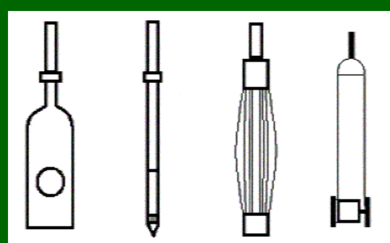
Use of Rock Pressuremeter for Deep Foundation Design



Roger A. Failmezger, P.E.

Aaron L. Zdinak, P.E.
Jesse N. Darden, P.E.

Randall Fahs

VIRGINIA GEOTECHNICAL SERVICES, P.C.

HILLIS-CARNES

Rock Pressuremeter Test

- Pressure applied by pumping hydraulic jack and extending piston downward inside probe
- Piston pressurizes ethanol glycol-water mixture inside membrane causing it to expand
- Piston displacement is measured with an LVDT
- Volume is computed as piston displacement times piston area
- Pressure is measured at surface with transducer


Dulles
National Airports

Rock PMT Advantages

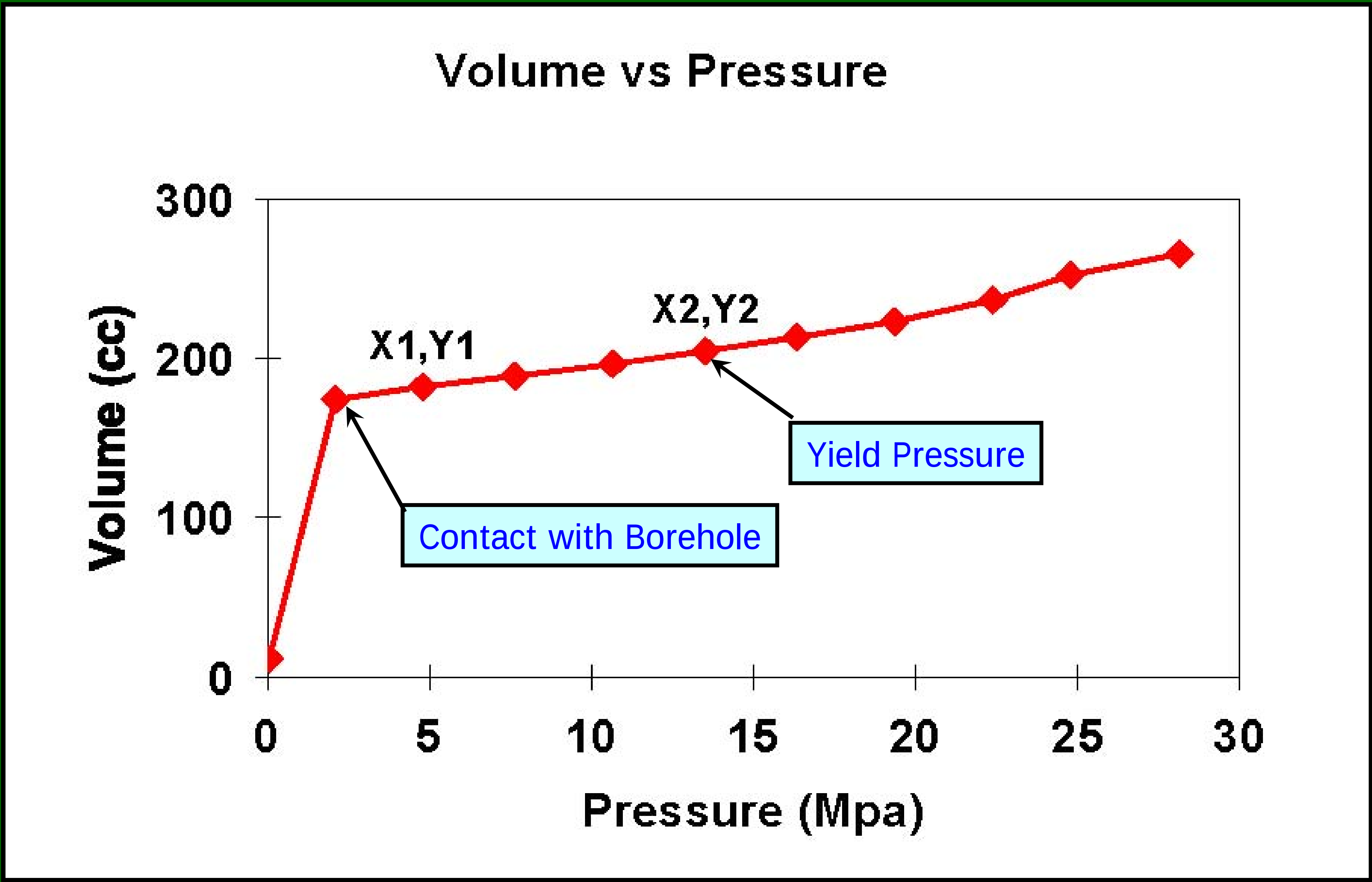
- Can apply 30 MPa of pressure
- Because volume is measured inside probe eliminate correction for tubing
- Can obtain accurate modulus values
- Can obtain limit pressure in softer rock
- Membranes are robust

