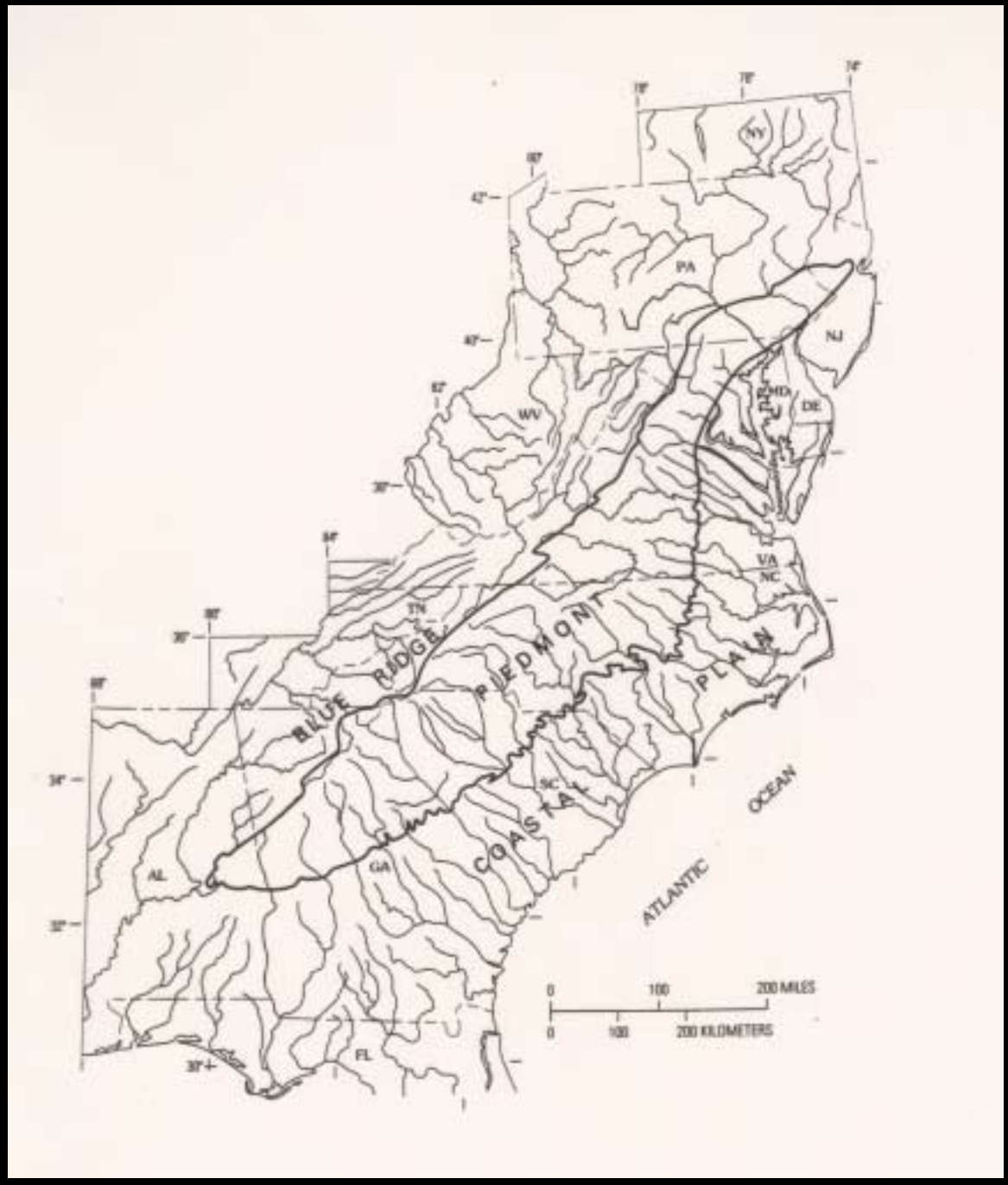
SAPROLITE AND ITS ROLE IN RECHARGE TO THE GROUND-WATER SYSTEM

Milan Pavich
U.S. Geological Survey
Reston, Va.

June 26, 2001

POTENTIAL FOR SCALING SYSTEMATIC REGOLITH CHARACTERISTICS

1. Systematic regional relations to rock & topography
2. Systematic depth relations
3. Anisotropic structures & fabrics
4. Soil, saprolite, & massive zone mediate recharge
5. Winter recharge – Seasonal & multi-annual water deficits
6. Rapid movement of contaminants in saprolite


NY
PA
NJ
MD
DE
WV
VA
NC
TN
SC
GA
AL
FL
BLUE RIDGE
PIEDMONT
PLAIN
COASTAL
ATLANTIC
OCEAN
0 100 200 MILES
0 100 200 KILOMETERS

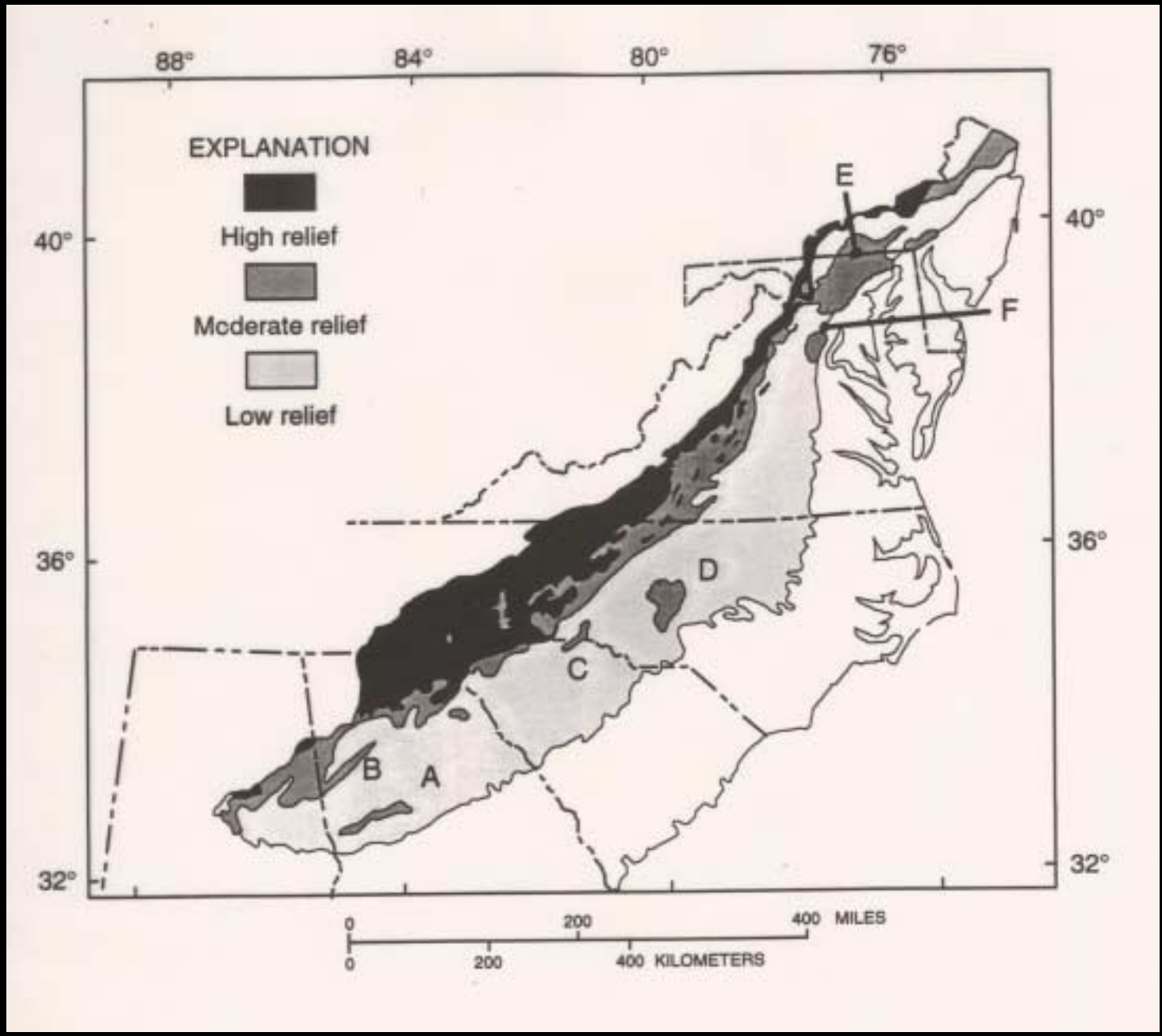
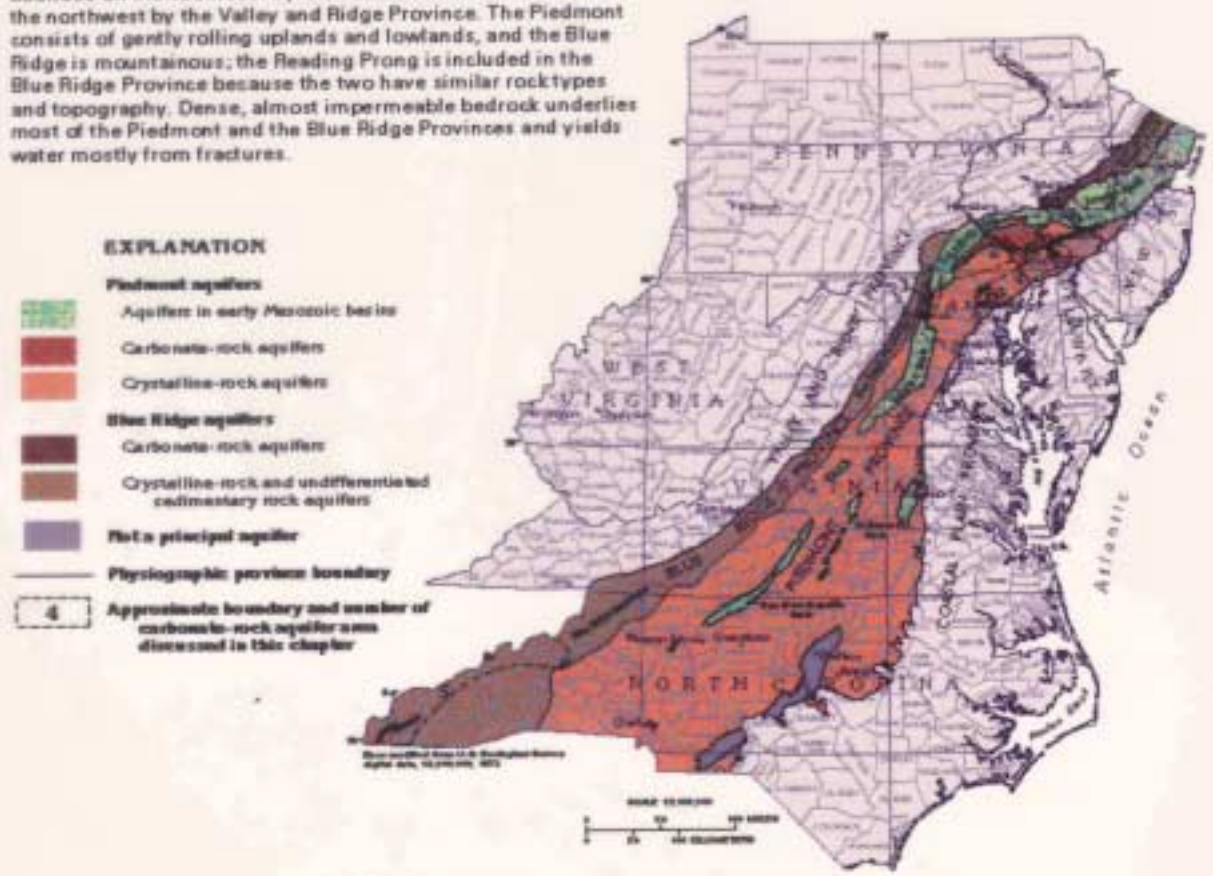

