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MARTI REEVE SPECIAL PUBLICATIONS DIRECTOR

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SHANE LASLEY MN PUBLISHER & EXEC. EDITOR

> CLINT LASLEY GENERAL MANAGER

MARY MACK CHIEF FINANCIAL OFFICER

KRISTEN NELSON EDITOR-IN-CHIEF

ALAN BAILEY SENIOR STAFF WRITER

ERIC LIDJI CONTRIBUTING WRITER

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MAPMAKERS ALASKA CARTOGRAPHY

JUDY PATRICK CONTRACT PHOTOGRAPHER

> HEATHER YATES BOOKKEEPER

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DEE CASHMAN CIRCULATION REPRESENTATIVE

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MAILING ADDRESS:

PO Box 231647 Anchorage, AK 99523-1647 Phone: (907) 522-9469 Fax: (907) 522-9583 Email: circulation@PetroleumNews.com Web page: www.PetroleumNews.com

To order additional copies of this special publication, contact Clint Lasley at clasley@petroleumnews.com

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Oil & Gas Guest Editorial

Alaska at the tipping point

BY DAN SULLIVAN Commissioner of the Alaska Department of Natural Resources

The State of Alaska is on the cusp of a promising new era of oil and gas development.

Governor Sean Parnell has outlined ambitious goals to increase the flow of oil through the Trans Alaska Pipeline System to one million barrels per day within a decade and commercialize the North Slope's enormous gas resources.

These two goals cannot be achieved without billions of dollars of additional private-sector investment. It's clear that the significant exploration incentives enacted by the State in recent years have attracted new exploration activity, particularly in the Cook Inlet region. If Alaska is going to realize its full potential, we must move from exploration to production. We are committed to attract the capital necessary to achieve our goals.

Oil and gas investors should look to Alaska for three primary reasons. First and foremost, the state possesses worldclass hydrocarbon resources; second, state government has taken action to boost oil and gas sector investment, particularly in Cook Inlet; and third, positive momentum has been created by a diverse mix of companies and the wide variety of resource plays — onshore and offshore, conventional and unconventional they are pursuing.

World-class hydrocarbon base

By any measure, Alaska has an enormous endowment of oil and gas resources.

In addition to the 16-plus billion barrels of oil produced from North Slope oil fields, which still hold roughly four billion barrels in reserves, federal agencies estimate that 40 billion barrels of undiscovered, technically recoverable oil and more than 200 tril-

lion cubic feet of natural gas remain untapped in state and federal lands and waters off the northern coast.

Those numbers do not include the North Slope's vast unconventional resources, such as heavy and viscous oil,

shale oil, shale gas, tight gas and gas hydrates. These unconventional resources likely add tens of billions of barrels of oil and hundreds of trillions of cubic feet of gas to the resource base.

How does Alaska stack up against its neighbors? According to the U.S. Geological Survey, Alaska's Arctic contains more undiscovered oil than any other comparable region of the Arctic, including northern Russia.

However, not all of Alaska's world-class

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hydrocarbons are in the Arctic. Cook Inlet — Alaska's first major oil field — has been producing onshore since the 1950s and offshore since the 1960s. Recently, the USGS studied the Cook Inlet region and found it still has enormous undiscovered, technically recoverable hydrocarbon resources, including an estimated 19 trillion cubic feet of natural gas, 600 million barrels of oil and 46 million barrels of natural gas liquids.

Last year's North Slope lease sale netted more than \$21 million and was one of the most successful lease sales of its kind in recent Alaska history. Long-time player ConocoPhillips and a variety of new players, such as Royale Energy, have staked out new positions on state land.

Beyond the established resource plays, the state is also reviewing the potential for hydrocarbons in regions that have not seen much exploration yet, with an eye toward developing cheaper energy supplies for local or regional use.The information devel-

oped will help explorers and communities hone in on areas that could be developed to reduce local reliance on expensive diesel imports.

That brings us to a critical point: Alaska remains relatively unexplored compared to other states. Alaska's North Slope has 500 exploration wells. Wyoming — a smaller area — has 19,000 exploration wells. When it comes to unconventional oil and gas resources, in particular, companies operating in

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Alaska have barely scratched the surface.

Government Action

In the past few years, the two main branches of state government — the executive branch and the Legislature — have worked to improve the state's oil and gas investment climate, particularly in Cook Inlet.

For example, the State has enacted tax and investment incentives to spur increased production from Cook Inlet onshore and offshore fields. These incentives are some of the most competitive

in the nation and are leading to a renaissance in oil and gas exploration in the region. This illustrates how tax reform can lead to new investment in our oil fields.

The state Legislature and Gov. Parnell recently agreed to extend incentives similar to those offered in Cook Inlet into six less-explored, lesser known energy basins throughout Alaska. The so-called "Frontier Basin" legislation will encourage exploration for oil and gas near Fairbanks, Kotzebue, the Bethel region, Glennallen and villages along the Alaska Peninsula.



Dan Sullivan

On the North Slope, the State offers very competitive credits for exploration drilling, but the Parnell Administration recognizes that the state needs to do more to incentivize production. The Parnell Administration and many legislators are still seeking to make the taxes levied on North Slope production more competitive with other jurisdictions. Our ultimate goal is to grow Alaska's economy through more oil and gas investment in production.

Finally, the state recently resolved its longstanding dispute with major North Slope producers over Point Thomson, the state's largest undeveloped oil and gas field. The companies committed to begin production from Point Thomson within the next four years — or lose significant acreage. In the short-term, Exxon and its partners will spend billions of dollars to develop infrastructure to transport liquids to the Trans Alaska Pipeline System, including a new 70 million-barrel-per-day common-carrier pipeline from Point Thomson to Badami. This pipeline will open up opportunities for companies interested in exploring on the eastern North Slope, between Prudhoe and the Arctic National Wildlife Refuge — one of the state's highly prospective areas.



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Positive Momentum

Alaska's world-class hydrocarbon resources and the government actions described above have helped boost interest in Alaska from a diverse set of companies exploring different kinds of resources in a variety of geographic settings.

It's worth recapping a few of the positive developments from the past year.

On the North Slope

Shell Oil is posed to drill exploration wells in the Chukchi and Beaufort seas this summer, and it also has leased acreage for exploration in state waters.

Significant progress has been made in

the State's ongoing effort to commercialize North Slope gas. The major North Slope producers and TransCanada Corp. are working together on a potential LNG export project from an Alaska port, the state has resolved the Point Thomson dispute that had created a significant roadblock for developing North Slope gas, and state and federal agencies are completing the environmental impact statement needed to develop an in-state gas pipeline. Commercializing North Slope gas isn't just an end to itself — we expect it will spur offshoot opportunities for the state and private sector, including additional oil exploration and production.

Progress has been made with uncon-

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ventional resources. BP is continuing its heavy oil production tests at Milne Point. These tests have gone well.Also, Great Bear is drilling the state's first shale oil exploration wells on the North Slope this summer.

Repsol has drilled three exploration wells on its acreage west of Prudhoe Bay.

Last year's North Slope lease sale netted more than \$21 million and was one of the most successful lease sales of its kind in recent Alaska history. Long-time player ConocoPhillips and a variety of new players, such as Royale Energy, have staked out new positions on state land. Royale intends to pursue conventional oil and a potential shale oil play.

In Cook Inlet

In Cook Inlet, we expect as many as 10 to 15 new oil and gas exploration wells to be drilled this year. Other new activities include one geothermal exploration well, one or two jack-up rigs, and 3-D seismic surveys throughout the region. This is significant, as the conventional wisdom two years ago held that Cook Inlet oil and gas exploration was basically dead.

In 2011 and 2012, Cook Inlet recorded some of its best oil and gas lease sales in decades.

Apache and Hilcorp are advancing ambitious new programs for developing the Cook Inlet basin — they are extremely bullish about its hydrocarbon potential.

Additional companies such as Linc Energy, NordAq, Cook Inlet Energy and Armstrong are investing in exploration, development and production in the basin.

Small companies are taking advantage of state tax incentives to bring jack-up rigs to drill on their leases in Cook Inlet.

This diversity of investment is welcome and we see it as critical to the state's future. New players will strengthen the oil and gas sector in Alaska and will help secure the future production needed to sustain our natural resource-based economy.

On that note, we strongly encourage investors to participate in our upcoming oil and gas lease sale for state lands on the North Slope, and in the Foothills and Beaufort Sea. The lease sale is tentatively scheduled for the fall and more details on the sale's lease terms are forthcoming.

The State of Alaska is diligently working to market Alaska's hydrocarbon potential and will continue its efforts to stimulate additional private sector investment.With more constructive government action and private investment, we see a bright future. We encourage you to join us.

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The Hunt for PETROLEUM



Petroleum Overview

Still the North Slope, but

BY KAY CASHMAN Petroleum News

Whether it's Repsol's recent massive acquisition of exploration acreage on the North Slope or Brooks Range Petroleum's

recent discoveries, there are still 30-plus billion barrels of undiscovered and/or undeveloped oil on the North Slope or in the near-shore state waters, running the gamut of conventional, heavy, source reservoired (shale), and tight oil.

And there are even more billions of untapped barrels of largely conventional oil in the National Petroleum Reserve-Alaska and the federal por-

tions of the Beaufort and Chukchi seas. But for those readers who are interested in exploring off the beaten path there are other Alaska nonproducing basins with the potential for natural gas, and in some cases oil. Geologist Robert Swenson, director of Alaska's Division of Geological and Geophysical Surveys, or DGGS, gave an overview of some of these less known basins and their resource potential in 2011.

> Alaska, Swenson explained, is traversed by several major geologic faults. The relative movement of rocks on either side of these faults has thrown up mountains in some areas, while causing other areas to sink into low-lying basins. Erosion of the mountains has caused sand and gravel to flow as sediment into the basins.

Robert (Bob) Swenson

The basins formed in this way are Tertiary in age and generally contain non-marine sediments — sediments consisting of sands, gravels and shales laid down from ancient rivers and lakes. Coal seams interspersed with these sediments have formed from rotting and compressed vegetation. And bacteria



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feeding on that rotting organic material have created methane, the primary component of natural gas, with that gas becoming adsorbed onto the coal.

If stresses in the Earth's crust cause

ENS pearls about to be strung

It has been more than 20 years since Alaska's Division of Oil and Gas officials coined the phrase "string of pearls" for the infrastructure-led exploration of the eastern North Slope. It has taken two more decades for the "string" — a metaphor for new pipelines — to come close to making its way from Pump Station 1 of the trans-Alaska oil pipeline at Prudhoe Bay to the border of ANWR's 1002 area, some 60 miles east.

Between ANWR and Endicott are numerous on- and offshore discoveries, several of which are thought to hold upwards of 100 million barrels of oil.

Not all are under lease, although that might change in the State of Alaska's annual areawide lease sales for the North Slope and Beaufort Sea, scheduled to occur sometime this fall.

First 'pearl' is Badami

Thirty-five miles east of Prudhoe Bay, the first "pearl" on the string is the Badami oil field. Put online in 1998 it is the farthest east development along Alaska's northern coast, its 35,000-barrel-per-day pipeline, or "string," connecting it to the Endicott field.

Today Badami produces a steady 1,300-1,500 barrels per month, leaving considerable space for third-party shippers.

By late 2016, it will likely be transporting oil and natural gas condensate from ExxonMobil's Point Thomson field, at its peak expected to produce 10,000 barrels a day from a gas-cycling development, and leaving two-thirds of the line open — and twice that amount open in the 22-mile, 70,000 barrel a day pipeline from between Badami and Point Thomson, the next pearl in the chain.

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The Spartan 151 jack-up was still drilling as this section of Fortune Hunt Alaska closed in late July 2012. It began drilling in September 2011 but took a break through the winter. The jack-up was brought to Alaska by Escopeta Oil, now Furie Operating Alaska, which is using the unit to explore the offshore Kitchen Lights unit in upper Cook Inlet that combines four distinct oil and gas prospects.

Hunting for elephants in Cook Inlet

It's good times for Southcentral Alaska explorers as promising geology gets boost from government

BY KAY CASHMAN Petroleum News

Dwindling oil and gas production and an aging infrastructure are normally the hallmarks of a mature oil and gas province. But despite its collection of declining oil and gas fields, Southcentral Alaska's Cook Inlet basin remains substantially underexplored, as evidenced by the sparse distribution of on- and offshore exploration wells in the region (see satellite image on page 16).

Cook Inlet, a major sea inlet between the Kenai Peninsula and the mainland of Southcentral Alaska, lies over part of a deep sedimentary basin between the Kenai Mountains and the mountains of the Alaska and Aleutian ranges. The basin extends beyond Cook Inlet under the western side of the Kenai Peninsula, under the lower land on the west side of the inlet and under the waters of Shelikof Strait.

Since the late 1950s the Cook Inlet basin has produced about 1.4 billion barrels of oil and 10 trillion cubic feet of natural gas, but U.S. Geological Survey scientists have theorized that only 4 percent of the petroleum that could have been generated by the basin's source rocks has ever been found. And the U.S. Department of Energy's 2004 report on the basin's natural gas hypothesizes that there are missing giants — large oil and gas fields — that remain to be discovered.

Even more surprising is the fact that

only a handful of wells have been drilled in the Susitna basin, a northern extension of the Cook Inlet basin

So, as residents of Southcentral Alaska become increasingly concerned about tightening natural gas supplies, and as the region's main oil

refinery has to import more and more of its feedstock, significant oil and gas resources remain to be found in Cook Inlet.

Two sequences

There are two major sequences of hydrocarbon-bearing rocks in the basin: a younger and shallower sequence that is Tertiary in age with sandstone reservoirs, and an older, deeper sequence that is Mesozoic in age.

explorers to the Tertiary.

Upper Cook Inlet basin, the prime focus of oil and gas exploration and the only part of the basin with producing oil and gas fields, attains its greatest depth near the northwest corner of the Kenai Peninsula. In that area about 25,000 feet of Tertiary, coal-bearing, terrestrial sediments

Oil exploration initially targeted the Mesozoic strata but the 1957 discovery of the Swanson River oil field in Tertiary sediments shifted the attention of later

quence of Tertiary rocks extends across the whole upper Cook Inlet area, but thins toward

the edges and toward the lower basin.

Oil exploration initially targeted the Mesozoic strata but the 1957 discovery of the Swanson River oil field in Tertiary sediments shifted the attention of later explorers to the Tertiary. To date there have been 11 significant oil finds and 28 significant gas finds in the upper Cook Inlet area, with all of the finds occurring in the Tertiary.

