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CHARACTERIZATION, APPRAISAL, AND ECONOMIC VIABILITY OF ALASKA NORTH SLOPE GAS HYDRATE ACCUMULATIONS

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The collaborative research program will help determine if gas hydrate accumulations can become an economic unconventional energy resource, initially in the onshore Alaska North Slope (ANS) arctic region beneath permafrost and existing production infrastructure. The cooperative research venture between BP Exploration (Alaska), Inc. (BPXA) and the U.S. Department of Energy (DOE) facilitates high levels of collaboration between industry, government, and university researchers. The mutually beneficial research activities would not otherwise have been independently conducted by industry. Collett (1998) estimates that up to 590 TCF in-place ANS gas resources may be trapped in clathrate hydrates. An estimated 44 to 100 TCF in-place ANS gas resources may occur beneath existing infrastructure (Collett, 1993). If a significant portion of this estimated in-place gas can be economically recovered, this unconventional resource could become an important part of future gas resource development in Alaska.

Gas from gas hydrates may help fill the projected future gap in U.S. domestic gas production. Other options include opening additional areas to exploration and production, increasing LNG imports, developing remote arctic regions conventional gas (Alaska and Canada) and/or developing other unconventional gas resources such as coalbed methane, tight gas, and shale gas. If methods can be developed to economically dissociate the methane from the clathrate, gas hydrates could help meet future energy resource needs. Sufficient economic motivations and infrastructure are needed to encourage future gas production from gas hydrate. Gas hydrates have the best gas storage capacity of unconventional gas resources, but they are also the most technically and economically challenging and are the only unconventional gas resource not yet currently economically proven.

Gas hydrates are present in many arctic regions and offshore areas around the world. In the U.S., notable deposits of gas hydrate occur in offshore Atlantic, Gulf of Mexico (GOM), offshore Pacific, offshore Alaska, and onshore Alaska beneath permafrost. However, much like conventional oil and gas resources, economic production of gas from gas hydrate resources will require a unique combination of specific parameters, including all petroleum system components, adequate industry infrastructure, industry access to acreage, familiar production technology, and favorable economics and risk assessment to estimate the ultimate recovery potential, daily production rates, operations costs, and potential profitability. Currently, the most likely areas for a favorable combination of these parameters are the Alaska North Slope and the Gulf of Mexico.

The ANS is only one of several arctic basins containing methane hydrates beneath permafrost. However, unique to Alaska is the considerable infrastructure and petroleum system associated with ANS oil fields. This infrastructure and the associated geological and geophysical data make the ANS one of the most important areas for gas hydrate research in the world.

In this project, ANS gas hydrate and associated free gas-bearing reservoirs are being studied to determine reservoir extent, stratigraphy, structure, continuity, quality, variability, and geophysical and petrophysical property distribution. Phase 1 (October 2002 – October 2004) is characterizing reservoirs and fluids, leading to estimates of recoverable reserve and commercial potential, and defining procedures for gas hydrate drilling, data acquisition, completion, and production. Phases 2 (November 2004 – December 2005) and 3 (January 2006 – December 2006) will integrate well, core, log, and production test data from additional wells, if justified by results from prior phases. Ultimately, the program could lead to future development of an ANS gas hydrate pilot project and help determine whether or not gas hydrates can become a part of the ANS gas resource portfolio.

Significantly, the 2 major methane hydrate trends currently identified within Alaska are within the infrastructure area (Figure 1). These 2 distinct areas have been penetrated by industry wells targeting deeper zones. Collett (1993) estimates that the Eileen Trend may contain up to 44 TCF in-place gas hydrate resources, along with and undetermined amount of associated free gas, and that the less-defined Tarn Trend, may contain up to 60 TCF in-place gas hydrate resources.

The Eileen Trend is the best described and is the focus of our current research. It encompasses portions three major field areas and occurs primarily below the permafrost from 2,000 to 4,000 feet in the subsurface sediments. This is the area in which gas hydrates were discovered and tested in 1972 by the NWEileen #2 well. A significant amount of free gas could be associated with these gas hydrates within their down-dip stratigraphic-equivalent units. The Tarn Trend is less well-defined and occurs both within and below the permafrost from 500 to 2,400 feet in the subsurface sediments.

A gas hydrate prospect requires more than just a pressure/temperature equilibrium field required for methane hydrate stability. All petroleum system components must also contribute to form a viable gas hydrate accumulation such as the Eileen and Tarn Trends. These components include:

- Source: In the case of these trends, a giant thermogenic source is associated with migration of gas from the deeper Prudhoe Bay, Kuparuk, and Milne Point fields.
- Migration: Much of the gas likely migrated through the extensive fault systems in this area. The USGS has sampled gas along the surface expressions of these faults and found compositions consistent with subsurface gasses.
- Reservoir: The shallow sands of the Sagavanirktok, West Sak, and Ugnu provide regionally extensive reservoirs beneath the permafrost.
- Trap and Seal: In additional to the conventional stratigraphic and structural trap components and unique to natural gas hydrate accumulations, hydrates may also help form their own trap and seal. Therefore, three-way closures are not necessarily required.
- Stability: In order to form the clathrate structure, both water and gas must be present in sufficient volumes within the specific gas hydrate pressure-temperature stability zone.

