INFLUENCE OF WEAK PENNSYLVANIAN SYSTEM SHALES IN OHIO AND KENTUCKY ON TRANSPORTATION PROJECTS

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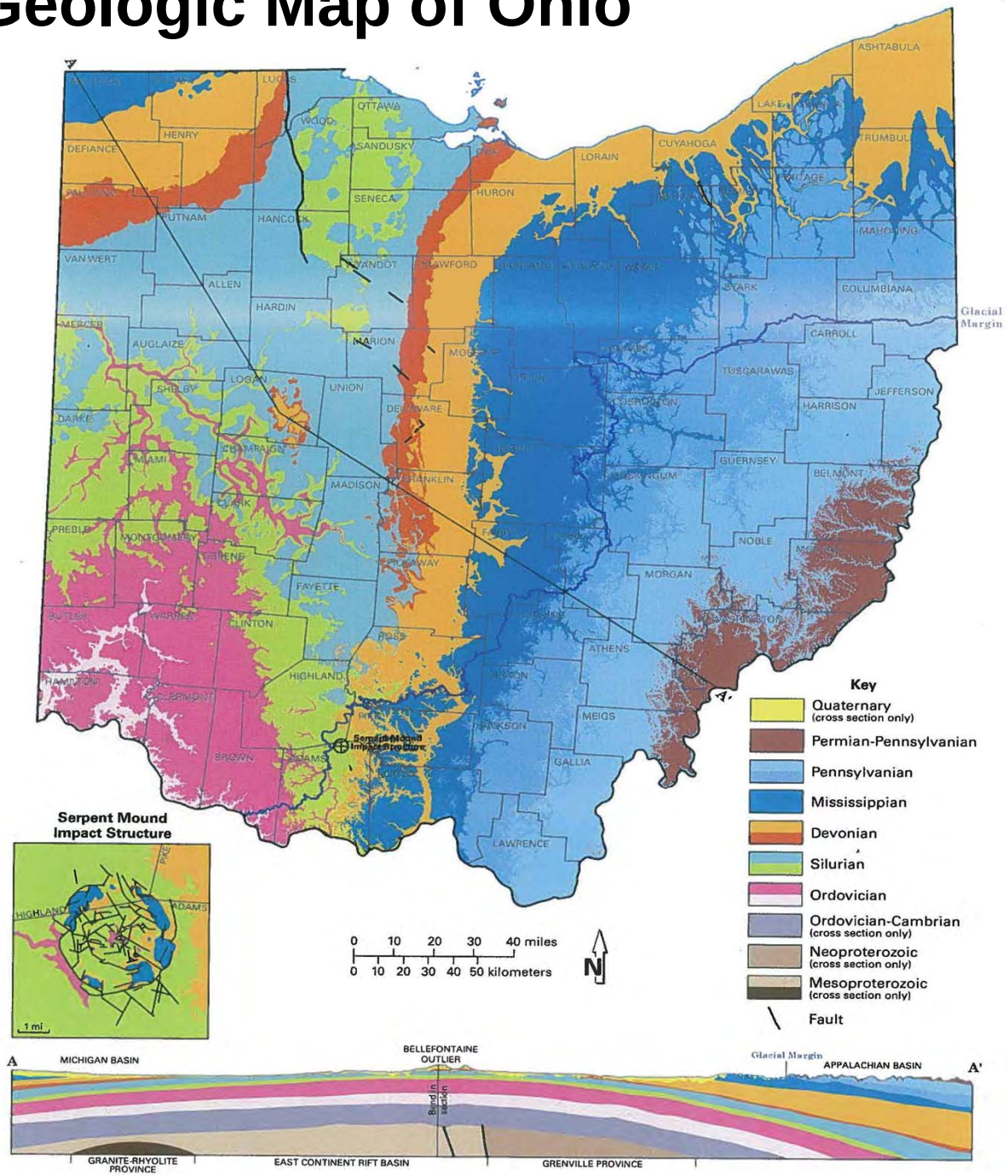