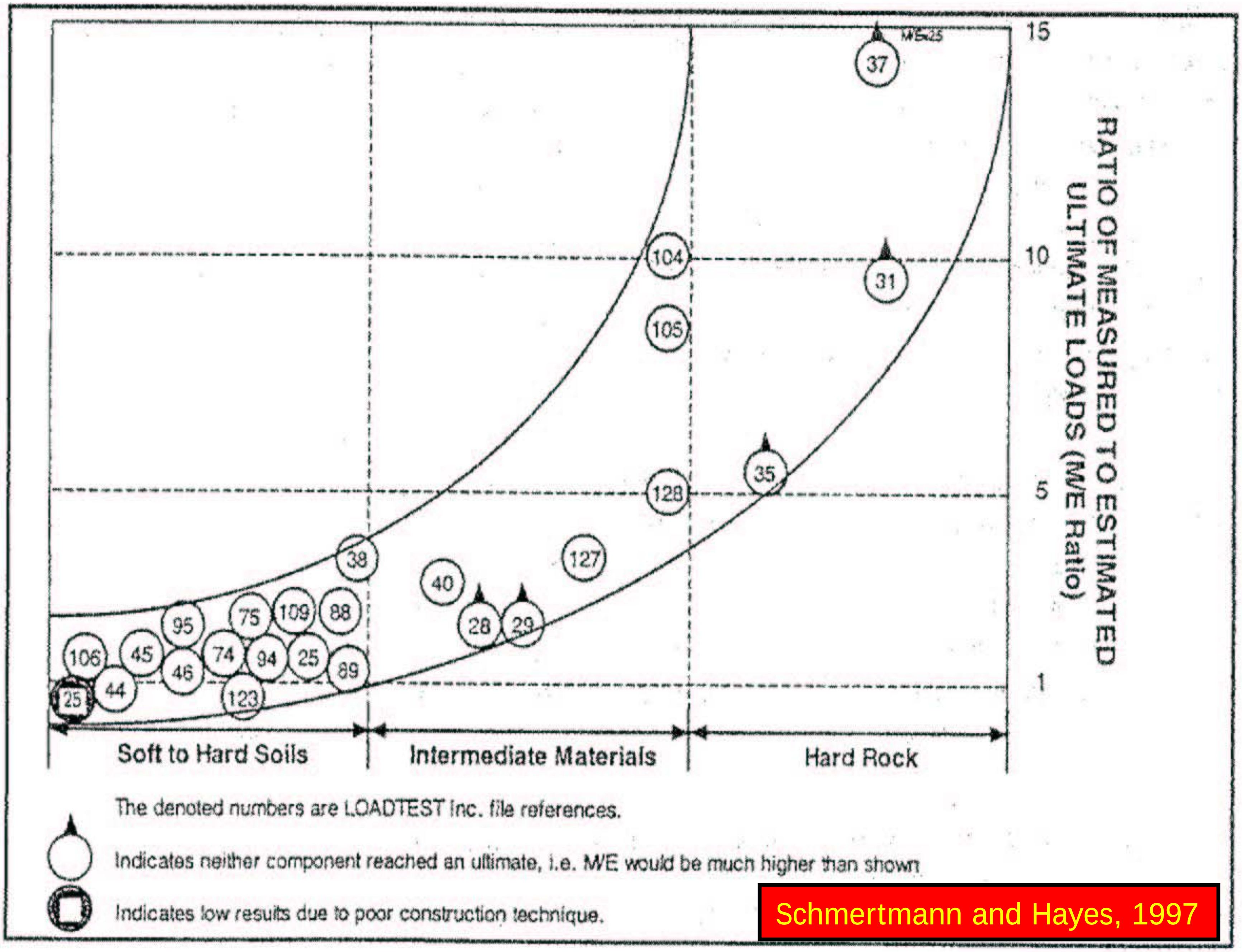
Rock PMT Disadvantages

- Can only practically expand membrane about 300 cm^3
- Clay filled rock seams can rupture membranes
- Membranes are costly (about $2500 U.S.)

