DEPARTMENT OF THE INTERIOR
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Compilation of Field and Laboratory Geotechnical Test Data for U.S. Geological Survey Drill Holes 1C-79, 2C-80, CW 81-2, and CE 82-1, Beluga Resource Area, upper Cook Inlet Region, Alaska

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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[In Pocket]

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INTRODUCTION

This report contains the results of field and laboratory measurements on core from the U.S. Geological Survey drill holes 1C-79, 2C-80, CW 81-2, and CE 82-1, located in the upper Cook Inlet region of south central Alaska (fig. 1). Some of the objectives of the Energy Lands Program in Alaska, of which this study was a part, was to provide information leading to an understanding of the location, nature, and extent of the engineering and environmental geology concerns in areas of potential coal and other development in the Beluga coal resource area of the upper Cook Inlet region, Alaska. This report contains lithologic and geotechnical information needed to evaluate and predict the response of the coal-bearing Tyonek Formation to large-scale mining and related development in the Capps and Chuitna coal fields of the Beluga coal resource area. Specifically the information may be used in determining or predicting the stability of natural and manmade cut slopes, ground response to seismic activity, blasting effects, equipment selection for excavation, ground-water conditions, and erosion and weathering potential of spoil pile and in-situ geologic materials.

LOCATION

Two principal coal fields are present in the Beluga coal resource area (fig. 1), the Capps field, approximately 100 km west-northwest of Anchorage, and the Chuitna field, approximately 80 km west of Anchorage. In the Capps field two holes were drilled: USGS 1C-79, 121-m deep (pl. 1), and USGS 2C-80, 61-m deep (pl. 2). Stratigraphic correlation of the Waterfall coal bed between drill holes indicates that the lower two-thirds of drill hole 2C-80 lies stratigraphically below the bottom of hole USGS 1C-79. Core from both holes is believed to be representative of the lower part of the Tyonek Formation of early Oligocene through middle Miocene age (Wolfe and Tanai, 1980). Preliminary lithologic and geotechnical field test data and geophysical log interpretation for these two drill holes were reported by Chleborad and others (1980, 1982).

Drill holes USGS CW 81-2, 102-m deep (pl. 3), and USGS CE 82-1, 115-m deep (pl. 4), are located in the Chuitna coal field on the west and east sides of the Chuitna River, respectively (fig. 1). Strata from these two holes are believed to be representative of the middle to upper part of the Tyonek Formation. However, because of local faulting, folding, and limited surface exposures, the exact stratigraphic relationship between the two holes is uncertain. The Chuitna coal bed of Barnes (1966), which crops out for 13.7 km along the Chuitna River canyon, is correlated with the stratigraphically highest coal bed in the Pan American well (fig. 1); Calderwood and Fackler, 1972), and with a coal bed termed the brown bed by Ramsey (1981) in the Chuitna River coal field east of the Chuitna River. Five other coal beds have

