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by

D.S. Pinney and R.A. Combellick

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794 University Avenue, Suite 200
Fairbanks, Alaska 99709-3645

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INTRODUCTION

The proposed North Slope Foothills state oil & gas lease sale occupies state onshore land between the Colville and Canning rivers north of Gates of the Arctic National Park and Preserve (fig.1). Geologic processes in this area will impose moderate constraints to exploration, production, and transportation activities associated with possible petroleum development, but can be mitigated through proper siting, design, and construction.

Primary potential hazards within and around the proposed lease area include earthquakes, frozen-ground phenomena, seasonal flooding, and stream icings (aufeis). This report provides a brief summary of available information related to these hazards in the area bounded by 69°45'-67°30'N and 157°00'W-145°00'W.

GENERAL GEOLOGY

Detailed surficial-geologic maps are available only for the Sagavanirktok A-1, A-2, B-1 and B-2 quadrangles (the area bounded by 69°00'W–69°30'N and 147°00'W-148°12'W) (Waythomas, 1991a,b). The only other detailed maps useful for hazards assessment in the area are engineering-geologic strip maps along the Trans-Alaska Pipeline System (TAPS) route (Ferrians, 1971) and along a prospective transportation corridor from Prudhoe Bay to the Canada border (Yeend, 1973a,b). A larger-scale derivative construction-materials map of parts of the Wiseman Quadrangle in the southern part of the region is also available (Combellick and others, 1993).

The northernmost parts of the area are underlain predominantly by primary and reworked fine-grained sand and silt deposits and fine-grained organic-rich thaw-lake deposits (Carter and others, 1986; Carter and Galloway, 1986; Kreig and Reger, 1982). Tracts along major rivers are generally underlain by stratified deposits of silt, sand and gravel comprising the floodplains and terraces.

Higher terrain in the central and southern parts of the area is predominantly underlain by Tertiary or Cretaceous sediments and sedimentary rocks (Ferrians, 1971; Rawlinson, 1993; Yeend, 1973a, 1983). Higher terrain along the major rivers draining the flanks of the Brooks Range is underlain by bouldery till, terrace gravel and sand, and coarse outwash gravels (Carter and others, 1986; Hamilton and Bauer, 1984; Yeend, 1973b).

EARTHQUAKES

Although northern Alaska is generally considered an area of low earthquake activity, there is a band of seismicity that extends south to north through the Arctic National Wildlife Refuge. The proposed North Slope Foothills lease sale area lies along the western margin of this seismic zone.

In the region around the proposed lease area, approximately 150 earthquakes were recorded between January 1968 and January 1998 (fig. 1). These included a magnitude 5.7 event in 1994, magnitude 5.2 event in 1993, and a magnitude 5.1 event in 1986. A magnitude 5.1 event occurred in the northeastern part of the proposed lease area on June 19, 1969, and a magnitude 5.0 event occurred near the western edge of the proposed lease area on August 31, 1995.

Wesson and others (1999) estimate a 10 percent probability of exceeding 0.10 g earthquake-generated horizontal acceleration in bedrock during a 50-yr period in this area (fig. 2). For comparison, ground acceleration in Anchorage during the great 1964 earthquake was estimated at 0.16 g. Accelerations in areas underlain by thick, soft sediments are likely to be higher than in bedrock due to amplification. However, thick