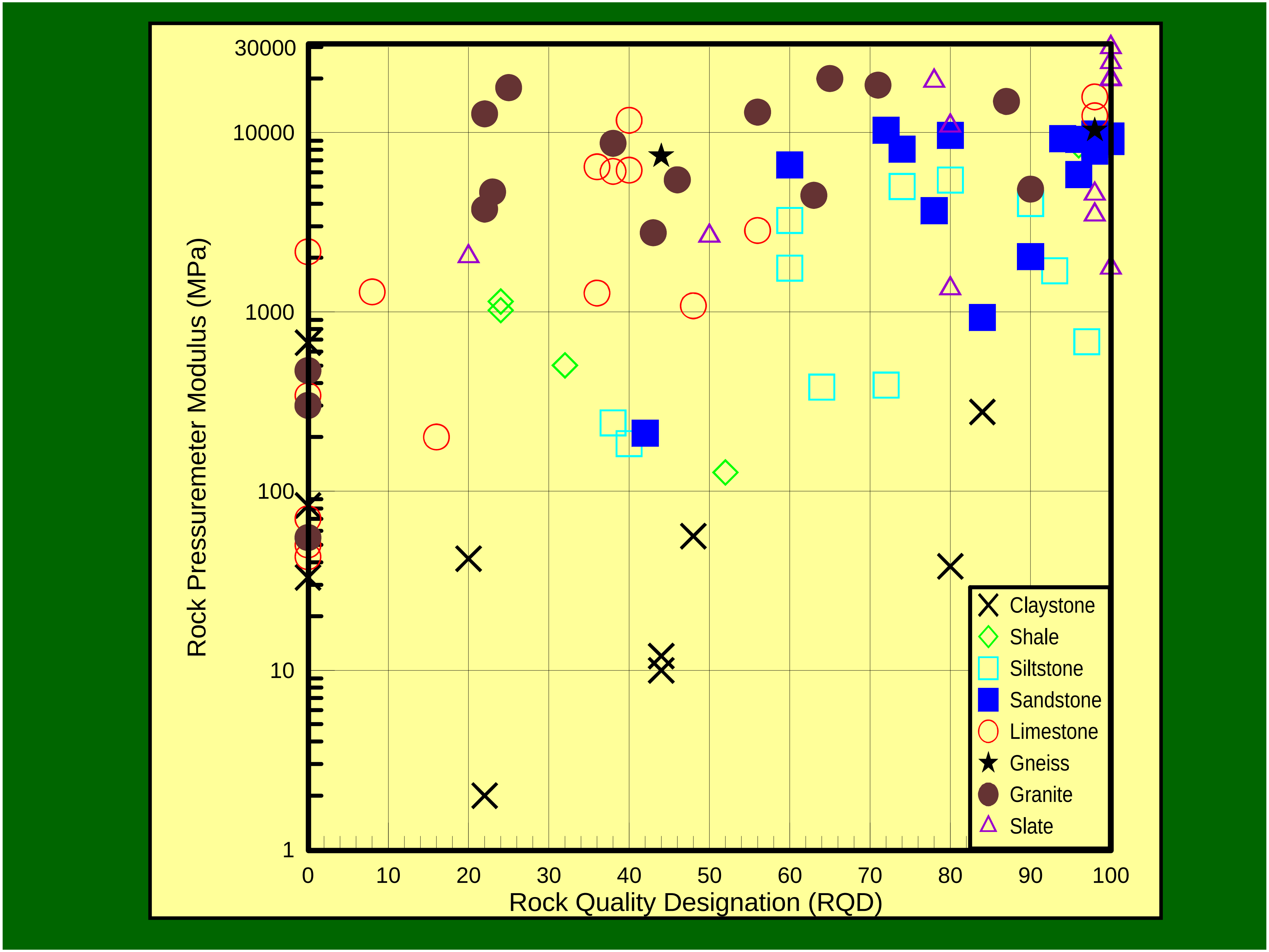
Typical Calibration Values

- System Compressibility: ~ 1 cm^3/MPa
- Membrane Resistance: ~ 2.5 MPa at 400 cm^3

