable full-scale development the testing will need to cross several hurdles.

"This is a journey that is going to take some time," West said.

Assuming that the initial well configuration works successfully, the team will try to improve flow rates — higher than normal cold heavy oil production rates will be needed to offset high Alaska well costs. The technique of choice for flow rate optimization is the use of multilateral horizontal wells but no one knows whether the sand production will work through horizontal well bores.

"No one has yet determined how you can pull sand along a horizontal well," West said. "That's our technology challenge."

And one key factor will be the use of good reservoir imaging from seismic data to enable precise well placement.

"In Alberta they have a 40 percent (CHOPS) well failure rate," West said.

Cost and value

The project team will try to apply innovative technologies to reduce costs. And, finally, the team will need to ensure that the footprint of the required surface equipment is acceptable.

By crossing these various hurdles, BP expects to overcome the two major challenges of heavy oil production: high production costs resulting from the high oil viscosity and the relatively low value of the product. Because the heavy oil contains a smaller proportion of high value products such as gasoline than light oil, BP expects the North Slope heavy oil to sell at about \$9 per barrel below the regular price for Alaska North Slope crude. But at current oil prices, the economics look good, West said.

And BP's strategy for its North Slope production is to bolster overall fluid oil production by bringing heavy oil on line.

"Without the heavy oil the future of Alaska is very much one of diminishing light oil, but then gas coming on big," West said. "But with heavy oil you ... have a rejuvenation of the fluids business for Alaska, and it becomes as much a fluids future as a gas future."

"This to me is the next big oil boom," Encelewski said. "... This is a domestic project that's under our noses." ♦

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Discovery fuels economic transformation

Experts point to Prudhoe Bay oil field as enduring backbone of Alaska's public, private funding sources and future economy

By Nancy Pounds
For Petroleum News

Alaska's economy would be much different without the discovery and development of Prudhoe Bay. Economists, industry officials and prominent Alaskans say the economic effects of the state's major oil discovery are far-reaching and dramatic. The one event, in fact, has proven to be the spark for an economic transformation of the 49th state.

Prudhoe Bay's discovery and subsequent production even touch every Alaskan today in the form of the annual Permanent Fund dividend, paid from a public savings account created with oil revenues paid to the state.

Terrence Cole, a history professor at the University of Alaska Fairbanks, published an article, summarized by the Institute of Social and Economic Research, in 2004 documenting Prudhoe Bay oil's economic impact.

"Prudhoe Bay oil was worth more than everything that has been dug out, cut down, caught or killed in Alaska since the beginning of time," Cole wrote. "The discovery of the Prudhoe Bay oil field in the late 1960s fulfilled even the most optimistic dreams for statehood."

Cole details a fledgling Alaska that was struggling financially, both before and after

statehood in 1959. But Prudhoe Bay helped change that scene.

According to Cole's report, Prudhoe Bay oil exponentially eclipsed the value produced from Alaska's other resources. "From 1867 to 1958, about \$40 billion (in 2002 dollars) worth of fur, gold, copper and salmon came out of Alaska in waves. ... But everything that came before pales in comparison with the value of oil. From 1959 through 2002, Alaska produced resources valued at nearly \$350 billion. More than 80 percent was from Prudhoe Bay oil."

Prudhoe Bay launches revenue bonanza

The development of Prudhoe Bay led to the development of other North Slope oil fields, said Scott Goldsmith, economics professor at the University of Alaska Anchorage's Institute of Social and Economic Research.

"If it weren't for Prudhoe Bay there wouldn't be anything else going on (on North Slope)," he said. "It's hard to imagine Alaska without oil."

Kevin Banks, director of the state Division of Oil and Gas, agreed. "Without Prudhoe Bay, there probably wouldn't have been a North Slope (oil industry)," Banks said.

Cook Inlet oil production was under way at the time, but was not a significant economic force, Banks said. The state's oil industry was a minor factor until the Prudhoe Bay discovery ... "then the econo-

my was absolutely transformed," Banks said.

Also, there would be no trans-Alaska oil pipeline without Prudhoe Bay, he added.

Goldsmith compiled a report in spring 2008 detailing the economic impacts of the North Slope oil industry. In 30 years, the North Slope has produced 15 billion barrels of oil, according to Goldsmith's research. That volume tallied up to \$378 billion — in 2007 dollars — based on value at the well-head. That would equal 5,400 of BP's Anchorage high-rise headquarters, based on recent tax assessment of \$70 million.

And North Slope oil has landed \$118 billion in cumulative revenue to the State of Alaska, Goldsmith cited. One more "billion" is connected to North Slope oil, according to Goldsmith's report — the value of the Alaska Permanent Fund was \$36 billion in mid-summer 2008.

Prudhoe Bay has landed billions of dollars in state government coffers.

"Prudhoe Bay alone has produced roughly \$23 billion in royalties (for) the state from first production through December 2007," said Cody Rice, a petroleum economist with the Division of Oil and Gas. The total is not adjusted for 2008 dollar value, though.

The State of Alaska also received about \$27 billion in taxes from North Slope oil fields through 2007, Rice noted.

That's a total of \$50 billion. But how much money is \$50 billion?

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it could underwrite the cost of 500 new 200,000-square-foot Dena'ina Convention Centers, based on Anchorage's current construction cost estimates of about \$100 million each.

Prudhoe paid lion's share of revenue

According to Goldsmith, the petroleum industry contributed 87 percent of state general fund revenue in fiscal year 2007 alone. Thanks to Prudhoe Bay, the state has collected a similar percentage every year for the past 30 years.

This means Alaska's other industries "have been able to enjoy a very light tax burden," he said. Also, without the oil industry, Alaska's other main sectors like fishing and tourism, would be less competitive internationally and would lack infrastructure purchased with oil-industry-infused state funds, Goldsmith said. These effects are difficult to quantify and often overlooked, he observed.

The Alaska oil industry also helps stabilize the state's work force year-round, so the labor market isn't skewed by seasonal jobs, and the oil sector adds high-paying jobs, Goldsmith said.

Another way oil development has buoyed the state economy is by what Goldsmith describes as "wealth creation." The chief component is the Permanent Fund dividend. To quantify the dollar-power of these dividends, Goldsmith said, if all the money distributed as dividends had been placed in a separate pot called 'Son of the Permanent fund,' and invested in the same kinds of assets as the Permanent Fund, itself, and all the earnings reinvested, that fund today would be worth \$35 billion, almost as

Alaska Permanent Fund Total Assets

2008	.....\$36.1 billion
2007	.....\$45.4 billion
2006	.....\$42.7 billion
2005	.....\$36.3 billion
2000	.....\$28.1 billion
1998	.....\$25 billion
1995	.....\$15.8 billion
1993	.....\$15 billion
1989	.....\$10 billion
1984	.....\$ 5 billion
1980	.....\$1.8 billion
1977	.....\$734,000

Source: Alaska Permanent Fund Corp.

much as the Permanent Fund.