88°
84°
80°
76°
40°
36°
32°
EXPLANATION
High relief
Moderate relief
Low relief
A
B
C
D
E
F
0
200
400 MILES
0
200
400 KILOMETERS

Figure 60. The Piedmont and the Blue Ridge Provinces are bounded on the southeast by the Coastal Plain Province and on the northwest by the Valley and Ridge Province. The Piedmont consists of gently rolling uplands and lowlands, and the Blue Ridge is mountainous; the Reading Prong is included in the Blue Ridge Province because the two have similar rocktypes and topography. Dense, almost impermeable bedrock underlies most of the Piedmont and the Blue Ridge Provinces and yields water mostly from fractures.



Modified from:

Fenneman, N.M., and Johnson, D.W., 1946, Physical divisions of the United States: U.S. Geological Survey, scale 1:7,000,000, 1 sheet.

Johnson, M.E., 1950, Geologic map of New Jersey: New Jersey Geological Survey, scale 1:250,000, 1 sheet.

Calver, J.L., and others, compilers, 1963, Geologic map of Virginia: Virginia Department of Conservation and Economic Development, Division of Mineral Resources, scale 1:500,000, 1 sheet.

Cleaves, E.T., Edwards, Jonathan, Jr., and Glaser, J.D., compilers, 1968, Geologic map of Maryland: Maryland Geological Survey, scale 1:250,000, 1 sheet.

Berg, T.M., and others, comp., 1980, Geologic map of Pennsylvania: Pennsylvania Bureau of Topographic and Geologic Survey, scale 1:250,000, 3 sheets.

Brown, P.M., and Parker, J.M., III, compilers, 1985, Geologic map of North Carolina: North Carolina Department of Natural Resources and Community Development, Division of Land Resources, scale 1:500,000, 1 sheet.

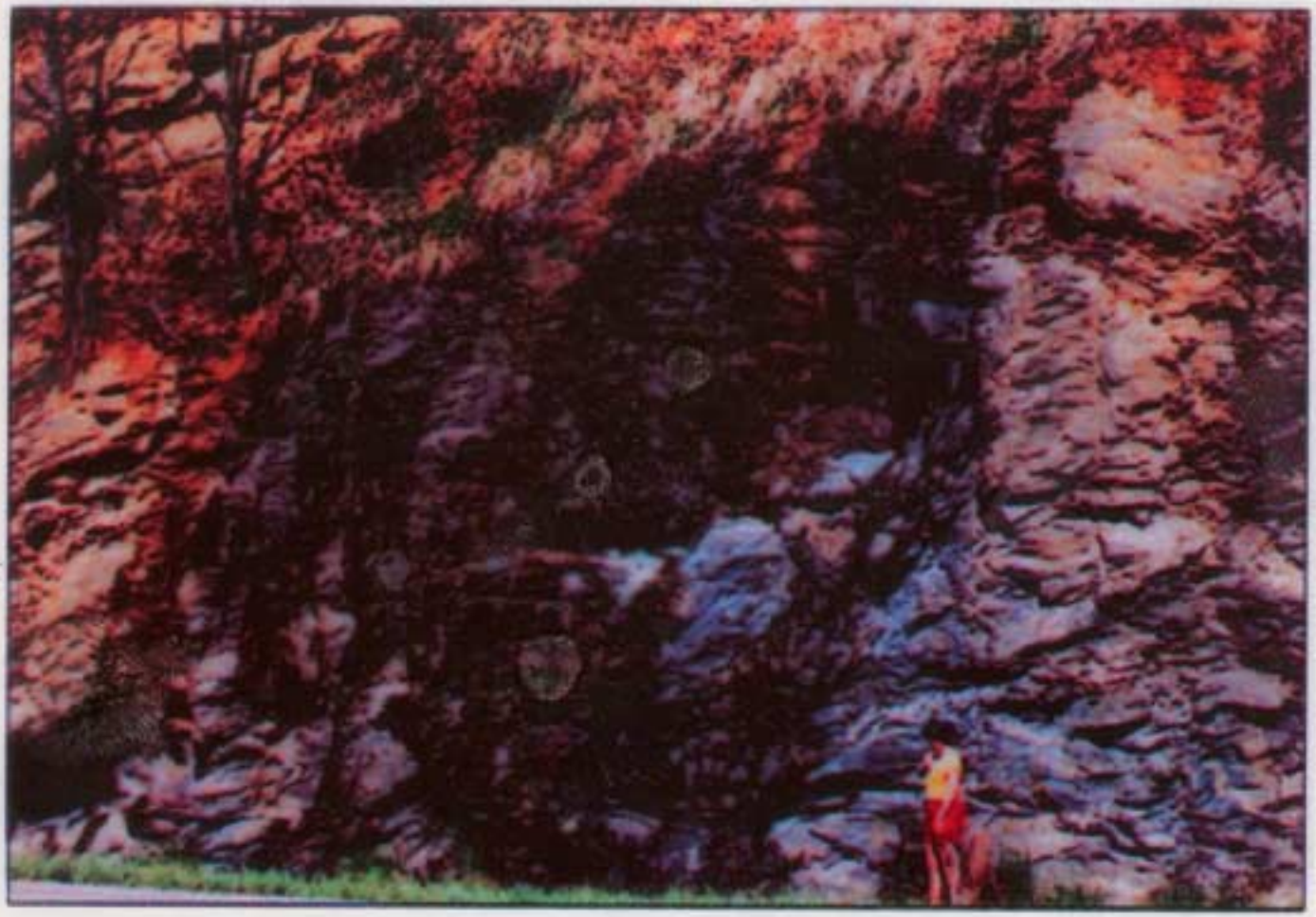


Figure 86. *In crystalline rocks, water moves through fractures. The dark spot in the photograph of this roadcut shows where water issues at the rock face from part of a nearly horizontal fracture. The water has first moved downward through vertical fractures, then moves laterally to its point of discharge. The surrounding, lighter colored rock is dry.*

- CECIL-MADISON-PACOLET
- CECIL-HIWASSEE-PACOLET
- MADISON-DAVIDSON-PACOLET
- CECIL-MADISON-ENON
- HERNDON-HELENA-GEORGEVILLE
- PACOLET-MADISON-CECIL
- APPLING-WEDOWEE-LOUISBURG
- TATUM-GEORGEVILLE-HERNDON
- CECIL-HIWASSEE-CATAULA
- GEORGEVILLE-NASON-LIGNUM

