DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE APPALACHIAN REGIONAL COMMISSION

MISCELLANEOUS FIELD STUDIES
MAP MF-685 A
(SHEET 1 OF 2)

INTRODUCTION

The general geologic framework of Allegheny County is well known. The approximate proportions of rock types within bedrock units are known, but knowledge of the lateral and vertical variations in these proportions countywide has been very limited. The purposes of this map and its tables are to show rock-type variations in bedrock and to summarize the general characteristics of the rocks. Surficial deposits are not treated in the tables and are shown on the map only where they conceal relatively large areas of bedrock. For a more complete discussion of surficial deposits, the reader is referred to O'Neill (1974).

This map was made possible by the recent completion of a detailed soil survey of the county; resulting soil descriptions include good generalized identification of the rocks from which the soils were weathered. In table 1, the soils series are shown in row C, the rocks from which they weathered are listed in row B, and the symbols used on the map are shown in row A. The identification and distribution of soil series form the chief basis for the rock-type map, refined somewhat by reference to known rock-type distribution, geomorphology, and geologic structure, with only minimal verification in the field. The lines of outcrop of the three principal stratigraphic marker beds of the county--the Upper Freeport coalbed, the Ames Limestone Member, and the Pittsburgh coalbed--are included in order to enable the map user to relate rock-type distribution to the conventional stratigraphy shown on the small-scale geologic map (fig. 1) and the columnar section (fig. 2).

GENERAL GEOLOGY

Bedrock stratigraphic units exposed from bottom to top are: the Freeport Formation of the Allegheny Group, the Glenshaw and Casselman Formations of the Conemaugh Group, the Pittsburgh and Uniontown Formations of the Monongahela Group, and the Waynesburg and Washington Formations of the Dunkard Group (fig. 2). The Allegheny, Conemaugh, and Monongahela Groups are Pennsylvanian in age, whereas the Dunkard Group ranges from Pennsylvanian to Permian.

About 150 ft of Allegheny Group strata are present above drainage at the northeasternmost point of Allegheny County. The Conemaugh Group overlies the Allegheny Group and ranges from about 600 ft thick in the western part of the county to about 650 ft thick on the east. The Glenshaw and Casselman Formations of the Conemaugh Group each form about one-half this total thickness, with the Glenshaw commonly slightly thicker than the overlying Casselman. The total thickness of the Monongahela Group ranges from about 300 to 350 ft, most of it in the Pittsburgh Formation; the overlying Uniontown Formation is 60 to 90 ft thick. Dunkard Group strata exposed in Allegheny County total no more than 270 ft thick; most Dunkard rocks are in the Waynesburg Formation, but about 105 ft of the Washington Formation are exposed in one hill in the southernmost part of the county.

Simply stated, the rock layers in Allegheny County dip gently southward with some irregularities owing to north-northeast trending folds (fig. 1). Attitudes of rock layering range from essentially horizontal to, rarely, dips of more than 200 ft per mile on the flanks of anticlines and synclines. Faults are few and minor in offset.

It is recommended that the reader refer to "Geology of the Pittsburgh area" (Wagner and others, 1970) for a more detailed discussion of the general geology.

CHARACTERISTICS OF ROCK TYPES

All bedrock types present in Allegheny County are sedimentary. The general characteristics of the bedrock types are combined and related to map symbols in table 1. In table 2, content, morphology, engineering, and other characteristics of the most prevalent rock types are described. For present purposes, thin-bedded siltstone is grouped under shale and claystone and dolomite is included with limestone. Silty claystone that has a number of characteristics significantly different from other claystone is listed separately. The most conspicuous difference is color, so the silty claystone is labeled "red beds," a descriptive term well known throughout the area.

Coal is an economically important feature of Allegheny County bedrock, but it comprises less than 2 percent of the rock outcrop. The Upper Freeport and Pittsburgh coalbeds are the most important coal units, and their outcrops are shown on the map. Coal in place is moderately to highly permeable, owing to closely spaced joints (cleats), and coal may contain significant amounts of potentially expansive sulfide minerals.

PROBLEMS IN ENVIRONMENTAL GEOLOGY

The most widespread problems that are primarily geological in nature in Allegheny County are those related to slope stability, mining, and foundation conditions.

Slope stability.--Areas generally susceptible to landsliding have been mapped in detail by J. S. Pomeroy and W. E. Davies (unpub. data). They have shown that the great majority of recent or recorded landslides in the county have two things in common: (1) they result chiefly from excavation, overloading, or other interference by man with the tenuous stability of many natural slopes; and (2) they are "thin skinned," that is, failure takes place in residual (weathered in place) and colluvial (transported downhill by gravity) soils and in weathered rock, rather than in relatively fresh bedrock. A few landslides have resulted entirely from natural forces, such as those in the Glassmere vicinity following the torrential rains associated with tropical storm "Agnes" in June 1972. A few important landslides involve bedrock, such as the massive failure at the Brilliant cut on the south side of the Allegheny River opposite Aspinwall.