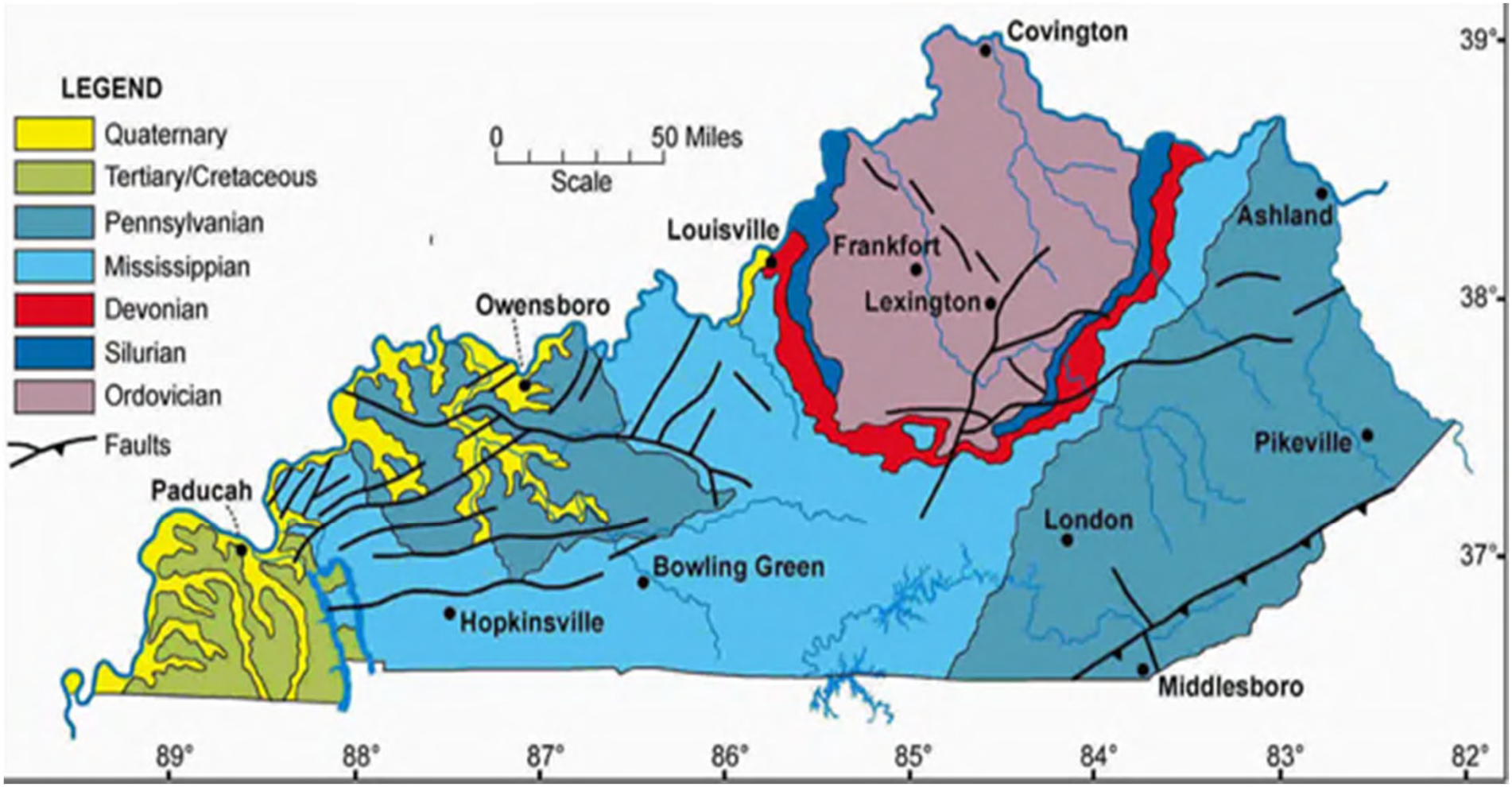
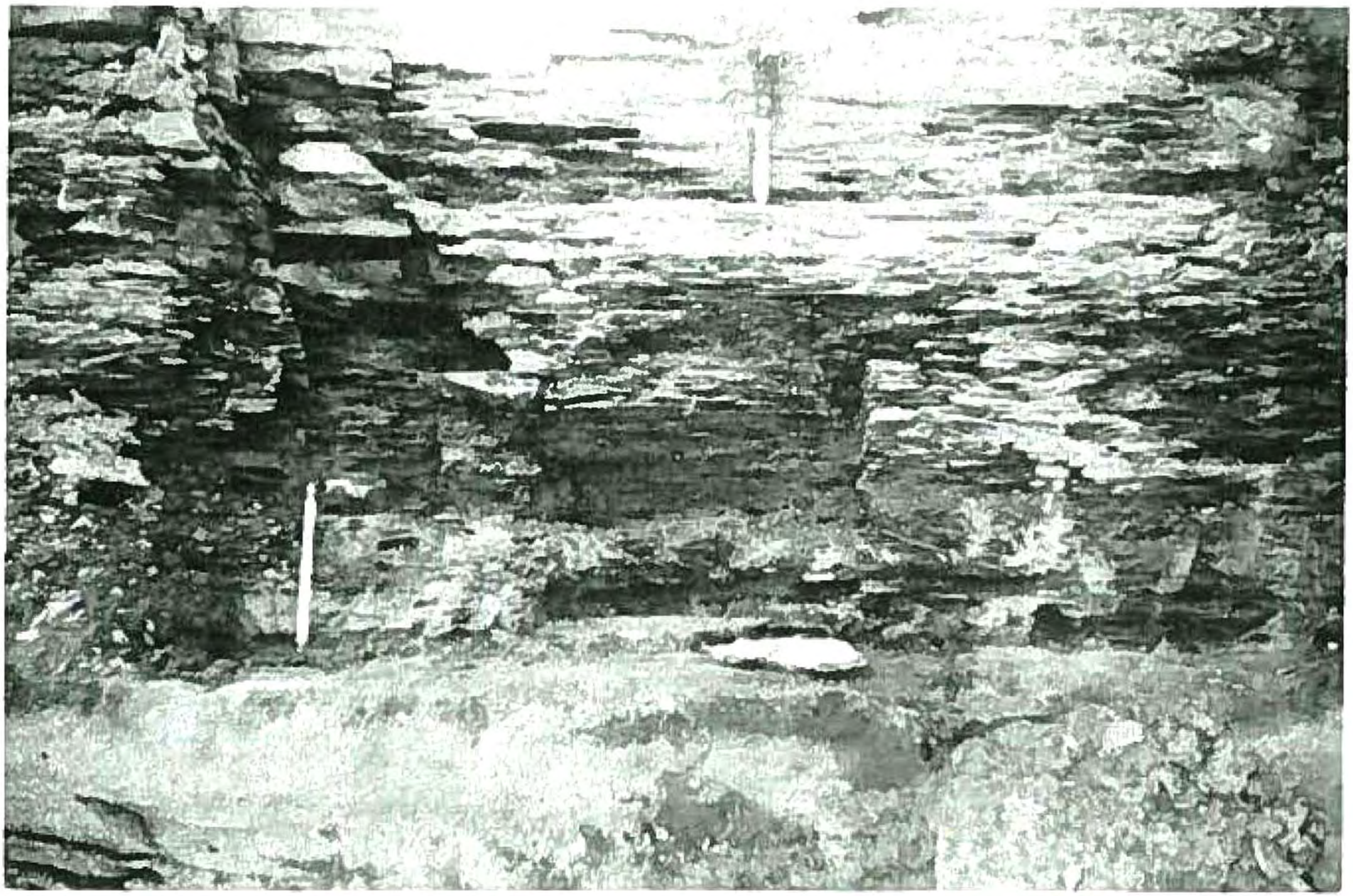
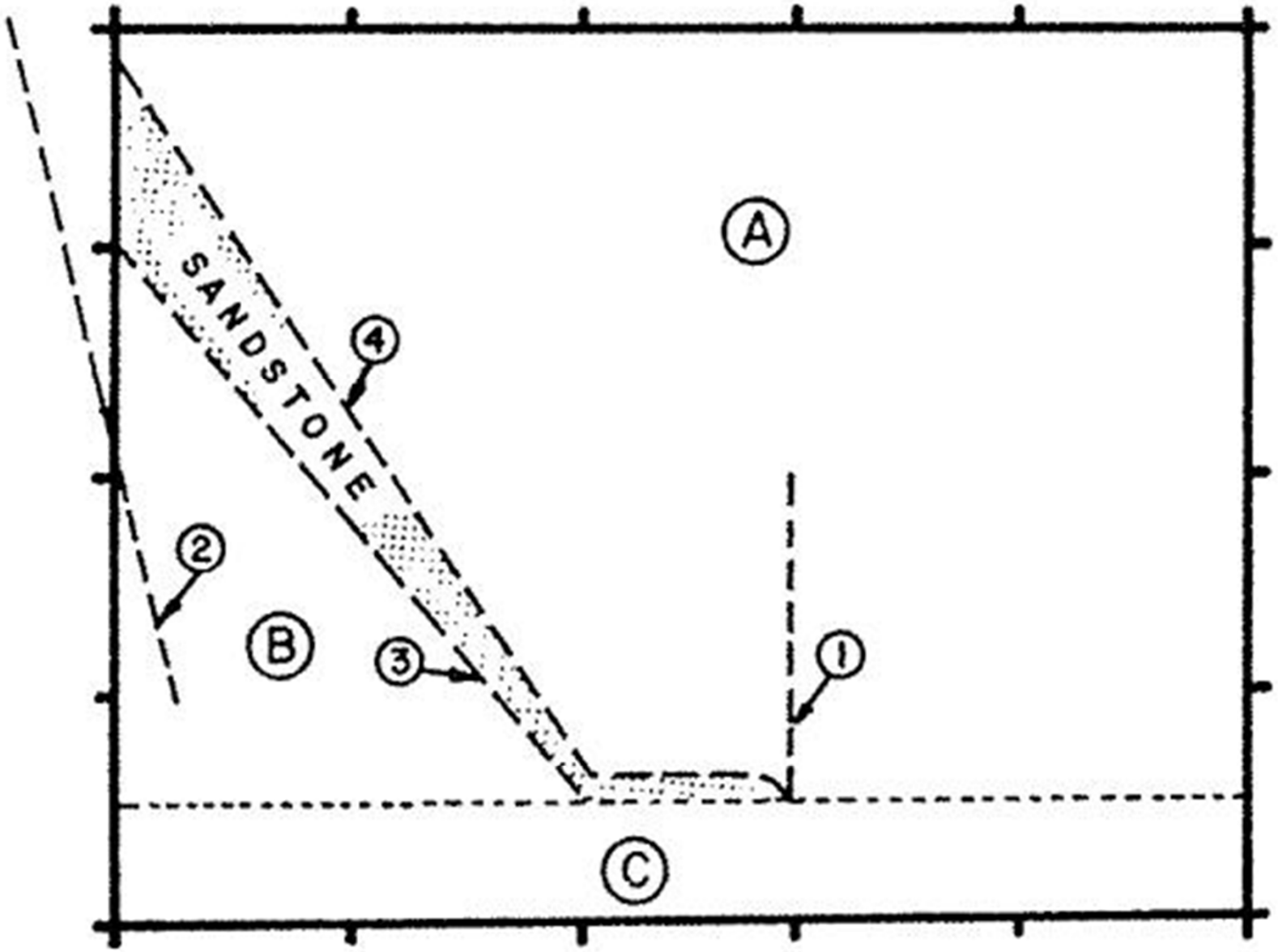
Bedrock Geologic Map of Ohio