Scale

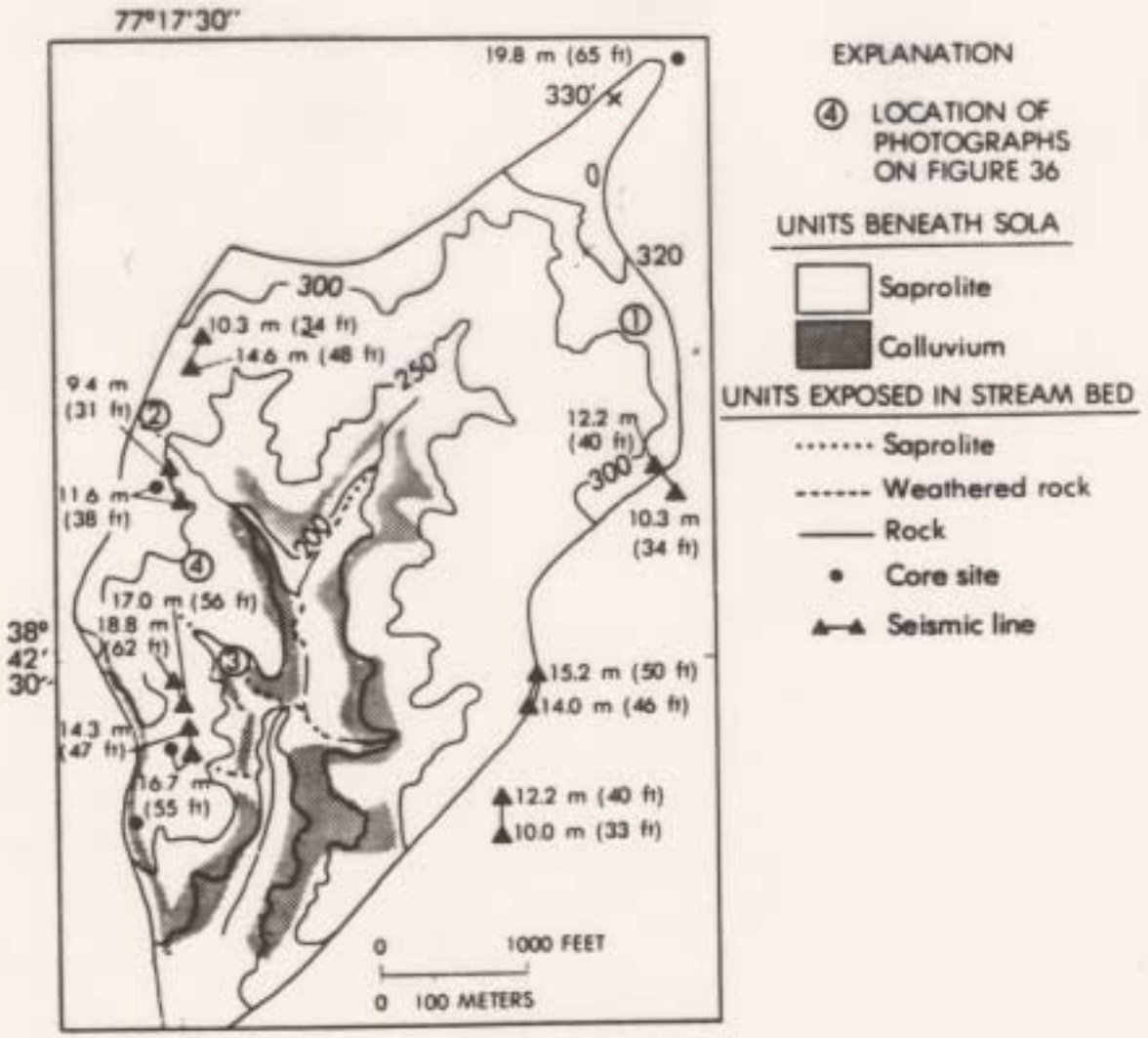
200 0 200

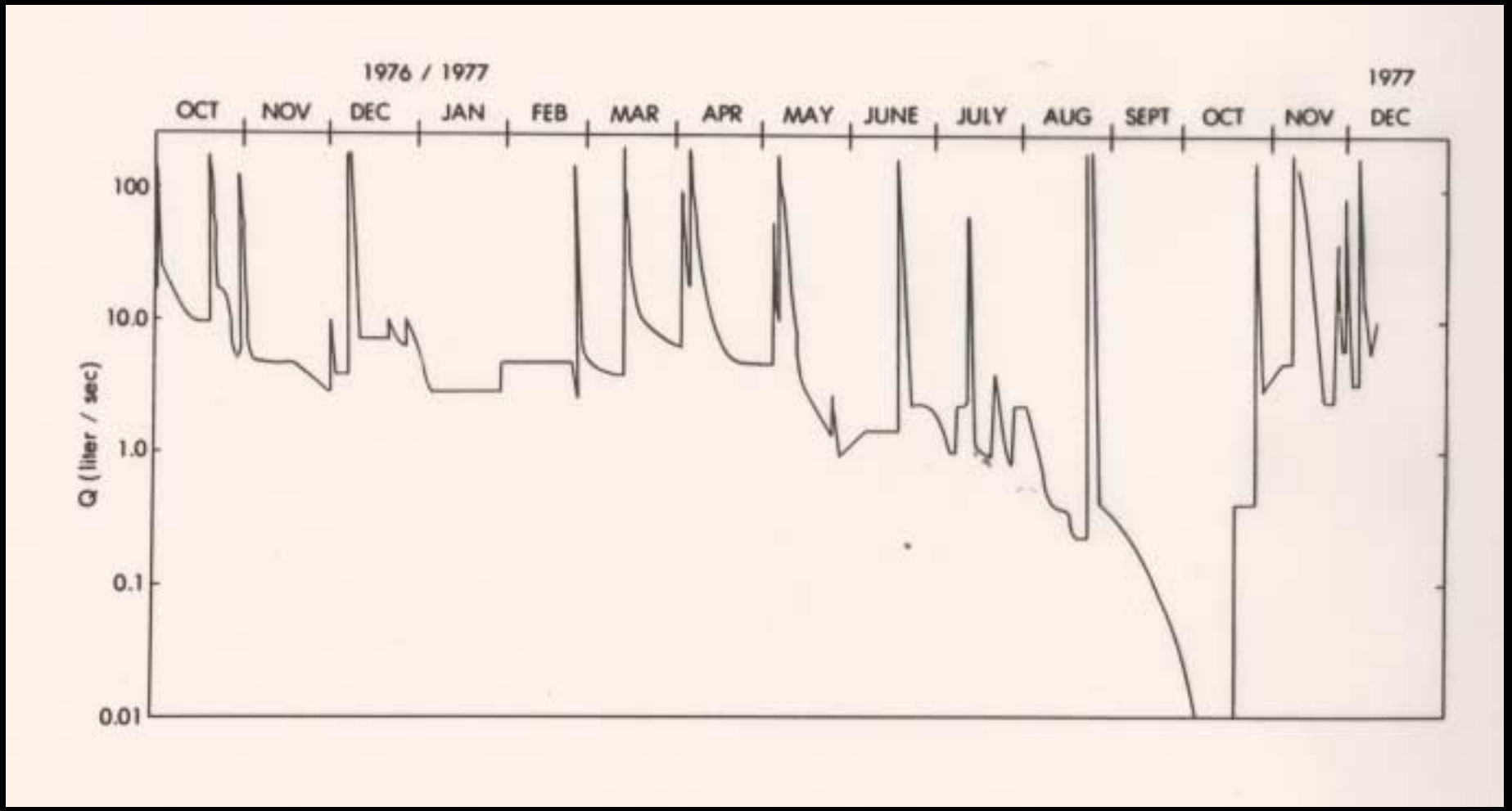
Miles

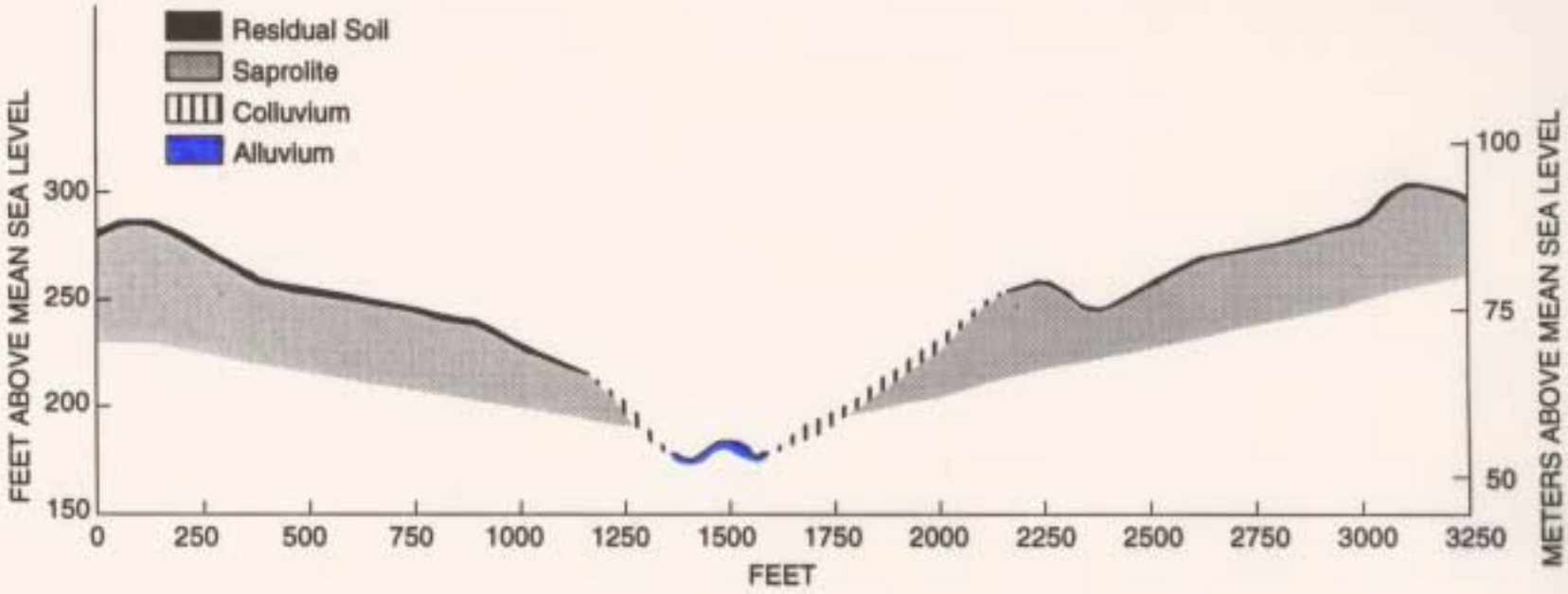
200 0 200

Kilometers


77°30'
77°15'
77°
39°
MARYLAND
POTOMAC
RIVER
VIRGINIA
Loudoun County
Fairfax County
Tysons Corner
Vienna
WASHINGTON D.C.
Pender
Arlington County
ZONE
PIEDMONT
Alexandria County
LINE
Fairfax County
Clifton
Prince William County
STUDY AREA
COASTAL PLAIN
FALL
OCCOQUAN RIVER
RIVER
MARYLAND
POTOMAC
COASTAL PLAIN- Sediments
TRIASSIC LOWLAND-Sedimentary
Igneous rock
PIEDMONT-Metamorphic rocks
0
5 MILES
0
5 KILOMETERS


77°17'30"
38°
42'
30"
19.8 m (65 ft)
330'
0
320
300
250
200
300
10.3 m (34 ft)
14.6 m (48 ft)
9.4 m (31 ft)
11.6 m (38 ft)
12.2 m (40 ft)