Basin's challenges

Exploring the Cook Inlet basin can be challenging. Fields typically contain multiple small reservoirs that may be difficult to find. Deposition of the Tertiary sediments from rivers and river fans, spreading from the ancient mountains surrounding the basin, has given rise to rock units that are often discontinuous. River channels and fans can be difficult to differen-

tiate using single rock samples from wells, thus giving rise to issues such as knowing how far a particular reservoir may extend.

"There's been a lot work over the years by the industry to try to predict reservoir continuity," per geologist Paul Decker of Alaska's Division of Oil and Gas.

Also, perhaps because of clay content of the sediments, it is often difficult to recognize pay zones using well logs, said Tim Ryherd, a commercial analyst with the division. It is not always obvious where the gas sands are, even if you drill right through the middle of a gas reservoir, he said.

And, Decker said, acquiring high quality seismic in the basin can be difficult, in part because of the basin's complex structures. The coal seams in the Tertiary sequence also tend to absorb seismic energy.

Nonetheless, Cook Inlet basin explorers have found some sizable fields. The largest oil field, McArthur River, had produced about 628 million barrels of oil by the end of 2008, with recoverable oil reserves of about 646 million barrels.

stratigraphic traps

A quick inspection of a map of Cook Inlet's discovered fields

shows that they follow two main trends on either side of the basin axis — one trend passes up the west side of the Kenai Peninsula and the other trend passes up the west side of Cook Inlet.

The trends lie on either side of the central axis of the basin. "If you look at a map of the well plots there's very few in the

core, along the axis (of the basin)," Ryherd said.

Interestingly, the Kitchen oil and gas prospects, where Furie Operating Alaska started drilling in September 2011 from a jack-up rig, is on the axis of the basin.

Decker also said much of the drilling in the Cook Inlet basin has focused on the crests of the major structures in the basin. He thinks there is scope for exploring the flanks of the structures, where fluids will likely have migrated up the structures. There is also scope to explore for stratigraphic traps.

"So far the basin has only really been explored for structural, not for stratigraphic traps," he said.

Mesozoic possibilities

The possibility of finding oil and gas in the Mesozoic, beneath the Tertiary basin, intrigues geologists, especially since Cook Inlet oil originated from the Jurassic Tuxedni group within the Mesozoic sequence, having presumably percolated upwards.

Cretaceous rocks in the Mesozoic exposed at either end of the basin show evidence of oil formation, Ryherd said.

However, geologists have also been concerned about the potential for minerals called zeolites to clog the pores of potential reservoir rocks — the chemistry of the Mesozoic rocks tends



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John Bedingfield, Apache's vice president for worldwide exploration and new ventures, said Cook Inlet is intriguing because of its "tremendous" oil potential.



A thin scattering of Cook Inlet wells, the white dots on this 2010 satellite image, indicates basin is underexplored.

to be conducive to zeolite formation.

But Decker thinks that the nature of the Mesozoic under the basin is not well understood. In fact the Mesozoic oil and gas potential has become one of several focuses of a multiyear Cook Inlet research program begun in 2006 by Alaska's Division of Geological and Geophysical Survey, or DGGS.

It's almost free

Drilling into the deeper Mesozoic is very costly. To encourage exploration and development, the State of Alaska offers Cook Inlet oil and gas producers one of the most favorable tax and royalty environments in the United States, with total rates at or below every other major producing state: Cook Inlet oil is assessed no production tax, and a 12.5 percent royalty rate; natural gas' royalty rate is the same but its gross production tax rate varies, depending on gas prices — at \$5 per mcf it's 3.6 percent, which assumes no capital credit-write-off.

Plus, the state pays up to 40 percent of exploration costs. And production tax increases and decreases with oil prices and the level of investment; in other words, the more you invest, the less tax you pay.

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On top of that, in 2010 Alaska lawmakers passed a bill with a \$25 million tax incentive for the first offshore Cook Inlet well drilled by a jack-up into the Mesozoic. Subsequent wells get \$22.5 million and \$20 million if they are drilled with the same jack-up.

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Newcomers forge ahead in Cook Inlet

Apache, Hilcorp waste no time in executing aggressive exploration and development plans

BY ALAN BAILEY Petroleum News

he last couple of years have seen substantial changes in the business landscape of Alaska's Cook Inlet basin, with independents Apache Corp. and Hilcorp Energy purchasing major positions in the basin and subsequently forging ahead with exploration and development plans.

Houston-based Apache, a company with a reputation as an innovative explorer, started purchasing Cook Inlet leases in July 2010, eventually establishing a lease position of some 800,000 acres around the basin. The company has stated its intent to primarily explore for oil, with natural gas as a secondary target.

Seismic acquisition

And, seeing modern high-resolution 3-D seismic data as an essential requisite to drilling in the challenging Cook Inlet geology, Apache has embarked on an ambitious three-year program of seismic data acquisition.

In April and May 2011 the company shot some test seismic on the west side of the inlet, trying out new seismic technology that does not require the laying of seismic cables.And, having met with success in that test, in the fall of 2011 the company embarked on a 3-D seismic survey covering a swath of land near Tyonek, also on the

west side of the inlet.Apache is extending that survey out into the offshore and plans to drill two exploration wells on the west side of the inlet, starting in the fall of 2012.

The offshore

seismic surveying is taking place between Apache's onshore survey area and leases held by Furie Operating Alaska in the middle of the inlet.

Deploying nodes

Onshore, the survey technique that

Apache is using involves the deployment of seismic recording nodes, each weighing about five pounds and about the size of a large food can. The nodes can be carried to and from location by backpack and, without any cabling required, there is no need to cut seismic trails through forest and other vegetation. Global positioning tech-

nology and satellitebased timing enable The exceptionally strong tidal currents, each node to operate shifting boulders the size of beat-up buses independently when recording seismic sigalong the seafloor and potentially lifting nals. After use, the and moving the seismic nodes, make recorded data are offshore seismic in the Cook Inlet downloaded from each node into a computer system for data storage and process-

ing.

especially challenging.

Offshore, the nodes are disc shaped, tethered along lines that lie on the seafloor and that are aligned parallel to the tidal currents of the inlet. The exceptionally strong tidal currents, shifting boulders the size of beat-up buses along the seafloor and poten-



tially lifting and moving the seismic nodes, make offshore seismic in the Cook Inlet especially challenging, John Hendrix, general manager of Apache Alaska Corp., told Petroleum News.

Pinpointing targets

Apache is expediting the processing of its seismic, to enable the pinpointing of targets for its initial drilling. The company has lined up some drilling prospects and is starting the permitting and planning for the drilling. It may be necessary to deviate wells drilled from pre-planned gravel drilling pads, once the precise positions of the drilling targets have been established from the seismic. Apache plans to drill to below the Jurassic, underneath the Tertiary strata of the basin, seeking oil in both the Tertiary and the older rocks. That may mean drilling to depths of around 16,000 feet in the prospect areas, although the seismic survey was designed to accommodate drilling down to 20,000 feet, Hendrix said.

In September Apache also plans to start a major 3-D seismic survey on the east side of the inlet, covering a broad area of land on the southern Kenai Peninsula as well as a three-mile offshore fairway, from Anchor Point up to Kasilof. Included in the company's extensive lease position on the east side of the inlet are some leases at the Cosmopolitan prospect, a known oil accumulation offshore Anchor Point.

Hendrix says that Apache's large lease position speaks to the company's commitment to Alaska.

"You don't come in and buy this much acreage with a shortsighted plan," Hendrix said. "We're not a one-well wonder and we don't have to bet the farm on one well.... It's a proven basin and we think it's been underexplored."

Hilcorp

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in aging oil fields, entered Alaska in July 2011 by buying all of Chevron's substantial Cook Inlet assets. Chevron subsidiary Union Oil Company of California owned the Granite Point, Middle Ground Shoals, Trading Bay and MacArthur River fields; interests in 10 offshore platforms; interests in onshore gas fields including the Ninilchik unit and the Beluga River unit; and two gas storage facilities.

In April 2012 came an announcement that Hilcorp was also going to purchase all of Marathon Oil Corp's Cook Inlet asset, thus making Hilcorp the dominant producer of oil and gas in the Cook Inlet basin. Marathon, a long-time player in the basin, operates gas fields in the Beaver Creek, Cannery Loop, Kasilof, Kenai, Ninilchik, North Trading Bay and Sterling units and owns pipeline assets, including the Cook Inlet Gas Gathering System that runs under the Cook Inlet, the Kenai Nikiski pipeline on the Kenai Peninsula and the Beluga pipeline on the west side of the inlet. Marathon also owns a gas storage facility in the Kenai gas field.

In June 2012 Hilcorp President Greg Lalicker told the Anchorage Chamber of Commerce that Hilcorp buys old fields, like those of the Cook Inlet, to exploit these aging properties with a focus on reservoir engineering; geology and geophysics; and field operations.

Lalicker said that Hilcorp's immediate focus in the Cook Inlet was on "revitalizing and reactivating and modernizing" equipment to enable drilling to continue over the coming decades. The company is stripping old drilling rigs from the aging Cook Inlet offshore oil platforms and is acquiring a modern rig that can move from platform to platform, drilling and working wells. And in the onshore Swanson River field a workover rig is repairing old wells.

With a remediation program in place across all producing assets and plans to bring old shut-in wells back on line, Hilcorp hopes to raise daily oil production from the old Chevron fields from 15,000 barrels at the end of 2011 to more than 25,000 barrels in 2014.

substantial spending

Hilcorp has a Cook Inlet capital budget of \$203 million for 2012 and anticipates spending around \$150 million per year over the next couple of years. However, the company sees a shortage of oilfield services supporting the Cook Inlet oil industry as one of the biggest challenges in its Alaska venture.

Lalicker attributed the service industry shortage to low levels of investment in the Cook Inlet oil industry in recent years.

"No one has been spending a couple hundred million dollars a year in the Cook Inlet for quite a while." Hilcorp is "working like mad to solve this and we will solve it — but that has been the biggest deterrent to getting things done," he said.



Cook Inlet: An 'oil museum'

Apache believes Southcentral Alaska's on and offshore basin has as much oil left as it has already produced

ERIC LIDJI For Petroleum News

F or Apache Corp., the Cook Inlet basin might be the Louvre of oil.

"When you go up there it's kind of like going back into time. It's like an oil museum, is kind of how I'd describe it," John Bedingfield, vice president for exploration and new ventures for Apache said at the large Houston-based independent's annual In-

vestor Day on June 14. "It's interesting, but things have just been frozen for 40-plus years."

Reprint From Petroleum News July 8, 2012 issue

Apache believes there is as much oil still to be discovered in the Cook Inlet basin as has already been produced in the 55 years since the first discovery well in the region.

To justify that enthusiasm, Bedingfield offered a glimpse of the ambitious threeyear 3-D seismic program Apache is conducting in the Cook Inlet. He showed investors a strip of data manipulated just enough to keep competitors from recognizing the location.

"I wish I had taken the scale bar off now," Bedingfield added as a beguiling aside.

Because daylight is one of the limiting factors

for seismic collection, Bedingfield said

Alaska presents a unique advantage during

its epic summer days. Apache expects to be

able to collect between 300 and 400 square

miles this year, or a third of its program.

The seismic uncovered eight previously unidentified leads. Extrapolated across its entire leasehold that suggests as many as 650 potential leads,

according to the company.

Based on those early results, Apache believes "only a handful of fields have been discovered out here," Bedingfield said. The field size distribution of the basin "strongly" suggests another 1.3 billion to 1.4 billion barrels of oil yet to be discovered, he said.

Bedingfield didn't say how much of that oil Apache believes is technically, not

to mention economically, recoverable. A June 2011 U.S. Geological Survey assessment estimated 599 million barrels of undiscovered but technically recoverable oil remained in the basin, the mean figure

of a possible range of 108 million to 1.359 billion barrels.

The reason operators have not found those fields yet is seismic, he said.

"Every single valid trap that's been drilled in this basin has hydrocarbons. It

does not mean it's commercial, but every trap has got hydrocarbons," Bedingfield said, meaning exploration will be "an exercise in trap definition and basically risking investment."

That's why the basin is "tailor made" for 3-D seismic.

Until now, much of the 3-D seismic shot in Cook Inlet has been "effectively development scale" and therefore "typi-



cally they would be, from a design perspective, insufficient to image some of the structural complexities that we see in the basin."

In addition to a large volume of plays, Apache expects the seismic work to reveal "complex plays." Noting the basin contains 100 million barrel fields covering only 800 acres, Bedingfield said the 3-D seismic should show "stacked plays" and "big columns."

Development in 2013?

So far, Apache has collected about 130 square miles of 3-D seismic in Cook Inlet.

The campaign started small in Novem-

ber, just enough to "shake out the operational business and see where our problems were," he said, and resumed at full steam in March.

Because daylight is one of the limiting factors for seismic collection, Bedingfield said Alaska presents a unique advantage during its epic summer days. Apache expects to be able to collect between 300 and 400 square miles this year, or a third of its program.

A collection of environmental groups recently challenged the seismic program in court, saying the National Marine Fisheries Service shouldn't have issued an au-

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ration, Drilling Support, & Geosciences • Fabri Craft Specialties • Operations & Maintenance thorization to Apache for the accidental disturbance of marine mammals during offshore program.

Apache plans to drill its first well in the third quarter and possibly a second later in the year. Acknowledging the many "ifs" involved, Bedingfield said Apache could begin development plans for the region as soon as next year, depending on exploration results.

Earlier this year, Apache outlined plans to drill wells on both sides of Cook Inlet, but subsequently decided to drill both on the west side, where it has gathered seismic data.

Major explo-



John Bedingfield

ration focus Cook Inlet is currently the largest exploration play in the Apache portfolio.

At more than 1 million acres, it is nearly double the next largest play.At 1.3 billion barrels of prospective reserves, it is barely trailing a prospect in the Kenyan deepwater.

It is also the only traditional exploration play in the Apache portfolio. The other exploration plays in the Americas and New Zealand are resource plays, such as shale or other unconventional formations. The Kenya program is targeting a deepwater field.



Source Reservoired Oil

A plentiful resource?