Geology of Kentucky







DISCONTINUITIES

SLICKENSIDES (IDENTIFIED BY NUMBERS)

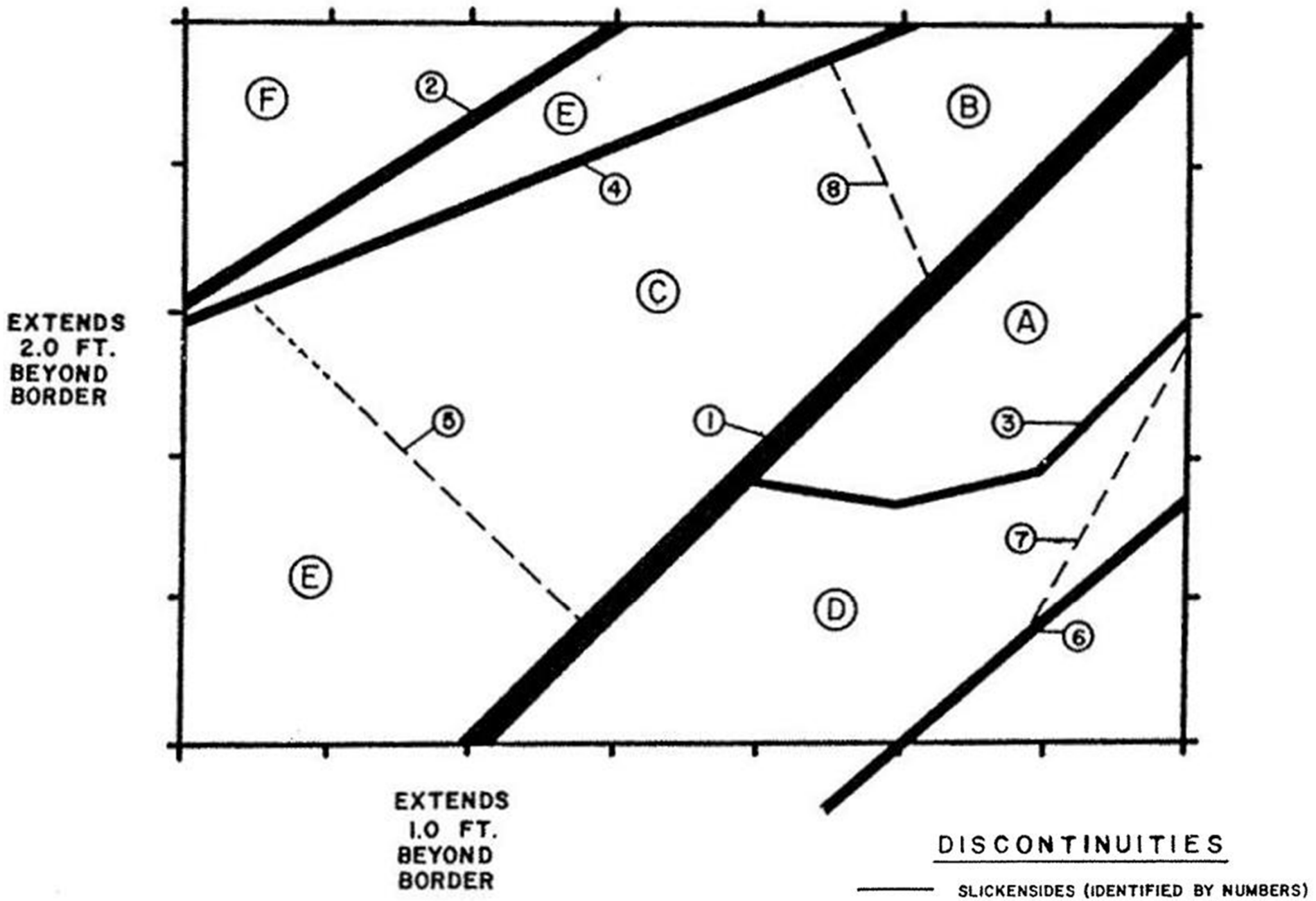
PARTINGS (IDENTIFIED BY NUMBERS)

BOUNDARY OF AREAS (IDENTIFIED BY LETTERS) CONTAINING BEDDING PLANES OR PARTINGS

Discontinuities in Window in Morgantown Shale, West Slope of U.S. 33 and 50, Station 644+50, Athens, Ohio

Grid is located 1 foot below top of member

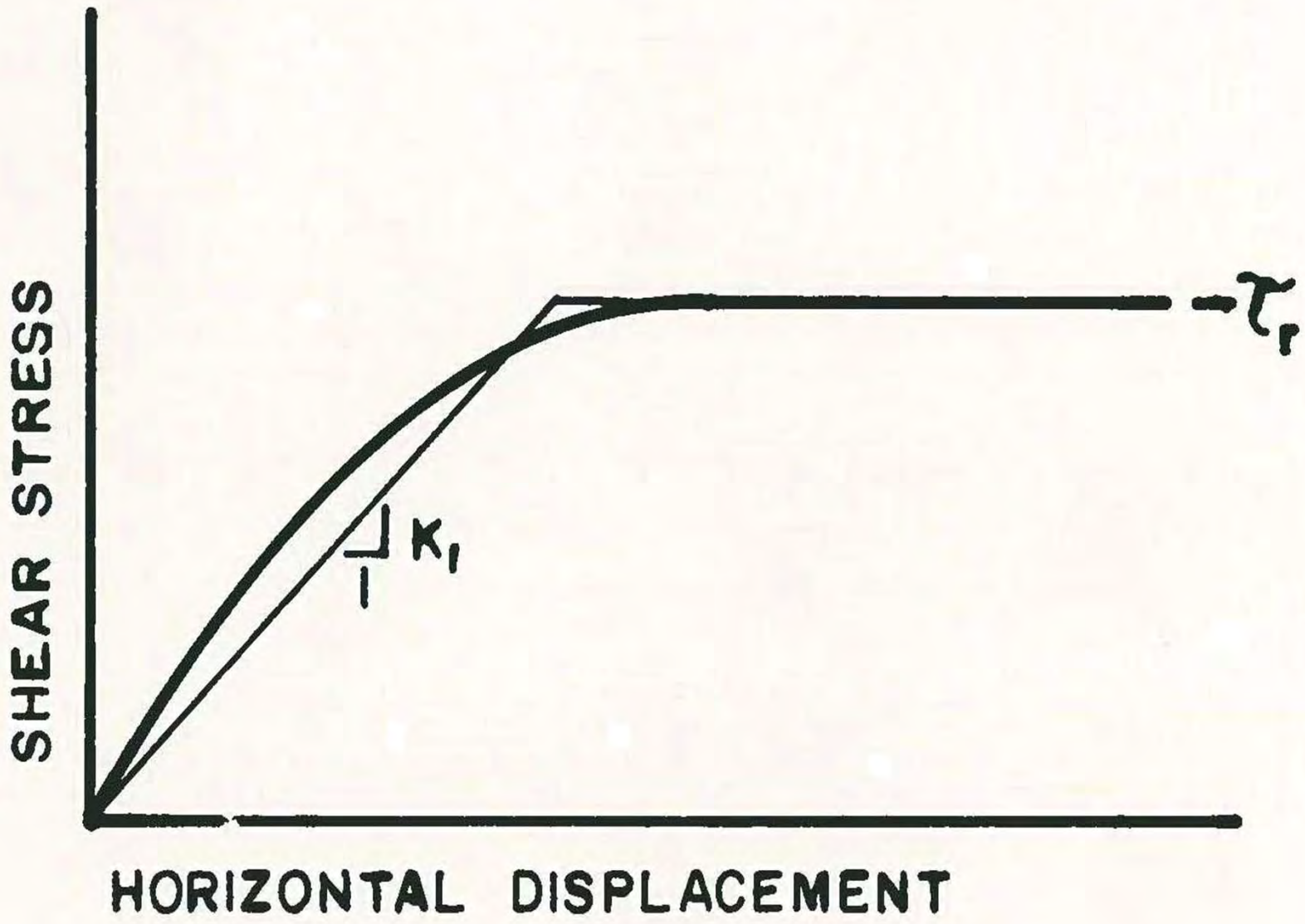
Feature	Strike	Dip	Thickness of Gouge	Comments
1	N 40° W	90°	None	Parting, irregular gray dry surface
2	S 52° E	69° N	None	Parting, irregular gray dry surface
3	S 35° E	80° N	None	Parting, irregular gray surface
4	S 35° E	85° N	None	Parting, irregular surface
A	N 89° E	5° S		Bedding planes, gray dry surface, .125 - .188 inch average spacing
B	N 20° E	6.5° SE		Bedding planes, gray dry surface, .25 inch average spacing
C	S 89° E	7° S		Bedding planes, gray shaley surfaces, .188 inch average spacing


EXTENDS 2.0 FT. BEYOND BORDER
EXTENDS 1.0 FT. BEYOND BORDER
F
E
B
C
A
E
D
1
2
3
4
5
6
7
8
DISCONTINUITIES
SLICKENSIDES (IDENTIFIED BY NUMBERS)
PARTINGS (IDENTIFIED BY NUMBERS)
BOUNDARY OF AREAS (IDENTIFIED BY LETTERS) CONTAINING BEDDING PLANES OR PARTINGS