"This illustrates the 'opportunity cost' of the Permanent Fund distribution that is what we alternatively could have had," he explained.

That \$35 billion would pay out more than 21 million dividend checks, based on the 2007 dividend amount of \$1,654.

Prudhoe Bay also lifted a huge income tax burden from the shoulders of Alaskans. The state repealed its income tax in 1980 amid oil industry payouts to the government and has never had to reinstate it. Goldsmith estimates Alaskans would have had to pay an average of 34 percent in personal income tax — since 1970 — to generate the same amount of state revenue for the general fund as the petroleum industry.

Oil revenue fuels projects, industries

Division of Oil and Gas director Banks first arrived in Alaska in 1975. He had hitch-

hiked to Fairbanks, where he found a boomtown economy during pipeline construction. He was intrigued by the dynamics of the economy, returning to the state in 1982 and researching the state's economic data with Goldsmith.

"It's been a pretty wild ride," Banks said of Alaska's dramatic economic changes.

Revenue to the state climbed drastically between first oil production in 1977 and 1982 — only five years, Banks said. Funds spawned state programs like the Alaska Housing Finance Corp. and construction projects that reshaped communities like the Alaska Center for the Performing Arts and the Sullivan Arena, both in Anchorage.

"We would not have been a state without the discovery of oil on the Swanson River," said Banks, who has worked for the state since 1991 and served as division director for nearly two years. "We would not be the state we are without Prudhoe Bay."

Three players active at Prudhoe Bay's discovery, — predecessors to BP, ExxonMobil and ConocoPhillips — are still North Slope powerhouses, he said. Banks now sees other companies pursuing Alaska oil development, and he often recalls policies precipitated by Prudhoe Bay beginnings.

Banks cited spin-off effects of the North Slope oil industry, including a strong service sector supporting the industry. Also, Alaska's commercial air freight business has grown largely due to available jet fuel manufactured by Tesoro and Flint Hills, Banks said.

A 30-year economic tale

Alaska's economic story from 1977 to the present shows unprecedented changes,

see **TRANSFORMATION** page 114

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Report: Oil industry crucial in Alaska economy

A recent statewide report details the major role the oil industry plays in Alaska.

The Alaska Oil & Gas Association in summer 2008 released, "The Role of the Oil and Gas Industry in Alaska's Economy." The report was compiled by Information Insights of Fairbanks and Anchorage and the McDowell Group of Juneau and Anchorage.

Among the report's findings:

The industry is the state's largest nongovernmental industry. It generates 12 percent of private sector jobs in the state and 21 percent of private sector payroll.

Oil and gas activity creates 41,744 jobs from various parts of the industry and related sectors or 9 percent of all employment statewide.

Oil industry wages tally \$2.4 billion, or 11 percent of all Alaska wages.

AOGA officials believe the most important aspect of the report is that it shows the industry's economic benefit to the entire state.

"It confirms what all of us believe to be true," said Marilyn Crockett, AOGA's executive director. "The oil and gas industry has been and continues to be a driving force in the Alaska economy."



MARILYN CROCKETT

Crockett cited report findings showing total oil revenue sent to the state in the last four years. Projected total revenue for fiscal year 2008, which ended June 30, could tally \$10 billion, doubling 2007's figure. The dramatic increase is due to a new production tax and high crude oil prices, Crockett said.

The oil industry registers the highest wage average in Alaska. "The average primary company pays a monthly wage of \$12,737 — 3.5 times higher than the statewide average of \$3,627," according to the report.

Oil important to regional economies

The industry plays a strong role in major regions of the state, including the Municipality of Anchorage, the Fairbanks North Star Borough, Kenai Peninsula Borough, Matanuska-Susitna Borough, North Slope Borough and Valdez area. The industry generates more payroll than any other nongovernmental industry in Anchorage, Fairbanks, the Kenai area, the North Slope and Valdez. The oil and gas industry comes in second-place in the Matanuska-Susitna Valley, behind the service industry.

This regional breakdown is another key point from the report, Crockett said. It helps people understand the significance of the oil and gas industry in their community and makes it more personal, Crockett said.

In Anchorage, the industry directly employed 1,649 residents in oil and gas extraction, refinery and pipeline sectors. Combined wages total almost \$295 million.

In the Fairbanks borough, the industry directly employed 353 residents with a payroll of \$39 million.

In the Kenai borough, the industry directly employed 939 residents with associated wages of \$99 million.

see **INDUSTRY** page 114

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continued from page 112

TRANSFORMATION

peaking with a 1980s boom followed by a late 1980s bust and steady growth and recovery into the new century.

State labor economist Neal Fried detailed the changes in a September 2007 Alaska Economic Trends article, "Alaska's economy transformed: Thirty years of the trans-Alaska oil pipeline."

Other industries like tourism, fishing and mining contributed to the state's economic changes in that era, Fried writes. "But then again, there is little doubt that without the discovery of oil on the North Slope, Alaska's economy would be vastly different today."

Fried compared key factors in 1977 and 2007. Alaska's work force tripled in that time. Payroll going to workers rose from \$3.5 billion to \$13 billion. The gross state product grew from \$8 billion to \$39 billion, according to the report. Alaskans generated \$5 billion in personal income, compared to \$25 billion for 2007. In 1977, 412,000 people lived in the state compared to 670,000 Alaskans today.

"Nearly every aspect of the state's economy grew at breakneck speed during the first five years of the 1980s," according to Fried. "The biggest boom Alaska would experience began around the same time the billionth barrel of oil came out of the ground in January 1980." Oil prices doubled that year, and the state's budget doubled in one year, from \$1.6 billion in 1980 to \$3.4 billion in 1981.

The spending spree peaked in 1985. "It created a demand for goods and services that acted as the catalyst for the most

dynamic expansion of any five-year period in Alaska's history," Fried said. In those five years, the population grew by 120,000 — a five-year record that has never been repeated — and the work force increased by 60,000, he wrote.

"This period of hyper-growth would be short-lived, and its aftermath continues to haunt Alaska's economic psyche," Fried said.

Oil prices fell and state government cut more than \$1 billion from its budget in a year. Real estate and construction industries had outpaced demand and crumbled in the downturn.

"In 1986 and 1987, Alaska lost more than 20,000 jobs. Between 1985 and 1989, 44,000 more people left Alaska than arrived," he said.

The economy started to recover in 1988 and has grown every year since then, representing the "the longest period of uninterrupted growth in the state's history," Fried wrote. However, the economy was forever changed in population and employment levels. Growth, though, comes at a slower pace than before.

"From 1959 to 1987, employment in Alaska grew by nearly 6 percent per year versus 2 percent during the most recent expansionary period," he said.