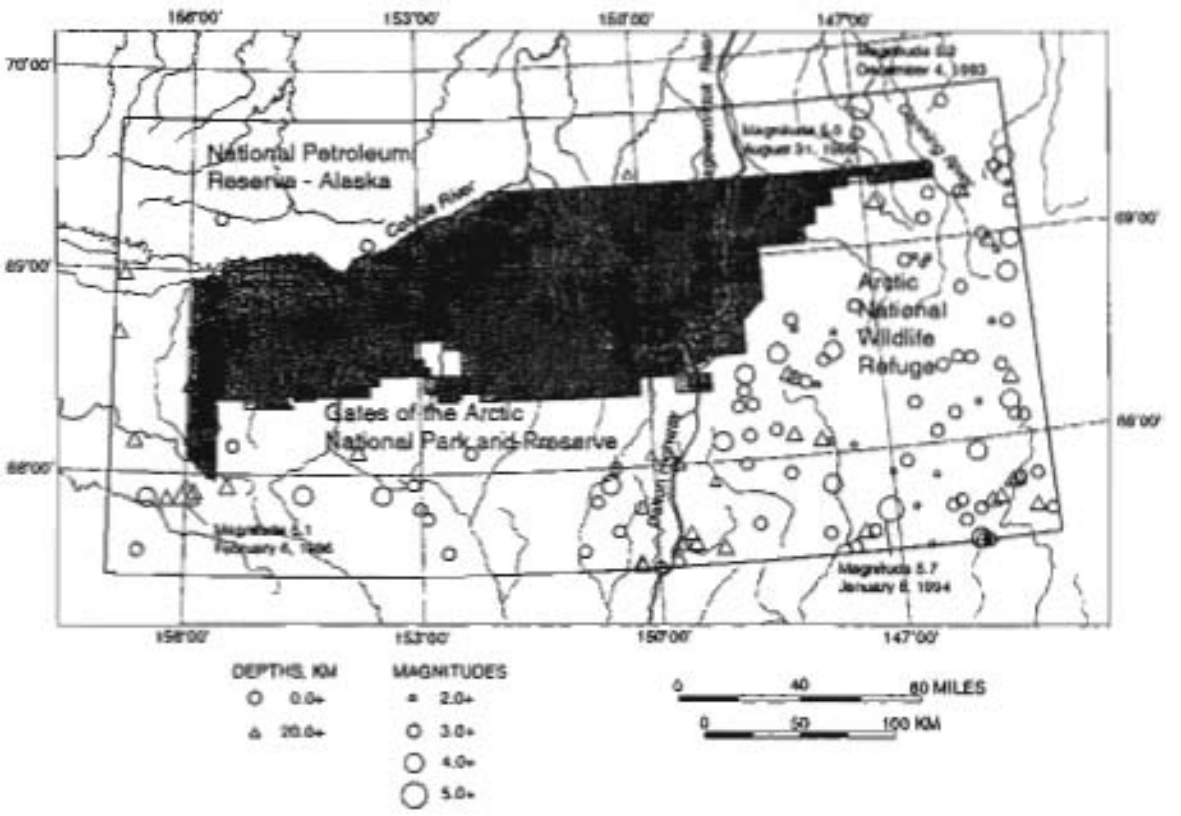

Figure 1. Map showing recent seismicity in the North Slope Foothills region, Alaska, and approximate boundaries of proposed state oil and gas lease sale (Alaska Earthquake Information Center, 02/28/2000).

permafrost may cause the earthquake response of sediments to be more like bedrock, which would limit amplification effects and would also tend to prevent earthquake-induced ground failure such as liquifaction. The effects of permafrost on earthquake response of sediments has not been documented.

The North Slope Foothills lease sale area is almost entirely within seismic zone 1 of the Uniform Building Code (on a scale of 0 to 4, where 4 represents the highest earthquake hazard). All structures in the area should be built to meet or exceed the UBC requirements for zone 1.

There are no known active faults in or around the proposed lease sale area (Plafker and others, 1994).

FROZEN GROUND

All areas of the proposed lease sale are underlain by perenially frozen ground. Depth of seasonal thaw is generally less than 1 m (3 ft) below the surface and 2 m (6 ft) beneath active stream channels. Ice content varies from minor segregated ice to massive