USGS publishes its new shale oil, gas assessment for the Alaska North Slope



A schematic cross section of Alaska's North Slope shows the oil window, where temperatures in the distant past were appropriate for oil generation, intersecting the Kingak and Shublik source rocks in a relatively narrow zone in the northern part of the Slope. However, fingers of Brookian source rock extend in the oil window farther to the south, placing the Brookian sources in a much broader area of potential oil generation than the other two source rocks.

BY ALAN BAILEY Petroleum News

The U.S Geological Survey has published its assessment of potential shale oil and gas resources under Alaska's North Slope. The agency says that there may be anywhere from zero to 2 billion barrels of undiscovered oil and zero to 80 trillion cubic feet of undiscovered natural gas recoverable from source rocks in the region using currently available technology. The assessment does not evaluate the economic viability of developing and producing these resources.

"Better knowledge of the untapped resource potential found in all areas of the country will help us better make sciencebased decisions about how we continue to grow domestic energy production for America," Secretary of the Interior Ken Salazar said on Feb. 24 when announcing the publication of the assessment."Alaska's energy resources hold great promise and economic opportunity for the American people, and we will continue to expand our scientific understanding of existing resources as part of our commitment to an all-of-the-above energy approach that includes safe and responsible production of American oil and gas resources."

USGS Director Marcia McNutt said that providing scientifically sound and publicly available assessments of untapped oil and gas resources in frontier areas forms the first step in weighing their potential contributions to energy supplies and in analyzing the potential impacts of recovering the resources. (See USGS map on jump page 24 of this article.)

Growing interest

Interest in shale oil development in Alaska has grown rapidly since the State of Alaska's October 2010 North Slope lease sale in which Great Bear Petroleum picked up 500,000 acres in leases with the intention of exploring for shale oil, oil that comes directly from an oil source rock rather than from a conventional oilfield reservoir rock. Shale oil development, using horizontal drilling and hydraulic fracturing, has resulted in a major upsurge in oil production in the U.S. Lower 48 states but has not yet been attempted in Alaska.

Great Bear plans to do its first shale oil drilling in Alaska in the coming months. And Royale Energy has also entered the Alaska shale oil scene by purchasing shaleoil-targeting leases in the December 2011 state North Slope lease sale

During a press briefing for the assessment announcement USGS geologist Dave Houseknecht said that the wide ranges in the potential volumes of recoverable resources, with the possibility of zero resource recovery at the bottom ends of those ranges, reflects the fact that as yet no drilling has successfully demonstrated shale oil or shale gas production on the North Slope. It is not possible to be sure of any production until the source rocks are tested, Houseknecht said.

And in a Feb. 27 interview with Petroleum News, Houseknecht said that if the Great Bear drilling demonstrates a flow of oil above a small, minimum rate, the lower range of the assessment's oil estimate would rise above zero, with the remainder of the estimate range also being raised to some extent.

Five assessment units

In carrying out its assessment the USGS scientists have recognized five distinct shale assessment units or plays. Three of these assessment units correspond to shale oil potential in each of the three main North Slope source rock systems: the late Triassic Shublik, the Jurassic lower Kingak and an assemblage of rocks of Cretaceous age, including the Hue shale and HRZ or GRZ, within what is known as the Brookian sequence. The other two assessment units relate to shale gas potential in the Shublik and the Brookian.

The Shublik is the most promising of the oil assessment units, with the Shublik formation known to be a prolific North Slope oil source and having abundant brittle rocks within it, particularly suitable for hydraulic fracturing; the formation also contains natural fractures along which oil might flow.The USGS scientists judge that there is about a 95 percent probability of it being possible to produce at least a minimal volume of shale oil or gas from this source rock, Houseknecht said.

The Brookian, like the Shublik, contains brittle rocks. But because these brittle rocks are not present everywhere on the Slope, the scientists have downplayed the Brookian shale oil potential just a little, to a probability of 90 percent, Houseknecht said.

The Kingak, although an excellent source rock and in geologic proximity to the Shublik, is thought much less promising as a candidate for shale oil development: The rock contains much ductile clay material that would likely render the rock unsuitable for fracturing. The scientists

Coring likely completed at Alaska's first shale oil test well

By the time Fortune Hunt Alaska goes to press at the end of July 2012, the first test well in Alaska to target source reservoired oil — called 'shale oil' because most source rocks are shale — will likely have been drilled and cored by Great Bear Petroleum and farm-in partner Halliburton.

Great Bear is pioneering the possibility of oil production on the North Slope using the hydraulic fracturing techniques that have proved successful in tight oil sands and source rocks elsewhere.

The 11,000-foot near vertical well,Alcor No. 1, targeted all three major North Slope source rocks, from deepest to shallowest: Shublik, lower Kingak, and an assemblage called the Hue shale and HRZ or GRZ.

Great Bear is sending core samples to laboratories for testing, to determine the production characteristics of the rocks.

After completing the vertical well at Alcor, Nabors rig 105AC will move south to drill a vertical hole at Merak, the next in a series of six drill sites south of the producing North Slope oil fields that Great Bear has staked along the Dalton Highway and the trans-Alaska oil pipeline corridor.

After taking core samples from Merak, Great Bear plans to proceed to the next stage of testing by drilling horizontal lateral wells from the vertical well bores.

The company wants to complete the two vertical wells and two horizontal wells, and drill another vertical well at a third site, Mizar, before the end of 2012.

- Kay Cashman



have assigned just a 40 percent probability of successful oil production from this source and have not assessed the likelihood of any gas production.

However, since all three source rocks often tend to be found at the same locations in the more prospective parts of the Slope, with the rocks at different depths and with the Shublik formation being deepest, any well drilled to test a Shublik play will likely penetrate all three source rocks and therefore provide opportunities to test multiple plays, Houseknecht said.

Oil and gas generation

The generation of oil or gas in shale in any of the assessment units depends on the shale having contained appropriate quantities of organic material that could have converted into hydrocarbons, and on the rocks having at some time in the past been heated to appropriate temperatures for oil or gas generation.

When a source rock becomes hot, deep underground, its temperature may become high enough to cause oil to form from the organic material in the rock. At higher temperatures natural gas rather than oil will form. Some of the oil and gas will subsequently escape from the source rock and flow into porous reservoir rocks to form conventional oil and gas fields. Some oil and gas is also likely to remain trapped in the source to become the target of shale oil or gas development.

Thermal history

Using information gleaned from rock samples geologists have been able to assess the thermal history of the rock strata under the North Slope. There is a zone in which rocks were heated many millions ago to oil generation temperatures. That zone appears to dip northward under the Slope, apparently intersecting the source rocks of the closely spaced Shublik and Kingak at depth along a relatively narrow fairway under the northern end of the Slope and under the nearshore state waters of the Beaufort Sea, Houseknecht said. This fairway defines the maximum possible outer limit of the Shublik and Kingak shale oil assessment units.

The subsurface configuration of the Brookian source rocks, on the other hand, indicates a likely broader intersection with that oil generation zone, leading to the potential for oil in the Brookian sources across much of the northern half of the Slope.

And a broad zone where temperatures reached levels suitable for natural gas generation lies below and to the south of the zone "in the oil window," so that the shale gas play assessment units for the Shublik and the Brookian lie in the more southerly part of the Slope.

Plotting the boundaries

To plot a boundary for each of the assessment units, the USGS scientists had to evaluate the subsurface distribution of the source rocks, discounting areas where the rock units are absent or unacceptably thin. But because of factors such as high levels of uncertainty in the sizes and positions of the subsurface thermal zones, there is major uncertainty over the locations of the assessment unit boundaries. This uncertainty is heightened by the probability that, rather than there being sharp boundaries between oil plays and gas plays in the source rocks, there will be transition zones containing varying combinations of oil, gas and condensate, Houseknecht explained.

Mapping the known extent of the Shublik onto the area of the inferred oil thermal window indicated a total shale oil play area of 5.0 million to 7.5 million acres, with a modal (or most likely) area of 7.3 million acres. And a plot of the thickness of the most



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A plot of the thickness of the most oil prone section of the Shublik source rock shows high oil potential near the coast to the northeast of Teshekpuk Lake (outlined in blue) and along a fairway south of the producing North Slope oil fields.

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oil-prone section of the Shublik suggests particularly high oil potential near the Beaufort Sea coast from Lake Teshekpuk in the northeastern National Petroleum Reserve-Alaska to the Kuparuk River field, and in the area to the south of the Kuparuk River and Prudhoe Bay fields, extending east to the Canning River. That more southerly area is where Great Bear and Royale have their leases.

Absent in ANWR

Ancient erosion of the Shublik rocks has resulted in an absence of the Shublik to the east of Prudhoe Bay, and hence resulted in no Shublik shale oil or gas potential, either under the 1002 area of the Arctic National Wildlife Refuge, or ANWR, or under the coastal area immediately west of the refuge, Houseknecht said.

The Shublik shale gas assessment unit, to the south of the oil assessment unit, covers a broad area of 20.0 million to 30.0 million acres with a modal estimate of 25.6 million acres.

The Brookian shale oil assessment unit covers a broad region over the northern half of the Slope, with an estimated area ranging from 14.0 million to 20.0 million acres, and a mode of 18.2 million acres. The Brookian shale gas unit, to the south, covers 14.0 million to 20.0 million acres with a mode of 17.3 million acres. With the Brookian source rock sequence becoming very thin to the east of the Canning River, at the western boundary of ANWR, the USGS scientists have, as with the Shublik, discounted any possibility of Brookian shale oil or gas development in ANWR.



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Federal Offshore Intriguing possibilities in Chukchi

Sherwood reviews geologic features that have lured explorers to North Slope's continental shelf

BY ALAN BAILEY Petroleum News

hen the U.S. Minerals Management Service held its Chukchi Sea lease sale in February 2008, the agency collected about \$2.6 billion in high bids on some 488 tracts. In fact, together with the

two other Chukchi lease sales that MMS conducted in 1988 and 1991 MMS has raised about \$3.1 billion in bonus bids from the Chukchi, MMS geologist Kirk Sherwood told a meeting of the Alaska Geological Society on Nov. 13, 2008.

Reprint From Petroleum News Nov. 23, 2008 issue

So what's the big deal when it comes to oil and gas interest in this remote and weather-challenged region?

Essentially, an abundance of large geologic structures combined with a suite of rocks that is similar to those in the prolific petroleum province of Alaska's North Slope, Sherwood said.

"The Chukchi is structurally complex and because of that there are a lot of prospects," Sherwood said. "We've got about 850 that we've mapped out."

Of those prospects that MMS has identified, 83 are larger than 40,000 acres in extent, thus making them comparable in size to some of the North Slope oil fields, Sherwood said. And if any of those prospects hold oil and gas, they may be large enough for vi-

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able development.

"Our studies have indicated that for the large pools out there we do see tolerable development economics, despite the high cost of operating in that harsh environment," Sherwood said.

Three sequences

There are three major sequences of rocks in northern Alaska: Each sequence is associated with a major petroleum system and all three occur under the Chukchi Sea.

The first of the sequences, known as the Ellesmerian, involves rocks deposited southwards from an ancient landmass to the north of what is now the Beaufort Sea coast, from late Devonian through Triassic times. The Ellesmerian sequence includes the reservoirs for the Prudhoe Bay, Lisburne and Endicott fields. Sediments of the Ellesmerian sequence accumulated in a basin termed the Arctic Alaska basin that extends east to west under what is now the southern North Slope and Brooks Range Foothills and which extends west under the Chukchi Sea, where it veers northwest into what is known as the Hanna Trough.

The next sequence, known as the Beaufortian or rift sequence, resulted from the breaking apart or rifting of the Canada basin of the Arctic Ocean in Jurassic and early Cretaceous times. The rifting resulted in the formation of fault blocks, with sagging blocks between higher blocks. Deposition of sand into the sags gave rise to reservoir quality sandstones. The Kuparuk River, Alpine, and Milne Point fields, among others, involve Beaufortian reservoirs.

The rift sequence is associated with the formation of the Barrow Arch, a major structural high that extends along the Beaufort Sea coast and that guided the migration of petroleum to major oil fields such as Prudhoe Bay. The Barrow Arch extends west under the Chukchi Sea, where it bifurcates into two arches. One of these arches extends northwest, before veering to the southwest. The other arch veers southwest immediately, to pass near the center of the U.S. sector of the Chukchi.

The third major sequence, known as the Brookian sequence, formed in Cretaceous and Tertiary times as a result of the emergence of the Brooks Range. The emerging mountain range caused sediments to flow into a huge basin, known as the Colville basin, under what is now the North Slope. That basin extends west under the Chukchi. Brookian sediments also spilled out over the Beaufort Sea continental shelf and into the North Chukchi basin in the northern part of the Chukchi Sea. Fields such as Meltwater, Tarn and West Sak are associated with the Brookian sequence.

seismic and well data

Much of what is known about the geology under the Chukchi Sea has emanated from the approximately 100,000 line-miles of 2-D seismic that was shot in association with the lease sales of 1988 and 1991, and from the five Chukchi Sea wells that were drilled during that era, Sherwood said.The five wells were called the Popcorn, Crackerjack, Diamond, Burger and Klondike.

To some extent, the 2008 lease sale represented a rerun of the earlier sales, with 172 of the tracts leased in 2008 having been leased previously, Sherwood said. However, companies involved in the 2008 sale did not seem interested in the Brookian plays that had attracted some bids in the previous sales. But Brookian plays in what is referred to as the foreland fold belt, in the southern part of the Chukchi Sea planning area, were excluded from the 2008 sale, he said.

Nor did companies show any interest in plays in older rocks in the northeastern part of the Chukchi.

"What everyone seemed to be going for (in 2008) focused on the plays relating to the Ellesmerian and the Rift sequences," Sherwood said.Almost all of the leases are on extensions of the Barrow Arch, he said.

And 91 percent of the high bids in the 2008 sale clustered around the Burger, Klondike and Crackerjack structures.

"That tells you where the exploration interest is being focused in the Chukchi Sea," Sherwood said."... They have favorable locations relative to the Chukchi oil generation kitchen and they are large prospects with opportunities that remain untested by existing wells."

And, although the Chukchi wells did not discover any oil pools that people viewed as economic at the time of the drilling, the wells did encounter hydrocarbons.

So what exactly did the wells find that continues to spark exploration attention? And what might the companies that bought leases in 2008 be looking for?

Burger gas field

The Burger well discovered a major gas field in a 107-foot-thick, rift-sequence sandstone occupying a huge dome-shaped structure, Sherwood said. And part of the Burger structure attracted the highest single bonus bid in the 2008 sale.