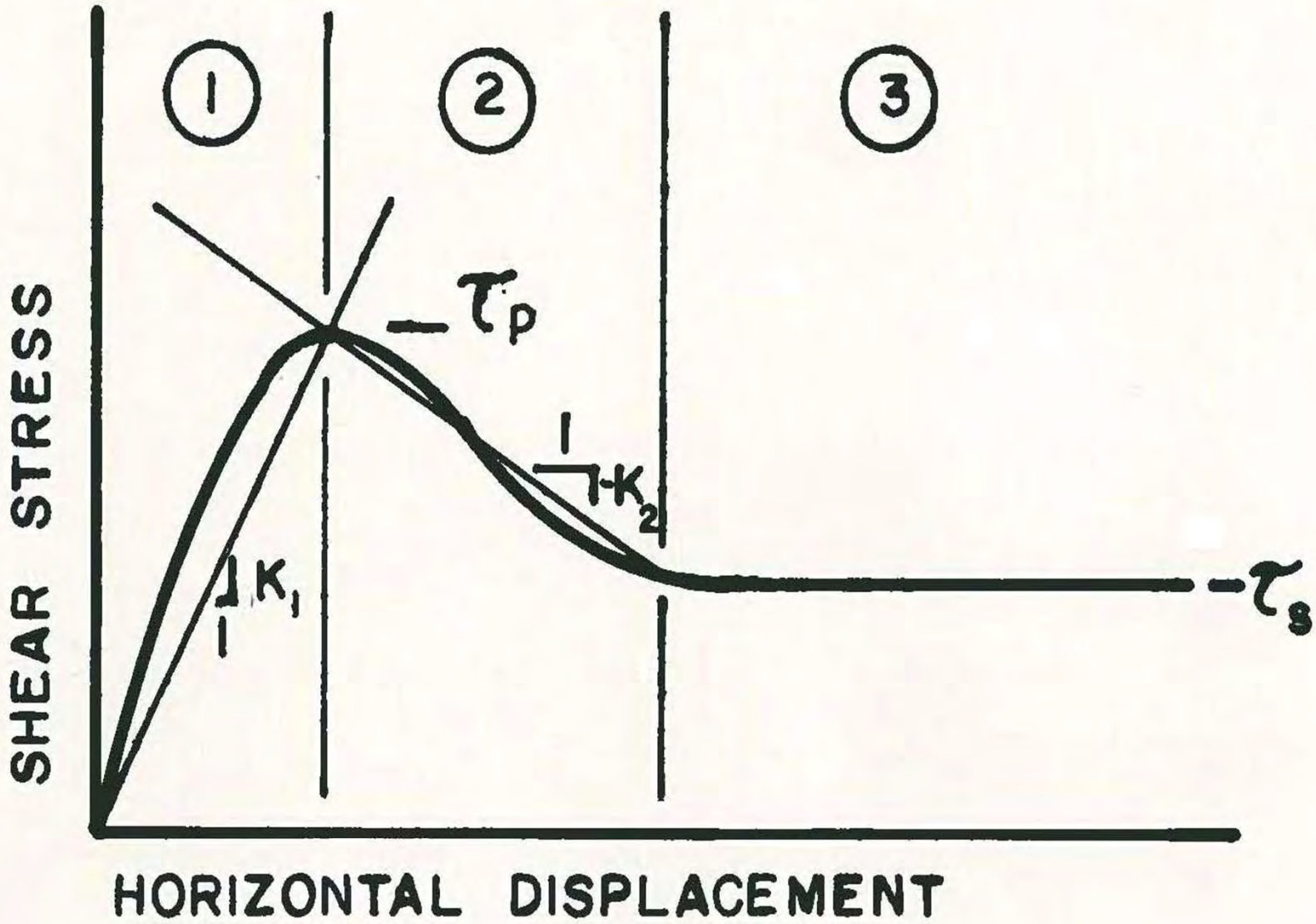
Discontinuities in Window in Round Knob Shale, West Slope of U.S. 33 and 50, Station 644+70, Athens, Ohio

Grid is located 2 feet above base of member

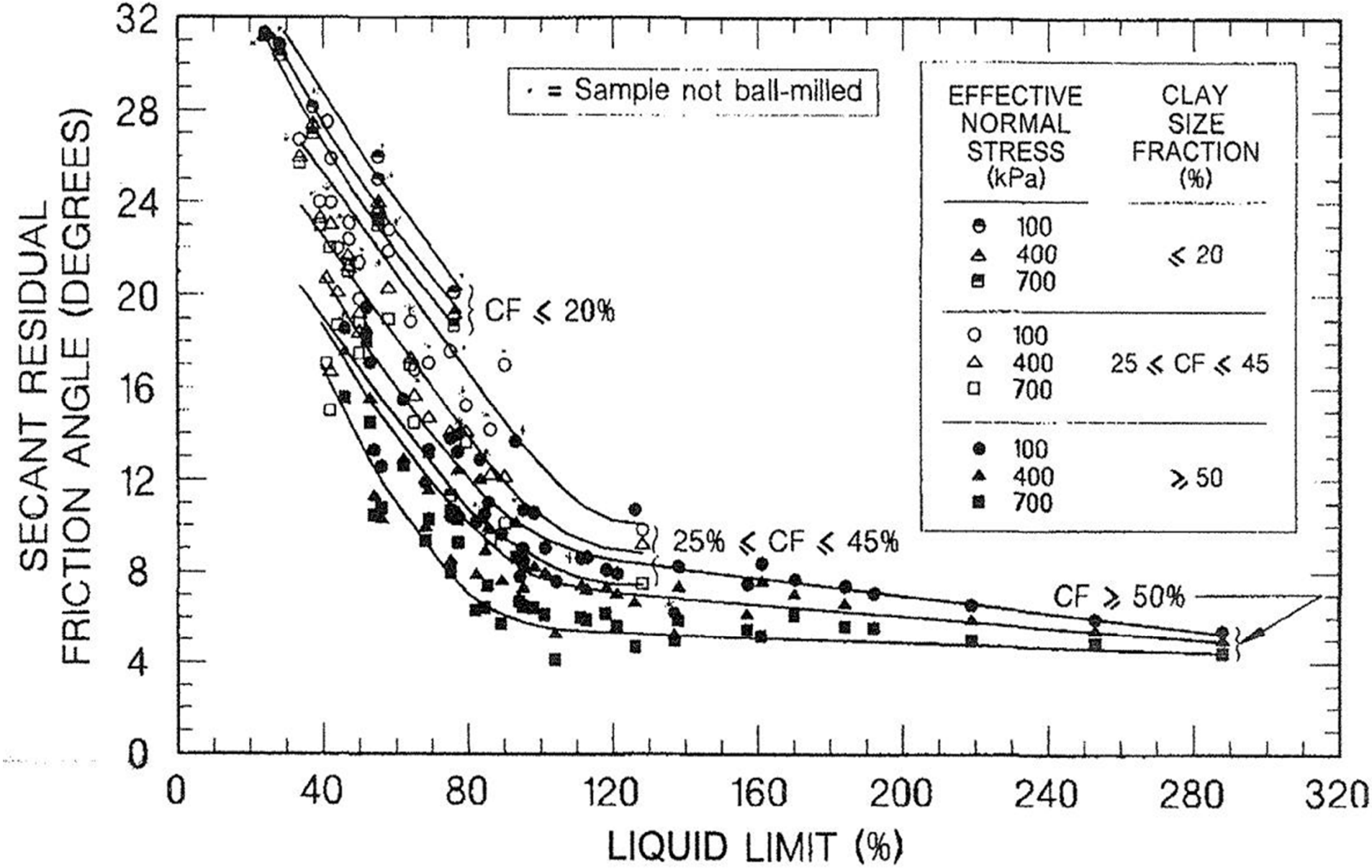
Feature	Strike	Dip	Thickness of Gouge	Comments
1	N 80° W	37.5° S	1.0 inch	Slickenside, gouge comprised of gray shale arranged in thin plates parallel to slickenside surface, extends 2 feet into slope
2	N 50° W	31.75° S	0.5 inch	Slickenside, same as Discontinuity 1, extends 4 feet into slope
3	N 52° E	35° S	0.25 inch	Slickenside, very smooth planar surface, gouge comprised of gray shale
4	N 66° E	20.25° S	0.25 inch	Slickenside, gouge comprised of gray shale
5	N 27° W	24.75° E	0.125 inch	Parting
6	N 86° W	30.5° S	0.25 inch	Slickenside, gouge comprised of wet gray shale, slickenside surface is moist
7	N 15° W	75° NE	None	Parting, red smooth surface
8	N 78° W	54° N	None	Parting
A	N 86° E	42.5° S		Bedding planes, red rough surface, .25 inch average spacing
B	N 78° E	9.5° S		Bedding planes, red surface, .068 - .125 inch average spacing
C	N 15° W	24° E		Bedding planes, red surface, .125 inch average spacing
D				Bedding planes, oriented parallel to Discontinuity 1, .25 inch average spacing
E				Bedding planes, oriented parallel to Discontinuity 4, .125 inch average spacing
F				Bedding planes, oriented parallel to Discontinuity 2, .125 inch average spacing