Fried believes other industries rather than oil have been factors in economic growth in the past 20 years. In that period, oil production began declining, and the price of oil per barrel was below \$15 in the 1990s, he said.

The state economist wrapped up his report by hinting at another major economic factor on the horizon, again coming from Prudhoe Bay — the proposed trans-gas pipeline.

Oil: A player for the future

Goldsmith's presentation, "How North Slope oil has transformed Alaska's economy," is relevant today. "People don't understand the importance of oil to the economy," he said. "We would be a very different place without oil. It would transform the whole economy — not just by fewer jobs."

Goldsmith foresees strong potential for the oil and gas industry in Alaska, especially with development of huge heavy oil accumulations in the Prudhoe Bay area and the field's vast natural gas reserves.

Adds Goldsmith: "Petroleum will continue to be the largest and most important private industry in the state for a long time to come." ♦

continued from page 113

INDUSTRY

Matanuska-Susitna borough residents work for the industry outside the area. About 830 residents work in the industry with wages of \$98 million.

In Valdez, the industry directly employed 284 people with associated wages of \$35 million.

The North Slope is home to the majority of oil and gas work, but employment and spending mostly occurs elsewhere in the state, the report concluded. However, significant tax revenues flow to the borough.

—Nancy Pounds



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Prudhoe discovery transforms ARCO, BP

Giant North Slope field helped shape development of international oil and gas companies

Geologists and geophysicists use technologically sophisticated methods, including CAT scans and magnetic resonance imaging, to locate and measure underground structures that may contain oil.

They feed data into computer models to create three-dimensional pictures of these underground formations. Here BP

Exploration (Alaska) Inc. scientists analyze the imagery in hopes of identifying pockets of untapped oil.



BP EXPLORATION (ALASKA) INC.

By Nancy Pounds
For Petroleum News

The discovery of oil at Prudhoe Bay positively altered the fortunes of British Petroleum and Atlantic Richfield Co., major international oil producers.

ARCO, except for its Alaska operations, was acquired by BP in 1999. ARCO Alaska Inc. was sold to Phillips Petroleum Co. at the same time, and Phillips is now a part of ConocoPhillips Inc. ARCO's Prudhoe Bay story is part of this combined company's history.

But it was ARCO predecessor Richfield Oil Co. that started it all with its success at drilling an exploratory oil well at Swanson River in the Kenai Wildlife Refuge in the 1950s.

As one Associated Press story put it: "Richfield's discoveries put Alaska on oil map." The news article detailed the significance of both Prudhoe and Alaska to the company.

"The success at Swanson River marked the beginning of a four-decade relationship that produced huge riches



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for both the state and the company whose name had been changed to Atlantic Richfield Co. when it discovered the real bonanza — Prudhoe Bay, the largest oil field ever found in North America,” according to the article

“You could say Alaska made ARCO, and ARCO certainly had a pervasive impact on the state,” said Gil Mull, a former Richfield geologist, in the article.

Field gives BP foothold in America

BP also reaped huge benefits from Prudhoe Bay.

“In the last 50 years, we’ve become the largest oil and gas producer in the United States, but it all started with Prudhoe Bay, Alaska,” BP says on its Web site. By 2001, BP had become the largest oil and gas producer and one of the largest gasoline retailers in the United States. The company is the second-largest refiner in

North America today and the second-largest fuels marketer.

“BP was radically affected in a positive fashion,” said former BP executive Roger Herrera in a recent interview.

In the 1960s BP controlled a significant percentage of the world’s oil, he said. The company had become adept at finding “super-giant” oil fields by then, he said.

The only reason BP was in Alaska was because it was searching for a U.S. “super-giant,” which would support BP’s entry into selling gas at the pump in America, he said.

“At that time Alaska was virtually unexplored,” he recalled.

The oil field’s history has proven to be successful, and Prudhoe Bay powers on into the future for Alaska and its operators.

“Prudhoe Bay continues to be a large part of the answer for the companies that own and operate it,” said Damian Bilbao, BP Exploration Alaska

Inc.’s manager for strategy and planning.

Advanced technology continues to increase the amount of total production and prolong the oil field’s life, Bilbao said. He cited future opportunities in production of heavy oil and other crudes.

But in 1968, both companies had been ready to abandon years of exploratory work on the North Slope before one final test produced signs of a massive oil field at Prudhoe Bay. ♦

The only reason BP was in Alaska was because it was searching for a U.S. “super-giant,” which would support BP’s entry into selling gas at the pump in America, Herrera said.
“At that time Alaska was virtually unexplored,” he recalled.

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What would Alaska look like without oil industry?

Economist says 49th state would bear strong resemblance to East Coast state of Maine

By Nancy Pounds
For Petroleum News

Without the oil industry as an economic power-player, Alaska might resemble Maine — more taxes, no Permanent Fund dividend, an older population with slower growth and a much-reduced gross state product.

Scott Goldsmith, economics professor at the University of Alaska Anchorage's Institute of Social and Economic Research, suggests the comparison in his spring 2008 report, "How North Slope oil has transformed Alaska's economy."

"The idea here is to conduct a thought experiment a la Einstein to think about what state Alaska would most resemble if oil had never been found on the North Slope," Goldsmith said.

Both states have many moose, few humans, a cold climate, a remote location and an independent streak, Goldsmith said.

The two states also find strength from identical industries: fishing, tourism, timber, mining and agriculture, he noted. Maine and Alaska are both constrained by limits on sustainable harvests, from the fishing industry, for example. Both states have small and declining manufacturing industries, and the states depend on federal

A Sharp Contrast

*A comparison of the effects of Prudhoe Bay and North Slope oil production on residents of Alaska with the lack of such resources in Maine.**

	Maine	Alaska
Wages	\$54,550	\$72,750
Taxes	-\$6,810	\$0
Dividend	\$0	\$6,800
Public Spending	\$28,868	\$49,064
TOTAL	\$75,607	\$128,614
Difference		+\$53,007

* Figures calculated based on a family of four

SOURCE: Scott Goldsmith, University of Alaska Anchorage Institute of Social and Economic Research; 2007 data

funds, Goldsmith said. Alaskans and Maine residents possess "conflicting visions about the use of resources," he said.

Maine and Alaska are different, however, according to Goldsmith's research.

"Throughout the second half of the 20th century, Maine has struggled to find a proper balance between resource-based industrial development and environmental

protection," Goldsmith wrote. "The state has come to rely heavily on tourism, small manufacturing enterprises and defense-related activities and installations for much of its economic base."

Economic factors emphasize the difference between Maine and Alaska, Goldsmith noted, citing recent data. While Alaska ranks seventh nationwide in gross state produce per capita, Maine is 43rd. The median paycheck in Maine is 77 percent as high as the median paycheck in Alaska. Alaska's job growth exceeded Maine's in recent statistics. Alaska ranked fifth nationwide in population growth, while Maine was 46th. Maine's projected population growth is only one-third of the U.S. average, but Alaska's population should grow 30 percent more than the national average, Goldsmith cited.