The incidence of slope failures is by far the highest in materials weathered from "red beds" (included in areas labeled Shu on the map), but landslides also occur elsewhere, notably in soils derived from rocks of the Monongahela Group (chiefly those labeled ShL). Other factors bearing on the problem of slope instability on both natural and cut slopes include the permeability of rock, thickness of rock units, geologic structure, and steepness of slopes.

Mining.--Extraction of coal has been widespread in Allegheny County. The two principal rock-related problems resulting from this activity are mine subsidence and disruption of ground by surface (strip) mining. Mine subsidence generally is considered to mean subsidence of ground surface, either by downward bowing or by ground breakage as a result of removal of coal during underground mining. Rock fractures resulting from subsidence also modify groundwater circulation in rock overburden between the coal horizon and the surface. Subsidence causes localized but relatively frequent damage to manmade structures. Surface mining creates reclamation problems and can also affect the groundwater regime. The distribution of mining-related features in Allegheny County is shown on a map by W. E. Davies and others (unpub. data) at the same scale as the present map. Incidence of mine subsidence and factors bearing on subsidence have been treated at smaller scales by Bushnell (1975a, 1975b), Bushnell and Peak (1975), and Craft (1974).

Foundation conditions.--Table 2 describes general strengths of individual rock types for foundations, and additional information is contained in a report by Philbrick (1960). Time constraints forbade a systematic attempt at collection and analysis of the large amount of other data on Allegheny County rocks present in files of governmental agencies and private firms. A critical foundation-condition factor that must be emphasized is the thickness of the rock units on which a foundation is set. For example, if a heavy structure is founded on a unit of hard sandstone only a few feet thick that overlies plastic claystone, damage may result owing to lateral compressive spreading of the claystone and resulting failure and subsidence of the sandstone unit. An additional critical feature in Allegheny County is the sporadic presence of potentially expansive sulfide minerals in dark shales and coal that can cause heaving and cracking of light foundations. The areal distribution of significant concentrations of such minerals is poorly defined, so the possibility of their presence must be considered during most site investigations.

HOW TO USE MAP AND TABLES

To go from map to table 1.--The map user wishing to estimate the rock characteristics that may prevail at a given site in Allegheny County first will locate the site on the map by reference to the map's topographic base, then identify the bedrock unit symbol or symbols that coincides with the site. If, for example, the unit symbol at the site is Sh, he will refer to table 1 and will find Sh at the top of column 2. Reading down column 2 and checking against headings in column 1, he will find generalized characteristics of material included in unit Sh, for example: relative facility of excavation is intermediate (row E), stability of cut slopes is fair (row F), and potential as riprap or dimension stone is poor (row I).

To go from table 1 to table 2.--If the map user requires more detailed information on rock characteristics in unit Sh, he must go to table 2. To do this, he looks first in row B of table 1, still under column 2, the Sh column. Here he finds the relative content of specific rock types in unit Sh, where shale and claystone predominate. Referring next to table 2, he finds shale and claystone at the head of column 2. Reading down this column, he will find, for example, a more detailed statement of excavation facility in claystone and shale.

In table 1, column 2, row B, he also will find that sandstone is a minor constituent of bedrock unit Sh. Column 5 of table 2 is headed sandstone, and by reading down this column he will find characteristics of sandstone.

To go from map directly to table 2.--A map user may wish more detailed characteristics than those which appear in table 1. He may, therefore, go directly from the map to table 2 by referring to row B of that table. If, as in the above example, the bedrock unit of interest is symbolized Sh, he will read across row B and find that rock types of column 2 (shale and claystone) are predominant in the Sh unit; rock types of column 3 ("red beds") and column 5 (sandstone) are minor constituents in the Sh unit; and the rock type of column 4 (limestone) is rare in the Sh unit. With these general proportions in mind, the map user can read down these columns and become better acquainted with the range of characteristics in the Sh unit.

To go from table 1 to the map.--If the map user is seeking, for example, potential shallow ground-water supplies, he will search the characteristics column (column 1) of table 1 to find the appropriate row (D). Reading across this row he will find that column 5 indicates a low to moderate potential and column 6 a moderate potential, whereas columns 2, 3, and 4 have a generally low potential. Reading up to the top of column 5, he finds the rock unit map symbol ShS and reading up column 6, Ss. He can then search the map for units ShS and Ss, Ss being the most favorable and ShS being a second choice for potential shallow ground water supplies.