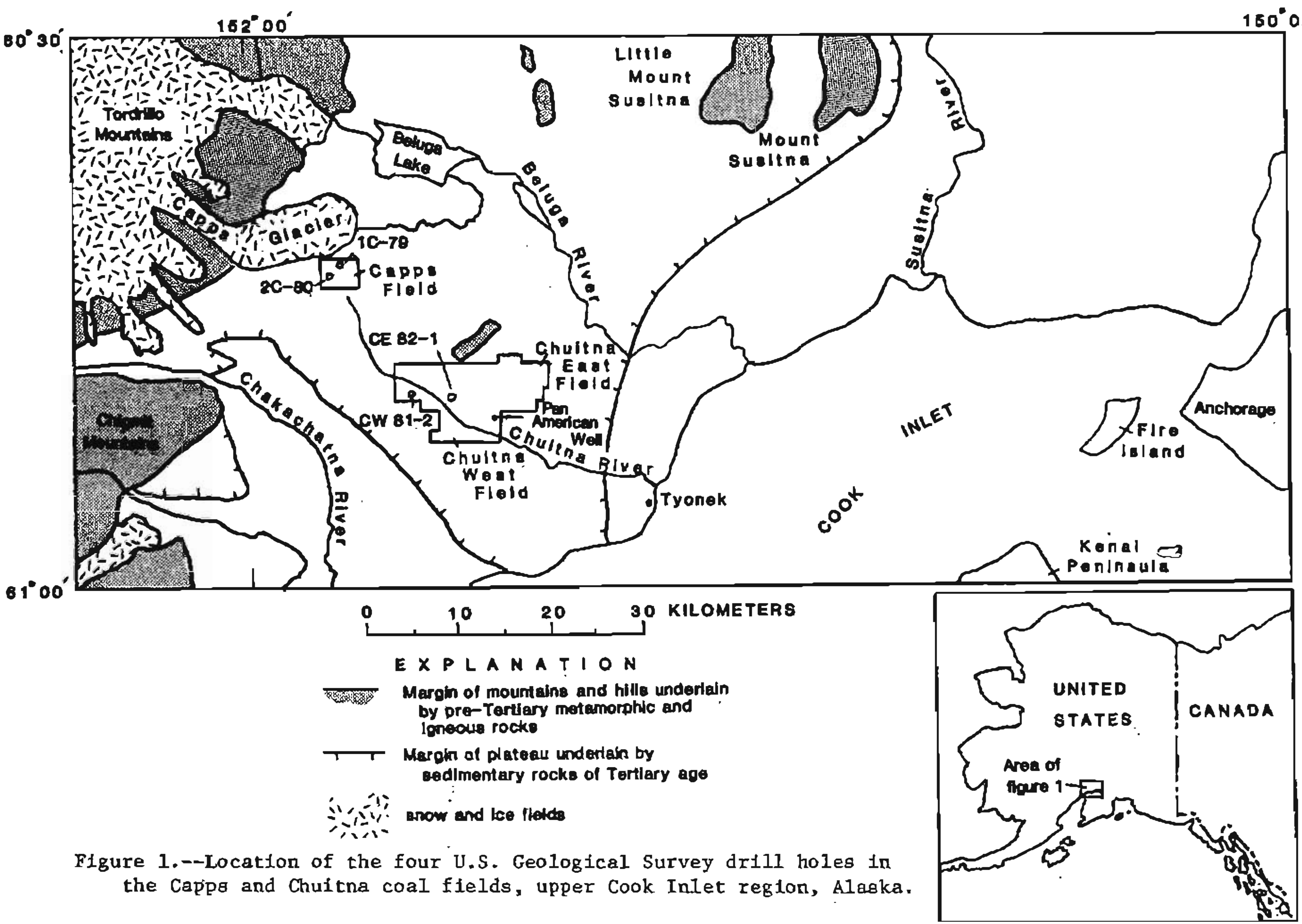

Figure 1.--Location of the four U.S. Geological Survey drill holes in the Capps and Chuitna coal fields, upper Cook Inlet region, Alaska.

been recognized beneath the brown coal bed. In stratigraphically descending order they are: the yellow, the green, the blue, the orange, and the red coal bed (Ramsey, 1981). The two major coal beds in drill hole USGS CE 82-1, referred to on plate 4 as the upper bed and lower bed, may correlate with the green and the blue beds, respectively (B. J. G. Pritsch, Placer U. S. Inc., San Francisco, CA, written commun., 1981 and R. B. Sanders, Diamond Alaska Coal, Co., oral commun., 1982). Preliminary field test data and geophysical log interpretation for drill holes USGS CW 81-2 and CE 82-1 were reported by Odum and others (1983, 1986), respectively.

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FIELD AND LABORATORY PROCEDURES

Field Testing and Logging Operation

All four drill holes were continuously cored using an HQ-sized rotary-wireline core system (6.35-cm core diameter). The cored sample was retrieved in split-tube samplers. Drilling information was recorded, including time of run, depths of core run, amount of recovery, nature of drilling fluids, and hydrologic conditions.

The core was photographed on color film using both an instantaneous-development camera and a 35-mm single-lens reflex camera. Included in each photograph was a card identifing the core-tube number, core depth, and the appropriate page from the rock-color chart of Goddard and others (1970). Information on discontinuites, color, laminations, hardness, and degree of weathering was recorded.

Point-load strength index and moisture-content measurements were performed on selected samples of core to provide a base of field data to compare with subsequent laboratory tests. The presence of any carbonate cement was determined by applying dilute (10-percent) hydrochloric acid to the core at 0.5-m intervals.

Untested core was wrapped in cheesecloth, labeled, coated with polycrystalline wax, and placed in cardboard boxes with split styrene inserts to protect the core and to minimize disturbance during transport to the U.S. Geological Survey, Golden, Colo. To avoid hydrocarbon contamination, core samples containing coal strata were not waxed, but instead were sealed in plastic sleeves.

Laboratory Procedures

The core samples upon arrival at the U.S. Geological Survey laboratory were stored in a controlled high-humidity environment. Cores were subdivided for geotechnical and geochemical testing. Samples selected for geotechnical and physical properties testing were prepared and tested according to ASTM (American Society for Testing and Materials) (1971) procedures. Index tests were performed according to guidelines developed by the originating authors and (or) modified by the procedures referenced on plates 1-4.

Physical properties

Measured physical property characteristics listed on plates 1-4 include grain-size distribution, Atterberg limits, natural-moisture content, density, and organic content. Grain-size distribution information was used to clarify lithologic descriptions. The Atterberg limits bar on plates 1-4 ranges from the plastic limit (smaller number on left) to liquid limit (larger number on right); the difference between the two limits is termed the plasticity index. Moisture-content measurements were taken at intervals of approximately 0.5 m or at changes in lithology. Samples, weighing 15-30 g, were dried for approximately four hours in an oven at 105 °C, and then weighed again to determine the moisture content in percent dry weight. Plotted in the Atterberg limits and moisture-content column are the results of a few organic content measurements. The results of grain, natural, and dry bulk density are also plotted on the plates.