10.3 m (34 ft)
17.0 m (56 ft)
18.8 m (62 ft)
15.2 m (50 ft)
14.0 m (46 ft)
14.3 m (47 ft)
16.7 m (55 ft)
12.2 m (40 ft)
10.0 m (33 ft)
0 1000 FEET
0 100 METERS
EXPLANATION
④ LOCATION OF PHOTOGRAPHS ON FIGURE 36
UNITS BENEATH SOLA
Saprolite
Colluvium
UNITS EXPOSED IN STREAM BED
Saprolite
Weathered rock
Rock
Core site
Seismic line


1976 / 1977
1977
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
100
10.0
1.0
0.1
0.01
Q (liter / sec)


Residual Soil
Saprolite
Colluvium
Alluvium
FEET ABOVE MEAN SEA LEVEL
300
250
200
150
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
FEET
100
75
50
METERS ABOVE MEAN SEA LEVEL

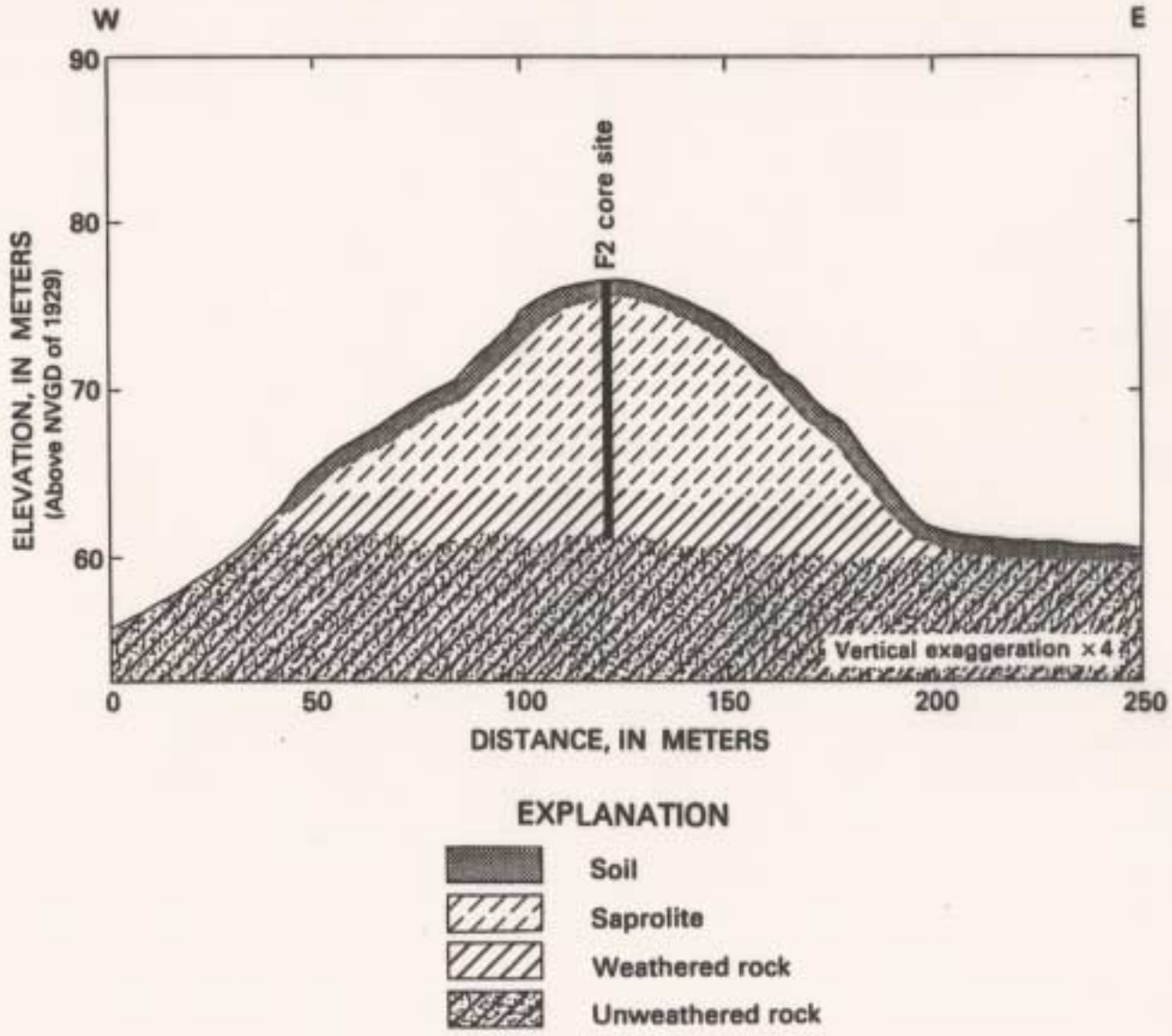


FIGURE 4.—Cross section of metapelite regolith, F2 core site.