To go from table 2 to the map.--As in the preceding example, the map user searches the characteristics column (column 1) of table 2 for the heading of interest. If, for example, he is looking for potential sources of aggregate for concrete, he will read down column 1 and find row Q. Reading across row Q, he will find that the most favorable characteristics are described in column 5. Reading the top of column 5 (row A), he will find that the rock type involved is sandstone. Just below in row B, he finds that sandstone predominates in map unit Ss, is important in map unit ShS, but is minor in other map units. Going to the map he will search preferentially for Ss units, with ShS as a second choice.

LIMITATIONS OF MAP AND TABLES

The distribution of rock types shown on the map is largely a derivation from soil surveys, and the tables present two levels of estimates of bedrock characteristics that are drawn chiefly from published geologic information. The map and tables thus are guides to expected characteristics, but it is probable that the characteristics assigned in the tables to bedrock units symbolized ShL, for example, will not be present in all areas symbolized ShL. Conversely, ShL characteristics may be present locally in areas labeled with other bedrock unit symbols.

Moreover, the emphasis of the map and tables is on bedrock. Surficial deposits that mantle bedrock in the bottoms of most valleys and on many lower slopes are not dealt with here, and where such deposits are thick their characteristics may be of greater importance for some purposes than are the characteristics of bedrock.

The map and tables, therefore, are planning tools only. They cannot be considered as adequate substitutes for detailed field studies of specific sites by competent technical personnel.

GLOSSARY [1]

Alluvium--Unconsolidated gravel, sand, silt, and clay deposited by running water in a stream bed, on a flood plain adjacent to a stream, or in related environments of deposition
Anticline--An upfold of rock layers. Opposite to syncline
Bedrock--Rock, usually solid, that underlies soil or other unconsolidated surficial material
Bloating--Expansion, usually of clay or claystone, produced by heat and resulting in the formation of a vesicular (bubble-like) structure
Calcite--A common rock-forming mineral composed of calcium carbonate ($CaCO_3$). Principal constituent of limestone
Chlorite--A clay mineral composed of hydrous (water-bearing) silicate of aluminum and varying proportions of magnesium and iron
Clay--An earthy aggregate of mineral or rock particles, most of which are less than 1/256 mm in diameter, commonly consisting chiefly of clay minerals and quartz
Clay minerals--A complex association of rock-forming minerals chiefly composed of crystalline or amorphous hydrous (water-bearing) aluminum silicate
Claystone--A rock composed of indurated clay
Conglomerate--A rock composed of indurated gravel
Contact--A boundary between different rock units
Dip--The angle by which the plane of rock layering (or other planar element, such as a joint) is inclined from the horizontal. Commonly expressed in degrees or in feet per mile
Dolomite--(1) A common rock-forming mineral consisting of calcium magnesium carbonate ($CaMg(CO_3)_2$). (2) A rock type composed chiefly of the mineral dolomite
Fault--A plane or zone along which rock on one side has moved relative to rock on the opposite side
Feldspar--A group of common rock-forming minerals composed of aluminum silicates of potassium (orthoclase--$KAlSi_3O_8$), sodium (albite--$NaAlSi_3O_8$), and calcium (anorthite--$CaAl_2Si_2O_8$)
Formation--The basic rock-stratigraphic unit in the local classification of rocks. Commonly of considerable thickness and lateral extent and commonly with distinct differences from formations immediately above and below
Geomorphology--The study of the configuration of the Earth's surface
Gravel--An unconsolidated natural accumulation of rounded to subangular rock fragments, most of which are larger than 2 mm in diameter
Group--A major rock-stratigraphic unit consisting wholly of two or more contiguous or associated formations having significant rock features in common
Illite--A clay mineral composed of hydrous (water-bearing) potassium aluminum silicate; elemental composition varies