"The sandstone was gas saturated with about 86 feet of pay.... Pressure data indi-



cated a possible gas-water contact 415 feet below the depth of penetration of the well," Sherwood said.

The well was abandoned at a depth of 8,202 feet when the drillers lost mud circulation in a tarry rock, he said.

The part of the structure most likely to be productive encompasses an area of 97,000 acres, while the area of the structure delimited by a possible spill point for the reservoir is almost 200,000 acres in extent, Sherwood said. Sherwood said that he and MMS geologist Jim Craig estimated that the Burger structure might contain 14 trillion cubic feet of natural gas, with a possible range from 2 tcf to 63 tcf. The high level of uncertainty in the estimate reflects the





3701 East Tudor Road, Anchorage AK 99507-1259 Phone: 907-337-6179 www.garnessengineering.com fact that only one well has penetrated the structure, he said.

However, if the 14 tcf estimate proved correct, that would represent a substantial increase to the 35 tcf of gas reserves known to exist in the central North Slope, Sherwood said. The Burger reservoir also contains some condensate, he said.

But one intriguing question at Burger is whether there is oil under the gas. The sidewall cores in the well showed a small, residual oil saturation, suggesting that the reservoir may have once contained oil that the gas later displaced, Sherwood said.

"That opens up the possibility of an oil ring or an oil column beneath the gas accumulation at Burger," he said. However, an investigation of the chemical data from the well has failed to either prove or disprove the presence of an oil pool, he said.

The Klondike prospect

The Klondike well tested a structure on the east flank of the Chukchi Platform, an area on the west side of the Hanna Trough. The well drilled into the lower part of the Sadlerochit Group, the set of Ellesmerian rocks that includes the Ivishak formation; the Ivishak forms the main reservoir in the Prudhoe Bay field. Unfortunately, at Klondike the rocks equivalent to the Ivishak turned out to be barren shales, rather than the sandstone reservoir rocks that are found at Prudhoe Bay.

"This, I think, was very bad news for the concept of exploring for traditional North Slope Ivishak formation reservoirs out here in the Chukchi, on the west side," Sherwood said.

The well did sample some oil and there is further exploration potential around the Klondike structure, Sherwood said. There may be a play where the rocks of the rift sequence thicken around the edge of the structure and there may also be a play in deeper

continued on page 57



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Shell still in holding pattern

ALAN BAILEY Petroleum News

Shell's drilling program remains in a holding pattern, with the drilling fleet at Dutch Harbor, while the company waits for the sea ice to clear from the area of its planned drilling site in the Chukchi Sea.

"Sea ice still lingers over our prospects and the earliest entry still appears to be the first week in August," Shell spokesman Curtis Smith told Petroleum News in a July 25 email.

Drilling permits

Shell also still needs drilling permits from the Bureau of Safety and Environmental Enforcement. The issue of those permits will require Coast Guard certification of the Arctic Challenger, the oil containment barge that Shell plans to station in the Arctic as part of its oil spill contingency arrangements.

"We are making good progress on the containment barge and working closely with the Coast Guard to present final construction projects for sign-off as they are completed," Smith said.

And the Environmental Protection Agency has yet to intimate its position on Shell's request to change the air quality permit for the Noble Discoverer, the drillship that Shell plans to use in the Chukchi Sea. Shell has also requested changes to the air permit for the Kulluk, the floating drilling platform that the company wants to use for its Beaufort Sea drilling. However, under the terms of the Kulluk permit, Shell can use the rig while EPA reviews the change request.

Shell had been planning to drill up to two wells in the Beaufort Sea and up to three wells in the Chukchi Sea during this year's Arctic open water season. The delayed start to the drilling will likely result in the completion of fewer wells than the company had intended, Smith told Petroleum News July 26. However, the company will probably drill some top holes at some drilling locations, to achieve a head start on drilling in 2013, Smith said.

Challenger certification

In a couple of recent emails to Petroleum News Cmdr. Christo-



pher O'Neil of the U.S. Coast Guard has explained the situation regarding the certification of the Arctic Challenger, characterized by O'Neil as "a unique vessel."

In December, the Coast Guard had accepted a proposal by Shell to certify the barge under the standard for a floating production installation. But in early July, Shell, saying that the barge could not meet that standard, proposed to the Coast Guard that the certification should instead be done under the standard for an offshore mobile drilling unit. Certification is required because of significant modifications to the barge as a consequence of retrofitting the new containment system.

The U.S. Coast Guard has accepted Shell's proposal for the change in the certification standard, O'Neil said.

"The Coast Guard accepted this proposal on July 13, 2012, and requested Shell provide calculations demonstrating compliance with that standard," O'Neil wrote in a July 25 email. "The Coast Guard is still awaiting data it requested from Shell."

And with construction on the vessel not yet complete, the Coast Guard cannot yet certify the vessel for safe operation, O'Neil wrote in an email on July 20.

"Major safety and operational systems are still being installed, tested and certified, and required tests such as an inclining experiment have not yet been performed by the shipyard," O'Neil wrote. "As construction items and plans are completed by Shell and the shipyard, the Coast Guard and ABS (the American Bureau of Shipping) have inspectors standing by to review and inspect them."

continued on page 57



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North Slope 🔀 Billions left in North Slope

BY KAY CASHMAN Petroleum News

here's a common misconception that, with production from major oil fields in northern Alaska declining, the North Slope has become a mature oil and gas province.

While it's true that most of the larger and easier structural plays, particularly onshore, have been drilled, it's also true that many stratigraphic, and some structural, plays have yet to be discovered or tapped, as evidenced by the arrival of Repsol on the North Slope and by stepped up exploration in the winter of 2011-12, especially close to existing infrastructure.

Success in the Tarn and Alpine fields in the late 1990s moved exploration attention away from the big Prudhoe Baystyle structures toward stratigraphic traps on-and near-shore the North Slope.

At the same time, the Northstar field, largely in state waters and the first Arctic project with a subsea oil pipeline, demonstrated continued success with structural reservoirs.

In general terms, people widely recognize the petroleum systems of northern Alaska as hydrocarbon-rich but reservoirpoor. So, with an abundance of excellent source rocks and a relative shortage of reservoir-quality rock formations, any isolated stratigraphic trap — a hydrocarbon trap formed by the juxtaposition of reservoir and seal rocks in the rock strata stands a good chance of containing oil or gas.

Thanks to sustained high oil prices, new found capabilities of high-end 3-D seismic techniques to find stratigraphic traps, the use of horizontal drilling, including the latest advancements in hydraulic fracturing, improved the ability to produce from low permeability reservoirs, so more North Slope accumulation became economic to produce.

Classic North Slope plays

The classic North Slope oil and gas plays occur along a structural high known as the Barrow Arch under the Beaufort Sea coast of the North Slope. These plays originated from the discoveries of oil fields like Prudhoe Bay and Ku-

2012 ANS discoveries

Pioneer touts Nuna: A 50 million barrel discovery south of Oooguruk http://www.petroleumnews.com/pnads/87988191.shtml

A Third Phase: Brooks Range Petroleum aiming for the era of the small independent http://www.petroleumnews.com/pnads/491885183.shtml

paruk River many years ago.

The Prudhoe Bay field consists of a giant combined structural and stratigraphic trap involving Triassic sandstone reservoirs in a Mississippian to lower Cretaceous sequence of sediments known as the Ellesmerian sequence.

Companies are still looking for opportunities in the Ellesmerian, especially near existing oil and gas infrastructure, where there are numerous such structural plays.

The reservoirs for the Kuparuk River field involve sandstones in what's called the Beaufortian or Rift sequence of Jurassic or lower Cretaceous age - the deposition of the sandstones is associated

with rifting or pulling apart of the Earth's crust that occurred during the opening of the Canada basin of the Arctic Ocean.

Although some of the Beaufortian sands can be thin and discontinuous, other areas of more continuous sands give rise to large reservoirs.

Basically, you get a huge range of potential sizes in the same rift breakup sequence but there are a lot of plays in the 20 million to 70 million or 80 million barrels size.

"There are still plays in the 300 million, 400 million or 500 million to a billion-plus size - they're still out there, but they're almost all stratigraphic," Mark Myers, former director of Alaska's Divi-

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sion of Oil and Gas and the U.S. Geological Survey, told Petroleum News in 2011.

Success with Alpine, the main field in the Colville River unit that came online in 2001, and its Beaufortian Jurassic sandstone reservoir, spurred interest in similar Jurassic plays. There is a series of upper Jurassic sands just below the Alpine sands:"There's at least a billion barrels in place, we think, in that trend," Myers said.

Brookian stratigraphic plays

There is a major Cretaceous and Tertiary sequence of petroleum bearing sedimentary rocks above the Ellesmerian and Beaufortian sequences in northern Alaska. Known as the Brookian sequence, this younger rock sequence extends all the way from the northern edge of the Brooks Range out over the North Slope and across the continental shelves of the Beaufort and Chukchi seas.

Stratigraphic plays involving topset or turbidite strata in submarine fans typify this Brookian sequence.

"Some of the ... submarine fans are very large," Myers said: "If you had reservoir quality and if you had closure you could approach the billion-barrel mark in some these if you had structural fill."

Then there are other situations where you may find smaller fans with as little as 20 million barrels of oil and where several smaller fans stack together the combined volume of oil could reach around 100 million barrels.

National Petroleum Reserve-Alaska

ConocoPhillips with its partner Anadarko Petroleum has been spearheading exploration and development west from the Colville River Delta, at the western extremity of existing North Slope oil infrastructure, into the northeastern part of NPR-A.

A series of wells drilled in the area by the partners since the renewal of leasing in NPR-A in 1999 have tested Alpine-equivalent prospects and have yielded discoveries of light oil, condensate and gas in stratigraphic traps, overlooked before the advent of 3-D seismic imaging.

The accumulations can be viably developed by extending the oil pipeline infrastructure west from their Colville River unit, which contains the first North Slope fields developed exclusively with horizontal well technology.

The unexpectedly prolific sands at Alpine, discovered in 1994 and put online in 2000, opened the door to extending a new Beaufortian play beyond the Prudhoe-Kuparuk infrastructure. The concept is to progressively move farther and farther west into NPR-A, opening up new oil pools as access to the pipeline infrastructure becomes available.

ConocoPhillips, Anadarko and others have also explored much farther west in NPR-A, but viable oil and gas development at such large distances from existing oil infrastructure would require a major oil find of at least 1 billion barrels.

If Shell, ConocoPhillips, Statoil and others develop their Chukchi Sea leases 100 miles offshore NPR-A, a pipeline across the reserve would open it, making it economically viable to drill a number of the larger structures there.

Armstrong latest coup

In October 2001, Armstrong Oil and Gas, a Denver independent, bought its first leases in the state's areawide North Slope and Beaufort Sea lease sales, leading to the development of the

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Minerals Overview 🔀

Most of Alaska's vast expanse is an accumulation of terranes that, riding on the backs of tectonic plates, have crashed onto the western shores of the North American continent. This dynamic geological history has contributed to the rugged beauty and immense mineral wealth of the Last Frontier.

Alaska blazes trail to mineral wealth

'Roads to Resources' stretches into resource-rich regions of Last Frontier

BY SHANE LASLEY Mining News

From the world-class Kennecott and Treadwell mines of days gone by to the massive Pebble, Donlin Gold, Arctic and Livengood deposits in line to become the state's next generation of superlative operations, Alaska has long been regarded as one of the most mineralized expanses of real estate on the planet.

When Canada-based think-tank Fraser Institute asked 490 mining executives to rank the mineral potential of the top 79 mining jurisdiction around the globe, the industry leaders voted the 49th state the most mineral-rich region on earth.

Alaska owes its rich mineral endowment and its rugged beauty to a dynamic geological history that spans eons. Most of the state — which is roughly twice the size of Texas with enough acreage left for Maine or South Carolina — is an accumulation of terranes riding on the backs of tectonic plates that crashed onto the western shores of North Amer-

ica.

"From a geologic perspective, Alaska occupies the space of a collision zone between the North American Plate and the Eurasian Plate. When you have two massive continents that have been bumping into each other for eons you get a lot of ground preparation, a lot of fracturing and obviously a lot of mineralization. That is fundamentally why Alaska

is such a good place to explore," explained Nova-Copper CEO Rick Van Nieuwenhuyse during a recent interview with Mining News.

Graphite, rare earth elements, ura-

nium, platinum group metals, tungsten and diamonds have been discovered amongst the gold, silver, zinc and copper that spilled across Alaska's landscape.

Yet, only a handful of mines dot the vast expanse of the Far North state.

When asked why Alaska's mineral po-

tential remains largely untapped,Van Nieuwenhuyse said, "It's pretty simple — lack of infrastructure and lack of power at commercial rates."

His contemporaries agree.

"Throughout our history, Alaskans have

blazed the trail for others. We are the

descendants of elders and pioneers who

pushed the boundaries of this Last

Frontier." — Gov. Sean Parnell, Alaska

The same group of mining executives that ranked Alaska as the most mineralized province on the planet placed the state a dismal 56th when it comes to infrastructure, according to the Fraser In-

stitute's "Survey of Mining Companies 2011/2012."

SHANE LASLE

This perception is not unfounded. Much of Alaska's resource wealth is locked up in a 350,000-squaremile expanse —

roughly the size of Texas and Oklahoma combined — that lacks roads and power.

"We are a young state; it is going to take a long time to get our infrastructure in place. It is an expensive place to operate; our geography and climate makes it



expensive," said Alaska Miners Association Executive Director Deantha Crockett.

Alaska is doing its part to overcome some of the challenges that face the fortune hunter seeking to explore and develop the immense mineral wealth of the Last Frontier.

Spearheaded by Alaska Gov. Sean Parnell, the state is investing millions in its "Roads to Resources" program to drive arterial routes into remote mineral- and oil-rich regions of the state. If realized, this endeavor would ultimately reach the limits of western expansion in North America.

"Throughout our history,Alaskans have blazed the trail for others. We are the descendants of elders and pioneers who pushed the boundaries of this Last Frontier. While these early Alaskans did not always know what challenges would arise between checkpoints, they never lost faith in where they were headed — to greater opportunity," Gov. Parnell said during his 2012 State of the State address. "Our journey today is no different. Rather than hunkering down and hoping for the best, it is time to act."

The state's 2013 budget also includes funding for streamlining the permitting process in Alaska, continued assessment of the state's rare earth element potential and a statewide digital mapping program. All of which are aimed at bolstering the development of the rich mineral resources of the Last Frontier.

