UNITED STATES DEPARTMENT OF THE INTERIOR

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# UNCONFINED COMPRESSIVE STRENGTH ON ROCK SAMPLES REPRESENTATIVE OF THE TYPES FOUND IN BRONX COUNTY, NEW YORK

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.

## INTRODUCTION

The rock specimens collected for this study came from Bronx County. The rocks have their greatest compressive strength normal to the foliation. The denser amphibolites and gneisses (such as the Yonkers Gneiss), tend to fail violently in shear (Table 1). These rocks also tend to wear drill steel, tungsten carbide, and diamond bits excessively. The unconfined compressive strengths tabulated here may be applicable to similar rocks from the same formations throughout the greater New York area.

Unconfined compressive strength, an index of mechanical behavior, is widely used as part of the criteria for rock design (Attewell and Farmer, 1976; Jumikis, 1983).

## TEST SAMPLES

The outcrop locations of the samples tested are (Fig. 1): GBW-25 gsmts* (Manhattan Schist) from 3rd Avenue between East 172 and East 173 Streets. GBW-26 pqpbg* (Yonkers Gneiss) is from the north Bronx between the Major Deegan Expressway (I-87) and the freshwater marsh in Van Cortlandt Park. GBW-27 is an amphibolite from the Hutchinson River Group (Baskerville, 1982) [Hartland Terrane] along the Hutchinson River between the New England Thruway bridge and Boston Post Road bridge. GBW-13 wcdm* (Inwood Marble) is from an excavation at East 157 Street and Elton Avenue. GBW-30 gqpbs* (Fordham Gneiss) is from the south side of East 176 Street between Anthony and Carter Avenues. GBW-31 (Hutchinson River Group) a schistose gneiss, is from Pratt Avenue south of East 233 Street. GBW-A1 b-wgpbg* (Fordham Gneiss) is

from Sedgwick Avenue just off I-87 near East 162 Street west of Yankee Stadium. GBW-A2 is an amphibolite from the ggpbs* member of the Fordham Gneiss near Carter Avenue on the westbound entrance of I-95 from southbound Webster Avenue.

Generally, the schists and gneisses are moderately hard to cut. Where very hard quartzose bands or igneous intrusives are encountered, cutting tools will wear rapidly and cutting time will be increased. These rock units cause great wear on tunnel boring machine cutter discs as well as on diamond and tungsten carbide drill bits. Most of the amphibolites contain a minimum of fifty percent ferromagnesian minerals; the gneisses, except for the "schist" facies of the Fordham Gneiss, have a high quartz and feldspar content, generally ± seventy-five percent.

In Table 1 the samples labelled "schist" were obtained from a very schistose facies of the Fordham Gneiss. Biotite mica controls the foliation of this rock unit to a high degree as indicated by the weak shear strength obtained on sample GBW-30 parallel to the strike (foliation) planes as contrasted to the strength normal to the foliation.

In the field the foliation planes have dip angles ranging from 18° to 78° for site GBW-13 to 90° at site GBW-A1. It should be recognized, therefore, that the strengths indicated in Table 1 would be greatest in the direction normal to the foliation of these rocks, which can be highly variable under in situ conditions. Joints tend to be more closely spaced near faults and more widely spaced away from faults.

* The groups of lowercase letters are lithologic abbreviations that give the color, key minerals, and rock type. The rank order of the minerals used follows Winkler (1979).

## LITHOLOGIC ABBREVIATION KEY (ALPHABETICAL)

b-wgpbg - Black and white garnet plagioclase biotite gneiss; gqbps - Gray quartz biotite plagioclase schist; gsmts - Gray sillimanite muscovite tourmaline schist; gspbg - Gray sillimanite plagioclase biotite gneiss; pqpbg - Pink quartz plagioclase biotite gneiss; wcdm - White calcite dolomite marble

## REFERENCES CITED


Attewell, P.B., and Farmer, I.W., 1976, Principles of engineering geology: John Wiley & Sons, 1045 p.

