Significant Gas Potential in an

The Bristol Bay is a frontier basin with very limited seismic and well data available to the public. Preliminary analyses of the limited subsurface data coupled with surface outcrop data indicate the existence of a Tertiary petroleum system and possibility of an underlying Mesozoic petroleum system. The basin is considered as primarily a gasprone province.

Prithiraj Chungkham, IHS, prithiraj.chungkham@ihs.com

The Bristol Bay Basin, also known as the North Aleutian Basin, is one of a series of structural sag features located in the southeastern part of the Bering Sea continental shelf, underlying the waters of Bristol Bay and northern coastal plain of the Alaska Peninsula. Water depths range from 5-220m in the offshore portion.

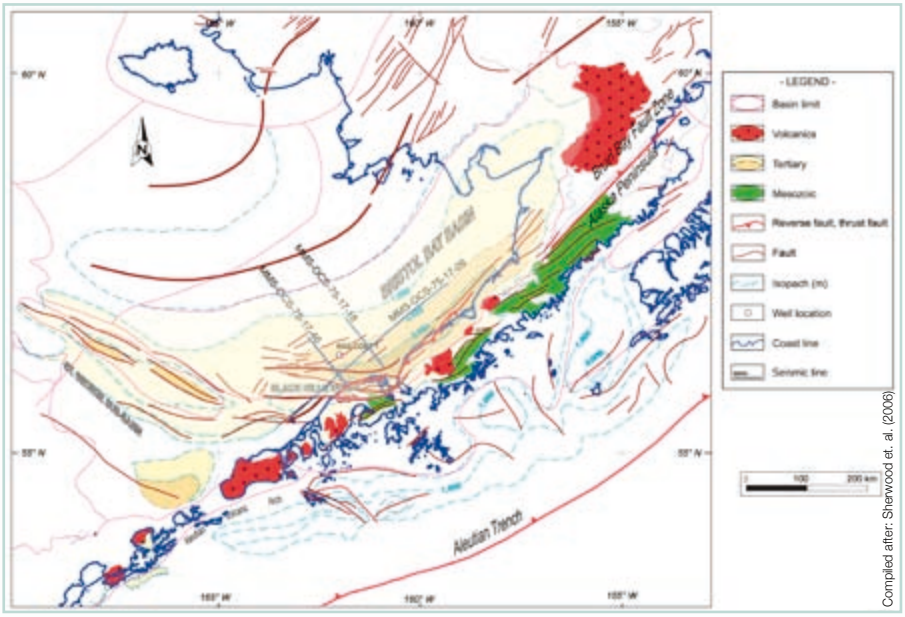
Only one offshore well

The basin is in the early stage of hydrocarbon exploration with limited geological and geophysical data and very few wells drilled to date.

Since 1903, a total of 27 onshore wells have been drilled in the Bristol Bay Basin and its surrounding areas in the Alaska Peninsula. At least 11 of them, all drilled between 1959 and 1985, are within the basin limit and a few of them have encountered oil and gas shows.

The only offshore well in the basin, OCS-Y-8218 (NAS COST 1), is a stratigraphic well that was financed by 18 companies with Arco as the operator. The well, drilled during 1982-83, bottomed in the Palaeocene-Middle Eocene Tolstoi Formation at a TD of 5,229 m. Minor gas peaks appeared on the mud log and drilled cuttings showed some oil stain below 4,663 m. The well has been used in defining seismic sequences which are assigned to onshore formation equivalents, based on biostratigraphic ages, lithology and petrophysical attributes.

Seismic acquisition in the basin and adjacent areas commenced in the 1940's. Approximately 172,400 line-km of 2D seismic acquired since the 1970's have been processed and made available by 2005. Out of the total 2D seismic data available, 36,000 line-km are in the public domain, while the rest is being marketed by vendors.



The Bristol Bay Basin is bounded on the northeast by metamorphosed Palaeozoic and Mesozoic rocks (Iliamma subterrane), the southwestern boundary of the basin is defined by the offshore extension of the Black Hills, an anticlinal structure composed of Mesozoic sedimentary rocks (Chignik subterrane), the southeast margin is defined by the northern limit of the compressional deformation that formed the core of the Alaska Peninsula, while the northwest boundary, lying beneath the Bering Sea shelf, is believed to consist of Mesozoic sedimentary, igneous and metamorphic rocks.