Indurated--Descriptive of rock material hardened by the action of heat, pressure, or the introduction of some cementing compound not commonly contained in the original material
Joint--A fracture or parting in a rock in which rock on one side has not moved relative to rock on the opposing side. Usually planar or gently curved. Often occurs in parallel joint sets with more or less regular spacing between joints
Kaolinite--A clay mineral composed of hydrous (water-bearing) aluminum silicate ($Al_4[Si_4O_{10}](OH)_8$)
Limestone--A rock consisting of more than 50 percent calcium carbonate ($CaCO_3$), primarily in the form of the mineral calcite
Marcasite--A mineral composed of iron sulfide (FeS_2). Differs from pyrite in crystal form
Marker, marker bed, or stratigraphic marker--An easily recognized bed or horizon having characteristics distinctive enough for it to be recognized in outcrops in a large area
Member--A subordinate rock-stratigraphic unit comprising some specially developed part of a formation. Commonly of moderate lateral extent and appreciably thinner than the formation, of which the member is a part
Mica--General name for common rock-forming minerals with platey or sheet-like structure. Composed largely of silicates of aluminum and subordinate other elements
Mineral--A naturally formed inorganic compound which has a chemical composition that is definite or ranges between definite limits and which usually has a characteristic crystal form
Montmorillonite--A clay mineral composed of hydrous (water-bearing) silicate of aluminum and varying proportions of calcium, sodium, magnesium, and iron. An "expanding clay" that readily absorbs water
Muscovite--A common rock-forming mica mineral composed of hydrous (water-bearing) potassium aluminum silicate ($KAl_2(AlSi_3O_{10}(OH)_2$)
Permeability--In rocks and soil, the capacity to transmit water. The greater this capacity, the greater the permeability
Pyrite--A mineral composed of iron sulfide (FeS_2). Differs from marcasite in crystal form
Quartz--A common rock-forming mineral. Pure quartz is composed entirely of silicon dioxide (SiO_2)
Residual material--Unconsolidated material, largely clay or sandy and silty clay, presumed to have developed by weathering in place from the consolidated rock on which it lies
Rock--(1) Any naturally formed consolidated or unconsolidated (loose) material composed of two or more minerals, occasionally of only one mineral. (2) A representative sample of such material
Sand--A loose aggregate of mineral or rock particles, most of which range from 1/16 to 2 mm in diameter. Most common mineral in sand is quartz
Sandstone--A rock composed of indurated sand
Shale--In usage common to the area, shale is moderately well indurated rock composed largely of clay- and silt-sized particles, commonly is thinly or very thinly layered, and commonly breaks down with weathering to platy fragments oriented parallel or subparallel to rock layering
Silicate--A chemical compound in which the elements silicon (Si) and oxygen (O) are combined with one or more other elements. Most common rock-forming minerals are silicates
Silt--A loose aggregate of mineral or rock particles, most of which range from 1/256 to 1/16 mm in diameter
Siltstone--A rock composed of indurated silt
Soil--(1) Engineering--all unconsolidated material above hard bedrock. (2) Agriculture--material that supports plant life and has undergone near-surface zonation resulting from the interaction of climate and living matter conditioned by slope and relief
Stratigraphy--The definition and description of major and minor natural divisions in layered rocks, such as groups, formations, and members
Surficial deposit--Unconsolidated or weakly consolidated earth materials that are at or near the land surface; underlain by bedrock, although at considerable depth in some places
Syncline--A downfold of rock layers. Opposite of anticline. In cross section a tight syncline would have the form of the letter U
Terrace deposit--Alluvial deposit on relatively level, commonly bench-shaped surface adjacent to river and stream valleys; generally at elevations well above those reached by historic floods. Terrace alluvium
Vermiculite--A clay mineral composed of hydrous (water-bearing) silicate of aluminum and varying proportions of magnesium, calcium, and iron. An "expanding clay" that readily absorbs water