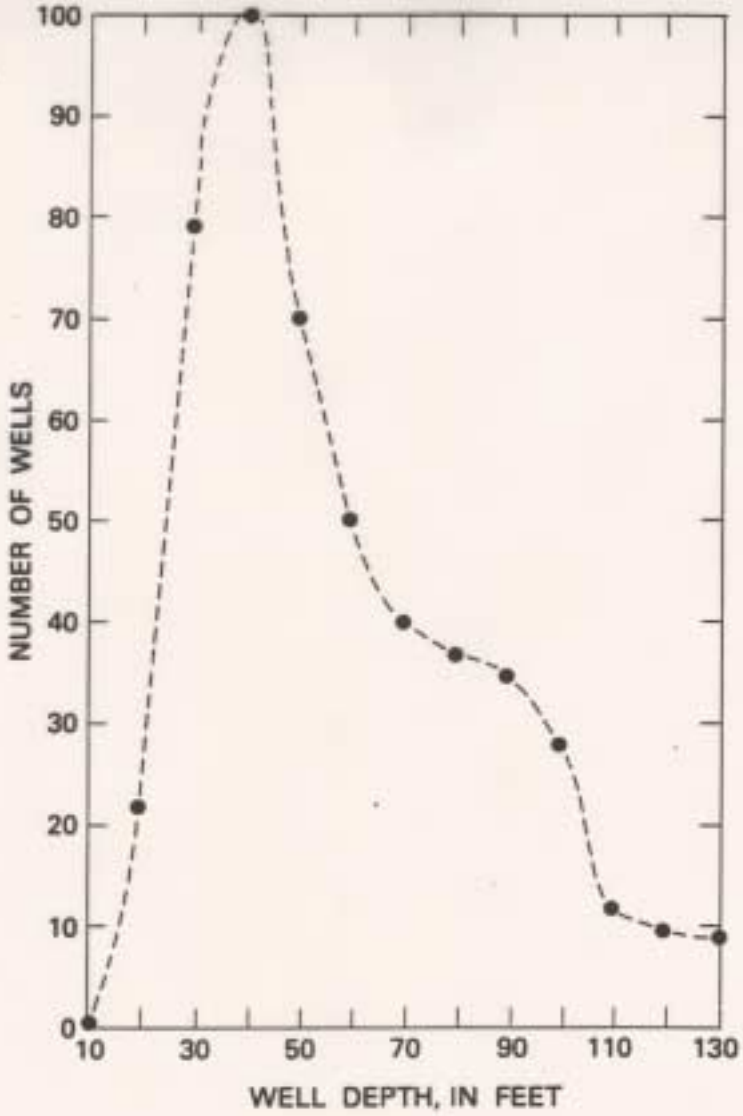
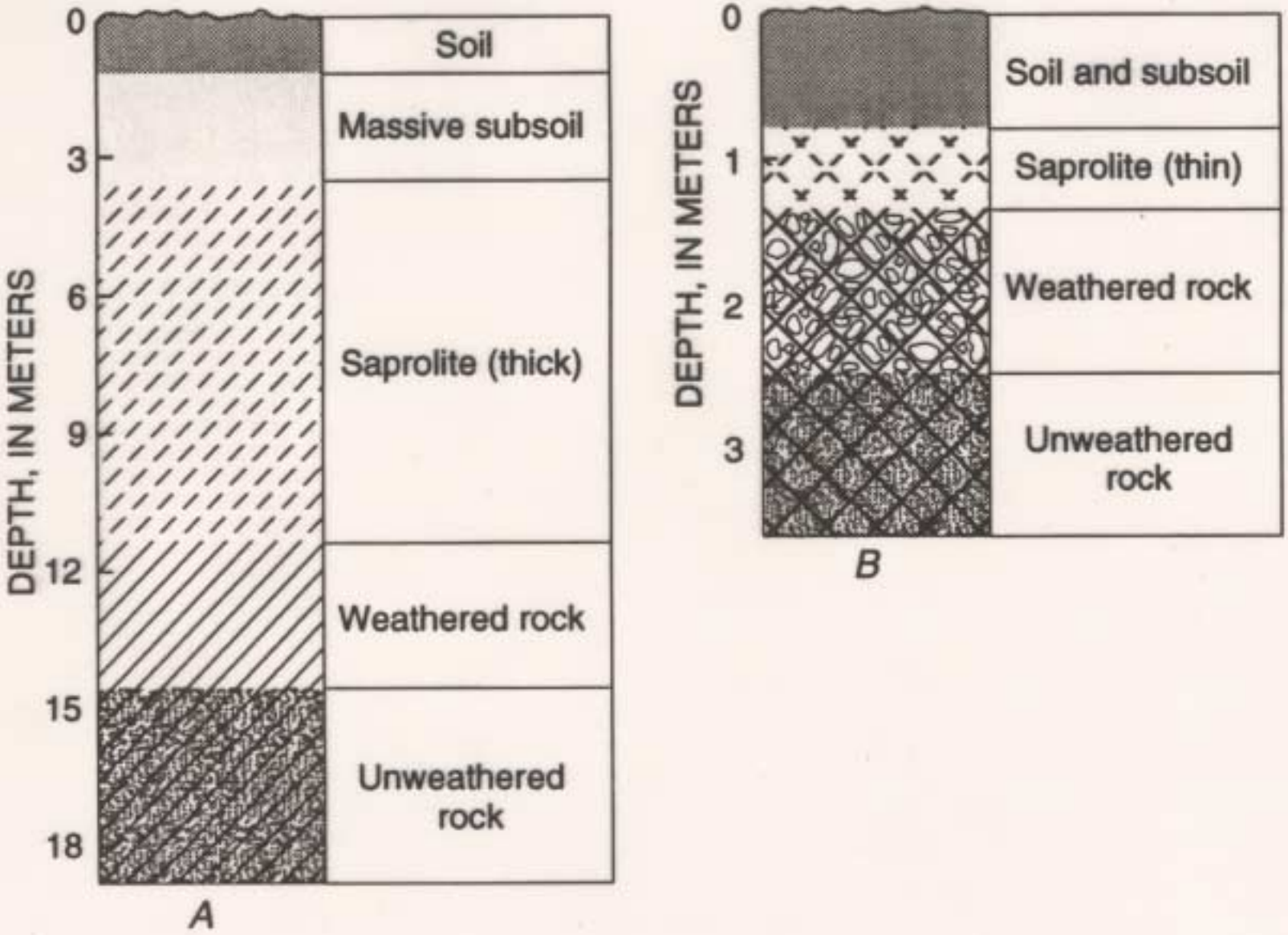
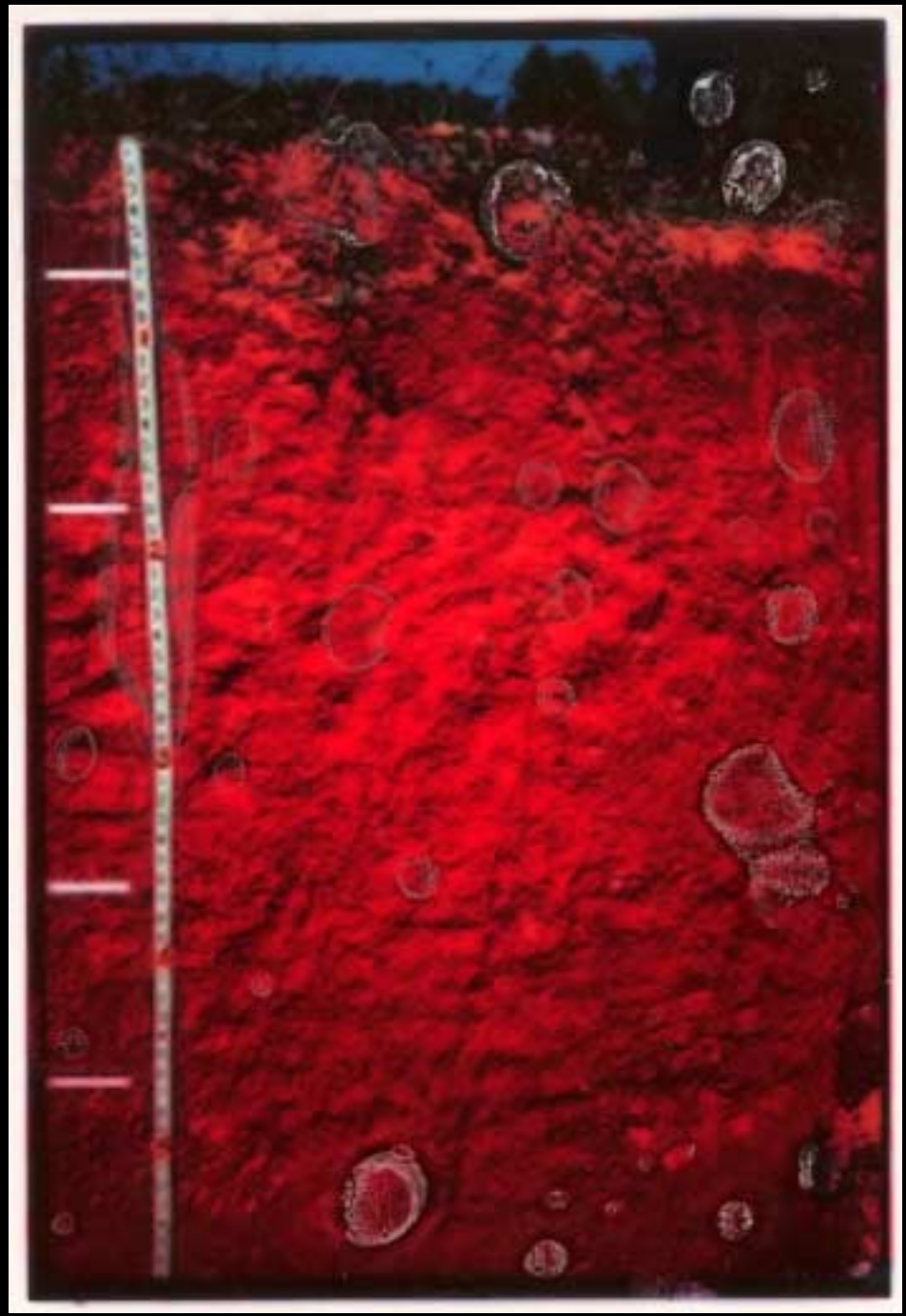


FIGURE 23.—Regolith thickness distribution as indicated by well-casing depths. Data points are from the Fairfax County and Vienna, Va., area; data points are not differentiated as to bedrock type (A.J. Froelich, 1977, unpublished data). Depth <20 ft means all wells are between 10 and 19 ft.