Unlike Alaska, Maine is physically attached to the continental United States. Another difference from Alaska is that Maine's Native American population is much lower, registering 1 percent, Goldsmith figured. Also, the federal government owns much less land in Maine, about 1 percent, than it does in Alaska.

Maine residents pay state income tax, unlike Alaskans. And Alaskans, not Mainiacs,

see **STATE** page 120

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Field fuels nation

Importance of Prudhoe Bay to U.S. oil production cannot be overestimated; field will support future heavy oil, natural gas output

By Nancy Pounds
For Petroleum News

Prudhoe Bay production has been a powerful force for the United States. The field's oil has long been a strong contributor to total U.S. oil production. And energy experts predict Prudhoe Bay and its North Slope counterparts will continue producing into the future.

Historically, the Prudhoe Bay discovery was important to America amid the world oil crisis of the 1970s.

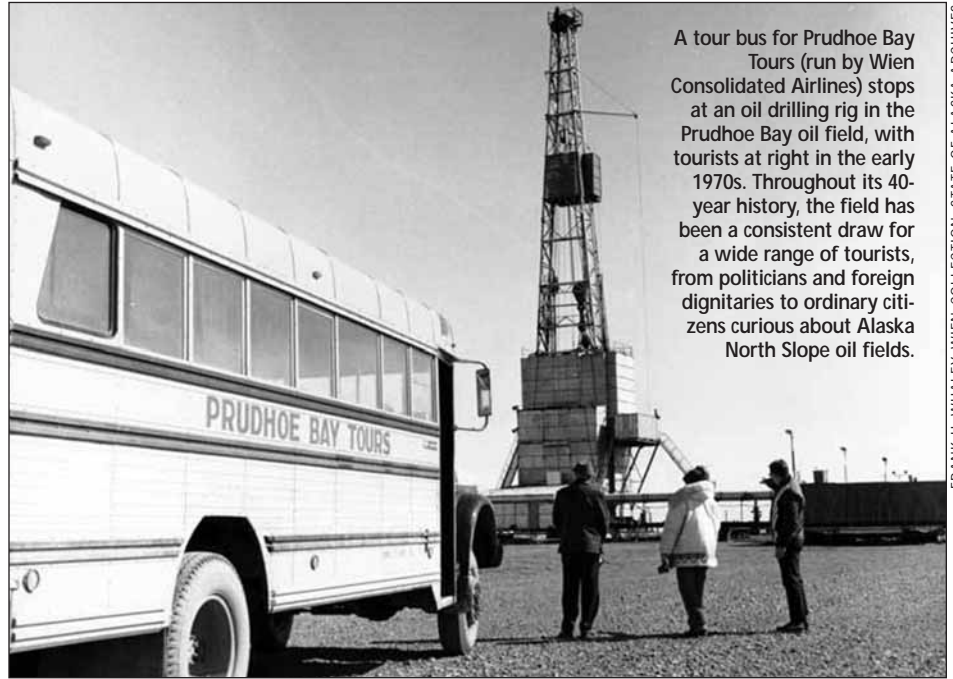
"It had a profound effect on the American government, on how they dealt with the crisis," recalled Roger Herrera, a former BP geologist and company executive. He now works as a consultant for Arctic Power.

Prudhoe Bay, at the time, had an estimated 9.6 billion barrels of recoverable oil. This fact helped the nation deal with oil crises imposed by Middle Eastern oil producers, he said. The first oil crisis was in 1973, followed by another one in 1979, Herrera noted. Prudhoe Bay oil began production in 1977.

"Prudhoe was hugely important in those days," Herrera said.

"I think what everyone has to remember is that before 1973, small-scale production in the U.S. was the status quo," he said.

Oil prices climbed in the 1970s, and



A tour bus for Prudhoe Bay Tours (run by Wien Consolidated Airlines) stops at an oil drilling rig in the Prudhoe Bay oil field, with tourists at right in the early 1970s. Throughout its 40-year history, the field has been a consistent draw for a wide range of tourists, from politicians and foreign dignitaries to ordinary citizens curious about Alaska North Slope oil fields.

FRANK H. WHALEY, WIEN COLLECTION, STATE OF ALASKA ARCHIVES

America's oil production peaked and declined, he added. "The discovery of Prudhoe Bay was a godsend to the American government."

One-fourth of U.S. oil at peak

At its peak of production in 1988, Prudhoe Bay and the North Slope accounted for 25 percent of total U.S. oil production, according to a Department of Energy

August 2007 report.

Brent Sheets, regional manager for the Energy Department's National Energy Technology Laboratory Arctic Energy Office in Fairbanks, co-authored: "Alaska North Slope Oil and Gas: A promising future or an area in decline?"

Prudhoe Bay is significant in size as the

see **FUTURE** page 120

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continued from page 118

STATE

largest oil accumulation in North America and as a catalyst for "the grassroots development of a petroleum infrastructure on Alaska's remote North Slope," Sheets said.

Development of Prudhoe Bay required construction of the trans-Alaska oil pipeline, production facilities, crew quarters and other facilities, the Energy Department report noted. This infrastructure allowed for additional development on the North Slope.

Those oil efforts are important for the nation today.

"The total Alaska North Slope — not just Prudhoe Bay — still produces about 15 percent of the U.S. domestic oil production almost 30 years after startup of production in 1977," Sheets said.

Advanced technology and reduced costs have allowed "this major oil production province to sustain a major role in the nation's energy supplies," Sheets said.

Prudhoe Bay's upcoming role

"Prudhoe Bay may have been discovered 40 years ago, but from an exploration perspective, the North Slope is not a mature petroleum province," Sheets said.

continued from page 119

FUTURE

receive the annual Permanent Fund dividend, paid out from an investment fund created with oil money paid (\$2,069 in 2008) to the state.

"If the oil industry had never been here, we wouldn't have those things (like the Permanent Fund and its dividend)," Goldsmith said. "We would look different." ♦

The region holds more room for exploratory wells, he said.

"Alaska's fossil energy resources will likely play a greater role in meeting the nation's energy needs in the future," Sheets said. "Alaska holds about one-fifth of America's remaining proved oil reserves, a significant portion of its natural gas reserves and over half of its coal resources. When North Slope unconventional resources such as viscous oil and methane hydrates are factored in, the potential is incredible."

Phil Budzik, of the U.S. Energy Information Administration, echoes Sheets' assessment of Prudhoe Bay's significance for the nation. Budzik works in the Oil and

Gas Division's Office of Integrated Analysis and Forecasting.