"A thriving minerals industry is essential for Alaska's economic growth," said Alaska Department of Natural Resources Commissioner Dan Sullivan. "If Alaska were a country, we would be among the top 10 countries in the world for coal, zinc, copper, lead, zinc, and silver resources. By responsibly developing these resources, we have the potential to support the economies of entire regions of the state and help secure a stable domestic supply of minerals."

Copper Road

For the mineral industry, the most important infrastructure project being funded by the state may be a proposed road to the Ambler Mining District — a region of Northwest Alaska renown for a 70-mile-long belt of world-class volcanogenic



massive sulfide deposits rich in copper, zinc, lead, gold and silver that sweep across its breadth.Among the 50-some known prospects in this landlocked district are Arctic and Bornite, considered to be two of the highest grade deposits of copper on the planet.

Alaska's 2013 budget includes \$4 million towards defining an optimal transportation corridor linking the Ambler Mining District to the state's highway system

some 200 miles to the east; establishing a

Gov. Sean Parnell

right-of-way; and beginning the environmental and permitting work to build a road to the remote copper-rich region. The new funding adds to the \$5.25 million approved by the Alaska Legislature during the past two budget cycles for scoping the viability of establishing a transportation link to Ambler.

"Getting a road into a district like Ambler will unlock a lot of value and create a lot of jobs for multi-generations," said Van Nieuwenhuyse.

The NovaCopper leader has a professional interest in seeing ground transportation linking the Ambler District to world markets. His company and NANA Corp., the Alaska Native regional corporation for Northwest Alaska, have forged a partnership to explore and develop the Ambler District.



From gold mines to pipelines and everything in between, MSI President Laurie Fagnani and her campaign team have what it takes to help Alaska's resource development industries kick their communications into high gear.

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NORTH SLOPE: continued from page 32

Pioneer Natural Resources-Oooguruk near-shore field and the Eni Petroleum-operated Nikaitchuq near-shore field

Armstrong sold its northern Alaska assets to Eni, and turned to developing a gas field on the Kenai Peninsula.

But it returned to the North Slope and recently brought in Spanish mega-major Repsol in as a 70 percent partner to help it explore and develop nearly 500,000 acres on state leases onand near-shore. Repsol, which paid \$768 million for the privilege, immediately initiated an aggressive multi-year exploration program.

Lots of room

There is still lots of room for newcomers, per Kevin Banks, the former director of the Division of Oil and Gas — and some incredible exploration and development credits available. (Bill Barron, with 35 years of experience in the industry, took over as director in mid-2011.)

"The State of Alaska takes seriously our responsibilities to our leaseholders. We encourage exploration through innovative new programs, paying as much as 40 percent of exploration costs for qualified applicants, and we share our insight into how state and federal agencies interact to help companies navigate smoothly through exploration and development activities. Alaska is a resource development state. We view the people and companies exploring and developing our natural resources as our partners," Banks said in an editorial aimed at oil and gas companies interested in entering Alaska, or investing in those that are already here.

Governor's goal

Industry thinks the state's progressive production tax regime has some problems, as does Alaska's current governor, who wants to see the state's oil production increase to 1 million barrels from the 600,000 range.

The tax, commonly referred to as ACES, takes a lion's share of net profits when oil prices are high, in the \$100-plus range. It's very competitive, however, when prices are low, which is where they were when the new production tax was established in 2007.

Optimistic about long term

Myers feels optimistic about the long-term future of the oil industry in northern Alaska.

"I think we'll see just a tremendous amount more oil produced, especially from the stratigraphic plays over time," he said. "I think someone will stumble into that 500 million to a billion barrel field size."

And where is that next big find on state acreage?

In 2005, Myers said, "In the long term if I were to bet on a big prospect, the Brookian stratigraphic plays are where I'd put my money."

In 2011, he also included shale oil (see source reservoired oil section).

Editor's note: Learn more about the division from its website at http://www.dog.dnr.state.ak.us/oil/ Or contact its office: 550 W. 7th Avenue, Suite 800 & 1100;Anchorage, Alaska 99504. Phone: 907-269-8800.



Drilling in the Ambler region uncovered Arctic and Bornite, and the district has a multitude of prospects waiting to be tapped.

Arctic — the most advanced deposit in the district — has an indicated resource of 19.45 million metric tons averaging 4.05 percent copper, 5.8 percent zinc, 59.55 grams per metric ton silver and 0.97 g/t gold.Additionally, the deposit has an inferred resource of 11.41 metric tons averaging 3.47 percent copper, 4.84 percent zinc, 46.75 g/t silver and 0.80 g/t gold.

A preliminary economic assessment completed by SRK Consulting (U.S.), Inc. investigated the viability of a 4,000-metric-ton-per-day underground operation at Arctic that would produce 1.7 billion pounds of copper, 2 billion pounds of zinc, 291 million pounds of lead, 266,000 ounces of gold and 22 million ounces of silver over a 25-year mine life.

While studying the economics of building a mine at Arctic, SRK determined that extending a road westward from the Dalton Highway to the village of Kobuk, would be the best route for linking the copper-rich deposit to Alaska's road-system.

For purposes of the study, SRK assumed that the road would be designed and constructed by the state, and NovaGold would then reimburse Alaska over the operating life of the mine. A similar arrangement exists between the state and the Red Dog Mine in Northwest Alaska for its road and port facility.

The Delong Mountain Transportation System — consisting of a 52-mile-long road, storage and port facilities — was built by state-owned Alaska Industrial Development and Export Agency to facilitate the shipment of zinc and lead concen-



DNR Commissioner Dan Sullivan

trates from Red Dog. The agency is being reimbursed for its \$267 million investment through fees paid by Teck Resources Ltd. and NANA, co-owners of the mine.

Bornite, which is being advanced by NovaCopper and NANA, is another rich copper deposit at the western terminus of the proposed road to Ambler.

Drilling carried out at Bornite in 2011 cut 4 percent copper over 178 meters, including 11.4 percent copper over 34.7 meters.

Other projects in the Ambler region also would benefit from access. Andover Ventures Inc.'s Sun deposit, for example, has a historical resource of 20.3 million metric tons averaging 74 g/t silver, 1.9 percent copper, 4.5 percent zinc and 1.2 percent lead.

"You are talking about a whole district here at Ambler and the exploration has only scratched the surface, and it has already been very successful," said Van Nieuwenhuyse. "If there was a road into there,

you would be able to build at least two or three mines with what is already known there, and we have probably 50 (other) prospects with historic

drilling on at least half of them.

Road to Nome

The road to Tanana — the first leg of a proposed 500-mile highway to the legendary mining town of Nome — is another ambitious project being studied under Alaska's Road to Resources program.

While the "Road to Nome" idea is not targeting any specific mining region as it wends its way to the Seward Peninsula, it would serve as an artery through the center of vast, mineralrich western Alaska.





The preferred route for building a 500-mile road to Nome begins near the end of the Elliot Highway. From here the envisioned highway heads west to the village of Tanana where it would roughly parallel the fabled Yukon River for much of its route to the limits of North America's western expansion.

The preferred route for building what would be the final leg of U.S. westward expansion begins at Manley Hot Springs near the end of the Elliot Highway. From here the envisioned



highway heads nearly due west for some 70 miles to the village of Tanana where it would cross to the north side of the Yukon River. From Tanana, the artery would roughly parallel the historical waterway for much of the route as it continues to the westernmost reaches of Alaska.

The state proposes building this ambitious project in seven stages — an endeavor that will take a number of years to complete.

Mining companies seeking to develop the Donlin Gold and Pebble projects are not waiting for the state to build infrastructure to their mega-deposits in western Alaska.

The 40-million-ounce Donlin gold deposit — being developed by Barrick Gold Corp. and NovaGold Resources Inc. — highlights the vast mineral potential of western Alaska and the expense of building a mine there.

It will cost nearly \$7 billion to build the mine facilities and supporting infrastructure at the enormous deposit located in the Kuskokwim Mineral Belt of Southwest Alaska, according to preliminary estimates released last September.

Affordable power is the biggest impediment to operating in this remote region. To address this, Donlin's developer plans to build a natural gas pipeline some 300 miles northwest from Alaska's Cook Inlet to the massive gold deposit. While a 12inch line would more than meet the needs of the mine, Donlin Gold is considering a 14-inch line to accommodate future expansion and to supply gas to other users in the Kuskokwim region.

"It is a vastly underexplored area, it is remote and it is expensive to operate there with the lack of infrastructure, but I suspect that will change when we get Donlin built," NovaGold founder Van Nieuwenhuyse said.

smoothing the trail

In addition to advancing projects to establish transportation corridors toward resource-rich regions of western Alaska, Parnell intends to smooth the way for companies seeking to gain permissions to extract these resources. To that end the governor's budget includes \$3.3 million for streamlining the state's permitting process.

The governor said that between 85 percent and 90 percent of Alaska's general fund revenue comes from the development and use of state's land and natural resources. Streamlining the



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This core drilled at the Bornite deposit in the Ambler Mining District of Northwest Alaska returned 34.7 meters averaging 11.4 percent copper. Under its "Roads to Resources" program, Alaska is studying the viability of building a 200-mile road to this remote, copper-rich corner of the Far North state.





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907.258.4704 www.judypatrickphotography.com permitting process would provide for timely decision-making for mining, timber, public access, land sales and transfers, and other resource development applications.

"Mineral exploration expenditures are up, and with our efforts to streamline the permitting process, we are working to secure Alaska's resources for Alaskans' benefit," Parnell said.

Alaska has secured \$15.9 million — \$3.7 million from the state's general fund, with the balance from federal funds — in this year's budget to initiate a statewide digital mapping program.

"One thing often overlooked in growing an economy is the value of a good map. USGS (United States Geological Survey) topographic maps of Alaska are more than 50 years old, inaccurate, and do not meet national mapping standards," Parnell explained. "Accurate elevation data is vital to responsible resource and economic development, aviation safety, navigational devices, modern-day emergency response, and routing for roads and pipelines."

Assessing Alaska's rare earth element and critical minerals potential has been a priority for Parnell. During the 2012 budget cycle, Alaska lawmakers approved \$498,000 proposed by the administration to begin a statewide REE evaluation. This year's budget includes \$2.7 million for a three-year project to continue this initiative.

"The timing is right for rare-earth development," Parnell told an audience at the Strategic and Critical Minerals Summit held Sept. 30 in Fairbanks. "We're on track to assess, incentivize and develop the rare earth elements we can provide the world."

From mapping Alaska's potential to blazing trails across its vast, rugged landscape, the state has set out to smooth the way for those who hunt for mineral fortunes on the Last Frontier.





Gold is where you find it in Alaska

Mammoth deposits only begin to account for legendary alluvial aurum districts

BY SHANE LASLEY Mining News

old is where you find it! Whether taken literally or metaphorically, this old adage is guiding a throng of modern fortune hunters to Alaska. Today, the Far North state has four hardrock mines churning out some 800,000 ounces of gold per year and with three enormous projects set to begin seeking operating permits this output could easily top 3 million ounces annually.

"I think it is significant that Alaska is the No. 2 gold producer in the United States. It is right behind Nevada and gaining ground. When you get projects like Donlin Gold into production it will start rivaling Nevada," said NovaCopper President and CEO Rick Van Nieuwenhuyse.

Over the past 25 years, explorers have outlined Pebble, Donlin Gold and Livengood - enormous accumulations of gold that are measured in the tens of millions of ounces. Though globally significant, these projects only begin to account for some 25 million ounces of placer gold recovered from the vast and underexplored expanse of Alaska.

"I think there is tremendous exploration opportunity in all of the alluvial districts that Alaska has. There are probably 50 districts in Alaska that have produced more than a quarter-million ounces of gold," said Van Nieuwenhuyse.

With only the oil-rich plains of the North Slope lacking an aurum discovery, Alaska is truly the Last Frontier for hunting mam-



Though globally significant, mega-gold deposits such as Donlin, Livengood and Pebble only begin to account for some 25 million ounces of alluvial aurum recovered from the vast and underexplored expanse of Alaska.

moth gold deposits in the United States.

TGB East

The Tintina Gold Belt is a popular destination in North American for fortune hunters seeking the next multimillionounce gold deposit in Alaska. World-class deposits at Fort Knox, Pogo, Donlin and Livengood only begin to account for the hardrock source of more than 17 million ounces of alluvial gold recovered from the vast aurum province that sweeps some 850 miles across the breadth of the state.

Alaska's portion of the Tintina Gold Belt can be divided into two distinct groups — the eastern extent, which runs from the Alaska-Yukon Territory border some 300 miles into the state, and the 74,000-square-mile Kuskokwim Mineral Belt in southwestern Alaska.

The eastern half of Alaska's Golden Arch is home to the state's two biggest gold operations - Kinross Gold Corp.'s Fort Knox Mine and Sumitomo Metal Mining's high-grade, underground mine at Pogo.

Though in terms of size. International Tower Hill Mines' Money Knob gold de-

posit at Livengood substantially outweighs its Interior Alaska neighbors. Similar in grade to Fort Knox about 70 miles to the southeast, Money Knob is the first significant lode discovery in Tolovana, a district that has produced some 600,000 ounces of placer gold.

Since 2006, Tower Hill has expanded Money Knob from an ob-

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scure prospect to a world-class ore-body encompassing 20 million ounces of gold.

The significance to contemporary gold explorers is that this recent top-tier gold discovery sits adjacent to, and potentially under, the Elliot Highway — demonstrating that even easily assessable regions of Alaska are woefully underexplored.

"I think Livengood underscores the lack of exploration that has been done in the region. Each one of these major placer gold districts — and there are quite a few of them — have a lode source and by-and-large these have not been explored for in any great detail," said Van Nieuwenhuyse.

The Circle Mining District, situated about 100 miles east of Livengood, and the Fortymile Mining District adjacent to the Yukon Territory border are two such promising areas.

Circle and the other mining districts in the eastern extent of the Tintina Gold Belt share a common geologic and glacial history to the celebrated White Gold and Klondike districts in neighboring Yukon.

This parallel begins to explain why the lode source of the placers remains hidden and hints at the techniques that could discover the hidden gold.

"There are a lot of these alluvial districts out there where gold has accumulated through weathering processes over the years but there is no outcrop," explains Van Nieuwenhuyse.

Full Metal Minerals Ltd. — which shared its managers and geologists with Underworld Resources Inc. during that junior's exploration of the renowned White Gold deposit in the Yukon — is applying similar exploration techniques in Alaska.