Slake-durability index

The slake-durability index test provides a means of estimating the deterioration potential of a geologic material to climatic wetting and drying (Franklin and Chandra, 1972). Slake-durability index results are here reported in percent of total sample weight remaining after two cycles of testing. A test cycle consists of: (1) Drying and weighing of ten irregular-shaped (roughly spherical) specimens with individual weights between 40 and 60 g, (2) tumbling in a mesh cage with 2-mm openings, partially submerged in a water tank, for 10 minutes, and (3) drying and reweighing of the specimen material remaining in the cage. The index is calculated by dividing the weight of material afer step 3 by the original weight times 100. A high-slake durability index percentage, therefore, indicates that the sample has a relatively high resistance to climatic wetting and drying weathering and disintegration. The slake-durability index test is not designed to measure rates of in-situ weathering or strength.

Point-load strength index

The point-load strength index is an inexpensive and rapid means of approximating unconfined compressive strength from measured tensile strength. The point-load strength, Is, is defined as P/D^2, where D is the diameter between the loading points of the test apparatus and P is the load applied. As prescribed by ISRM (International Society of Rock Mechanics), Commission on Standardization of Laboratory and Field Tests (1972), the point-load strength value (Is), for the diametral tests (load applied parallel to the bedding planes, normal to the core axis) are adjusted using the chart developed by Brock and Franklin (1972) to a reference diameter of 50 mm. This resultant value, Is(50), is then referred to as the point-load strength index. More than one empirically determined coefficient (ranging from 22 to 35), by which the point-load strength index is to be multiplied by to obtain an approximation of unconfined compressive strength, appear in today's literature (Dunrud and Osterwald, 1980). For consistency with the previously published field test data (Chleborad and others, 1980, 1982; Odum and others, 1983, 1986) all of the approximated unconfined compressive strength values on plates 1-4 are computed by multiplying the resultant value (Is(50)) by Brock and Franklin's (1972) empirical coefficient of 24. Also displayed on each plate is the ratio of the axial load test to the diameteral test. This ratio is a measure of strength anisotropy.

Laboratory unconfined compressive strength

Core samples representing the various lithologies were collected from all four drill holes. These samples were prepared and tested for unconfined compressive strength according to ASTM (1971) guidelines (D 2938-71a). Specimens had a length to diameter ratio of 2.0 to 2.5 and core-cylinder end planes were prepared to be within 0.024 mm of perpendicularity with the core axis. The moisture content of the samples were maintained as close to natural conditions as possible by rapid waxing in the field and subsequent storage in a controlled high-humidity room. Due to the naturally weak nature of many of the Tyonek Formation lithologies, demonstrated by low slake-durability and point-load strength index test values, and by additional sample loss incurred during specimen preparation (paralleling of cylinder ends), test results must be considered to be somewhat biased toward the more physically competent members of a specific lithology.

Ultrasonic compressional- and shear-wave velocities

Ultrasonic testing uses high-frequency mechanical vibrations (generally in the range of 10 to 100 kHz) to characterize the physical properties of an elastic material-like soil and rock. The testing system used consisted of a pulse generator, an oscilloscope, sample support device and two ultrasonic probes (one transmitter and one receiver). Frequencies used during testing ranged from 50 to 90 kHz.

Compressional- and shear-wave velocity measurements were obtained from the two Chuitna coal field drill holes only. Due to the relatively low-tensile and compressive strengths of the cored Tyonek Formation lithologies, velocity test data are considered to be somewhat biased and are probably more representative of the more physically competent members of the strength spectrum for a specific lithology.

SUMMARY

The inherently nonhomogeneous nature of many of the Tyonek Formation lithologies cause difficulty in sample selection, preparation, and testing. Thin laminae of micaceous minerals are zones of weakness which may produce significantly diverse test results for similar appearing samples. In addition, coal laminae of variable thickness and (or) randomly oriented coaly stringers may increase or decrease the strengh of a specimen based soley upon their orientation with respect to the direction of applied load.

The hardness classification of most Tyonek Formation lithologies ranges from soft soil to soft rock (Jennings and Robertson, 1968). Test result ranges of slake-durability index, point-load index strength, laboratory unconfined compressive strength, and ultrasonic velocities differ widely for a specific lithology. However, on the basis of computed means the lithologies within a given drill hole or coal field area can be arranged in the following order of increasing strength and durability: weakly lithified sandstone, siltstone, claystone, carbonaceous claystone, and coal. Because the majority of the Tyonek Formation sandstone units encountered were essentially nonrecoverable because of their nonlithified character, an arrangement of lithologies into three groups is more realistic. The unlithified sandstone, for all practical purposes, can be considered to have zero unconfined compressive strength and no durability. Siltstone, claystone, and carbonaceous claystone all have low to moderate strength and durability. The coal samples have unconfined compressive strengths at least double those of the other finer grained lithologies. The rare carbonate-cemented pebbly sandstone unit from drill hole CW 81-2 has a strength that is anomalously higher than all the other lithologies. If these sandstone units were found in thicker, larger quanities, and had a relatively wider lateral extent, they would definetly be of major engineering significance.

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