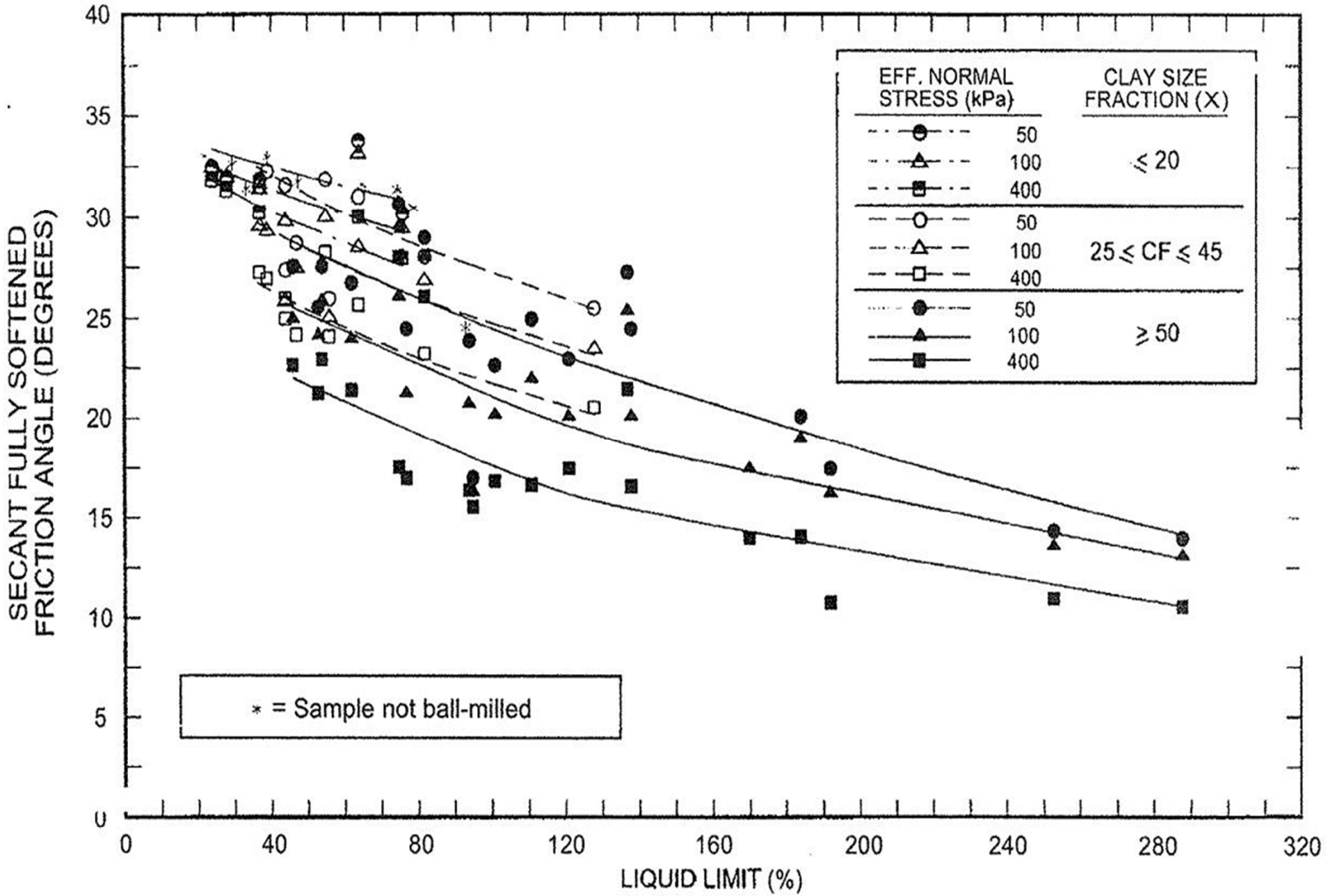
b) Stress-displacement relationship for elastic-perfectly plastic material



a) Stress-displacement relationship for strain-softening material



From Stark et. Al. (2005)



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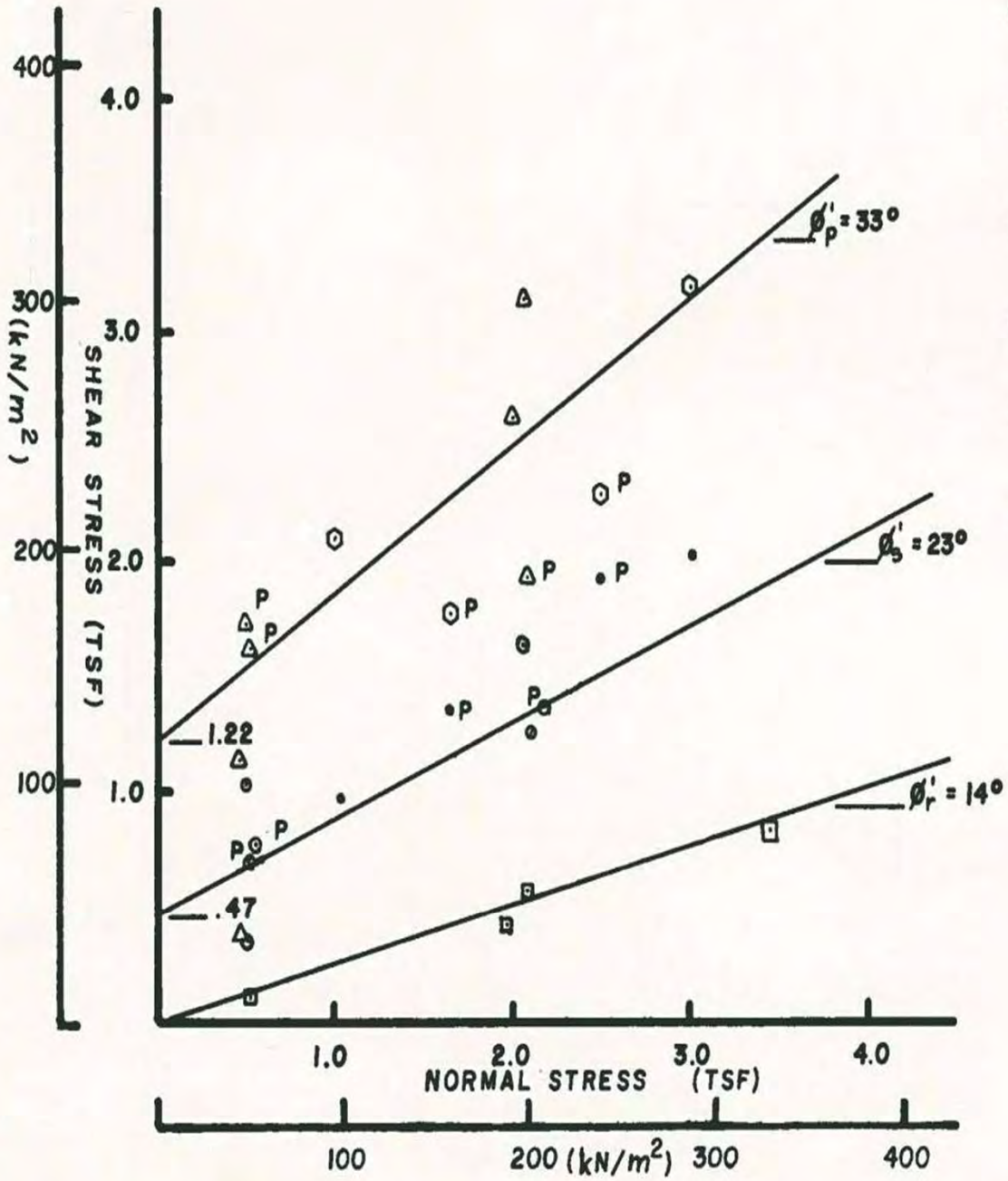


△ PEAK SHEAR STRENGTH; BLOCK SAMPLE - INTACT, STATE ROUTE 682, STATION 19+50, ATHENS.