Recognizing the belt of Cretaceous-age deposits, prospects, and placer gold mines of Yukon's White Gold district trends into Alaska,

Full Metal geologists surmised that similar mineralization might be the undiscovered lode of more than half a million ounces of placer gold recovered from streams draining the rolling hills of the Fortymile district some 60 miles to the northwest.

Using placer gold-producing streams to vector their search, Full Metal geologists have traversed the hilltops and ridges of the ju-

nior's Rolling Thunder claims in the Fortymile. This reconnaissance sampling and mapping has identified multiple areas of strong alteration and quartz veining reminiscent of White Gold.

Full Metal is applying the same system to seek the hidden lode of some 1 million ounces of placer gold recovered from the streams of the Circle district. Like the Fortymile, Klondike and White Gold districts to the east, bedrock exposure in the Circle region is very limited, with soil sampling the most effective reconnaissance tool in this unglaciated terrane.

Though legendary placer mining districts are compelling targets, fortune hunters should not limit their

search to these areas. The Goodpaster Mining District, for example, has only produced about 2,000 ounces of alluvial aurum, yet it is home to Pogo, Alaska's most prolific gold mine.

With ore that averages about 14 grams per metric ton, the 2,500-metric-ton-per-day underground operation at Pogo churns out some 380,000 ounces of gold per year.

Geologists believe that Pogo is only the first economical gold deposit that will be discovered in this region between the Fairbanks and Fortymile districts.

"I honestly believe that there will be other ore-bodies found in that area — it very underexplored so far," said Millrock President and CEO Greg Beischer. "There is going to be more mines in that region."

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The Pyramid project — which hosts 125 million metric tons of near-surface mineralization grading 0.403 percent copper and 0.025 percent molybdenum — is being explored by Full Metal and Chile-based project partner Antofagasta Minerals S.A. This deposit underscores the porphyry potential of the Alaska Peninsula and Aleutian Islands — a 1,000-mile-long active island arc being formed as the Pacific Ocean plate dives under the North American plate.



The Pedro Gold Dredge, which mined some 55,000 ounces of gold from Chicken Creek in the legendary Fortymile Mining District of eastern Alaska, now serves as a tourist destination. The hardrock source of more than 500,000 ounces of placer gold recovered from this region is yet to be found.

The eastern half of the Golden Arch is also known to host goldenriched volcanogenic massive sulfide deposits and is highly prospective for porphyry gold-copper deposits.

Heatherdale Resources Ltd. is exploring precious metals-enriched VMS mineralization at its Delta project, located in the southern margins of the Tintina Gold Belt about 36 miles southwest of the town of Tok.

An inferred resource of 15.4 million metric tons grading 0.6 percent copper, 1.7 percent lead, 3.8 percent zinc, 62 g/t silver, and 1.7 g/t gold has been calculated for Delta. Explorers also found large massive sulfide boulders on the 39,840-acre (16,123 hectares) property that average 113 g/t silver, 7.3 percent lead, 5.6 percent zinc, 113 g/t silver and 0.7 g/t gold.

"Delta is an early-stage project, but it also represents an emerging massive sulfide district with the potential to be in the top tier of global districts of its type," Heatherdale President and CEO Patrick Smith said of the find.

Hints of porphyry gold-copper mineralization have been found in the Fortymile district and near Livengood in the Tolovana district.

Kuskokwim Mineral Belt

The geology of the Tintina Gold Belt begins to change as it continues westward from Livengood and begins to arc southwest. This sub-region — referred to as the Kuskokwim Mineral Belt — has produced some 4 million ounces of gold, 500,000 ounces of silver and more than 40 million ounces of mercury.

The 40-million-ounce Donlin Gold project — being developed by Barrick Gold Corp. and NovaGold Resources Inc. — is the crown jewel of the Kuskokwim. Over the past several years, majors and junior explorers alike have scoured this region in search of other large intrusive-related gold deposits, uncovering several promising prospects. "There are a lot of porphyries throughout that belt that are a similar age to Donlin so I think there is tremendous opportunity

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In the summer of 1906 this stack of gold bullion at the Miner's and Merchant's Bank in Nome, Alaska was valued at \$1.25 million by the photographer. About 10 million ounces of placer gold has been recovered from the Seward Peninsula since gold was discovered there in 1898.

there," said Van Nieuwenhuyse.

McGrath, a century-old gold mining town, serves as a hub for companies seeking Donlin-style porphyritic intrusive rock in the upper reaches of the Kuskokwim Mineral Belt.

Ganes Creek — which is famed for its enormous gold nuggets, including the 5th- and 13th-largest ever found in Alaska, at 122 and 62.5 troy ounces, respectively — is an alluvial stream about 25 miles west of McGrath that is reminiscent of Donlin.

This legendary stream has given up some 250,000 ounces of placer gold and an estimated 734,000 ounces of the alluvial aurum still remains. The coarse nature of the gold suggests that the lode is lurking in the nearby uplands.

Vinasale — found about 16 miles south of McGrath — is another intrusive-related gold project that demonstrates the promise of this gold-rich region. Freegold Ventures Ltd. — the junior exploring Vinasale — is expanding on some 1.33 million ounces of gold outlined here to date.

To the northeast of McGrath lies Ruby-Poorman — another Alaska mining district that has produced 500,000 ounces of gold with a yet-to-be discovered hardrock source.

"Ruby-Poorman is a 30- to 40-mile-long alluvial district that has produced a substantial amount of gold, yet there is not rock-one you can look at," explained longtime Alaska explorer Van Nieuwenhuyse. "We have got to build up that database of detailed geophysical surveys and get in on the ground and do some baseline auger-type sampling to see what's down there."



Besides Donlin Creek-style mineralization, the Kuskokwim belt also hosts Nixon Fork, a carbonate skarn deposit rich in copper, silver and high-grade gold. Mercury, antimony, tin, platinum, tungsten, rare earth elements, and native bismuth have been recovered with the placer gold found here.

Porphyry-rich SW Alaska

Paralleling the Tintina Belt to the south lie a band of mineralrich terranes, or related rock formations, drawing the attention of senior and junior miners. This arc consists of the Wrangellia Composite and Kahiltna terranes, two interrelated but distinct assemblages.

The Kahiltna Terrane — home of the enormous Pebble deposit — is highly regarded for its potential to host other worldclass porphyry copper-gold and intrusive gold deposits.

With its 80.6 billion pounds of copper, 107.4 million ounces of gold and 5.6 billion pounds of molybdenum, the Pebble deposit ranks amongst the world's largest for any of these metals — combined it is extraordinary.

Formed when the Wrangellia Composite Terrane thrust up the ocean floor as it collided with Alaska and pumped with copper and gold-bearing fluids at least twice, the more than 400-mile-long Kahiltna Terrane provides the ideal setting for explorers to search.

"The discovery potential is very high for porphyry deposits generally in this arc environment, but I would also say that Pebblelook-alikes are probably not likely. However, this does not preclude the potential to find other large porphyry deposits with their own unique sets of characteristics. So, we should not over-focus on the Pebble model, but we should focus more on the favorable environment that Pebble represents," Pebble Partnership Chief Geologist Jim Lang observed.

Though the Kahiltna assemblage is best known for its porphyry and other intrusive-related copper and gold projects, the region also is highly prospective for other styles of mineralization.

"All over the Kahiltna Terrane keep your mind open to any style of mineralization — it could be VMS, a skarn or a great big vein," Beischer said.

Southwest of Pebble, the Alaska Peninsula and Aleutian Island stretches some 1,000 miles out into the Pacific Ocean.

"I think the other area that is kind of forgotten is the Alaska Peninsula.You have Pebble out there, one of the largest metal accumulations on the planet.The rest of the peninsula ranks high in potential," said Van Nieuwenhuyse.

This island arc, formed as the Pacific Ocean plate dives under the North American plate, has received limited modern exploration and is prospective for both epithermal gold, and porphyry copper-gold mineralizing systems.

The Pyramid copper-molybdenum porphyry and the nearby Unga-Popov epithermal gold projects highlight the potential of the region.

Pyramid — which hosts 125 million metric tons of near-surface mineralization grading 0.403 percent copper and 0.025 percent molybdenum — is being drilled by Full Metal and Chile-based project partner Antofagasta Minerals S.A.

Unga-Popov — an epithermal gold project on an island about 25 miles (40 kilometer) south of Pyramid — hosts two historical resources; Apollo with 280,000 metric tons averaging 27.7 g/t gold and 92.6 g/t silver and Centennial, which has about 6 million metric tons at 1.5 g/t.

Legendary Seward Peninsula

From the 1898 gold strike made by the "Three Lucky Swedes" a

SHANE LASLEY



The Elliot Highway skirts the western flank of the 20-million-ounce Money Knob gold deposit at International Tower Hill Mines' Livengood project in Interior Alaska. This world-class discovery adjacent to Alaska's sparse roadsystem underscores the exploration potential of the Far North State.

few miles from Nome, to the Discovery Channel's reality series, "Bering Sea Gold", the Seward Peninsula is legendary.

Though this 20,600-square-mile isthmus in Northwest Alaska is one of the world's most prolific placer-producing regions, only about 30,000 ounces of lode gold has been mined there.

The rivers and beaches of the Nome Mining District itself produced more than half of the placer gold that lured tens of thousands of fortune hunters to this far western region of Alaska at the turn of the 20th Century.

"The (Nome) district has produced some 5 million ounces of alluvial gold.We certainly see the potential for additional targets there,"Van Nieuwenhuyse said.

Rock Creek, which NovaGold put on care and maintenance before reaching commercial production, is the only modern hardrock mine on the peninsula. Bering Straits Corp., the area's Alaska Native regional corporation, recently agreed to acquire the defunct operation and plans to put it into operation.

Exploring two Seward Peninsula gold properties, Millrock Resources is among the most tenacious of the contemporary explorers in the region. This junior, in partnership with Kinross, is gearing up to drill Council, a 900-square-mile land package that blankets a region that has produced some 500,000 ounces of placer gold.

NANA Regional Native Corp. — Bering Straits Corp's traditional neighbors to the north — is seeking the lode source of some 580,000 ounces of alluvial aurum recovered from the Fairhaven Mining District on the north coast of the Seward Peninsula.

Exploration by NANA has outlined an orogenic-stratabound gold system adjacent to the Kugruk Fault. Geologists have picked up rock samples assaying up to 9.4 g/t and 7.6 g/t silver at Motherwood Point, where this fault zone meets the northern shore of the Seward Peninsula.

"There is very little outcrop on the northern part of the Seward Peninsula — those districts have produced a fair bit of gold, and there is known copper and zinc occurrences all through that country," said Van Nieuwenhuyse.

Due to the lack of outcrop, NANA geologists are using geochemical surveys to refine their search of this gold-rich region located at the southern margin of their traditional territory.

Big Arctic nuggets





Sumitomo Metal Mining's Pogo Mine produces some 380,000 ounces of gold per year, making it the most prolific aurum producer in Alaska. Geologist familiar with the region believe other economic gold deposits will be discovered in the Goodpaster Mining District where Pogo is located.

The Brooks Range — a chain of mountains that spans the more than 600-mile-width of Alaska north of the Arctic Circle — marks the northern extent of known gold mineralization in Alaska.

Chandalar and Koyukuk-Nolan districts along the southern slopes of the central portion of this mountain chain are particularly rich placer-gold regions. High-grade orogenic veins are the suspected source of the large gold nuggets found in these placer districts located above the Arctic Circle about 200 miles north of Fairbanks.

"Those are very rich gold deposits so I am a bit surprised that there hasn't been more work there,"Van Nieuwenhuyse commented on these Brooks Range gold districts.

An estimated 84,000 ounces of gold has been recovered from the Chandalar district. About 76,000 ounces of the yellow metal, or about 90 percent of the total, was alluvial gold found in the stream beds and frozen bench gravels. Most of the remaining 10 percent of the total was recovered from the Mikado Lode.

Goldrich Mining Co., a junior mining company that holds claims over most of the Chandalar district, said Mikado is one of about 30 auriferous quartz-sulfide veins that are now documented on the property. Very little modern exploration work has been completed at Chandalar.



3701 East Tudor Road, Anchorage AK 99507-1259 Phone: 907-337-6179 www.garnessengineering.com The Koyukuk-Nolan district, which lies directly west of Chandalar, has produced about 350,000 ounces of placer gold. The region is well-known for producing large nuggets. The third (146 troy ounces), fourth (137 troy ounces), 14th (61 troy ounces) and 17th (55 troy ounces) largest gold nuggets ever found in Alaska were mined on the Hammond River, a tributary to the Koyukuk River.

A lode source for these big nugget producing placers is yet to be discovered.

Juneau Gold Belt

Alaska's gold potential was recognized in 1880 when Auk Chief Kowee, a Tlingit from Admiralty Island, led prospectors Joe Juneau and Richard Harris to the headwaters of the appropriately named Gold Creek.

A year after the find credited to Juneau and Harris, operations began at the Treadwell gold mine situated southeast of Juneau. At its peak, Treadwell employed 2,000 Juneau residents and was the largest gold mine in the world. From 1881 to 1922, more than 3 million troy ounces of gold were extracted from the mine.

The Treadwell Mine lies in the 100-mile-long Juneau Gold Belt, an orogenic gold district that has produced more than 7 million ounces of gold.Today, Coeur d'Alene Mine Corp.'s Kensington Mine about 45 miles north of Juneau is the only current gold operation in Southeast Alaska.

Herbert Glacier, located midway between Treadwell and Kensington, demonstrates the prospectivity of this belt. One hole drilled by Grande Portage Resources Ltd. in 2011 cut 15.3 meters averaging nearly 1.1 ounces per metric ton gold. An initial resource estimate outlines a deposit of 1.57 million metric tons averaging 4.86 g/t gold.

A 450-mile long belt of late-Triassic volcanogenic massive sulfide deposits stretches along the entire length of the Southeast Alaska panhandle encompasses such metals-rich deposits as Niblack, Greens Creek, Palmer and, as the belt continues into British Columbia, Windy Craggy.

Explorers are also finding high-grade orogenic gold in Southcentral, a region noted for historical high-grade gold mines. The historical Independence and Lucky Shot gold mines in Southcentral are just a few examples of historical high-grade gold regions that hold promise for the contemporary fortune hunter.