DEPTH, IN METERS
0
3
6
9
12
15
18
Soil
Massive subsoil
Saprolite (thick)
Weathered rock
Unweathered rock
A
DEPTH, IN METERS
0
1
2
3
Soil and subsoil
Saprolite (thin)
Weathered rock
Unweathered rock
B



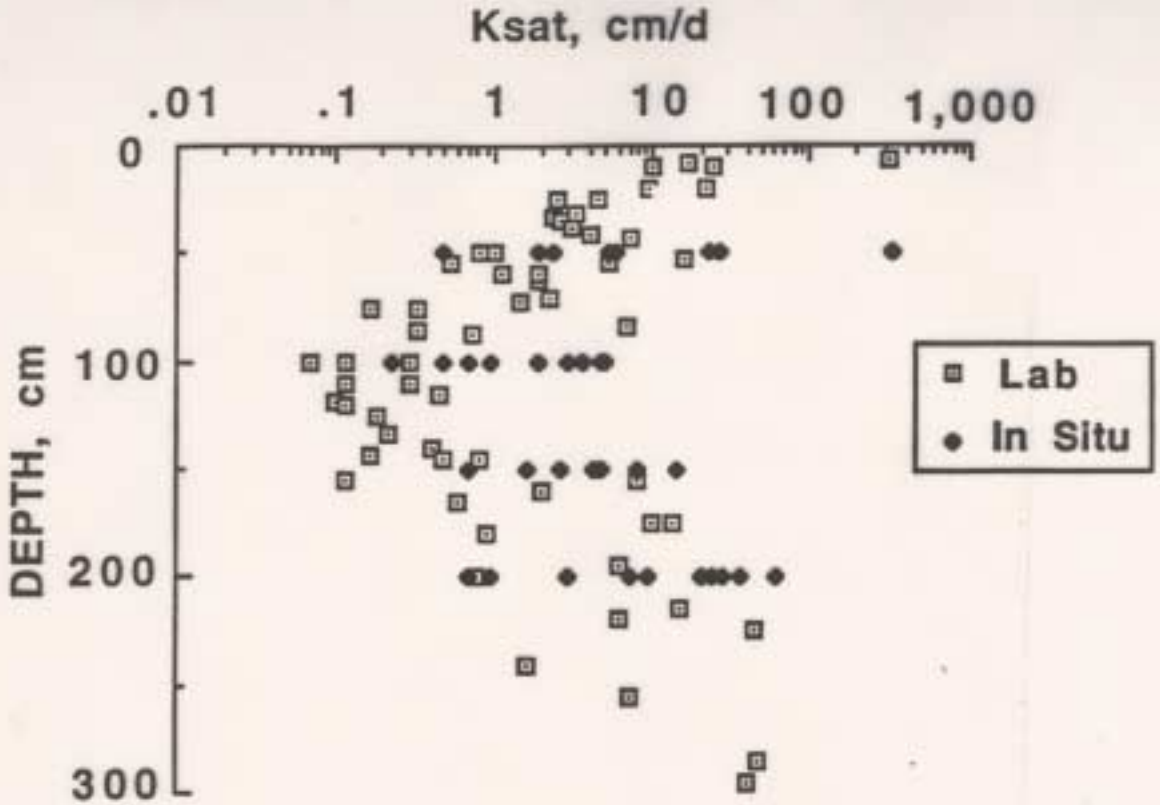


Figure 18. In situ and laboratory determined saturated hydraulic conductivity (K_{sat}) of the Appling soil at Site Number 4 in the Piedmont region.

TYPE III

FROM AMOOZEGAR et al., 1993

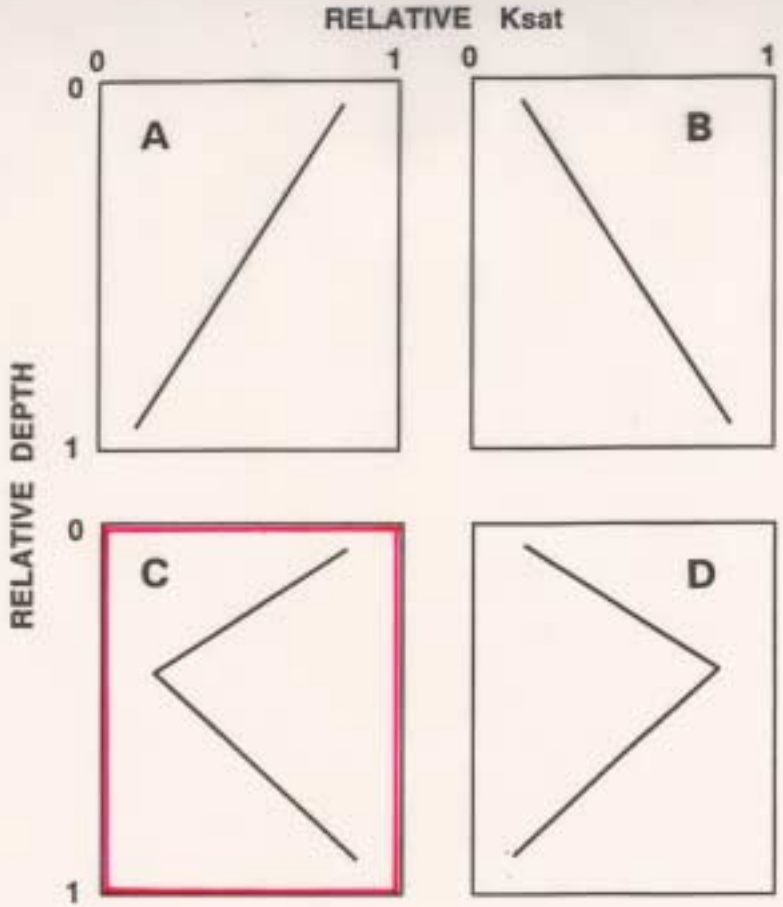


Figure 4. Schematic diagram of the four types of saturated hydraulic conductivity (K_{sat}) profiles (A) Type I, (B) Type II, (C) Type III, and (D) Type IV.

From AMOOZEGAR et al., 1993

"ON-SITE WASTEWATER DISPOSAL"

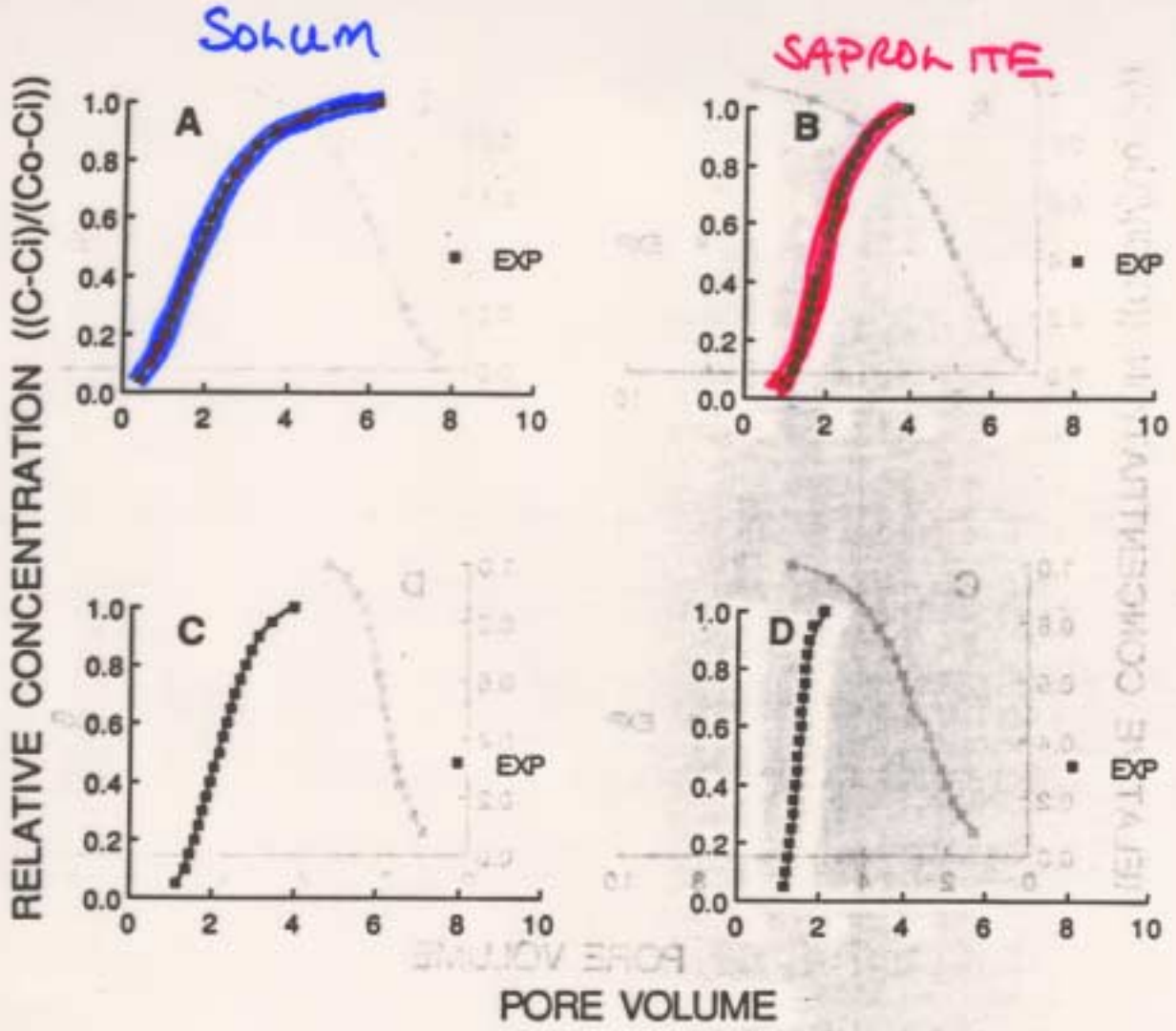
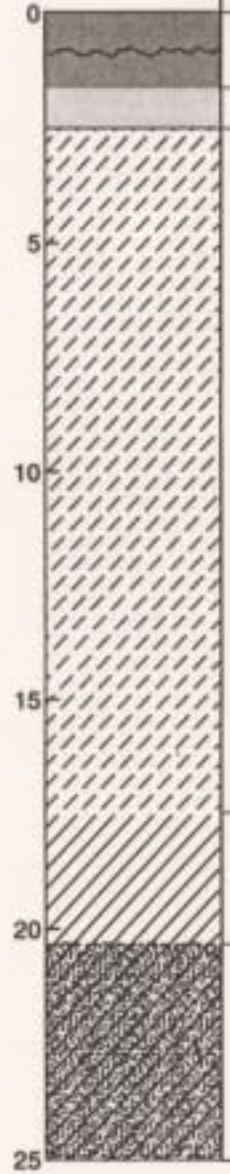