A total of four lease sales were held in the area, including the federal offshore portion of the Bristol Bay, between 1968 and 1988. However, tracts that were awarded were later repurchased by the Federal government in 1995, following a congressional moratorium executed in October 1989. The moratorium was a result of a widespread protest to protect the fishing industry in the Bristol Bay by Native organizations.

Since then, the Bristol Bay region has been off limits for some time as local communities feared potential environmental effects from an oil spill would ruin the areas' salmon fishing industry. However, the fishing industry has been in decline over the last few years and some local communities lobbied and approached the government in 2002 to open the area for leasing as a potential source of revenue.

37 blocks awarded

On 22 March 2003, Alaska Government signed two bills into law that will facilitate oil and gas exploration in the Bristol Bay area. Subsequently, on 26 October 2005, the State of Alaska Department of Natural

Underexplored Basin

Resources (DNR) held the Alaska Peninsula Areawide 2005 (AP 2005) Lease Sale, in Anchorage, AK. A total of 1,047 blocks encompassing 23,465 km^2 onshore and offshore was offered in the AP 2005. Most of the area offered was onshore, including lowlands Alaska Peninsula and around Bristol Bay itself, but 7,080 km^2 are offshore in state-owned areas within the three-mile limit.

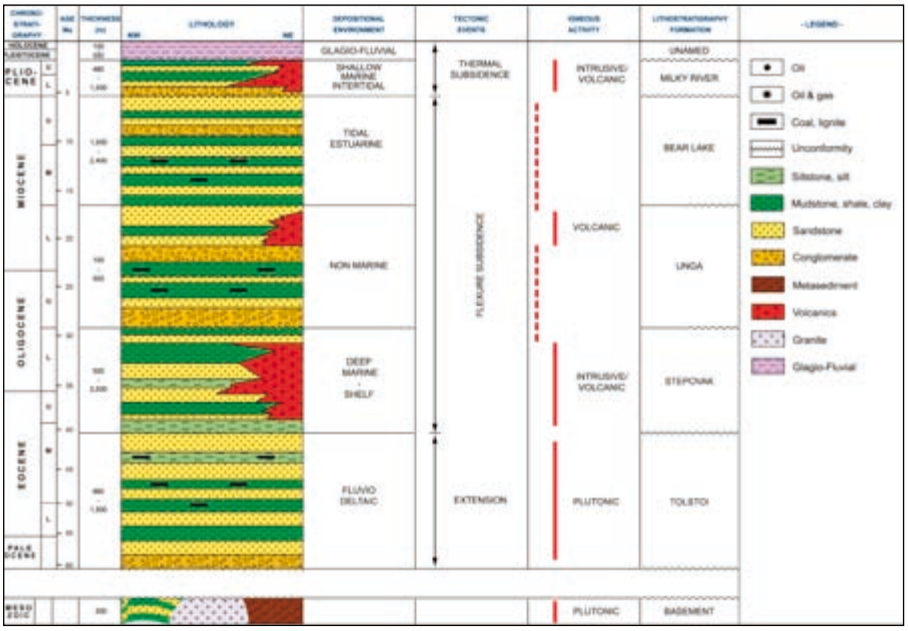
In late October 2005, DNR announced the preliminary award of 37 blocks from the AP 2005. Shell was the most successful bidder being awarded 33 blocks, while Oklahoma based independent Hewitt Mineral Corp. was awarded four blocks. The 37 blocks, with a total area or 851 km^2, are located in the Port Moller and Herendeen Bay area.

The Minerals Management Service (MMS), by presidential order under section 12 of the OSC (Outer Continental Shelf) Lands Acts, excludes the North Aleutian Basin Planning Area, which includes the federal portion of the Bristol Bay Basin, from the next federal lease schedule for 2007-2012. However, the governor of Alaska has requested that the president modifies the order to allow the inclusion of the Sale 92 area (held in 1988) in the 2007-2012 programmes.

Geological Setting and Basin Evolution

Development of the Bristol Bay Basin in a back-arc setting in relation to the Alaska Peninsula is closely related to the evolution of the Bering Sea margin since the earliest Tertiary times. With the initiation of the Aleutian Island Arc as the new plate boundary to the west, plate motion along the Bering Sea margin ceased. The isolated Bering Sea margin underwent extensional deformation followed by differential subsidence during the Cenozoic.

