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BOREHOLE LOGS FROM JOINT GSC-INDUSTRY MACKENZIE DELTA GEOLOGY/PERMAFROST TRANSECT

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Contributors

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INTRODUCTION

During March and April of 1992 a field drilling and geophysics project called the Mackenzie Delta Geology/Permafrost Transect was undertaken by a joint GSC-Industry research team. The project, which was multi-disciplinary in nature, was designed to obtain information about the geological, geotechnical and permafrost conditions of the Mackenzie Delta in the vicinity of three known hydrocarbon reservoirs. Borehole data linked with surface geophysics studies formed a geological transect over 30 km long.

This Open File Report presents initial field and laboratory data from the three deep boreholes 92GSCUNIPKAT, 92GSCTAGLU and 92GSCKUMAK. As of September 1992, the date of the Open File release, scientific investigations related to the project including further laboratory testing, field measurements and modeling studies are still in progress. Additional data and interpretations will become available through future publications planned for 1993.

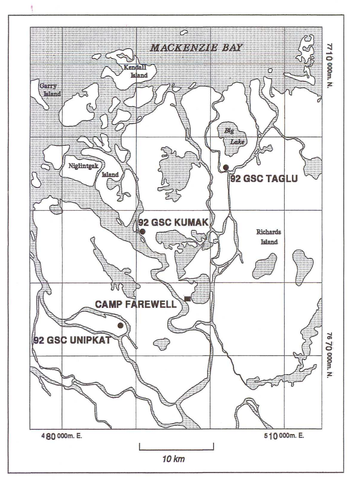

Figure 1: Location of drill holes, Mackenzie Delta area.

DRILLING PROGRAM

Logistical assistance for the drilling program including construction and maintenance of drill pads and roads, accommodation and communication, was provided by Shell Canada Resources Ltd. from their Camp Farewell base on Richards Island.

The drilling program was conducted by Foundex Explorations Ltd. of Surrey, British Columbia who utilized their top drive HT2000 electric drill. The rig components were enclosed in five skid-mounted containers which were interconnected during operations. A wireline PQ core barrel was used throughout the program collecting 89 mm diameter samples. The upper 7.5m of each hole was cased with 200 mm diameter casing upon which a Grant Rotating Head Blowout Diverter was mounted.

A particular effort was made throughout the drilling operations to limit thermal disturbance to core samples. To that end the temperature of the drilling fluids was carefully controlled with a chiller unit. Upon retrieval at the surface, the temperature of the core samples was measured and observations were made on the character of ice bonding. Samples were then placed in scientific freezers set at temperatures similar to *in situ* ground temperature until transit to the thermal testing laboratory at Camp Farewell.

92GSCUNIPKAT
Location: 69 11'32"N 135 20'27"W
Drilling period: 92-03-13 to 92-03-17

92GSCUNIPKAT is located in the centre of the Mackenzie Delta in an area characterized by relatively thin permafrost (<100m). The site is on the inside of a meander bend of Arvoknar Channel approximately 30m southwest of Unipkat B-12 an exploration well drilled during 1992 by Shell Canada Resources Ltd. (Fig. 1). The borehole was drilled at the edge of an ice pad constructed for this well. The area, which was originally thickly vegetated with 2 to 5m high willows, had been partially cleared of vegetation and was covered by approximately 30 cm of spray ice.

Completion depth of the borehole was 94.8m, with downhole geophysical logging carried out to approximately 75m.

92GSCTAGLU
Location: 69 22'17"N 134 56'47"W
Drilling period: 92-03-18 to 92-04-02

92GSCTAGLU is located in the eastern part of the Mackenzie Delta in an area characterized by thick permafrost (>500m). The site is on the east side of Kuluarpak Channel just north of the Kuluarpak-Harry Channel bifurcation (Fig. 1). The borehole drilled through a gravel pad which is thought to have been constructed in 1973 as part of activities related to drilling the TAGLU F-43 exploration well. The vegetation in the surrounding area is characterized mainly by low shrub tundra, however, the drill site consisted of exposed gravel raised about 1.5m above the surrounding land surface. It is estimated that the borehole is located about 20m south of the original Taglu F-43 well site.

Completion depth of the borehole was 451.1m, with downhole geophysical logging carried out to approximately 400m.

92GSCKUMAK
Location: 69 11'37"N 135 20'27"W
Drilling period: 92-04-03 to 92-04-09

92GSCKUMAK is located between the other two GSC boreholes near the edge of a permafrost boundary between thick permafrost (>500m) to the east and thinner permafrost (<100m) to the west. The drill site is situated on the east side of Middle Channel near the Middle Channel - Kumak Channel bifurcation (Fig. 1). The borehole was drilled on a snow and ice pad sited in an area of undisturbed tundra approximately 180m south of the Kumak E-58 exploration well. The vegetation cover in the vicinity of the drill site consisted of low shrub tundra and grass.