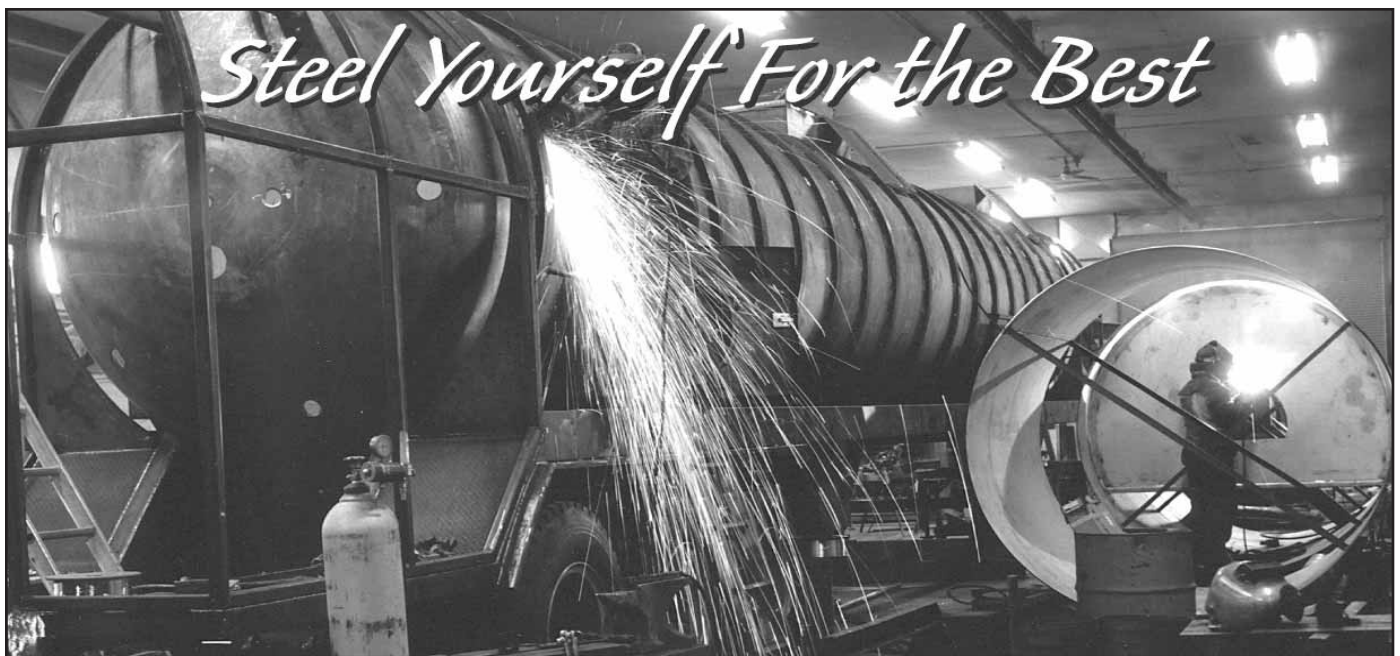
"The discovery of Prudhoe Bay opened the entire North Slope of Alaska to oil and gas development by providing a pool of oil and natural gas large enough to justify the building of a trans-Alaska oil pipeline and eventually a natural gas pipeline," Budzik said.

Prudhoe Bay is responsible for all the oil development on the North Slope, which amounts to 15.4 billion barrels produced through 2006, and another 6 billion barrels that are currently expected to be produced, not including new discoveries, to total 21.4 billion barrels, Budzik said.

"All these Alaska North Slope developments, both past and future, pivoted on the development of Prudhoe Bay," he said. "In other words, without Prudhoe Bay, North Slope oil and gas ... production wouldn't have taken place."

Budzik estimates Prudhoe Bay natural gas resources at 23 trillion cubic feet — one year's worth of total U.S. gas consumption.

"Prudhoe Bay natural gas resources will be the anchor field for the development of a 4.5-billion-cubic-feet-per-day pipeline to the Lower 48," Budzik said. "Development of Prudhoe Bay as an oil field paved the way for the development of a gas pipeline." ♦



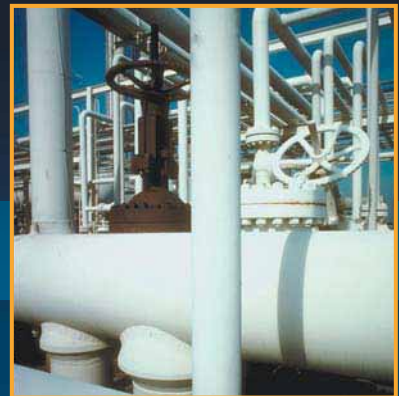
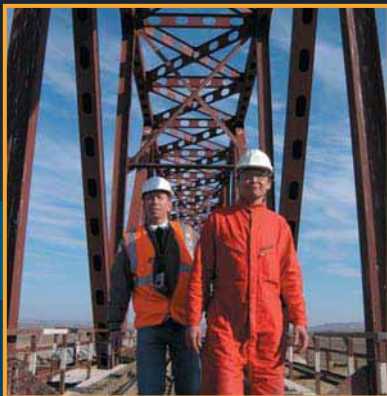
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A view of the Prudhoe Bay State No. 1 discovery well at sunrise/sunset in early February 1968. The giant oil field's discovery and development might have taken an entirely different route if 21st Century technology had been available in the 1960s.



C.G. "GIL" MULL

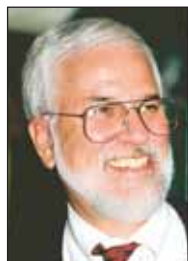
A whole different ballgame

If 21st century technology had been available in the 1960s, would discovery, development of Prudhoe Bay have been different?

By Ken Boyd
For *Petroleum News*

The discovery of the Prudhoe Bay oil field has a long and colorful history as detailed elsewhere in this publication.

But what if Prudhoe had not been discovered using only the technology available 40 years ago? What if we were able to transport today's oilfield technology back to the mid-1960s? How would the exploration and development of the largest oil field in North America have changed using modern technology and what might Prudhoe look like today?



KEN BOYD

In order to think this proposition through, we need to make some assumptions. Let's assume that the early exploration took place as it did; much of this exploration was done by the United States Geological Survey and a lot of that work focused on the Naval Petroleum Reserve No. 4 (now NPR-A).

Let's further assume that Tom Marshall read the same article in *Fortune* magazine in 1957 and came to Alaska the following year. Thus Tom, despite overwhelming opposition, selected the lands that contain the Prudhoe Bay field for the brand-new

State of Alaska. This selection was made in 1961 and was based predominantly on regional geology. The selection, after a lot of stressful debate, became final in 1964.

Primitive seismic

Let's look at the early seismic work as it was done in the mid-1960s. Compared to seismic technology today, the early North Slope explorers were working with the equivalent of stone tools.