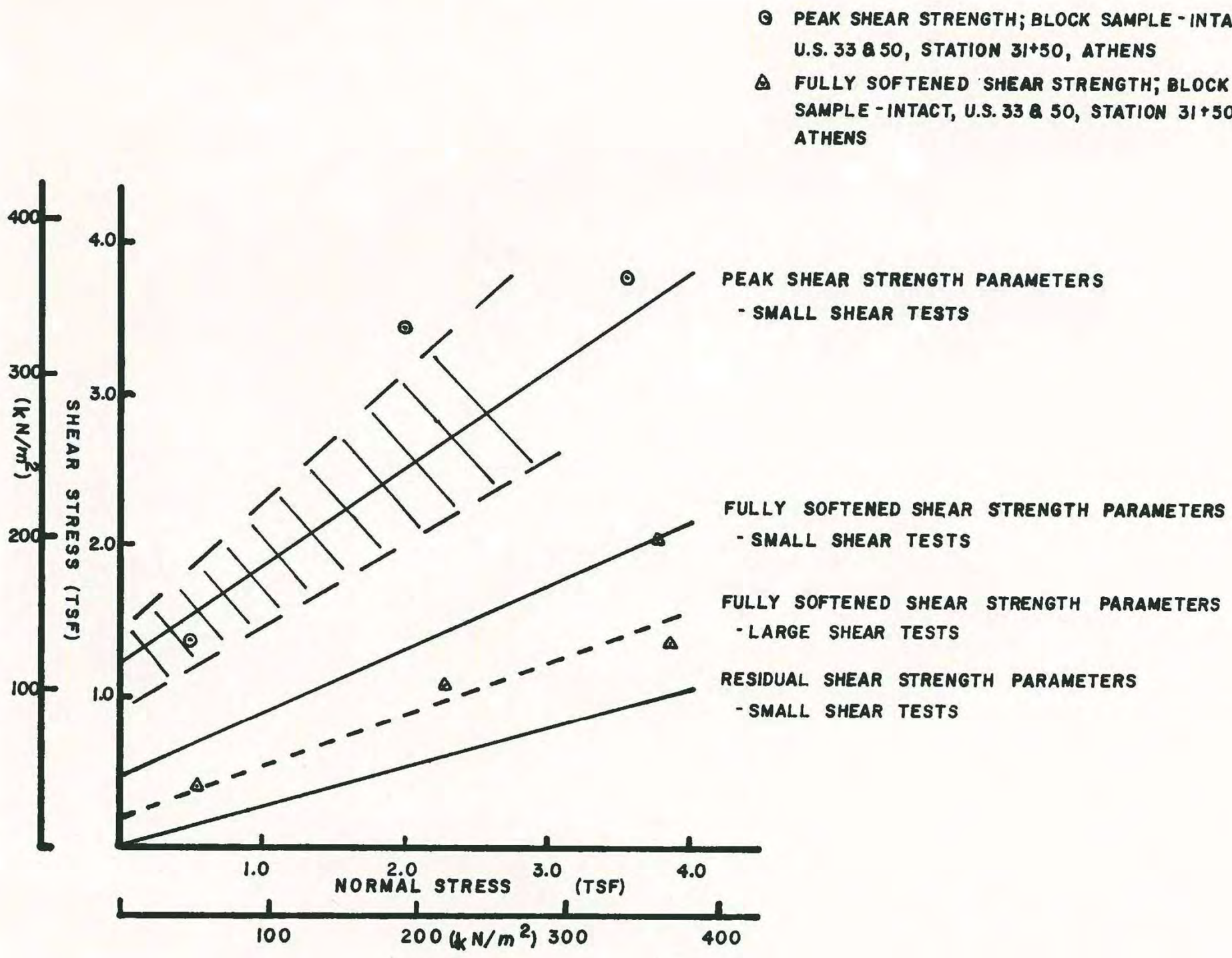
⊙ FULLY SOFTENED SHEAR STRENGTH, BLOCK SAMPLE - INTACT, STATE ROUTE 682, STATION 19+50, ATHENS.

⊡ RESIDUAL SHEAR STRENGTH, BLOCK SAMPLE - SLICKENSIDE, U.S. 33 & 50, STATION 31+50, ATHENS.

⊙ PEAK SHEAR STRENGTH, CORE SAMPLE - INTACT I-70, MILE 188.9.

• FULLY SOFTENED SHEAR STRENGTH, CORE SAMPLE INTACT, I-70, MILE 188.9.

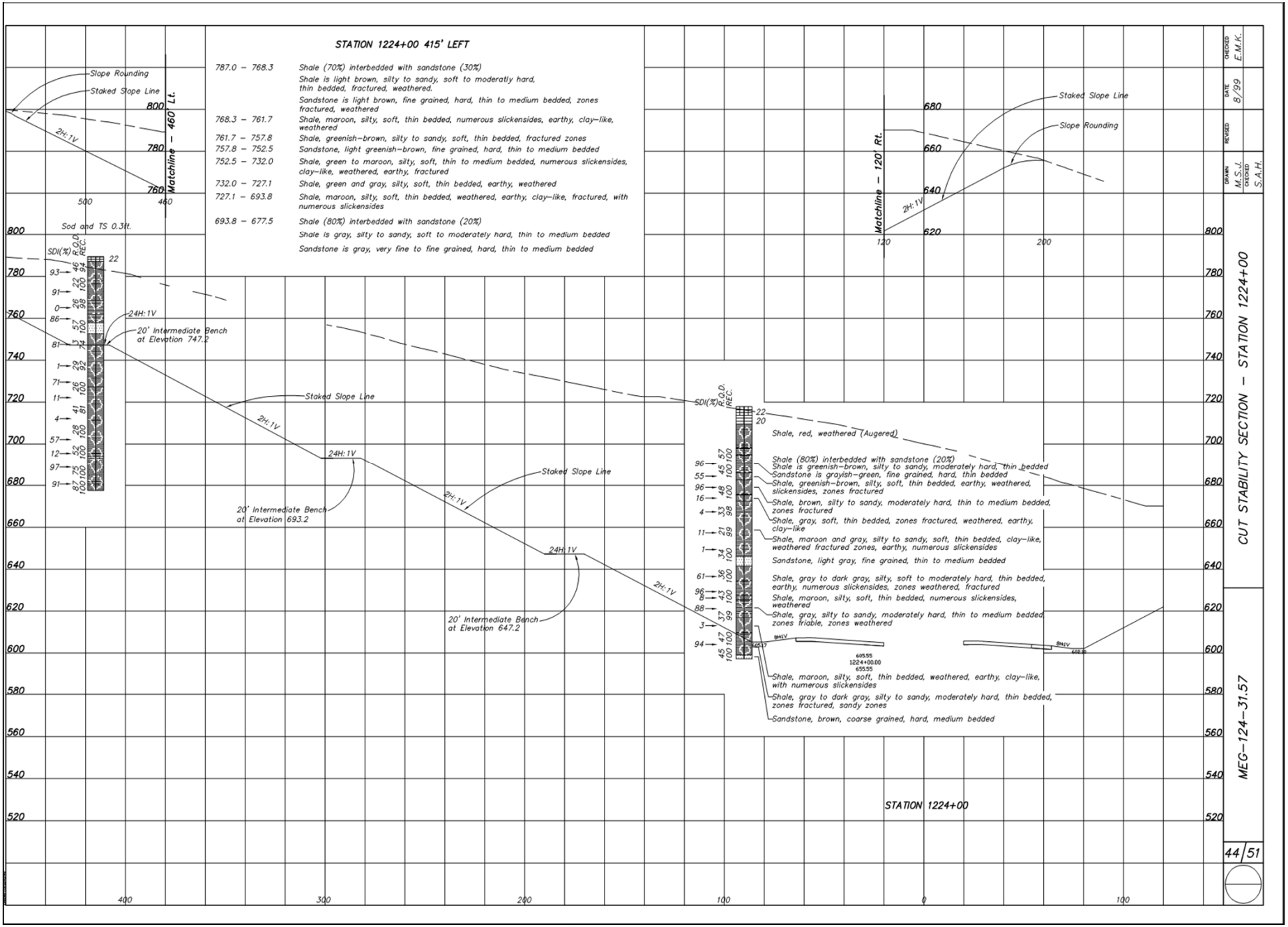
P PARTING NOTED BEFORE TESTING, PARTING ALIGNED WITH SHEAR ZONE.


⊙ PEAK SHEAR STRENGTH; BLOCK SAMPLE - INTACT, U.S. 33 & 50, STATION 31+50, ATHENS
△ FULLY SOFTENED SHEAR STRENGTH; BLOCK SAMPLE - INTACT, U.S. 33 & 50, STATION 31+50, ATHENS
PEAK SHEAR STRENGTH PARAMETERS - SMALL SHEAR TESTS
FULLY SOFTENED SHEAR STRENGTH PARAMETERS - SMALL SHEAR TESTS
FULLY SOFTENED SHEAR STRENGTH PARAMETERS - LARGE SHEAR TESTS
RESIDUAL SHEAR STRENGTH PARAMETERS - SMALL SHEAR TESTS
SHEAR STRESS (TSF)
400
300
200
100
(kN/m²)
4.0
3.0
2.0
1.0
1.0
2.0
3.0
4.0
NORMAL STRESS (TSF)
100
200 (kN/m²)
300
400