Baskerville, C.A., 1982, Adoption of the name Hutchinson River Group and its subdivision, in Bronx and Westchester Counties, southeastern New York: U.S. Geological Survey Bulletin 1529-H, Stratigraphic Notes, 1980-1982, Contributions to Stratigraphy, p. H1-H10.

Jumikis, A.R., 1983, Rock mechanics: 2nd ed., Series on Rock and Soil Mechanics, vol. 7, Trans Tech Publications, 613 p.

Winkler, H.G.F., 1979, Petrogenesis of metamorphic rocks: Springer-Verlag, 5th ed. 348 p., see especially p. 340-344.

UNCONFINED COMPRESSIVE STRENGTH ($S_c$)

| CORE IDENTIFICATION | ROCK TYPE | STRENGTH (Sc) ($MN/m^2$) | STRENGTH (Sc) (psi) | TYPE OF FAILURE | CORE LENGTH INCHES | CORE DIAMETER INCHES | CORE FAILURE INFORMATION |
|---|---|---|---|---|---|---|---|
| GBW-25 Core axis normal to strike (foliation) | gsmts Manhattan Schist | 115.246 | 16,715 | Shear | 3.141 | 1.506 | Non-violent failure |
| GBW-26 | pqpbg Yonkers Gneiss | 130.931 | 18,990 | Shear | 4.418 | 2.070 | Violent failure |
| GBW-27 | am Hartland (amphibolite) | 152.995 | 22,190 | Shear | 3.032 | 1.504 | Violent failure |
| GBW-13 Core axis parallel to strike (foliation) | wcdm Inwood Marble | 81.979 | 11,890 | Shear ? | 3.780 | 1.512 | Non-violent failure -- Type of failure questioned due to the uncertainty of the crack propagation |
| GBW-13 core axis normal to strike (foliation) | wcdm Inwood Marble | 107.834 | 15,640 | Shear | 3.647 | 1.510 | Semi-violent failure |
| GBW-30 Core axis parallel to strike (foliation) | gqpbs Fordham "schist"* | 44.781 | 6,495 | Shear | 2.394 | 0.993 | Very mild failure |
| GBW-30 Core axis normal to strike (foliation) | gqpbs Fordham "schist"* | 78.669 | 11,410 | Shear | 2.395 | 0.994 | Very mild failure |
| GBW-31 | gspbg Hartland Gneiss | 78.014 | 11,315 | Shear ? | 3.695 | 1.510 | Mild failure -- Type of failure questioned due to the uncertainty of the crack propagation |
| GBW-A1 FORD Core parallel to strike (foliation) | b-wgpbg Fordham Gneiss | 125.519 | 18,205 | Shear | 2.481 | 0.994 | Mild failure |
| GBW-A1 FORD Core normal to strike (foliation) | b-wgpbg Fordham Gneiss | 126.243 | 18,310 | Shear | 2.275 | 0.991 | Mild failure |
| GBW-A2 Core axis parallel to strike (foliation) | gqpbs Fordham "schist"* (amphibolite) | 171.990 | 24,945 | Shear | 3.555 | 1.504 | Violent failure |
| GBW-A2 Core axis normal to strike (foliation) | gqpbs Fordham "schist"* (amphibolite) | 199.879 | 28,990 | Shear | 3.035 | 1.505 | Violent failure |

Table 1. Unconfined compressive strength test results for a representative group of rocks in Bronx County. The strain rate (load), a dimensionless value, applied to the specimens ranged from 3.3 to $4.8 \times 10^{-5}$/second. * are samples from the extensive schistose facies in that unit. Tests were run at the USGS Geotechnical Laboratories, Denver, CO.