Tomes can be, and have been, written about Alaska's gold potential, and more chapters are sure to be added as fortune hunters continue to make new discoveries in this vast aurum-pro-



Goodnews beckons with PGM prospects

From placer streams to historical mines, hints of elusive metal span Alaska

BY SHANE LASLEY Mining News clinopyroxene veins in the area.

Prime hunting grounds

ints of the enigmatic platinum group metals — platinum, palladium, rhodium, iridium, osmium, and ruthenium — have been found across Alaska.

"You have Goodnews Bay sitting there, and from Salt Chuck through Goodnews Bay, there is a whole belt of those Ural-Alaska types that could be explored," said Dave Szumigala, former senior minerals geologist at the Alaska Department of Natural Resources Division of Geological & Geophysical Surveys.

For the fortune hunter seeking platinum, a town named after the elusive metal seems to be an obvious choice.

The Goodnews Bay district of Southwest Alaska, where the town of Platinum is located, is the only current platinumproducing region in the state. Though an economic PGM lode-source has yet to be found there, about 650,000 ounces of the rare metals have been recovered from

placers of the Salmon River drainage. XS Platinum — an unlisted public company — is using modern gravity separation techniques to recover fine-grained platinum, palladium and gold left in the tailings of dredge operations of days gone by.



Dave Szumigala

An Ural-Alaska-type ultramafic complex is believed to be the lode source of this historical placer production. Claims held by XS Platinum cover hardrock prospects that are believed to be the source of the precious metals found in the alluvial deposits.

Rock samples taken from an outcrop on Red Mountain at the head streams feeding the Salmon River returned assay results up to 2.27 grams per metric ton platinum. Geologists also discovered platinum and palladium enriched magnetite The Wrangellia Composite Terrane a series of associated assemblages that span some 1,250 miles from Southeast Alaska through Southwest Alaska is prime PGM hunting grounds.

During its heyday, the Salt Chuck Mine

located on Prince of Wales Island in Southeast Alaska was the top palladium producer in the United States. From 1915 to 1941, this Southeast Alaska operation produced some 300,000 metric tons of ore averaging 0.95 percent copper, 1.96 g/t palladium, 1.12 g/t gold and 5.29 g/t silver, according to U.S. government summaries (1948).

One hole drilled at Pure Nickel's Man project in 2010 cut 165.9 meters averaging 0.253 grams-per-metric-ton platinum plus palladium, including 0.318 g/t platinum and palladium over 24 meters.





The community of Platinum was founded in 1926 shortly after Yup'ik residents Walter Smith and Henry Wuya discovered the town's namesake in the streams of the Goodnews Bay Mining District.

Though Salt Chuck was never put back into production after its wartime shutdown, a 7,000-meter-by-1,600-meter mafic-ultramafic igneous complex is prospective for the metals recovered at the bygone operation.

Pure Nickel plans to test this prospective geology with a drill program scheduled for the last half of 2012.

From Salt Chuck to Brady Glacier, located some 300 miles to the northwest, a number of PGM prospects have been discovered along the entire Southeast Alaska Panhandle.

The Wrangellia Composite Terrane continues northward into Yukon Territory before arcing back into Alaska. Prophecy Platinum Corp.'s Wellgreen PGM-nickel-copper project is found in the assemblage as it sweeps through southwestern Yukon.

Pure Nickel Inc. is seeking similar ultramafic-associated mineralization at Man, a PGM-nickel-copper project located in Alaska's Wrangellia Terrane about 250 miles northwest of Wellgreen.

In 2010 Pure Nickel discovered two horizons at Man reminiscent of the PGM-layered intrusions found at the Bushveld Complex of South Africa. One hole drilled that year cut 165.9 meters averaging 0.253 g/t platinum plus palladium. Horizon 2, included in this intercept, cut 0.318 g/t platinum and palladium over 24 meters.

Chip-Loy, located some 250 miles southwest of Man, is a cobalt-copper-nickel prospect that has geochemical markers associated with platinum metals.

Chip sample intervals from the deposit run up to 3.3 percent nickel, 0.25 percent cobalt, 2.1 percent copper, 12.1 g/t silver,





This dredge, put into operation by Goodnews Mining Co. in 1937, recovered the majority of the 650,000 ounces of platinum extracted from the Salmon River area of Southwest Alaska.

and 43.2 percent iron.

Tetradymite was found in the samples taken from Chip-Loy in the 1980s. Though this bismuth-tellurium-sulfide mineral is commonly associated with platinum, PGM have yet to be discovered at this prospect.

Intriguing sniffs

While the Wrangellia Composite Terrane is considered the best place in Alaska to hunt for platinum, a number of prospects exist beyond this belt.

From the Seward Peninsula in western Alaska to the Fortymile district adjacent to the Yukon border, small amounts of alluvial platinum have been recovered as a by-product of gold mining. These anomalous occurrences underscore the potential of discovering PGMs across Alaska's vast gold-producing districts.

The Valdez Creek Mining District, located about 65 miles southeast of Fairbanks, is one such region. According to a 1988 U.S. Bureau of Mines report, concentrates from 52 alluvial samples collected from placer gold streams in the district contained measurable quantities of PGM elements.

One sample from Gold Creek contained 3,100 parts-per-billion platinum; another sample from Tyone Creek measured 4,100 ppb platinum and 280 ppb palladium, while a sample from Fourth of July Creek returned 2,500 ppb platinum.

Late Triassic flood basalts characteristic of the Wrangellia Terrane have been found through the Talkeetna Mountains some 50 miles southwest of the known extent of the assemblage, according to a report by U.S. Geological Survey geologist Robert Kelley.

No ultramafic rocks have been mapped to date in this possible extension of the Wrangellia, but field geophysical data suggest the possibility of buried ultramafic bodies, and nickel-copper-PGM stream sediment geochemical anomalies occur in close proximity to the basalts.

"What's intriguing is there are sniffs in a number of places. All it takes is for someone to come up with a model that makes sense, which could lead to a lot of exploration and/or discoveries," observed Szumigala, who now works for Kinross Gold Corp. "But, with the conventional models, these little hits here and there have not evoked an exploration target looking totally at platinum."





Hecla Mining Co.'s Greens Creek Mine in Southeast Alaska recovered some 6.5 million ounces of silver in 2011, making it the top-producing silver mine in the United States.

Alaska reigns as top silver producer

Poor man's gold enhances luster of a number of deposits in Far North state

SHANE LASLEY Mining News

Thanks largely to the 6.5 million ounces of silver produced at Hecla Mining Co.'s Greens Creek Mine in 2011, Alaska remains the United States' top producer of "poor man's gold."

The nation's top silver-producing mine is situated in the middle of a 450-mile-long belt of late-Triassic VMS deposits that spans the Southeast Alaska panhandle and extends to the north, encompassing the Windy Craggy deposit in British Columbia.

Volcanogenic massive sulfide deposits similar to Greens Creek hold great promise for fortune hunters seeking the white metal in Alaska.

At some 8 million tons of reserves averaging 421 grams per metric ton silver, 3.2 grams per metric ton gold, 9.2 percent zinc and 3.5 percent lead, Greens Creek is by far the most silver-enriched of the known deposits along this trend.

Woewodski Island is one Southeast Alaska prospect that demonstrates promise to be a Greens Creek contemporary.A hole drilled by Bravo Ventures Group Inc. in 2003 cut 1.8 meters grading 222 g/t silver, 6.34 percent lead and 16.15 percent zinc and underscores the potential of the prospect. But limited drilling has uncovered no signs of thick zones of high-grade massive sulfides there.

Prince of Wales Island, found at the southern tip of the Southeast Alaska panhandle, is home to several promising silverrich VMS prospects. The best known of these is Heatherdale Resources Ltd.'s Niblack project, which contains has an indicated resource of 5.65 million metric tons of ore averaging 29.52 g/t silver — along with 1.75 g/t gold, 0.95 percent copper and

1.73 percent zinc.

The ore at Constantine Metal Resources Ltd.'s Palmer Project at the north end of Alaska's portion of the VMS belt contains about 31 g/t silver — accompanied by 2 percent copper, 4.8 percent zinc, and 0.30 g/t gold.

More VMS deposits

Southeast Alaska is not the only place to find silver-rich VMS deposits in the state.

Andover Ventures Inc.'s Sun deposit in the Ambler Mining District of Northwest Alaska, for example, has a resource, calculated for the project in 1977, of 20.3 million metric tons averaging 74 g/t silver, 1.9 percent copper, 4.5 percent zinc and 1.2 percent lead.

Sun is located at the eastern extent of a belt of VMS deposits that stretch some 70 miles along the southern slopes of the Brooks Range.

Arctic — the most advanced deposit along this belt — has an indicated resource of 19.45 million metric tons averaging 4.05 percent copper, 5.8 percent zinc, 59.55 g/t silver and 0.97 g/t gold.

In the Alaska Range about 36 miles southwest of the crossroads town of Tok, Heatherdale Resources is also exploring the silver-rich Delta Property in an emerging VMS region in Interior Alaska. An inferred resource of 15.4 million metric tons grading 62 g/t silver, along with 0.6 percent copper, 1.7 percent lead, 3.8 percent zinc and 1.7 g/t gold, has been calculated for Delta.

Two holes drilled by Heatherdale in 2011 reaffirmed the presence of precious metals-rich VMS mineralization on the property. Hole 2011-154 cut 13.4 meters averaging 85 g/t silver,



Although the value of the silver pales in comparison to the spectacular zinc grades, Teck Resources' Red Dog Mine in Northwest Alaska produced a whopping 7 million ounces of silver in 2010.

0.56 percent copper, 5.2 percent zinc, 2.4 percent lead and 1.56 g/t gold.

"Initial drilling has more than justified our belief that Heatherdale's extensive land position at Delta presents tremendous opportunities for delineating sizable deposits of high-grade, precious metalsenriched VMS mineralization," said Heatherdale President and CEO Patrick Smith.

Northwest SEDEX

Although the value of the silver pales in comparison to the spectacular zinc grades,Teck Resources' Red Dog Mine in Northwest Alaska produced a whopping 7 million ounces of silver in 2010.The silver-enriched ore at Red Dog is part of a high-grade sedimentary exhalative, or SEDEX, body.

Exhalative deposits are formed over millennia when the earth "exhales" mineral-rich brine onto the ocean floor, creating layers of sulfide ore.

Northwest Alaska is home to several other SEDEX deposits and is prospective for others.These include Teck's Anarraaq and Zazu Metals Corp.'s Lik deposits.

"Red Dog is one of the greater leadzinc deposits in the world, and there is more potential for those in Northwest Alaska as well as other places (where) there are Paleozoic rocks that are similar to Red Dog," observed Millrock Resources Inc.Vice President of Exploration Phil St. George.

According to a 2004 report written for the Society of Economic Geologists, the Anarraaq deposit consists of a barite body estimated to be as big as 1 billion metric tons and a zinc-lead-silver zone with a resource of about 18 million metric tons grading 18 percent zinc, 5.4 percent lead, and 85 g/t silver.

Lik is estimated to contain about 4.6 billion pounds of zinc, 1.5 billion pounds of lead and 41 million troy ounces of silver and its grade averages about 8 percent zinc, 2.6 percent lead and 47 g/t silver.

Statewide potential

In addition to SEDEX- and VMS-style mineralization that host Alaska's two silver-producing mines, several other types of ore found across the state are known to contain rich stores of the white metal.

When mineral-laden brine is not exhaled, but instead is trapped in oceanfloor sediments, it forms replacement-style deposits. Full Metal Minerals Ltd. is exploring one such deposit at its Fortymile project in eastern Alaska.

Hole LWM10-64 drilled at Fortymile last year cut 5.89 meters averaging 198 g/t silver, 7.4 percent zinc, 13.8 percent lead. LWM10-68 intersected 4.4 meters averaging 314 g/t silver, 23.7 percent zinc and 23.6 percent lead

Epithermal gold prospects found along the Alaska Peninsula and the Aleutian Islands typically contain high concentrations of silver, but are relatively unexplored.

Shumagin and Apollo, two such epithermal gold deposits being explored by Full Metal on Unga Island, contain a combined historical resource of 280,000 metric tons averaging 27.7 g/t gold and 92.6 g/t silver.

Next Gen Metals Inc.'s Silver Chalice prospect — found on the banks of the Yukon River about 330 miles west of Fairbanks — reflects Interior Alaska's potential for silver-rich epithermal deposits. Rock chip samples from the property returned assays up to 462 g/t silver. The average silver-gold ratio of these samples is about 40:1.

Most of Alaska's tin prospects such as Kougarok, Sleitat, Win, Won and Coal Creek also contain silver, and the precious metal is typically a significant byproduct in porphyry copper deposits such as Pebble.

With silver prices remaining strong, the white metal continues to enhance the luster of mineral deposits across Alaska.

Strategic Metals Alaska accepts rare earth challenge

Governor unveils a five-part strategy to develop state's strategic metals

BY SHANE LASLEY Mining News

everaging its global dominance in the realm of rare earth elements, China has set in motion a strategy to gain supremacy in manufacturing the vast array of technologically advanced products that depend on these metals.

"China can exploit rare earths that they control all the way out to electric cars, wind turbines, whatever it is - and that is the grand strategy," American Elements Chairman and CEO Michael Silver told about 200 participants in the Alaska Strategic and Critical Minerals Summit held in Fairbanks last September.

Silver, who founded American Elements two decades ago, is a firsthand witness to China's rise to dominance as the global supplier of REEs.

In order to avoid exporting its hightechnology manufacturing jobs to China, Silver told the legislators, regulators, miners and members of the media attending the summit that the United States needs to get into the REE game — from mining the critical minerals through assembling the products that benefit from the unique properties of these "magical" metals.

It is a game in which the American Elements executive believes Alaska could play a significant role.

"Alaska certainly has an opportunity to be the pre-eminent U.S. producer of rare earths in the future," Silver told Mining News."Good for Alaska, good for the country."

"Alaska has accepted the challenge," Gov. Sean Parnell told participants of the summit."Where China has said, 'We're going to curtail exports,' ... Alaska is accepting the challenge of saying, 'We've got them here, and we want to provide them to our nation and to the world beyond."

The Department of Natural Resources organized the daylong summit to brainstorm ways to encourage the development of Alaska's strategic and critical minerals.