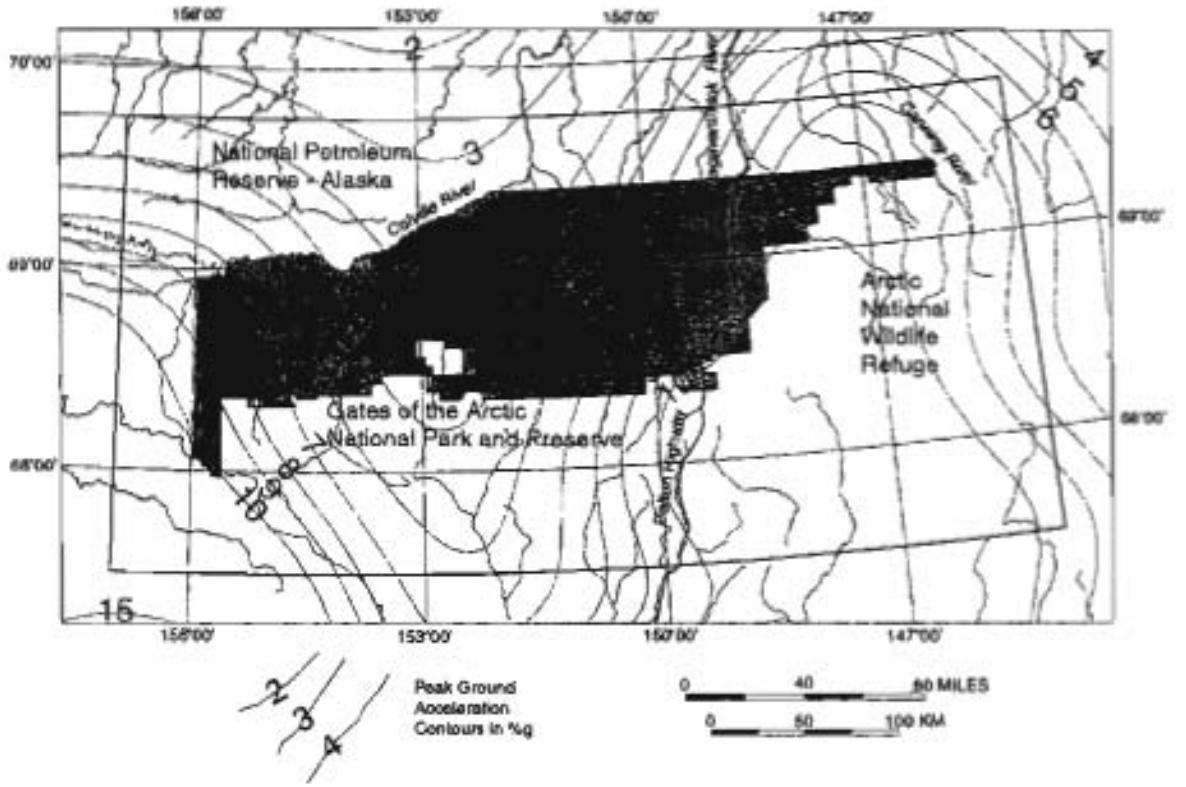

Figure 2. Map showing peak ground acceleration with 10 percent probability of exceedance in 50 years in the North Slope Foothills region, Alaska, and approximate boundaries of proposed state oil and gas lease sale (Wesson and others, 1999).

ice in the form of wedges and pingos. Ice content is highest in fine-grained, organic-rich deposits and lowest in coarse granular deposits and bedrock. Depth to the base of ice-bearing permafrost ranges from less than 122 m (400 ft) in the southern part of the area to about 500 m (1600 ft) in the northern part of the area (Collett and others, 1989).

Thaw settlement will potentially occur wherever a heated structure is placed on ground underlain by shallow, ice-rich permafrost if proper engineering measures are not taken to adequately support the structure and prevent the building heat from melting the ground ice. Seasonal freeze-thaw processes will cause frost jacking of unheated structures placed in and on frost-susceptible soils unless the structures are firmly anchored into the ground with deep pilings or supported on non-frost-susceptible fill. Frost susceptibility is highest in fine-grained alluvium, colluvium, and thaw-lake deposits; moderate in alluvial-fan deposits and till; and lowest in coarse-grained floodplain deposits, alluvial terrace deposits, and well-drained bedrock (Carter and others, 1986; Ferrians, 1971; Yeend, 1973a,b). Proper siting, design, and construction can mitigate these frozen-ground problems, as has been demonstrated at Prudhoe Bay.

SEASONAL FLOODING AND ICINGS

Floods occur annually along most rivers and many adjacent low terraces due to seasonal snow melt and jamming (Rawlinson, 1993). Additionally, rivers in this area are subject to seasonal icing (aufeis) prior to spring thaw due to overflow of stream or ground water under pressure. In areas of repeated overflow, residual ice sheets often become thick enough to extend beyond the floodplain margin. Very large overflows and residual ice sheets have been documented on the Ambler, Anaktuvuk, Sagavanirktok, Shaviovik, Kavik, Ivishak, Junjik, Ribdon, Killik, Canning, Saviukviayak, and Echooka rivers (Dean, 1984).

RIVER-BANK EROSION

River banks in the region are subject to thermo-erosion processes that involve (1) thawing and removal of frozen sediments by stream water, creating a niche at the base of the bank, (2) collapse and slumping of overhanging riverbank materials, and (3) removal of the materials by flowage and stream action. Rates of erosion are highest along riverbanks composed of fine-grained, ice-rich sediments.

Sediment cohesiveness is a major factor in determining bank erodibility. Higher erosion rates occur in braided channels, which usually form in noncohesive sediment (Scott, 1978). Along the Sagavanirktok River, aerial photographs showed a maximum erosion rate of 15 ft per year during a 20-yr period, but less than 12 percent of the vegetated bank was affected (Brice, 1971). Most of the erosion appears to occur in small increments during breakup flooding and is concentrated in specific reaches where local conditions are favorable for thermo-erosional niching.

CONCLUSIONS

Development in the proposed North Slope Foothills lease area will be subject to moderate geologic hazards, including earthquake shaking, thaw settlement, and seasonal frost action. Structures along rivers may be affected by seasonal flooding, local stream icing and bank erosion. All structures should be build to meet or exceed requirements of the Uniform Building Code for seismic zone 1. Additional precautions should be taken to identify and accommodate special considerations such as unstable ground, flooding, and other local hazards. Proper siting and engineering will minimize the detrimental effects of these natural processes.

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