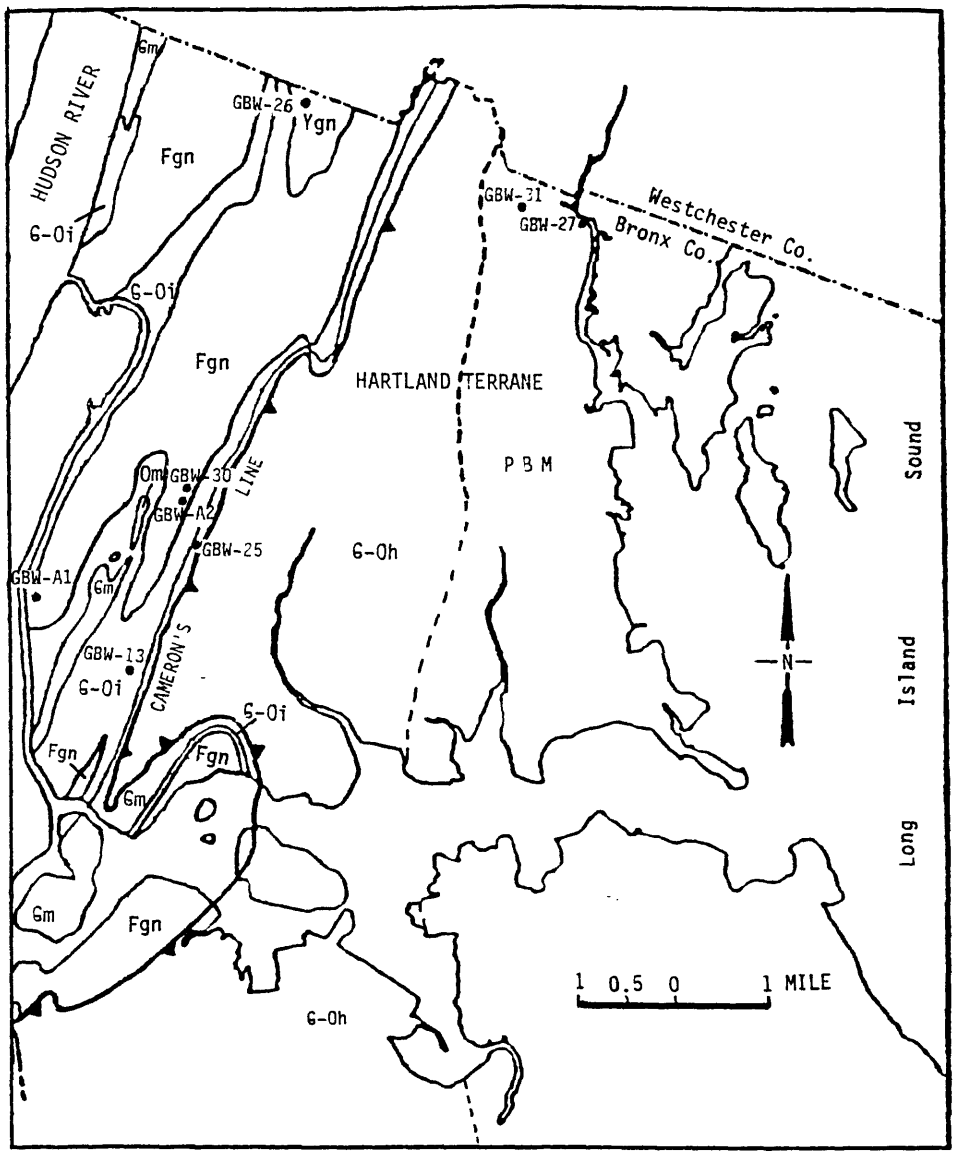


Figure 1. Geology of Bronx County, New York with the locations (•) of the samples (e.g. GBW-13) used in this study. G-Oh = Cambrian and Ordovician Hartland Formation; G-Oi = Cambrian and Ordovician Inwood Marble; Om = Ordovician Manhattan Schist member A; Gm = Cambrian Manhattan Schist member C; Ygn = Proterozoic Yonkers Gneiss; Fgn = Proterozoic Forham Gneiss (undivided); PBM = Pelham Bay Member of the Hutchinson River Group (Hartland rocks).