The shallow gas hydrate-bearing reservoirs of the Tertiary Sagavanirktok formation are part of a complex fluvial-deltaic system further complicated by extensive structural compartmentalization within the Eileen trend. Stacked sequences of fluvial, deltaic, and nearshore marine sands are interbedded with both terrestrial and marine shales. Facies changes, intraformational unconformities, and high-angle normal faults disrupt reservoir continuity.

Despite the hundreds of well penetrations, these shallow sands have not been systematically studied and data is sparse. Additionally, ANS wells are directionally drilled from a centrally located gravel pad. Most of these wells do not deviate from vertical until below the permafrost (1,600 ft), which can result in a cluster of more closely spaced data points around each development pad. Therefore, seismic interpretation can reveal significant undelineated gas hydrate prospects between well pads.

Interim results from this research have identified gas hydrate play areas within the Milne Point Unit (MPU) field area. Some of these prospective areas are interpreted to contain both gas hydrate and associated free gas and may provide the best potential for production of hydrate-sourced gas, based on our current understanding of production methods. Seismic interpretation, normalized log correlation, structural mapping, cross section analyses, facies mapping, and net pay sand mapping help assess reservoir continuity and are helping to refine the regional estimates of in-place and potentially recoverable gas within prospective areas. The reservoir and fluid characterization will be integrated into reservoir models to help define a range of recovery factors, producible gas, and economic potential needed for evaluation of future development scenarios.

This project will help identify technical and economic issues to help government and industry to make informed decisions regarding the resource potential of unconventional gas hydrate accumulations. These interim research results highlight the importance of the resource characterization phase prior to production testing. Accurate description of reservoir and fluid compartmentalization will help ensure selection of the best sites for potential future operations.

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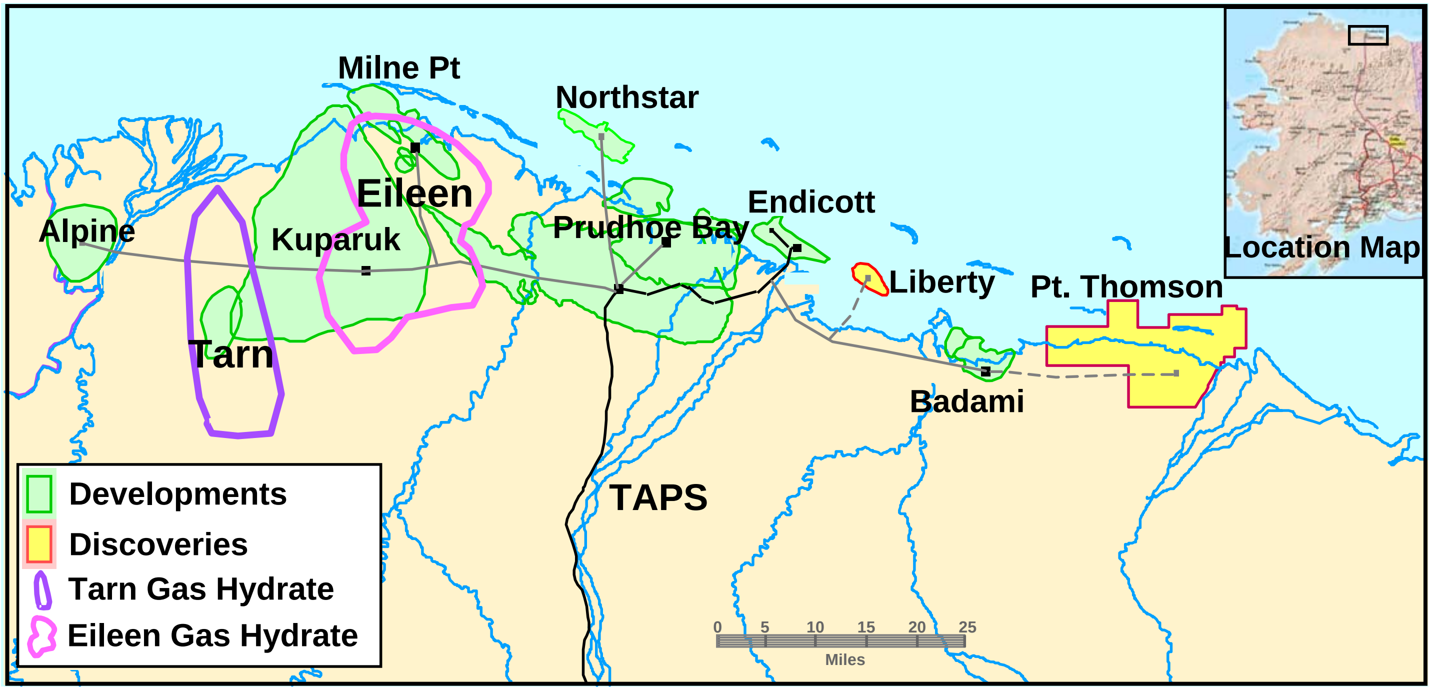

Figure 1: Alaska North Slope (ANS) development infrastructure. Gas hydrate trends after Collett, 1993.