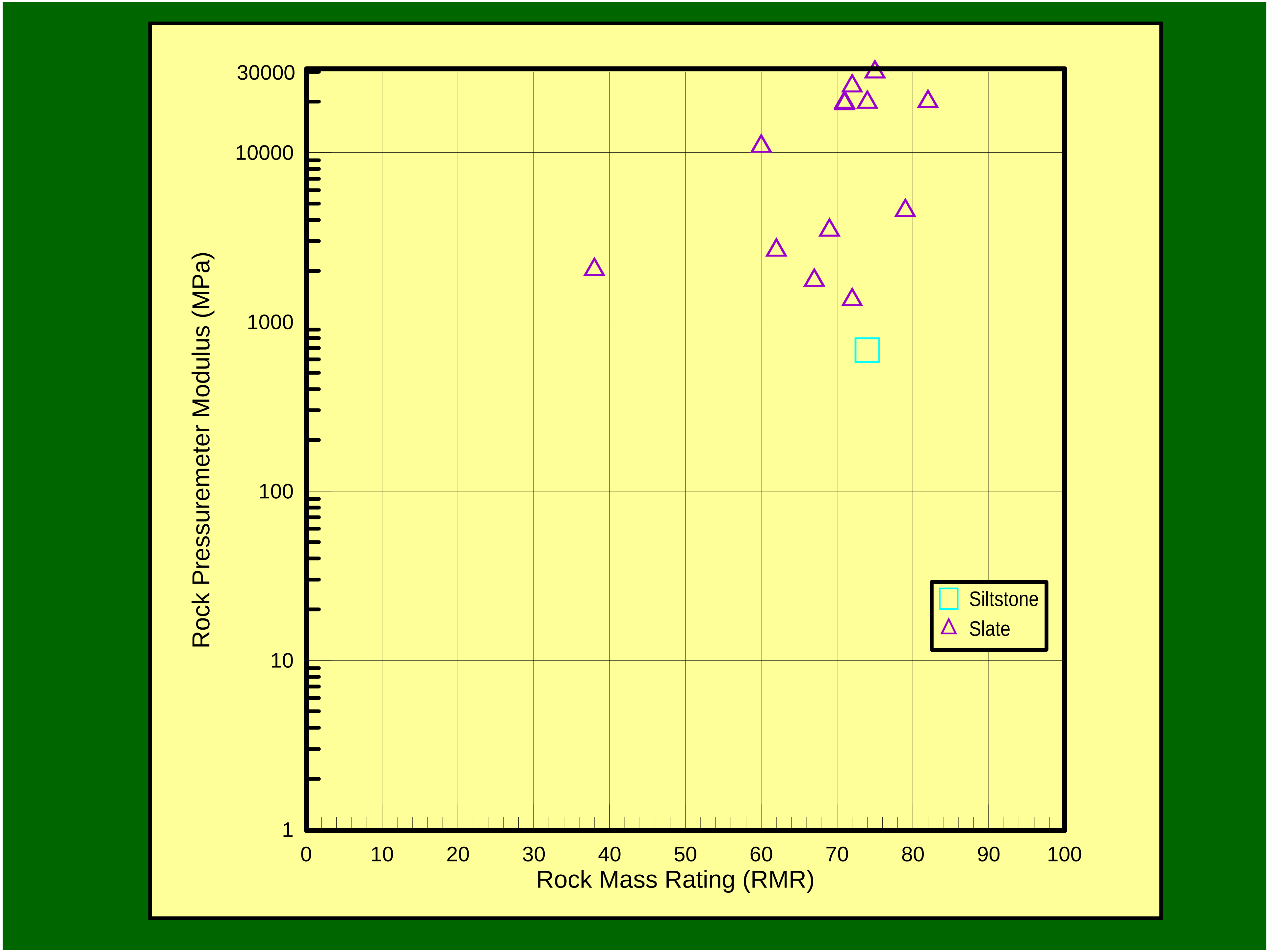

Volume vs Pressure
Volume (cc)
300
200
100
0
0
5
10
15
20
25
30
Pressure (Mpa)
X1,Y1
X2,Y2
Contact with Borehole
Yield Pressure



Schmertmann and Hayes, 1997



30000
10000
1000
100
10
1
Rock Pressuremeter Modulus (MPa)
0
10
20
30
40
50
60
70
80
90
100
Rock Quality Designation (RQD)
Claystone
Shale
Siltstone
Sandstone
Limestone
Gneiss
Granite
Slate



30000
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Rock Mass Rating (RMR)
Rock Pressuremeter Modulus (MPa)
Siltstone
Slate

Lateral load design procedure
(Modified from Robertson, et al., 1985)