[1] See also: American Geological Institute, 1972

SELECTED REFERENCES

American Geological Institute, 1972, Glossary of Geology: Washington, D.C., 857 p.
Berryhill, H. L., Jr., Schweinfurth, S. P., and Kent, B. H., 1971, Coal-bearing Upper Pennsylvanian and Lower Permian rocks, Washington area, Pennsylvania: U.S. Geol. Survey Prof. Paper 621, 47 p.
Briggs, R. P., 1974, Map of overdip slopes that can affect landsliding in Allegheny County, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-543.
Bushnell, K. O., 1975a, Map showing areas that correlate with subsidence events due to underground mining of the Pittsburgh and Upper Freeport coalbeds, Allegheny, Washington, and Westmoreland Counties, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-693C [in press].
_____1975b, Map showing depths to the Pittsburgh coalbed, mining activity, and related surface subsidence, Allegheny, Washington, and Westmoreland Counties, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-693A [in press].
Bushnell, K. O., and Peak, J. R., 1975, Map showing depths to the Upper Freeport coalbed, mining activity, and related surface subsidence, and the Redstone coalbed mines, Allegheny, Washington, and Westmoreland Counties, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-693B [in press].
Campbell, M. R., 1903, Description of the Brownsville and Connellsville quadrangles [Pennsylvania]: U.S. Geol. Survey Geol. Atlas, Folio 94, 19 p.
Craft, J. L., 1974, Preliminary overburden-thickness map on the Pittsburgh coal: Pennsylvania Geol. Survey open-file map.
Dougherty, M. T., and Barsotti, N. J., 1972, Structural damage and potentially expansive sulfide minerals: Assoc. Eng. Geologists Bull., v. 9, no. 2, p. 105-125.
Fasiska, E. J., Wagenblast, H., and Dougherty, M. T., 1974, The oxidation mechanism of sulfide minerals: Assoc. Eng. Geologists Bull., v. 11, no. 1, p. 75-82.
Flint, N. K., 1965, Geology and mineral resources of southern Somerset County, Pennsylvania: Pennsylvania Geol. Survey, 4th ser., County Rept. C 56A, 267 p.
Gallaher, J. T., 1973: Summary of ground water resources of Allegheny County, Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Water-Resource Rept. W 35, 71 p.
Hamel, J. V., 1971, The slide at Brilliant cut, in Symposium on rock mechanics, 13th, Urbana, Illinois, 1971: preprint, 24 p.
Hamel, J. V., and Flint, N. K., 1969, Analysis and design of highway cuts in rock: A slope stability study on Interstate Routes 279 and 79 near Pittsburgh, Pennsylvania: Pennsylvania Dept. Highways Research Proj. no. 41472, 130 p.
Hughes, H. H., 1933, Freeport quadrangle--geology and mineral resources: Pennsylvania Geol. Survey, 4th ser., Topog. and Geol. Atlas A 36, 272 p.
Johnson, M. E., 1925, Mineral resources of the Greensburg quadrangle, Westmoreland County, Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Topog. and Geol. Atlas A 37, 162 p.
_____1929, Pittsburgh quadrangle, [Pennsylvania], geology and mineral resources: Pennsylvania Geol. Survey, 4th ser., Topog. and Geol. Atlas A 27, 236 p.
Kent, B. H., Schweinfurth, S. P., and Roen, J. B., 1969, Geology and land use in eastern Washington County, Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Gen. Geol. Rept. G 56, 31 p.
McGlade, W. G., Geyer, A. R., and Wilshusen, J. P., 1972, Engineering characteristics of the rocks of Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Environmental Geol. Rept. EG 1, 200 p.
Munn, M. J., 1911, Description of the Sewickley quadrangle, Pennsylvania: U.S. Geol. Survey Geol. Atlas, Folio 176, 16 p.
Nickelsen, R. P., and Hough, V. N. D., 1967, Jointing in the Appalachian Plateau of Pennsylvania: Geol. Soc. America Bull., v. 78, p. 609-629.
O'Neill, B. J., Jr., 1974, Greater Pittsburgh region construction aggregates: Pennsylvania Geol. Survey, 4th ser., Mineral Resources Rept. M 67, 60 p.
O'Neill, B. J., Jr., Lapham, D. M., Jaron, M. G., Socolow, A. A., Thomson, R. D., and Hamlin, H. P., 1965, Properties and uses of Pennsylvania shales and clays: Pennsylvania Geol. Survey, 4th ser., Mineral Resources Rept. M 51, 448 p.
Philbrick, S. S., 1959, Engineering geology of the Pittsburgh area [Pennsylvania], in Geol. Soc. America, Guidebook, Field Trip no. 6, p. 189-203.
_____1960, Cyclic sediments and engineering geology: Internat. Geol. Cong., 21st, Copenhagen, 1960, Rept., pt. 20, p. 49-63.
Richardson, G. B., 1932, Geology and coal, oil, and gas resources of the New Kensington quadrangle, Pennsylvania: U.S. Geol. Survey Bull. 829, 102 p.
Roen, J. B., Kent, B. H., and Schweinfurth, S. P., 1968, Geologic map of the Monongahela quadrangle, southwestern Pennsylvania: U.S. Geol. Survey Geol. Quad. Map GQ-743.
Shaw, E. W., and Munn, M. J., 1911, Description of the Burgettstown and Carnegie quadrangles, Pennsylvania: U.S. Geol. Survey Geol. Atlas, Folio 177, 16 p.
Subitzky, Seymour, 1975a, Hydrogeologic framework and generalized shallow ground-water circulation system, Allegheny County, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-641B.
_____1975b, Mining and related problems of the shallow hydrogeologic regime, Allegheny County, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-641C.
_____1975c, Summary of behavior of the hydrogeologic regime as related to environmental characteristics, Allegheny County, Pennsylvania: U.S. Geol. Survey Misc. Field Studies Map MF-641A.
U.S. Soil Conservation Service, 1973a, Volume 1--Soil survey maps for Allegheny County, Pennsylvania [Interim Rept.]: Washington, D.C., [250] p.
_____1973b, Volume 2--Soil survey interpretations for Allegheny County, Pennsylvania [Interim Rept.]: Washington, D.C., [127] p.
Wagner, W. R., Heyman, Louis, Gray, R. E., Belz, D. J., Lund, Richard, Cate, A. S., and Edgerton, C. D., 1970, Geology of the Pittsburgh area: Pennsylvania Geol. Survey, 4th ser., Gen. Geol. Rept. G 59, 145 p.
Winters, D. M., 1972, Pittsburgh red beds: Stratigraphy and slope stability in Allegheny County, Pennsylvania: Pittsburgh, Pa., Univ. Pittsburgh, Master's thesis, 49 p.
Woolsey, L. H., 1905, Description of the Beaver quadrangle, [Pennsylvania]: U.S. Geol. Survey Geol. Atlas, Folio 134, 15 p.