Fig. 31. Average breakthrough curves for the movement of NO_3 through undisturbed solum (A), undisturbed saprolite (B), disturbed solum (C), and disturbed saprolite (D).

<table>
<tr><th>Sowers, 1963</th><th colspan="2">Deere and Patton, 1971</th><th>Martin, 1977</th><th>Pavich, 1986</th><th>Stolt et al., 1992</th></tr>
<tr><td>Upper Zone</td><td rowspan="3">Residual Soil</td><td>A Horizon</td><td rowspan="3">Residual Soil</td><td>Soil</td><td>Soil</td></tr>
<tr><td rowspan="2">Intermediate zone</td><td rowspan="2">B Horizon</td><td>Massive Zone</td><td>Transition Zone</td></tr>
<tr><td>Saprolite</td><td>Saprolite</td><td>Saprolite</td></tr>
<tr><td rowspan="2">Partially Weathered Zone</td><td rowspan="2">Weathered Rock</td><td>Transition to partly weathered rock</td><td rowspan="2">Disintegrated Rock</td><td rowspan="2">Weathered Rock</td><td rowspan="2">Partially Weathered Rock</td></tr>
<tr><td>Partly Weathered Rock</td></tr>
<tr><td colspan="6">Unweathered Rock</td></tr>
</table>

1-2. Classification systems for regolith materials formed from metamorphic and igneous rocks.

FROM STOLT & BAKER, 1994



ZONE	HORIZON	MAJOR MINERALS	STRUCTURE AND FABRIC	MAJOR WEATHERING PROCESS
Soil	A B	Kaolinite, vermiculite, quartz	Pedogenic	Chemical and Mechanical
Massive subsoil	C	Kaolinite, Muscovite, quartz	Massive	Mechanical
Saprolite	Inert	Halloysite, muscovite, quartz	Macroscopically rocklike; some mineral etching and disintegration on microscale	Slight chemical
Saprolite	Reactive	Halloysite, muscovite, quartz, plagioclase	Macroscopically rocklike	Chemical (plagioclase dissolution)
Weathered rock	Reactive	Quartz, muscovite, plagioclase, biotite	Macroscopically rocklike	Chemical (oxidization of mafic minerals and hydration)
Unweathered rock				

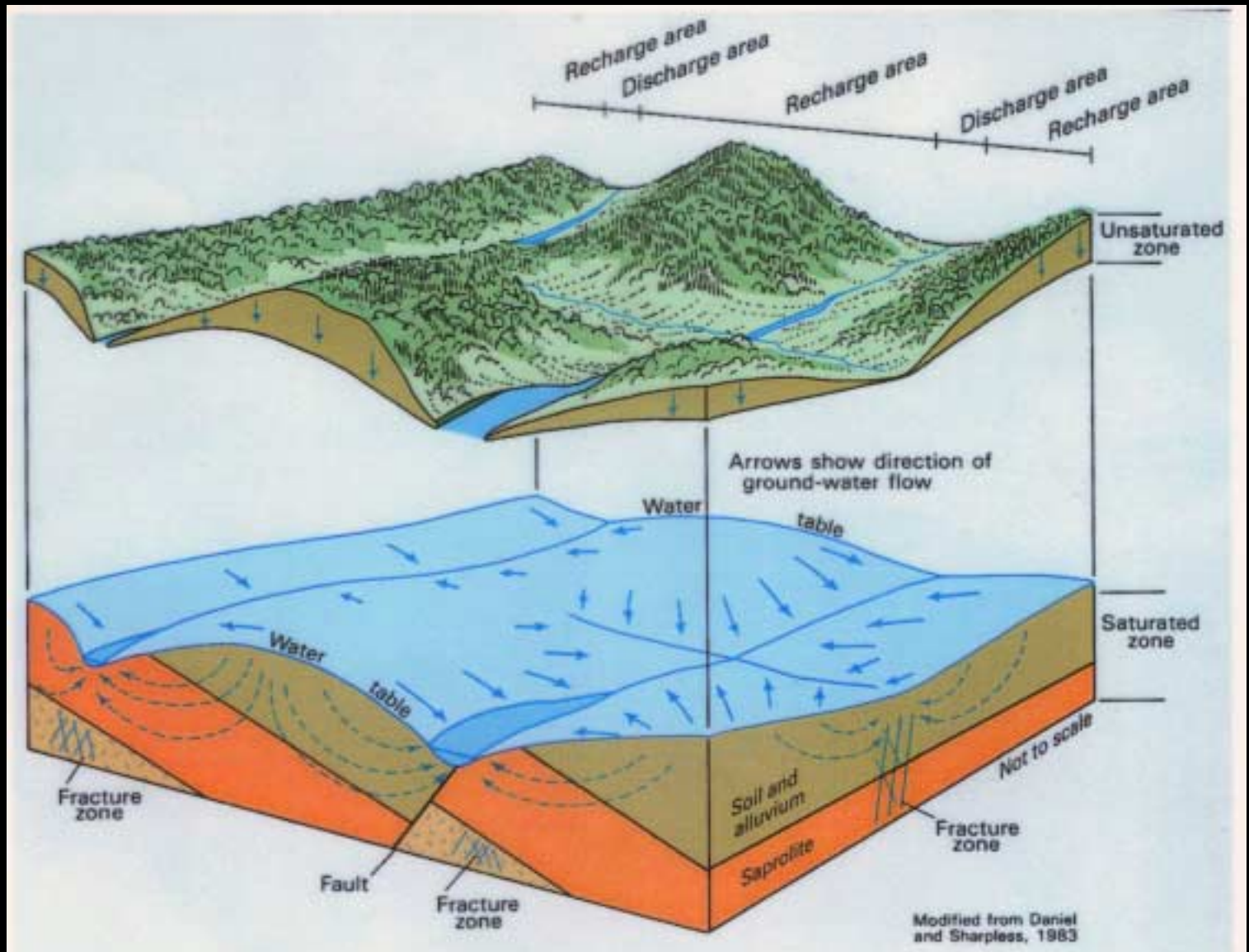


Figure 92. *Ground water percolates downward through the unsaturated zone (shown lifted up) to the water table, then moves laterally to discharge points. In the bedrock, the water is channeled through fractures.*