Completion depth of the borehole was 263.8m. Severe blockage problems in the hole after drilling limited downhole geophysical logging to approximately 180m.

BOREHOLE LOGS

Graphics for the composite borehole logs have been prepared by Northwood Geoscience Ltd. of Ottawa. Information is presented on the logs according to the nature of the testing, either as *in situ* downhole measurements, or laboratory measurements on core samples. Details on the individual borehole parameters are given below. Depths shown on the logs are below ground surface.

Laboratory Testing

Laboratory data included on the borehole logs were collected at field laboratories set up either at Camp Farewell or at the Inuvik Research Centre in Inuvik.

Sedimentary Features Lithology

A description of the major lithologies observed in the drill core has been summarized on the borehole logs. The major stratigraphic units have been described according to their texture and classification based on the Unified Soil Classification System. Supplementary text describes the major attributes of the borehole stratigraphy.

Studies carried out as part of the sedimentology program included detailed descriptions of sedimentary structures, evidence of macro fossils and bioturbation as well as core photography and sub sampling for further biostratigraphic studies. Some of these observations are recorded in the sedimentary features column along with observations of visible gas emission made immediately after retrieval of the core at the drill site.

Physical Property Testing (Grain size, moisture content, salinity and plasticity)

Standard physical property tests were conducted at a soil testing laboratory set up at the Inuvik Research Centre. In most instances testing was carried out on representative sub samples taken by logging personnel. Salinity determinations were made either on excess pore water liberated upon thawing or by extractions of pore water made with a mechanical sediment press.

Natural Remnant Magnetism

Measurements of Natural Remnant Magnetization were conducted under contract by Y. Wang and E. Evans of the University of Alberta. Initial studies were conducted in Inuvik utilizing a Molspin spinner magnetometer. Sub samples of the main core, approximately 2 cm in diameter, were used for testing. Where these samples were ice-bonded they were maintained in this state during testing. Since the borehole core was not oriented, data presented on the logs are measured as deviations from the horizontal plane.

Several stages of partial demagnetization (cleaning) were carried out on samples with an alternating field (AF) coil with a sample tumbler in the centre.

Magnetic Susceptibility

Laboratory determinations of magnetic susceptibility were conducted under contract by Y. Wang and E. Evans of the University of Alberta. Measurements were made with a Bartington meter equipped with a 10 cm MS2C or 3.3 cm MS1B sensor. The sensor is basically an oscillation circuit which generates a 500Hz signal in the absence of a sample. When core lengths or small sub samples are inserted, signal frequencies change depending on the magnetic properties of the sample. The instrument sets up a time window, counts the number of pulses received from the sensor, calibrates and displays the results. Data are presented as Bartington readings, which are approximately equal to 10^{-5} SI per unit mass.

Thermal Conductivity

Thermal conductivity testing was undertaken on thermally equilibrated drill core at a thermal property testing laboratory at Camp Farewell. A needle-probe technique developed in house by Terrain Sciences Division was used for the testing. The needle-probe method is an absolute technique with the system and software standardized by using the known conductivity of water (0.59W/mK at room temperature).

Acoustic Properties

Acoustic wave propagation tests were carried out on ice-bonded and non-bonded samples using a OYO 5217-A Sonic viewer. An attempt was made to carry out testing at temperatures close to *in situ* temperatures. Bulk density measurements were also made as part of this testing program.

Ice Bonding

Observations of ice bonding were made on the basis of the physical appearance of the drill core upon initial inspection following retrieval. Non-bonded samples were essentially thawed when they were retrieved, while partially ice-bonded samples had evidence of higher strengths because of some ice present in the soil pores. Well ice-bonded samples had clear evidence of pore ice bonding within the soil matrix. General comments on degree of ice-bonding were also made based on drilling rate and character of a particular stratigraphic unit.

In Situ Testing

Downhole Geophysical Logging

Downhole geophysical logging was carried out under contract by BPB Wireline Services. In general, logging was undertaken on an opportunity basis during drilling, taking advantage of bit changes and other interruptions in drilling production. Five tools were used during the program; data is presented on the logs from four of the five tools. Each of the four are briefly described below.

RO1 Focused Electric (Resistivity Log)
Because of its slim profile, this tool was generally run first during a logging sequence. The tool is a single function 3-electrode laterolog which provides a quantitative measure of formation resistivity.

DD3 Dual Density, Gamma Ray, Caliper (Gamma and Caliper Log)
This tool provides a measure of bulk density, gamma ray count as well as a mechanical caliper reading. For the purposes of this project the caliper arm was modified to provide for displacements up to approximately 600 mm.

Multichannel Sonic Sonde
This tool provides sonic transit velocity data determined by travel time measured to three separate receivers at distances 20 cm, 40 cm and 60 cm from the source.

MSU Magnetic Susceptibility Sonde
This tool provides a measure of the magnetic susceptibility useful for discrimination of different stratigraphic units.