The single-fold data (where each point in the subsurface is only sampled once) they acquired was primitive even by the standards of the time. Common Depth Point seismic (where a point in the subsurface is sampled multiple times) was being widely used in other areas, but not on the North Slope. Because of this limitation, it was nearly impossible to separate the seismic signal from the background noise. In addition, it was difficult to account for the sound-altering permafrost, and accurately locating the position of geologic faults was hopeless.

Despite these obstacles, the early subsurface maps of the area did provide a reasonably accurate picture of the Prudhoe Bay structure.

Not only were there no computers in the field, there also were no electronic hand-held calculators. The computing power on our desks today far exceeds that available to the most sophisticated compa-

ny of that era. Of course there were no cell phones or satellite communications. There were no global positioning systems and no accurate maps. There were no roads and a very limited amount of access by airplane.

Now the stage is set.

Lease sales a question

Rather than move Prudhoe Bay (in the mid-1960s) into the future, let's move today's technology into the past.

At that time, all the information available consisted of some primitive maps and a vague notion of the regional geology. Oil had been discovered in Cook Inlet and companies were excited about moving forward with exploration on the North Slope. Even with the limited knowledge available (and virtually no infrastructure), it was time for the State to lease some land on the North Slope.

Alaska's state oil and gas lease sales 13 and 14 were held in 1964 and 1965. Most of the (future) producing lands at Prudhoe Bay were picked up by a few companies as partners, notably British Petroleum, Richfield Co. (now ConocoPhillips), and Humble Oil & Refining Co. (now ExxonMobil). The agreement between Richfield and Humble was finalized late in the fall of 1964, not long before the first North Slope sale No. 13.

State Lease Sale 18, held in 1967, drew limited interest because of the repeated

exploration failures that plagued the North Slope during those years. These were the last lease sales prior to the discovery of the Prudhoe Bay field in 1968 by Richfield and Humble. Bonus payments for these three lease sales totaled less than \$15 million.

Of course none of these companies knew exactly what they were leasing, or that they were getting one of the best deals of all time. The subsurface maps they were using as a guide look, today, like scribbles on a cocktail napkin. Partners Richfield and Humble appeared to have won the best tracts on the top of the structure, while BP was relegated to the flanks. Nobody knew about the huge gas cap and the fact that over half of the oil was actually on the BP acreage.

The exploration of the mid-1960s, which resulted in at least 10 dry holes being drilled, led many companies to simply give up the search. The producers at Prudhoe Bay today are there because they persevered through unrelenting disappointment and hardship. They took enormous risks. The list of companies that walked away is long.

Impact on industry decisions

What would have been the outcome of these sales if the exploration technology we have today had been available then? Again, I will assume that companies had done some primitive seismic and had made some preliminary maps. They knew, roughly, that there was some kind of big structure near Prudhoe Bay. But they had drilled a lot of dry holes and patience was wearing thin in the company boardrooms. Money for further exploration was drying up.

But what if, prior to Lease Sale 13, companies were able to obtain modern 3-D seismic data along with the computing power to process those data. Let's assume all the companies

that were working on the North Slope had access to these data. What would the effect on those three lease sales have been?

Up to this point companies had to rely on single-fold 2-D data. They could not correct for near-surface "statics" (like permafrost) that distorted the seismic signal. The sections were full of noise that could not be eliminated. The faults were all poorly known, or were mapped in the wrong place in the subsurface. Modern 3-D seismic (and the computer wizardry that goes along with it) eliminates or reduces all these problems. A simplistic analogy would be to compare an out-of-focus X-ray with a CATScan. Suddenly, a lot more subsurface detail was available to the explorer.

With modern 3-D seismic available, the structure at Prudhoe Bay becomes pretty clear; the big geologic features are exposed and even the details of the fault patterns can be understood. But 3-D seismic, as good as it is, still has one shortcoming that has yet to be undone: it cannot directly discern liquid or gas in the subsurface. There are hints to be sure; things like "bright spots", "dim spots" and "flat spots" all provide tantalizing clues. Sophisticated modeling helps predict the presence of liquids and gas, but drilling is still the only true test.

Different outcome likely

My guess is the bidding would have been more comprehensive at the first sale and perhaps the two subsequent sales would not have been needed. I wonder if the partnership of Richfield and Humble would have happened. Perhaps there would have been other partnerships given that the additional information might have emboldened management from other companies to participate. On the other hand, the new seismic would have shown the real complexity of

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The Prudhoe Bay oil field production facilities are situated on Alaska's North Slope, a flat, treeless plain that covers 88,000 square miles, an area slightly larger than Idaho. Prudhoe Bay is the largest oil field in North America and ranks among the 20 largest fields ever discovered worldwide. Of the 25 billion barrels of original oil in place, more than 15 billion barrels can be recovered with current technology.

Prudhoe; it would now be clear that it is much more than a simple, big anticline. The fault patterns and stratigraphy, now seen clearly, may have given some companies pause for concern. So far the only wells drilled were dry holes, and there were no wells in the Prudhoe structure itself.

Even if the same players prevailed, we are left to wonder if the gas cap could have been discerned prior to the sale. Had the Richfield-Humble partnership known about the gas cap prior to the sale, I presume there would have been more spirited bidding on the flank acreage and less interest on top of the structure. The oil-rim/gas cap ownership remained a divisive issue until the merger in the late 1990s. Only then did common equity (an equal division of interest in oil and gas) come to the Prudhoe Bay field. Had the companies understood the Prudhoe Bay structure with more certainty, perhaps this important milestone could have taken place earlier.

Effects of drilling advances

In addition to the new seismic techniques, we are also transporting our 21st century drilling technology back to 1967. Now that the lease sales are over, it is time to drill the first well. Atlantic Richfield (Atlantic and Richfield merged after the lease sales) and Humble might drill the discovery well in a different location, but that is probably of little consequence. The discovery well, wherever it was drilled, would not likely have been a single straight hole (which was all that could be accomplished back then).

In 1967 the drill bit on the end of the drill pipe had one basic purpose: to make a hole in the ground. Today, sophisticated Measurement While Drilling tools are available to go along with the bit. While drilling, well information regarding the various rock formations is transmitted in real-time to the explorationist. And, of course, we have provided our 1960s explorer with all the computer firepower we have today to analyze these data.

It is also likely that the initial well would have delivered more than merely a single hole in the ground. Using multilateral drilling perhaps four or five well-bores could be drilled from the initial location. A confirmation well would still be drilled, but the most advantageous location for that well would be more certain. Extended reach wells could be drilled from the same pad. In sum, a lot more would be known about Prudhoe early in the drilling program.