SOUTH
7
OHIO RIVER
SCENIC BYWAY

Core Box Containing Redbed Shale Sample

Example of Slickensided Bedrock Surface



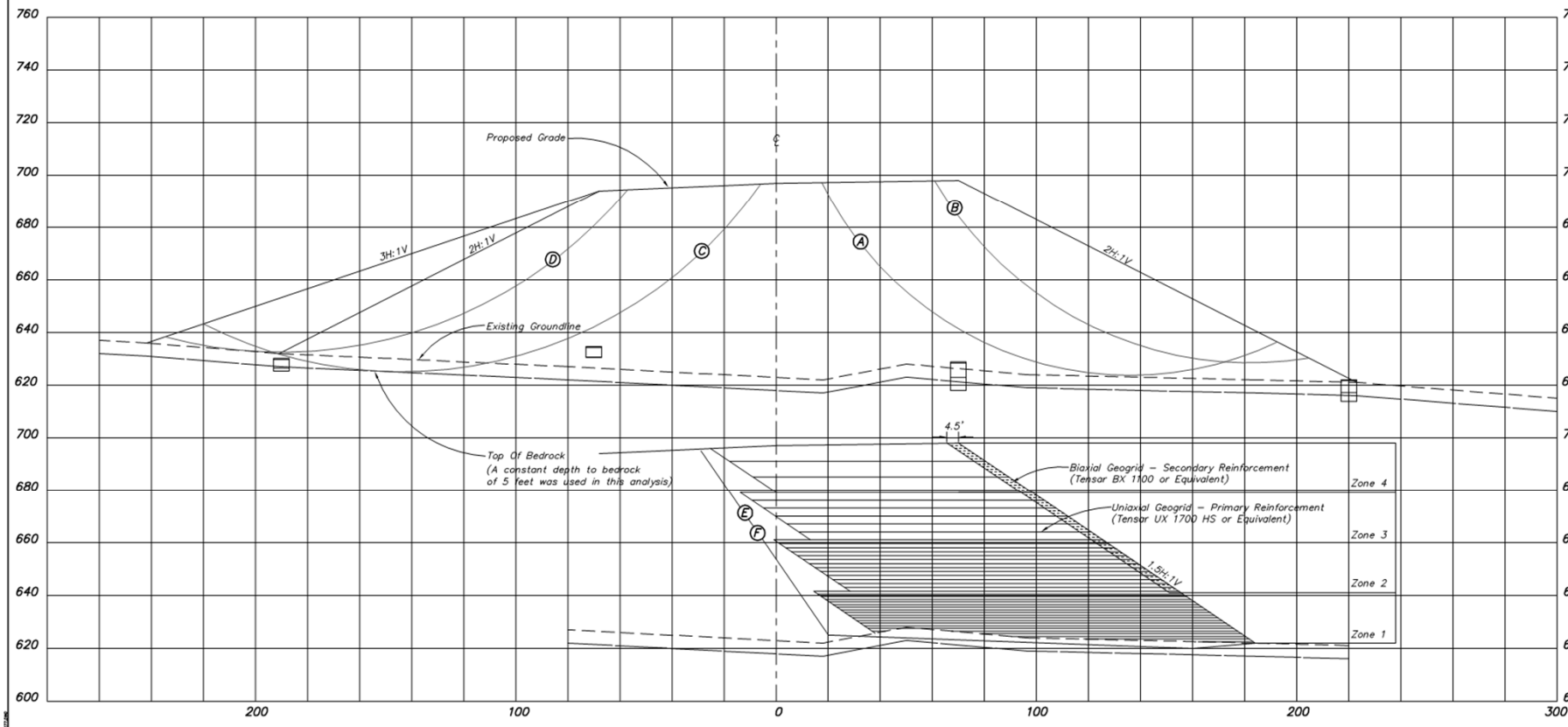
Cut Section Design


JDS
KRUPP
OVERSIZE LOAD

Geogrid Specifications			
Zone	Primary Reinforcement Spacing (ft.)	Secondary Reinforcement Spacing (ft.)	Length of Geogrid Embedment (ft.)
1	1.0	–	140.4
2	1.5	1' Spacing 1.5' Max.	126.4
3	3.0	1' Spacing 1.5' Max.	112.4
4	9.0	1' Spacing 1.5' Max.	98.4

Soil Parameters			
Soil	Unit Weight (p.c.f.)	Total Stress	Effective Stress
Embankment Fill	125	c = 1500 p.s.f. ϕ = 0	$\bar{c}$ = 200 p.s.f. $\bar{\phi}$ = 20°
Silt And Clay	125	c = 2000 p.s.f. ϕ = 0	$\bar{c}$ = 300 p.s.f. $\bar{\phi}$ = 30°

Summary Of Stability Analysis						
Failure Surface	Failure Mode	Condition	Factor Of Safety	X	Y	R
Ⓐ	Circular	Short Term 2H : 1V Slope	1.3	136.0	756.0	132.3
Ⓑ	Circular	Long Term 2H : 1V Slope	1.1	182.0	769.0	140.5
Ⓒ	Circular	Short Term 3H : 1V Slope	1.9	−144.0	794.0	168.9
Ⓓ	Circular	Long Term 3H : 1V Slope	1.5	−190.0	806.0	173.5
Ⓔ	Translational	Short Term With Geogrid	1.8	N/A	N/A	N/A
Ⓕ	Translational	Long Term With Geogrid	3.1	N/A	N/A	N/A



CHECKED E.M.K.
DATE 8/99
REVISED
DRAWN M.S.J. CHECKED S.A.H.