Ground Temperature Measurements

Several precision temperature-measuring cables were placed to different depths in each borehole after completion and temperatures were monitored using automatic data loggers. The temperature cables were made to standardized GSC specifications of cable design, wiring and plug termination by M-Squared Instruments, Cochrane, Alberta. Yellow Springs Inc. type YSI 44033 thermistors were wired into a 25 conductor polyurethane jacketed cable at designated intervals and over-molded with polyurethane for physical protection.

Three solid state data loggers were used during the program; a 64 channel Sea Data model 1250A and two 64 channel Brancker Research model XL-100.

ACKNOWLEDGMENTS

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The project would not have been possible without provision of considerable 'support in kind' in the form of logistical assistance from Shell Canada Ltd. Shell Canada Ltd. and Esso Resources Canada Ltd. also provided considerable technical advice which was critical to the planning and implementation of the field work.

Field and laboratory work benefited from the support of the Polar Continental Shelf Project and access to the fine facilities at the Inuvik Research Centre of the Science Institute of the N.W.T.. As discussed above, considerable logistical assistance was also provided by Shell Canada Ltd., in particular the field assistance provided by Dick Levagood and his staff were much appreciated.

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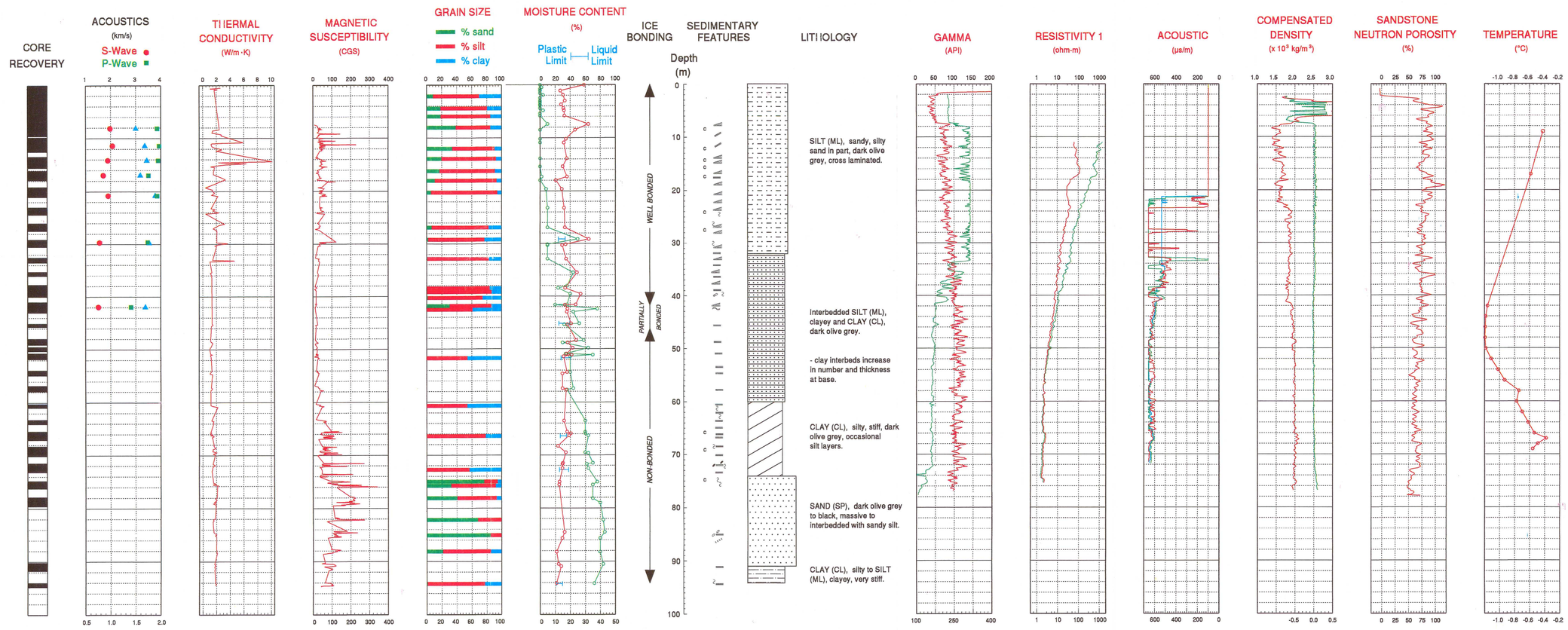
92 GSC UNIPKAT

LABORATORY TESTING

IN SITU TESTING



LEGEND FOR SEDIMENTARY FEATURES

- cross lamination
- horizontal laminae (distinct)
- horizontal laminae (vague)
- inclined laminae (distinct)
- inclined laminae (vague)
- roots
- organic detritus
- bioturbation
- rip-up clasts
- oxidized zone
- cross-bedding
- wavy laminae
- wood
- shell

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