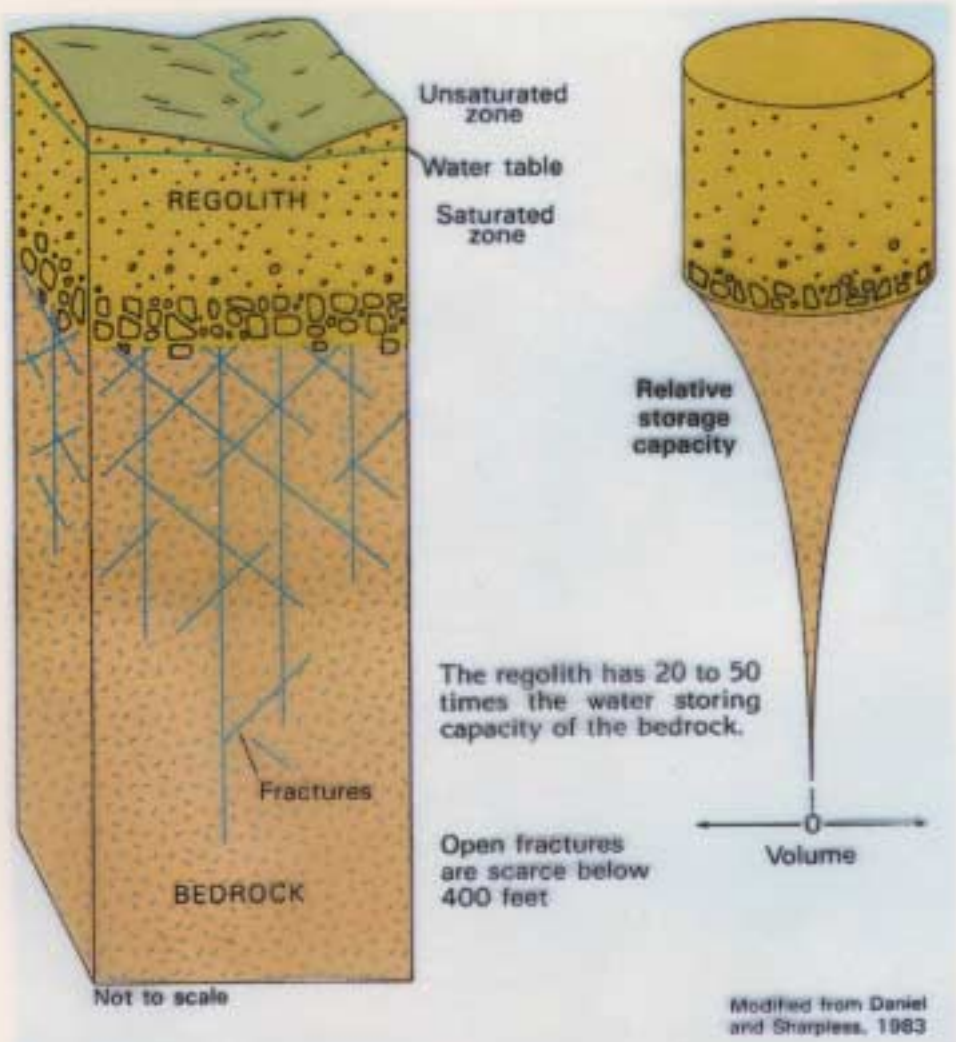
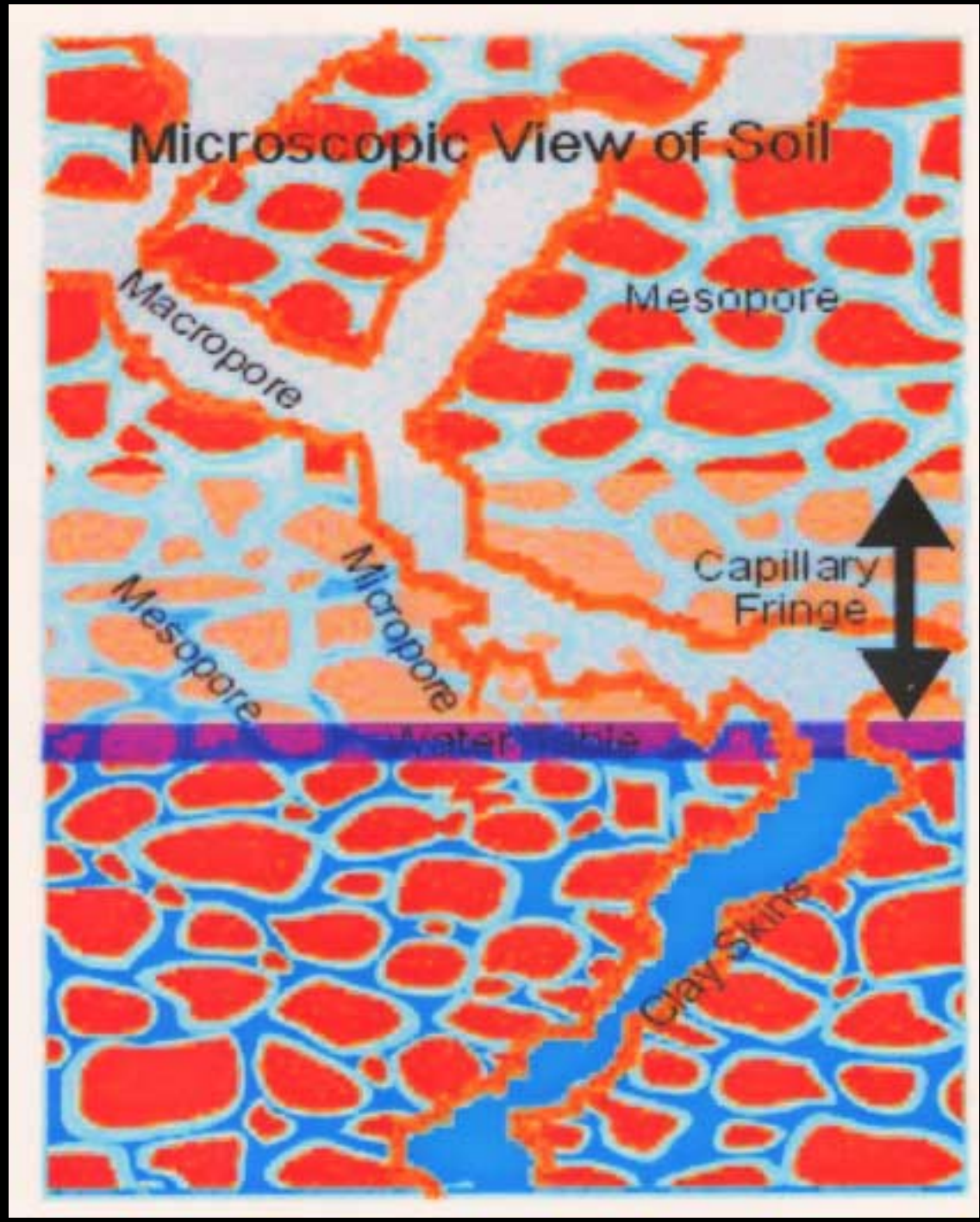
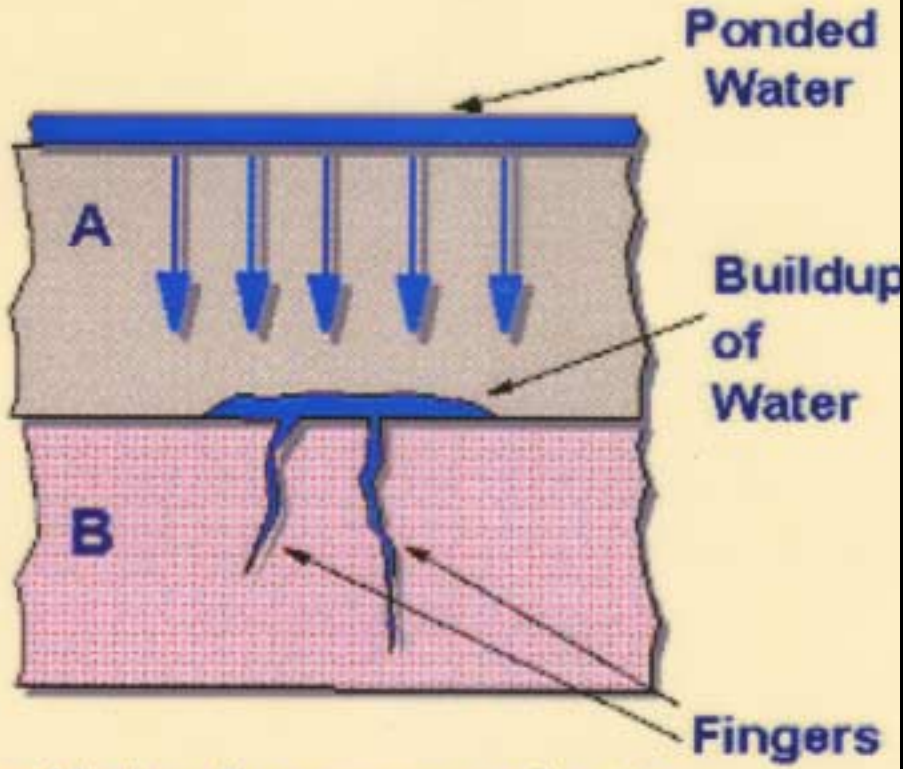


Figure 90. *The regolith, or layer of weathered rock material, soil, and alluvium overlies fractured crystalline bedrock. The majority of the water is stored in the more porous regolith and percolates downward into the interconnected fractures. Therefore, wells can obtain some of this stored water even though they are cased entirely through the regolith.*


Microscopic View of Soil
Macropore
Mesopore
Capillary Fringe
Micropore
Mesopore
Water Table
Clay Skins

Fingering (Streaming)



★ Hydraulic pressure of water exceeds a certain limit and flows horizontally to a crack or pore

★ Water quickly streams down pore(s) until excess hydraulic pressure is relieved.

$\delta^{18}O$ CRAWFORD ELLIOT CWRU