EMBANKMENT STABILITY SECTION – STATION 1277+00

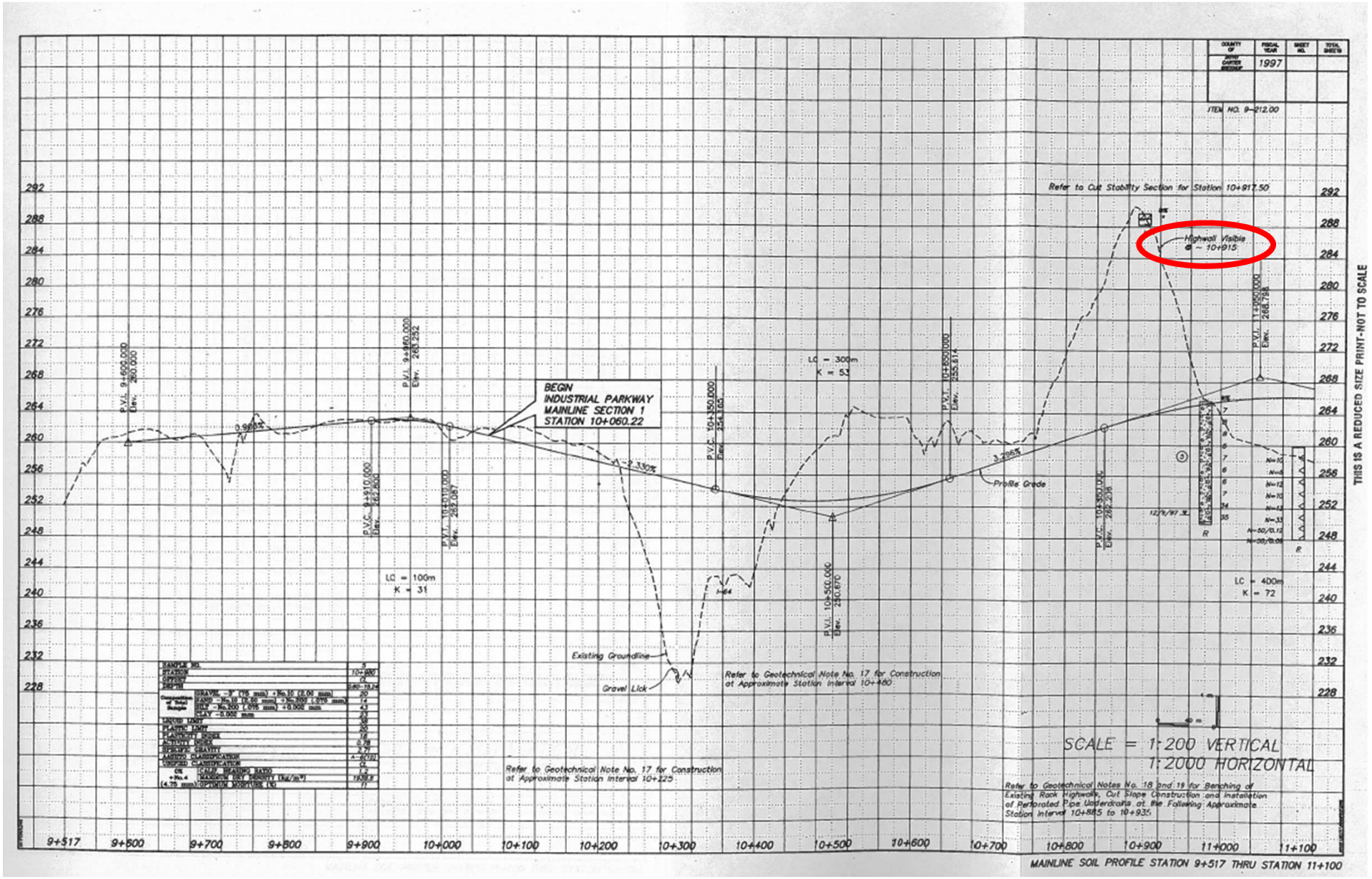
MEG-124-31.57

29/51

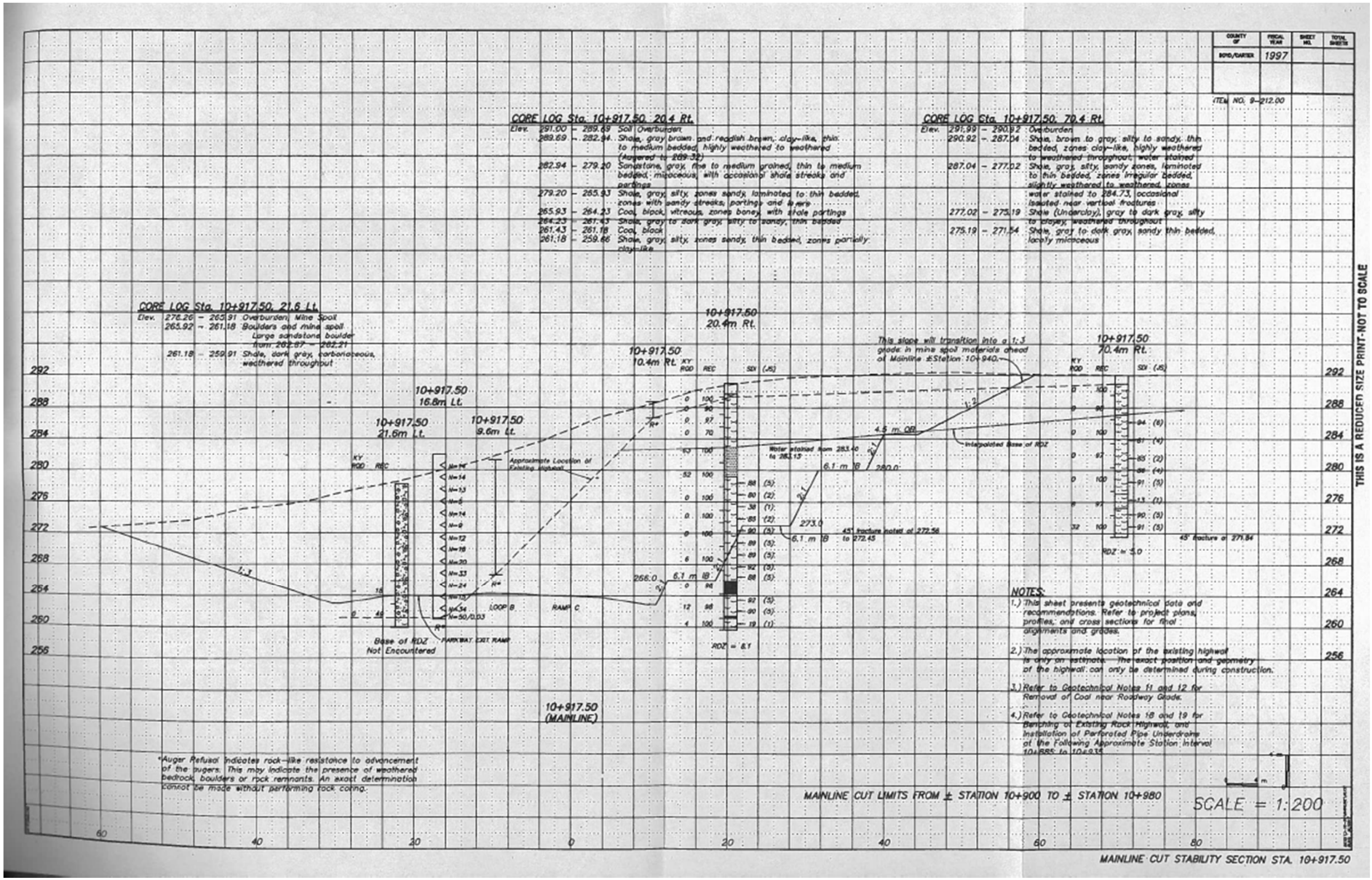
Embankment Section Design

Constructed Reinforced Soil Slope

Back-Stacked Highwall Area



Industrial Parkway Profile depicting Back-Stacked Highwall Position near Station 10+915



Designed Cut Section through Mine Spoil Back-Stacked Highwall

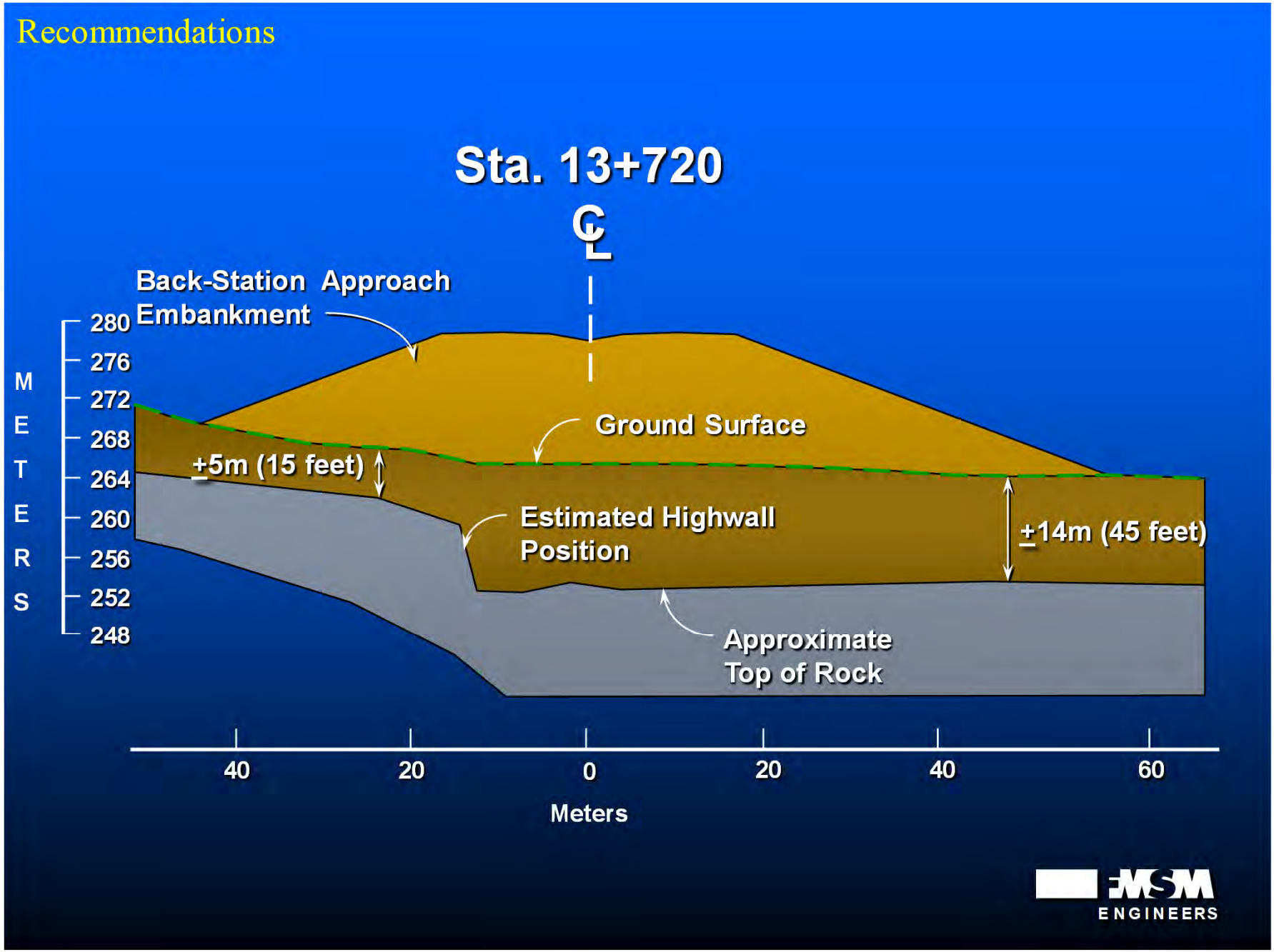
Silt Pond and Mine Bench Area Encountered at Project Site

Typical Hollow Fill Encountered Along the Project

Table 1. Results of CU Triaxial Tests – Industrial Pkwy.		
Sample Description and USCS Classification	**Range of Values Obtained**	
	Cohesion, $\bar{c}$ (psf)	**PHI, $\bar{\phi}$ (degrees)**
Lean Clay – CL	210 - 240	25 - 28
Silty Clay, Sandy Lean Clay, or Clayey Sand – CL, SC	0 - 70	31 - 32
Mine Spoils – CL	0	26

Table 2. Slope Geometries for Soil/Mine Spoil Cuts – Industrial Pkwy.	
Approximate Depth of Cut	**Recommended Slope Grade (H:V)**
Less than 10 feet	2:1
10 feet to 30 feet	2.5:1
30 feet to 120 feet	3:1

Roadway Cut being Constructed within Non-Durable Shales



Approach Embankment Modeled for Stability Analysis

View of Approach Embankment after Construction

Industrial Parkway / I-64 Interchange

SPECIAL THANKS

- **OHIO DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING**

- **KENTUCKY TRANSPORTATION CABINET DIVISION OF STRUCTURAL DESIGN – GEOTECHNICAL BRANCH**

THANK YOU