During the summit, Parnell unveiled a five-part strategy on strategic minerals. This plan, which focuses heavily on rare



The unique properties of rare earth elements — a group of 17 previously obscure metals that include scandium, yttrium and the 15 lanthanides — are a key ingredient to a number of military, high-tech and green energy applications. More than 150 REE prospects have been identified in Alaska.

earths, involves:

 undertaking a statewide assessment of our strategic mineral potential;

• providing incentives for the development of known or highly-prospective strategic mineral occurrences;

• making improvements in the structure and efficiency of Alaska's permitting processes;

• strengthening partnerships and cooperation with other government entities, Alaska Native corporations and potential developers; and,

 attracting new investments and markets for Alaska's mineral resources.

As part of this strategy, Parnell included \$2.7 million in the Alaska's fiscal year 2013 budget to find out just how prolific REEs are in the state.

The Alaska Division of Geological and Geophysical Surveys - which began this investigation in 2011 - has identified more than 150 REE occurrences across the state. This project includes the review of existing geophysical data on REEs, as well as new geochemical analyses of samples at the state's Geologic Materials Center in Eagle River.

"The timing is right for rare earth de-

velopment," Parnell said. "We're on track to assess, incentivize and develop the rare earth elements we can provide the world."

Bokan underscores potential

Alaska's REE potential is underscored by Ucore Rare Metals Inc.'s Bokan Mountain property on Prince of Wales Island.

An inaugural NI 43-101-compliant resource calculated for Bokan in 2011 estimates that the deposit hosts an inferred mineral resource of 3.7 million metric tons grading 0.75 percent total rare earth oxides.

Though not particularly large or highgrade, 39 percent of the TREO found at Bokan are the more valuable heavy rare earth oxides.

Technology Metals Research cofounder Jack Lifton - considered to be a leading authority on the sourcing and end-use trends of rare and strategic metals - said Bokan Mountain is key to securing a domestic supply of the critical heavy REEs.

Among the heavy rare earths found at Bokan are dysprosium and terbium two metals considered to be especially



Alaska Gov. Sean Parnell, Alaska Department of Natural Resources Commissioner Dan Sullivan and American Elements Chairman and CEO Michael Silver discuss Alaska's potential to be a pre-eminent U.S. producer of rare earth elements during the 2011 Alaska Strategic and Critical Minerals Summit.

vital to high-tech and green industries.

Dysprosium has been ranked by the U.S. Department of Energy as the number one most critical strategic metal to the United States.

The mineral resource at Bokan Mountain contains an estimated 0.29 kilograms of dysprosium per metric ton. Of the remaining four rare earth metals DOE deemed critical, Bokan contains an estimated 1.08 kilograms per metric ton neodymium, 0.05 kilograms per metric ton terbium, 0.03 kilograms per ton europium and 1.88 kilograms per metric ton yttrium.

In its initial assessment, DGGS identi-



fied a trend of REE prospects stretching along the entire 135-mile length of Prince of Wales Island; many of which display characteristics similar to Bokan.

Based upon preliminary work carried out by the United States Geological Survey and subsequently reviewed by Fairbanks-based Avalon Development Corp., Contango Ore Inc. snatched up Salmon Bay and Stone Rock Bay — two of the island's REE prospects.

The Stone Rock Bay property is located about 12 miles south of Bokan Mountain and Salmon Bay is located on the northern shores of the island.

Dora Lake, located about 20 miles north of Bokan Mountain, is another interesting REE prospect unveiled in the initial DGGS assessment. Geological investigations in 1990 discovered REE-bearing pegmatites along a two-mile trend. The geologists that conducted the survey estimate a 1-meter-thick vein dike contains an inferred resource of about 500,000 tons of material with 442 parts-per-million niobium, 71 ppm uranium, 1,775 ppm yttrium, 1.53 percent zirconium, and 2,816 ppm REE. And, like Bokan, nearly half of the REE content of this prospect is estimated to be the highly sought-after heavy variety.

The REE-trend on Prince of Wales Island is a subset of a 350-mile belt that spans Southeast Alaska. All told, more than two dozen REE prospects have been identified along the panhandle.

REEs across Alaska

Another band of REE prospects about 90 miles east of Nome is strikingly similar to the geology that hosts the REE deposits on Prince of Wales Island.

"It is the same sort of geology as far as we know right now. It is one of those unusual type granites that tend to have these types of elements in them — uranium, thorium and the rare earths," said Kinross Gold Corp.' Dave Szumigala, who until recently served as senior minerals geologist at the Alaska Department of Natural Resources Division of Geological and Geophysical Surveys.

Not only is the geology right, but a dozen REE-bearing occurrences have been identified along the prospective trend.

Mount Prindle in Interior Alaska is a particularly exciting prospect due to the high concentrations of REEs discovered there.

The property — located about 60 miles north of Fairbanks — was staked for uranium by MAPCO Inc. in 1978. Sub-



sequent exploration identified several small deposits with extremely high concentrations of REEs and thorium. Rock samples taken from Mount Prindle returned grades of 15 percent REE and 0.1 percent uranium oxide.

The downside to this high-grade REE prospect is it lies within the White Mountain National Recreation Area. Though it is located in a region off limits to mining, the U.S. Secretary of the Interior could allow for hardrock minerals leases in the area. In a draft resource management plan for Eastern Interior Alaska, the U.S. Bureau of Land Management is considering mineral leasing in the White Mountain Recreation Area.

Another belt of highly prospective strategic metals hunting ground stretches along the fringes of the 3,000-square-mile (8,000 square kilometers) Ruby batholith in Interior Alaska.

"The Ray Mountains and the Kokrines Hills area of the state is one of the places that stand out of rare earths," explains Avalon Development Corp.President Curt Freeman.

A field investigation carried out by DGGS in 2011 has unearthed some high concentrations of REEs in the Kokrines Hills area of the Melozitna Mining District, one of several rare earthprospective areas in the Ruby Terrane.

Following up on this success, state geologists are investigating the REE potential of the Ray Mountains, another Ruby batholith-related prospect area that spans an enormous region from just north of the Yukon River along the Dalton Highway to about the Arctic Circle.

NURE outlines prospects

The National Uranium Resource Evaluation program — originally charged with evaluating domestic uranium potential when initiated by the U.S.Atomic Energy Commission in 1973 — was expanded to test for REEs and other strategic metals. This led to the identification of a number of large REE prospective areas across Alaska.

Between 1975 through 1979, this extensive geological initiative blanketed about 80 percent of Alaska with stream sediment, soil and rock samples.

Though little work has been done to follow-up on the discoveries made under NURE, several large swaths of REE anomalies were discerned by the program. Areas of note are a 175-milelong trend stretching along the southern slope of the Alaska Range and a region stretching about the same distance west from the Cook Inlet.

With China putting a squeeze on supply, many of the REE anomalies found across Alaska are being further scrutinized by government agencies and exploration companies seeking a domestic supply of these minerals critical to high-tech and greenenergy manufacturing.

SOURCE RESERVOIRED OIL: continued from page 24

Used well logs

The USGS scientists evaluated the Brookian oil and gas assessment units by using well log data to plot the thickness of zones with relatively high radioactivity, an indicator of a high organic content in the rock and potential good source rock quality. The use of this technique indicates an area that may have high oil potential in NPR-A, to the north of Lake Teshekpuk, and another especially high potential area along an east-west fairway of state land somewhat inland from the Beaufort Sea coast and extending east to the Canning River.

The area of the Kingak oil play appears somewhat similar to that of the Shublik, with an estimated area ranging from 5.0 million acres to 8.0 million acres and a mode of 7.4 million acres. But, in the absence of well log data suitable for inferring possible Kingak source oil potential, the USGS scientists have simply recognized broad areas in which the Kingak is known to be a good quality source rock.

Lower 48 analoques

Having delineated the possible extent of each assessment unit, the USGS scientists used comparisons between the North Slope source rocks and analogous source rocks that currently produce shale oil or gas in the Lower 48 to infer broad ranges of possible production profiles for potential North Slope shale oil and gas wells. Comparisons with Lower 48 analogues also enabled estimates of the area of source rock that each North Slope well might successfully access.

However, the USGS scientists also had to factor another major uncertainty into their calculations: The fact that no operational shale oil or gas play has uniform production rates throughout its entire geographic extent. Instead, production tends to be highly variable from one place to another, with development particularly focusing on what are termed "sweet spots" where production is especially prolific.

The locations of sweet spots within the North Slope shale plays will remain unknown until there is a track record of shale oil and gas drilling. However, the USGS scientists used the pattern of possible source rock oil potential that they had determined for each assessment unit to infer the proportion of each unit that might eventually be characterized as sweet spots, thus enabling a statistical evaluation of sweet spot occurrence to be meshed into the shale oil and gas estimates.

Statistical techniques

The scientists estimated ranges of possible oil and gas production from each assessment unit by calculating the total number of wells required to fully develop the unit and adding up the possible production from each well. Statistical techniques enabled the uncertainties in the areas of the plays and in the production characteristics of wells to be factored into the calculations, thus giving a range of uncertainty in the estimated potential production.

But there are some uncertainties that cannot be quantified.

One of these uncertainties arises from the fact that oil from the Shublik source rocks tends to be more viscous, or "heavier," than oil from shale oil plays such as the Eagle Ford or the Bakken. No one knows whether, when heated towards gas-generating temperatures, the heavier oil would crack into natural gas or whether it would form some kind of rock-clogging tarry residue, Houseknecht explained.

Another uncertainty arises from what is termed the "overpressure," the fluid pressure in excess of what would be expected from the depth of burial of the rocks. Geologists think that overpressure, probably caused by the thermal cracking of some oil into gas inside the rock, is a significant factor in driving oil from source rocks into production wells in successful shale oil plays such as the Eagle Ford in Texas.

But overpressures in the area of the North Slope shale oil plays appear relatively low or absent, and no-one really knows how that might impact oil production.

Estimated volumes

Crunching all of the various assessment numbers together resulted in an estimate of zero to 928 million barrels of technically recoverable oil for the Shublik oil assessment unit; zero to 72 trillion cubic feet of gas for the Shublik gas assessment unit; zero to 955 million barrels for the Brookian oil assessment unit; zero to

The rest of this story can be found in Petroleum News archive at www.petroleumnews.com/pnads/997126880.sbtml.



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SHELL: continued from page 29

Safety systems

O'Neil said that major safety systems such as the primary and emergency power; and fire detection and extinguishing systems have not yet been completed. Coast Guard inspectors have been working closely with the shipyard — for certification the Coast Guard must confirm that the vessel provides for the safety of crew and workers on board in the conditions anticipated in the area of operations.

O'Neil explained that the originally proposed floating produc-

CHUKCHI: continued from page 28

Ellesmerian strata than those tested by the well, he said.

Crackerjack

The Crackerjack well was looking for Ivishak sandstone on the

OCS resource assessment released

In conjunction with its 2012-17 proposed outer continental shelf lease sale program, the U.S. Department of the Interior also released a 2011 OCS resource assessment.

The assessment, of undiscovered, technically and economically recoverable oil and natural gas resources outside of known OCS oil and gas fields, uses information available as of Jan. 1, 2009, and incorporates advances in petroleum exploration and development technologies, the Bureau of Ocean Energy Management said in a fact sheet on the assessment.

Mean estimates of undiscovered technically recoverable resources, or UTRR, for the Alaska OCS region remain relatively unchanged in comparison to the 2006 assessment,

\$3 billion on new Arctic Alaska OCS

Reprint From Petroleum News BOEM said, noting that since the prior Nov. 13, 2011 issue assessment industry has spent almost

leases, but "there has been no significant new geologic data gathered in the region and none of the leases acquired since the previous assessment have been tested."

The agency also said that due to sparse data from the majority of the plays in the Alaska, Atlantic and part of the Pacific OCS regions, "analog plays were developed with a more subjective approach to cover the range of uncertainties associated with these plays."

Estimates from the assessment for the entire OCS range from 66.35 billion barrels of oil at the 95 percent probability level to 119.11 billion barrels at the 5 percent probability level; the mean is 88.59 billion barrels. Natural gas estimates range from 308.28 trillion cubic feet (95 percent probability) to 544.83 tcf (5 percent probability) with a mean of 398.37 tcf.

When the figures are converted to a barrel of oil equivalent basis, 55 percent of the potential resources are in the Gulf of Mexico (87.45 billion barrels of oil equivalent) and 31 percent in the Alaska OCS region (50 billion BOE). The Atlantic and Pacific OCS regions are estimated to contain smaller volumes, 8.87 billion BOE for the Atlantic OCS region and 13.07 billion BOE for the Pacific OCS region.

The majority of the mean BOE for the Alaska OCS, 29.04 BOE, is in the Chukchi, with 13.14 BOE in the Beaufort.

tion installation certification requires the vessel to have an anchoring system capable of handling a 100-year storm, on the assumption that the fixed structure would not be able to move out of a storm's path. The mobile offshore drilling unit certification, for a vessel able to move out of the way of a storm if necessary, only needs a mooring design to cope with a 10-year storm.

However, although the American Bureau of Shipping, the organization setting the certification standards, has said that it will apply the 10-year storm criterion to the Arctic Challenger, bearing in mind that the vessel would not be fixed in one location, the bureau will require minimum environmental standards for the vessel, as would be required for a fixed facility, O'Neil said.

east flank of a huge, 100-mile-long elevated, faulted block, Sherwood said. Unfortunately, the Ivishak turned out to be missing at the well location and the well drilled instead into a lower unit of the Sadlerochit group.And, although Ivishak-equivalent rocks are likely present not too far from the well, experience at the Klondike well suggests that drilling into the local Ivishak would prove futile.

"Probably you don't have a reservoir out there anyway," Sherwood said.

But the well did encounter oil and gas in several sandstones and, as at Klondike, there are some untested exploration possibilities at the prospect. There may be deep Ellesmerian reservoirs below the Sadlerochit Group, and there may also be rift sequence reservoirs on the flanks of the faulted block.

"The well itself penetrated a thin rift sequence but there were no sandstones associated with it," Sherwood said.

But the Burger, Klondike and Crackerjack wells lie right in the area where oil is likely to have flowed into reservoir rocks. And the findings from the Chukchi Sea wells dispelled worries that the rocks might have become overheated as a result of deep burial at some time in the past - that was a big concern during the Chukchi exploration that took place 20 years or so ago, Sherwood said.

"We had a fear, and I think industry to a certain extent shared that fear, that we'd go out there and find a bunch of smoking cinders where our reservoirs ought to be," Sherwood said.

In fact reservoirs like Burger were found to be in pretty good shape, he said.



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