Units of measurement

Customary (English) units of measurement are used for present purposes in preference to International System (SI or metric) units, except for grain-size ranges stated in table 2. To convert the units used to units of the alternative system:

Multiply	By	To obtain
millimetres	0.03937	inches
inches	25.4	millimetres
inches	2.54	centimetres
feet	30.48	centimetres
feet	0.3048	metres
miles	1.609	kilometres
feet per mile	0.189	metres per kilometres
feet per mile	0.0189	percent of grade or metres per hectometre
gallons per minute	3.785	litres per minute
pounds per square inch	6.9	kilonewtons per square metre
tons per square foot	95.8	kilonewtons per square metre

Table 1. - General engineering characteristics of bedrock units symbolized on the map (combines rock type characteristics from table 2)

A. MAP SYMBOL / 1. CHARACTERISTICS	2. Sh	3. Shu	4. ShL	5. ShS	6. Ss
B. ROCK CONTENT (See table 2 for characteristics of principal rock types)	Shale and claystone - predominant "Red beds" - minor Limestone - rare Sandstone - minor	Shale and claystone - important "Red beds" - important Limestone - minor Sandstone - minor	Shale and claystone - important "Red beds" - minor Limestone - important Sandstone - minor	Shale and claystone - important "Red beds" - rare Limestone - rare Sandstone - important	Shale and claystone - rare "Red beds" - very rare Limestone - very rare Sandstone - predominant
C. OVERLYING AGRICULTURAL SOILS (From U.S. Soil Conservation Service, 1973 a, b)	Cavode, Gilpin, Rayne, Wharton, Brinkerton, Clarksburg, and Ernest soil series	Upshur soil series, and Gilpin-Upshur, Guernsey-Vandergrift, and Ernest-Vandergrift, soil complexes	Guernsey, Library, Ernest, and Clarksburg soil series	Culleoka, Weikert, and Ernest soil series	Clymer and Hazleton soil series
D. POTENTIAL FOR SHALLOW GROUNDWATER SUPPLIES	Low	Low	Low	Low to moderate	Moderate
E. RELATIVE FACILITY OF EXCAVATION WITH POWER EQUIPMENT	Intermediate	Easy	Intermediate	Intermediate	Difficult
F. RELATIVE STABILITY OF CUT SLOPES	Fair	Poor	Fair	Fair	Good
G. RELATIVE FOUNDATION STRENGTH (Unconfined compressive strength)	Intermediate	Low	Intermediate	Intermediate to high	High
H. POTENTIAL SOURCE OF CONSTRUCTION AGGREGATE	Fair	Poor	Fair	Good	Excellent
I. POTENTIAL SOURCE OF RIPRAP AND DIMENSION STONE	Poor	Poor	Fair	Fair	Good
J. POTENTIAL SOURCE OF MATERIAL FOR WELL-DRAINED STABLE EMBANKMENTS	Fair	Poor	Fair	Fair	Good

Table 2. Summary of physical properties and engineering characteristics of principal rock types