The Bristol Bay Basin is basically a southward thickening wedge, terminated abruptly by series of folds and thrust-faults that form the northern limit of the compressional deformation in the Alaska Peninsula. Two broad structural domains are recognised in the basin: extensional grabens, half-grabens and horsts in the basin interior; and compressional fold and thrust-fault structures along the southeastern margin.



Stratigraphic Chart

Petroleum Geology

Source Rocks

Paleocene/Eocene to Miocene coals and shales are considered to be potential source rocks, based on organic geochemistry analyses of drill core and outcrop samples They contain predominantly gas-prone kerogen Type III, with some kerogen Type II, which are capable of generating light oil or condensate. The coals are also potential source for biogenic gas.

The source rocks in Palaeocene-Middle Eocene **Tolstoi Formation** (compare stratigraphic chart) are the most important ones considering their deeper stratigraphic position in grabens and half-grabens with sufficient burial for hydrocarbon maturation.

Thermal maturity models with the help of Vitrinite Reflectance (R_o) data of core samples from NAS COST 1 well indicate that the source rocks in the Tolstoi formation in the deep grabens are within the hydrocarbon windows. The lowest part could have attained sufficient burial depth by the latest Eocene or Early Oligocene times for initiation of oil generation. With progressive burial, successive hydrocarbon generation from source rocks in the shallower strata continues to the present time.

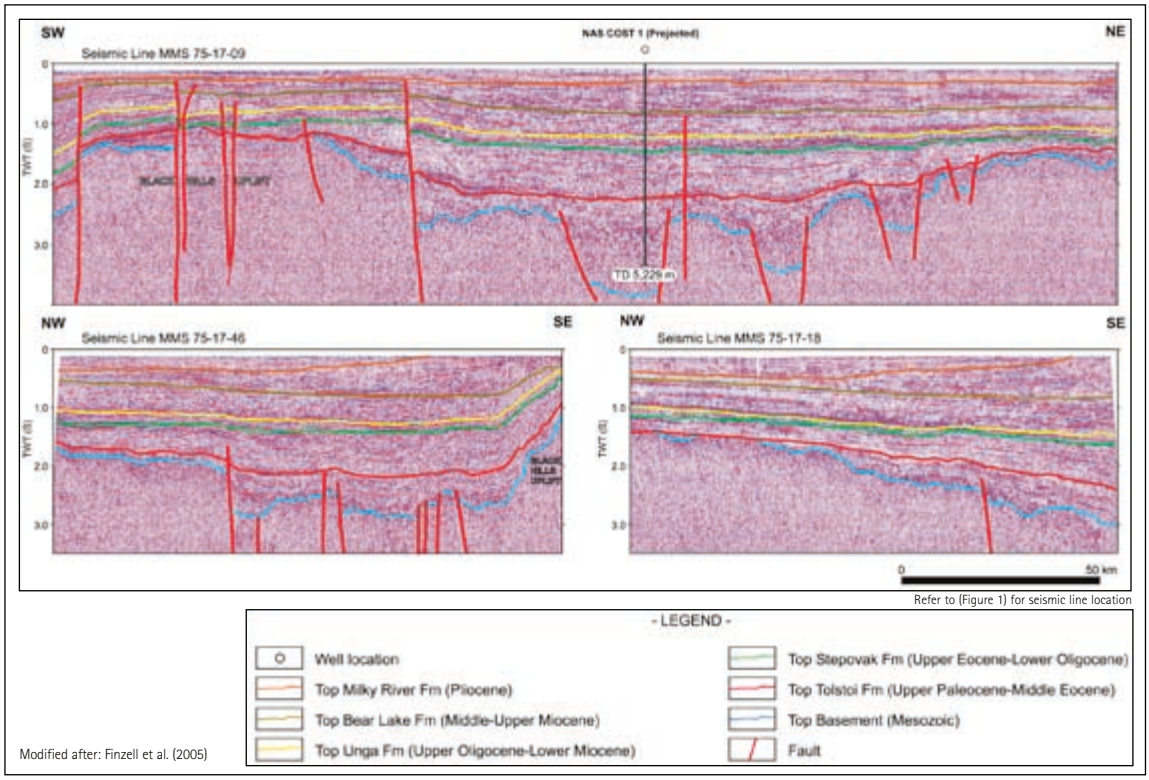
Widespread volcanics could also have resulted in early thermal maturation for the source rocks in the vicinity.