Using the results of the early wells, in conjunction with the subsurface mapping derived from the 3-D seismic data, relatively accurate predictions could be made about the entire field. Rock types and reservoir quality would be able to be discerned with some certainty. Additional productive formations, which would not be known for years using "old" technology, would be discovered earlier. The Kuparuk formation would likely have been identified, understood (and developed) earlier and other parts of Prudhoe (Point McIntyre, Niakuk, and others) also would have gotten earlier scrutiny. Heavy oil development might have gotten an earlier start.

More accurate recovery estimate

All this new technology would have played an important role in the early days of the Prudhoe Bay field. More would have been known sooner. The size of the field might be better known. Originally thought to contain 9 billion recoverable barrels, the field's crude recovery number would have become larger earlier in the game. This might have had some effect on the missing piece in 1968: a way to get the oil to market. There was no pipeline.

The building of the pipeline certainly would have benefited from new technology and better materials, etc. Whether the pipeline would have been built earlier or better, I will leave as an exercise for the reader. I presume that, one way or another, the pipeline gets built.

More responsive to environment

Naturally, along with all this marvelous 21st century technical equipment and technology, we also would expect an increased awareness of the environment and a need to decrease the impacts of drilling and associated activities.

The availability of 3-D seismic technology means fewer wells need to be drilled since these data provide so much additional subsurface information. There are fewer dry holes drilled and the wells that are drilled will evaluate more of the subsurface and will provide much more geologic information.

Of course all the seismic data is acquired in the winter and thus has virtually no impact on the underlying tundra.

Vibroseis, a seismic technique that uses a specialized vehicle to transmit sound waves into the ground without any disturbance, is used exclusively. No more seismic surveys use dynamite as a sound source and bulldozers no longer tear up the tundra. All support vehicles have very low-pressure tires specially designed to leave no remnant footprint.

Better drilling rigs

The drilling rigs themselves are lighter, stronger and more easily transportable. They are safer as a result of years of Arctic drilling experience. All are equipped with at least one blowout preventer. The mud systems are more sophisticated and the real-time monitoring of subsurface pressure has advanced to a point that blowouts are virtually unknown. The mud itself, an important drilling component needed for lubrication and pressure control, now has a benign chemical composition.

Reserve pits have been eliminated. Once a staple of North Slope exploration drilling, these big pits were used to dispose of the mud and cuttings from the well. Now these well-wastes are ground into a paste and re-injected back down the well bore. This decreases the size of the drilling "footprint" dramatically and eliminates any future con-

amination problems due to leakage from the reserve pits. Exploration drilling is done entirely from ice pads which are accessed by ice roads. At the end of the drilling season, there is no trace of the winter drilling operation.

Infrastructure and well spacing

Prudhoe Bay is the largest oil field in North America and one of the largest in the world. Developing a field of this size requires a certain amount of infrastructure including wells, well pads, pipelines, gathering centers and employee housing. These requirements would not change simply because new technology was available, but technology would certainly reduce the amount of infrastructure needed.

A visitor to Prudhoe today sees row after row of wells, all spaced fairly far apart. This is because most early wells at Prudhoe were drilled as straight holes, and it took a lot of wells to delineate the field and develop the oil.

Done with technology available today, the picture would be much different. I would envision a series of small development "islands", each with a few wells. The wells would be very close together on a gravel pad perhaps covering 15 percent of

the surface of pads using earlier technology. Because of multilateral, horizontal and extended reach drilling techniques available today, much more oil could be produced with a much smaller surface footprint.

Alpine, the ConocoPhillips-Anadarko field near the Colville River west of Prudhoe, is an example of the application of this technology. At Alpine, 500 million barrels of oil is being produced from a gravel pad that covers less than 100 acres. This is only possible using technology that has evolved in the last 15 years.

Smaller, less-intrusive oil fields

The discovery of oil in Cook Inlet in 1957 certainly helped Alaska achieve statehood. Just as certainly, the discovery of the giant Prudhoe Bay field shaped, and continues to shape, Alaska's future. Prudhoe Bay remains a testimony to the ingenuity and determination of those who brought this field into production despite overwhelming obstacles. But there will be no more Prudhoe Bays. New technology and a heightened awareness of the environment means that future fields on the North Slope will be smaller, environmentally sound and safer. ♦

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Prudhoe Bay's legacy

*"... if we can live and work here, in these conditions, we can go to Mars."
—Comment by Apollo 17 astronaut Harrison Schmitt, after a tour of Prudhoe Bay in mid-winter*

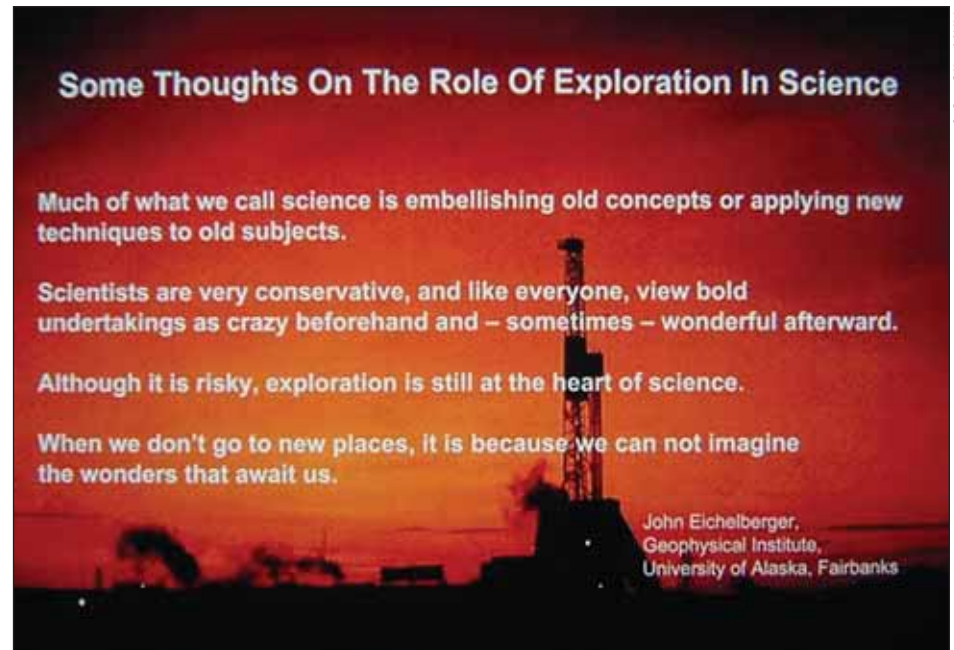
By Frank E. Baker
For Petroleum News

For the U.S. news media, Prudhoe Bay startup in the summer of 1977 was more of a pipeline story rather than an oil field story. How would the new, \$8 billion pipeline perform on its trial run? When would the oil front reach Valdez? The wager captured everyone's imagination. The feat of barging Prudhoe Bay oil field facilities thousands of miles from the U.S. West Coast to the Arctic Ocean; the massive effort of constructing the field's power station and other oil field installations in a hostile, Arctic environment; the daunting task of drilling oil wells in sub-zero weather conditions through 2,000 feet of permafrost and another 6,000 feet to tap into Prudhoe's rich oil reservoir; the multibillion-dollar investments need-

ed to produce that first barrel of oil, were for the most part, unheralded.