A. ROCK TYPES / 1. CHARACTERISTICS	2. SHALE AND CLAYSTONE (Many shale layers largely composed of silt-size fragments; many silty claystones)	3. "RED BEDS" (Commonly composed of silty claystone)	4. LIMESTONE (Includes dolomite)	5. SANDSTONE	6. SOURCES OF PUBLISHED INFORMATION
B. RELATIVE SIGNIFICANCE OF ROCK TYPES IN BEDROCK UNITS (Units shown by symbol on map and in table 1, row A)	Sh - predominant Shu - important ShL - important ShS - important Ss - rare	Sh - minor Shu - important ShL - minor ShS - rare Ss - very rare	Sh - rare Shu - minor ShL - important ShS - rare Ss - very rare	Sh - minor Shu - minor ShL - minor ShS - important Ss - predominant	
C. RELATIVE SIGNIFICANCE OF ROCK TYPE BY STRATIGRAPHIC GROUP (See figure 1 for areal distribution of groups)	Dunkard Group - predominant Monongahela Group - predominant Conemaugh Group - important Allegheny Group - important	Dunkard Group - minor Monongahela Group - minor Conemaugh Group - important Allegheny Group - rare	Dunkard Group - important Monongahela Group - important Conemaugh Group - minor Allegheny Group - minor	Dunkard Group - minor Monongahela Group - minor Conemaugh Group - important Allegheny Group - important	
D. PREDOMINANT RANGE IN GRAIN SIZE (Millimetres)	Less than 1/256 mm to 1/16 mm in diameter.	Less than 1/256 mm to 1/16 mm in diameter.	Less than 1/256 mm to 1/4 mm in diameter.	1/16 mm to 2 mm in diameter.	
E. COLOR (From a number of sources; usage not consistent)	Medium-gray, greenish-gray, dark-gray, locally black.	Dull-red predominant; includes layers, zones, and patches of gray, medium-gray, greenish-gray, pale-green, and purple.	Medium-gray, bluish-gray, and yellowish-brown.	Medium-gray, olive-gray, buff, and yellowish-brown.	
F. MINERAL CONTENT	Illite, most abundant clay mineral; subordinate chlorite, kaolinite, mixed-layer illite-chlorite, vermiculite(?), montmorillonite(?); quartz, feldspar, muscovite (present in Monongahela and Dunkard Groups; Allegheny and Conemaugh Groups believed generally similar by present writers). Three Casselman Formations (Conemaugh Group) samples averaged (composition in percent): "mica" (largely illite), 40; quartz, 35; kaolinite, 7; chlorite, vermiculite, and montmorillonite combined, 6; calcite and dolomite commonly present. Black and dark gray shales commonly contain more than 1 percent pyrite and(or) marcasite and appreciable carbonaceous material.	One sample from the "Pittsburg red beds," upper Glenshaw Formation (Conemaugh Group) (composition in percent): quartz, 42; mica (largely illite), 40; chlorite, vermiculite, and montmorillonite combined, 3; kaolinite and feldspar, 11; calcite and dolomite present. Quartz and mica contents may be erroneously high. Principal expandable mineral in "red beds" is vermiculite.	Chiefly calcite; commonly somewhat impure, locally with as much as 50 percent impurities, largely clay minerals and quartz. In some localities, chiefly in the Monongahela and Dunkard Groups, rocks called limestone are more accurately dolomite (or dolostone), in which the chief mineral is dolomite.	Composition in percent: quartz, 60-75; feldspar, 10-20; "clay minerals" (chiefly kaolinite, illite, chlorite), 1-15; muscovite, 3-7; others, 1-4 (in Monongahela and Dunkard Groups; Allegheny and Conemaugh Groups believed very similar by present writers). Some sandstones are cemented by calcite. Some contain 0.6-1.6 percent pyrite and(or) marcasite.	Information largely from Berryhill and others (1971), Dougherty and Barsotti (1972), Kent and others (1969), O'Neill and others (1965), and Wagner and others (1970), and H.F. Ferguson (oral comman., 1974).
G. THICKNESS OF ROCK LAYERS	Claystone layering is poorly defined and may range from less than 1 in. to as much as 10 ft thick. Shale layers range from a feather edge to, rarely, 6 in. thick.	Layers poorly defined, commonly more than 1 ft thick. Layering is reported as lacking in one unit 60 ft thick.	Ranges from 6 in. to 3 ft thick, commonly less than 2 ft thick.	Ranges from less than 1/2 in. to more than 10 ft; commonly less than 3 ft thick. Layers thickest in Conemaugh and Allegheny Groups.	Information on "red bed" layering from Hamel and Flint (1969).
H. THICKNESS OF ROCK UNITS (Composed of one or more layers of the principal rock type)	Commonly ranges from 1 to 40 ft thick, less commonly from less than 1/2 in. to 50 ft thick.	Commonly range from 1 to 40 ft thick, less commonly as much as 64 ft thick.	Commonly range from 1 to 4 ft thick. In the Monongahela Group one unit locally is as much as 40 ft thick.	Commonly range from 3 to 30 ft thick. Extremes are from less than 1/2 in. thick in shale units to 100 ft thick. Units are thickest in Conemaugh Group.	Information largely from Berryhill and others (1971), Hamel and Flint (1969), Philbrick (1959), Wagner and others (1970), and Winters (1972).
I. JOINT OR FRACTURE CHARACTERISTICS (Approximate; locally altered by fracturing related to mine subsidence)	Joints more or less vertical with irregular spacing ranging from inches to more than 10 ft. Joints commonly tight.	Jointing poorly developed or absent. Commonly closely fractured in random directions with fractures very tight in unweathered rock.	Joint or fracture surfaces more or less vertical, but irregular with spacing ranging from 1 to more than 5 ft. Joints commonly open and enlarged by solution.	Joints more or less vertical with spacing commonly from 3 to less than 10 ft in outcrop; locally many tens of feet. Joints commonly open.	Information largely from Hamel and Flint (1969), Nickelsen and Hough (1967), and Philbrick (1960).