Reservoir rocks

Reservoir quality sandstones are present throughout the Tertiary succession. The sandstones in the Middle-Upper Miocene **Bear Lake Formation** (compare stratigraphic chart) are considered the most prospective reservoirs, because of their fair to good reservoir quality, ample thickness and stratigraphic position just below the Miocene-Pliocene Unconformity.

Deformed Mesozoic sedimentary rocks and fractured and weathered buried granitic hills are also prospective reservoirs in the basin. Reservoir quality will depends on nature and extent of the fracture systems and degree of weathering.

Prithiraj Chungkham is IHS Energy's Geneva based Basin Coordinator. He joined Petroconsultants, S.A. Geneva, in 1998 after a short stint with Total in Paris during 1996-1998.



Selected public domain seismic lines illustrate that the Basin has a northeast-southwest trend and is asymmetrical in cross section with a gently dipping northwest flank and a steeply dipping southeast flank. It contains over 6,000 m of Tertiary sedimentary successions, which are thickest in the onshore southeastern part. The basin was developed as a result of block-faulting of Mesozoic basement rocks and flexure subsidence.

Seals

Lower silty part of the **Stepovak Formation** could provide the regional seal for the underlying Tolstoi reservoirs. Interbedded thin nonmarine to shallow marine siltstones and shales could provide the intraformational seals for the Stepovak-**Unga-Bear Lake** reservoirs. Fault related seals are expected in some of the structural traps.

Lower part of the **Milky Way Formation** with minor mudstones just above the Miocene-Pliocene unconformity could provide the top seal for the **Bear Lake Formation** reservoirs. The same seal could act as the regional top seal for the Tertiary petroleum system; however, its integrity and lateral continuity is questionable due to its poorly consolidated nature.

Trapping

Fault bounded horsts and grabens have been mapped in the offshore southwestern part of the basin. Horsts with several metres of structural relief at the basement level are draped by Tertiary rocks younger than Late Eocene (Stepovak, Unga and Bear Lake formations).

Drape anticlines in the shape of domes are developed in the rocks over the basement uplifts, primarily due to the differential compaction and fault movements. Such drape anticlines over basement highs extend from the Upper Eocene unconformity to Miocene-Pliocene unconformity. Some of the dome structures have closure area up to 540 km^2 (the size of a North Sea quadrant). They are likely to be charged either from the Tertiary source rocks in the grabens or from the Mesozoic source rocks or both.

The southeast margin of the basin is an area of folds, thrust faults and normal faults, and the east-west trending Black Hills uplift forms the southeastern boundary and separates it from the St.George Basin to the south. Top Basement (Mesozoic) seismic horizon, defined as the unconformity underlying the Tolstoi Formation, is a down plunge projection of the Black Hill uplift. The top Basement horizon has been extended to the north and east, with decreasing confidence in offshore part of the Bristol Bay Basin.

The Miocene-Pliocene unconformity is locally strongly angular in many outcrops and is recognisable offshore as a more subtle truncation and downlap surface. Structural discordance at the unconformity is characterized by a chaotic brecciated horizon at the base of the Milky River Formation and a broad range of structural styles at the top of the Bear Lake Formation.

Formation of drape anticlines over the basement highs continued throughout the deposition of the Stepovak, Unga and Bear Lake formations. These domal anticlines were mostly available to trap the peak oil generation which is considered to have occurred during Late Oligocene-Early Miocene.

Early formed dip and fault closures and fault related traps on the horst flanks during the Eocene extensional phase are likely to be charged principally by up-dip migration via passage beds. Drape anticlines are likely to be charged via vertical migration along the deep seated bounding faults.

Envisaging an LNG plant

Economics of development and production models envisage a grassroots LNG plant and liquid hydrocarbon gathering facilities at Balboa Bay on the southern side of the Alaska Peninsula. The LNG plant and facility hub would be connected by pipelines to the offshore platforms where gas and liquid hydrocarbons are gathered by subsea pipelines from surrounding fields. The LNG could be transported by sea to new receiving terminals either in northern Cook Inlet or on the U.S. West Coast. If the high oil and gas prices during the 2005 and 2006 are sustained; the hydrocarbon resource in the Bristol Bay Basin would certainly become very attractive.

Acknowledgment
The author is grateful to IHS Energy for permission to publish this paper. The article is a short compilation of papers and documents available in public domain, and he wishes to thank his colleagues for their help and support.