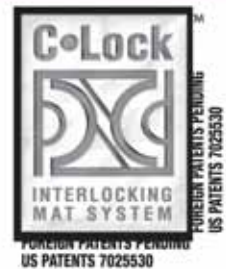
In its remote spot near the top of the world, Prudhoe Bay has been generally

overlooked by most of the nation, taken for granted by the general public. But over the past 30 years, the field has told its own story — in billions of dollars of



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taxes and royalties to the State of Alaska; billions of dollars of investments within the state; an Alaska Permanent Fund savings account that has grown to more than \$38 billion; more than 56,000 Alaska jobs, not counting construction of the Alaska pipeline; and the emergence of many

local companies that support the oil and gas industry.

The industry's many contributions also include infrastructure and improvements to facilities across the state that include schools, hospitals, roads, airports, docks, shopping centers — improvements that have vastly enhanced the

quality of life for generations of Alaskans; and energy — about 15 billion barrels of oil sent to market in the U.S., accounting for an average 15-20 percent of the nation's production for three decades.

But over the past 30 years, Prudhoe Bay has yielded more than oil, revenue and jobs. It has been a proving ground for oil field technology and Arctic engineering.

It has been a one-of-a-kind, outdoor laboratory for environmental science. It has helped advance knowledge of the region's earliest aboriginal inhabitants.

Because of Prudhoe Bay, there are now 24 separate oil fields on the North Slope — five of which are among the nation's top 10 largest producing fields.

And despite the natural oil production decline of the big fields, the North Slope is today producing about 700,000 barrels of oil per day — a significant contribution to America's energy production.

Because of Prudhoe Bay, Alaska is poised to reap a new Arctic bounty — the trillions of cubic feet of natural gas lying beneath the surface. It is natural gas needed by an energy-hungry America.

A few years after his moon landing on Apollo 17, former

It has been a one-of-a-kind, outdoor laboratory for environmental science. It has helped advance knowledge of the region's earliest aboriginal inhabitants.

NASA astronaut and New Mexico Senator Harrison Schmitt visited Prudhoe Bay. After being toured around the area in the depths of winter, when chill factors can reach minus 100 degrees Fahrenheit and colder, he commented: "If we can live and work here, in these conditions, we can go to Mars."

He got it right. In one sentence he revealed a profound understanding of Prudhoe Bay's underlying importance to Alaska, the nation and the world.

Prudhoe Bay has been a testament to what human beings can do when they set their minds to it. ♦

A lifetime Alaska resident, Frank Baker retired from BP Exploration (Alaska) Inc. in March 2007 with 29 years service. He has been writing and reporting for the oil and gas industry for more than 30 years.

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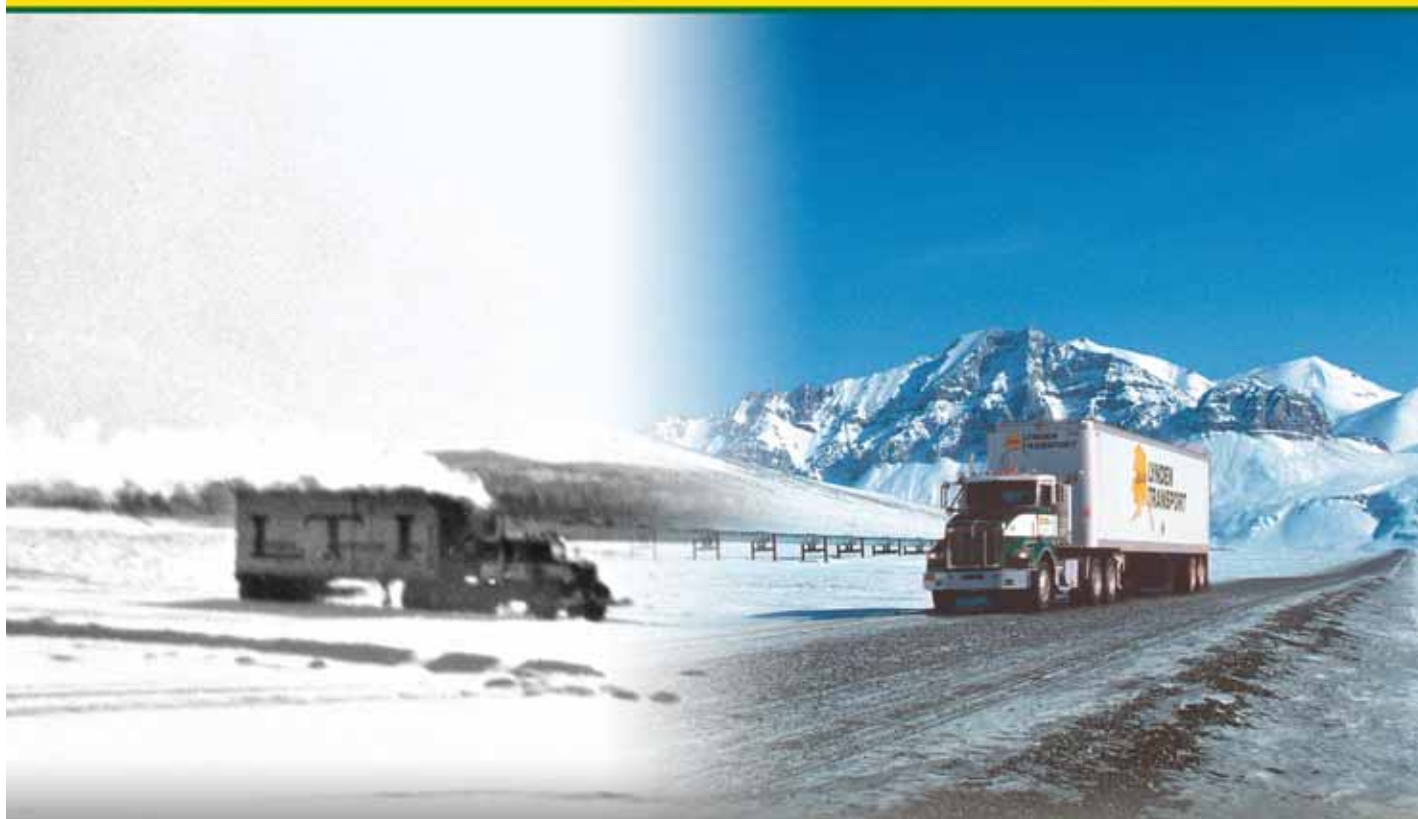
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