J. NATURAL PERMEABILITY (Locally altered significantly by fracturing related to mine subsidence)	Low permeability.	Low permeability.	Moderate permeability through open joints and planes of layering.	Moderate permeability through intergrain voids, open joints, and planes of layering.	Treated in greater detail by Subitzky (1975a, b, c).
K. GROUNDWATER POTENTIAL (Yields given in gallons per minute, gpm)	Yields from wells generally are less than 5 gpm; wells drawing from units below drainage may yield 20 gpm. Water commonly is hard and may have an objectionably high iron content.	Yields from wells rarely are greater than 2 gpm. Water commonly is moderately mineralized.	Yields of inventoried wells commonly are less than 1 gpm; locally yields are as high as 15 gpm. Water commonly is moderately hard and may have an objectionably high iron content. Springs and seeps are common where limestone overlies less permeable claystone and shale, causing rapid weathering of these subjacent rocks, thus contributing to slope stability problems.	Yields from wells range from 2 to 400 gpm; most commonly less than 75 gpm. In places water is moderately mineralized and hard. In some wells drawing from units 100 ft or more below drainage, water ranges from brackish to a concentrated brine. Springs are common where sandstone overlies less permeable claystone and shale, particularly where ground water may be perched in a synclinal axis and not dewatered by mining-induced fracturing of the otherwise less permeable rock layers.	Information from Gallaher (1973), Kent and others (1969), and McGlade and others (1972).
L. RELATIVE RATES OF ROCK WEATHERING	Moderate to rapid. Exposed claystone at one locality in the Conemaugh Group weathered at rates ranging from 0.2 to 0.6 ft/yr.	Rapid. When a fresh surface is dried and rewetted, surface layer about 1 in. thick may slake or disintegrate in minutes.	Slow to moderate if relatively pure; moderate to rapid if highly impure.	Generally slow, commonly imperceptible during a human lifetime.	Information on claystone, shale, and "red beds" largely from Philbrick (1959 and 1960).
M. THICKNESS OF OVERLYING RESIDUAL MATERIAL	Commonly ranges from 1 1/2 to 5 ft thick. Over calcareous claystone and shale, thickness, though irregular, is rarely less than 4 ft.	Commonly more than 5 ft thick; locally appreciably thicker.	Commonly ranges from 3 1/2 to 6 ft thick and commonly irregular in thickness; zero on a few slopes where limestone forms ledges.	Commonly ranges from 3 1/2 to 6 ft thick; zero on many slopes where sandstone forms ledges and cliffs.	Information adapted from U.S. Soil Conservation Service (1973b).
N. FACILITY OF EXCAVATION	Generally rippable to at least 8 ft below ground surface with light power equipment; locally may be rippable to more than 20 ft with heavy equipment; blasting generally required for deep excavations.	Rippable to at least 8 ft below ground surface with light power equipment; entire thickness of "red bed" units probably rippable with heavy equipment, provided there is room to maneuver.	Generally rippable to at least 8 ft below ground surface with light power equipment; locally may be rippable to more than 20 ft with heavy equipment; blasting generally required for deep excavations.	Generally rippable to depths of at least 5 ft below ground surface with light power equipment, such as a backhoe; where thinly layered probably rippable to more than 10 ft with heavy equipment. Blasting required for deep excavations and for shallow excavations where hard sandstone is in very thick layers.	Information largely from McGlade and others (1972) and U.S. Soil Conservation Service (1973b).
O. STABILITY OF UNSUPPORTED CUT SLOPES (All cut slopes should be somewhat flatter where cuts result in overlip-slope conditions; slope ratios given as vertical: horizontal)	Slopes no steeper than 2:1 recommended for most cuts. Variable rock properties such as thick layering, widely spaced joints, relatively high contents of coarser grained minerals, and calcite cement locally may permit cut as steep as 4:1. Some cuts may require slopes of 1:1 or flatter for stability.	Slopes no steeper than 1:1 recommended. Some cuts may require slopes of 1:3 or flatter for stability. Weathered "red beds" are the chief source of slope-stability problems in Allegheny County.	Slopes no steeper than 4:1 recommended. Also see column 4, row K.	Slopes no steeper than 4:1 recommended. Rockfall is a consistent hazard where fractured or jointed sandstone is underlain by more readily erodible claystone, shale, or "red beds". Some thick sandstone units form vertical natural cliffs.	Recommendations are those of Philbrick (1960), based on experience of the U.S. Army Corps of Engineers. Other information from Briggs (1974), J.S. Pomeroy and W.E. Davies (unpub. data), and Winters (1972).
P. FOUNDATION STRENGTH (Measurement data are available from only a few places, but are considered generally representative)	Unconfined compressive strength 3,600 to 4,200 lb/sq in. and bearing capacity 8 tons/sq ft in middle part of Conemaugh Group. Mineral expansion caused by hydration of pyrite or marcasite can cause upward pressures of 500 lb/sq ft or more, with resulting heaving and cracking of foundations. These minerals have been identified in coal, black shale, and dark-gray shale in the Conemaugh and Monongahela Groups.	Unconfined compressive strength 1,600 to 2,100 lb/sq in. and bearing capacity 4 to 8 tons/sq ft in middle part of