- Re-interpret pressuremeter results in terms of radial strain and pressure
- Generate P-y curves
  - Multiply radial strain component by pile half-width
  - Multiply pressure component by pile width
  - Do not reduce pressure component by an α-factor

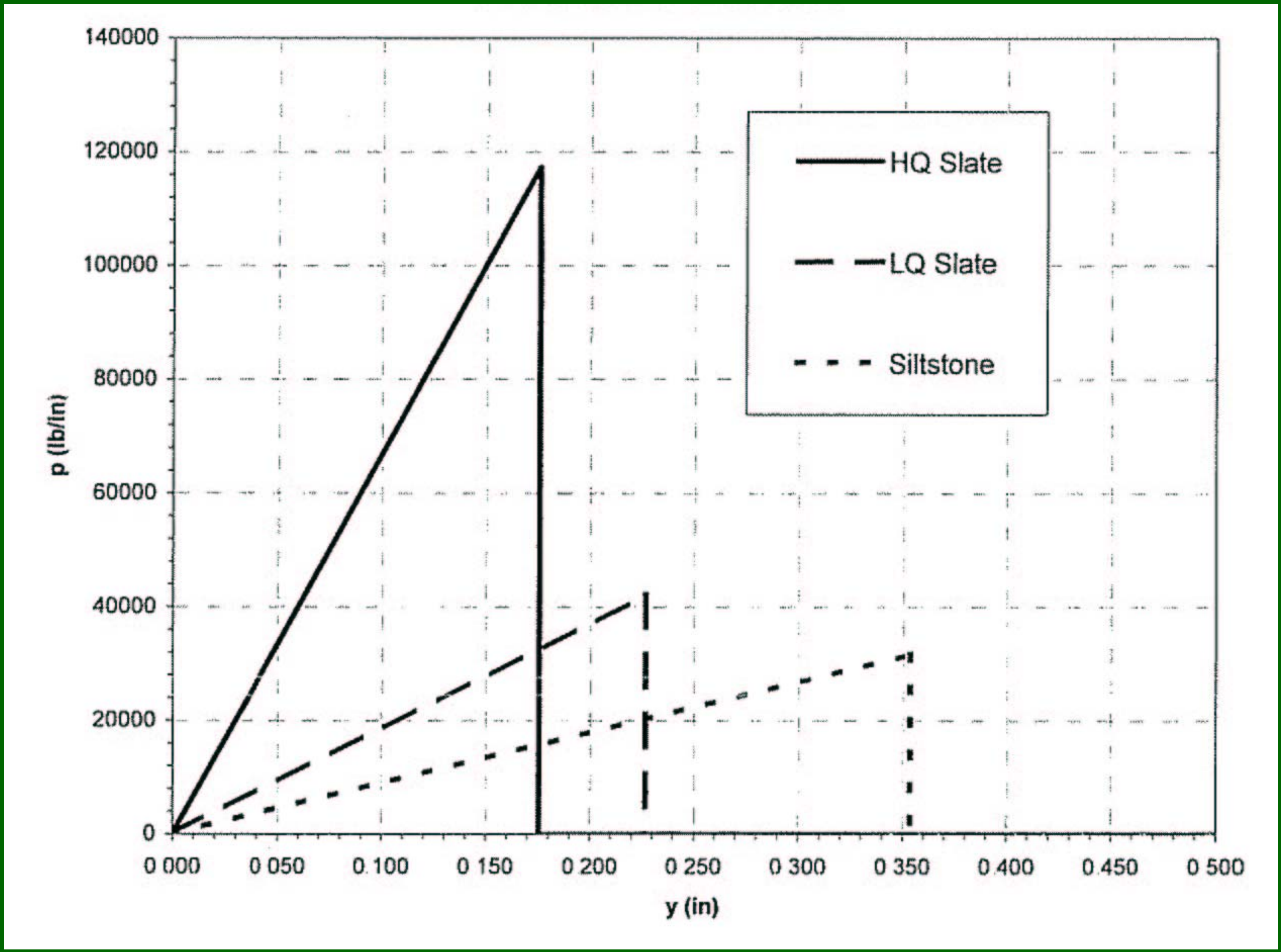
Lateral analysis (cont.) (Proposed Procedure)

- Compute the average slope and its standard deviation for each rock group
- Set the design slope equal to the average slope minus 2 standard deviations
- Apply a “limiting strain” value to account for brittle behavior
  - Set value equal to PMT yield pressure

Case Study—I-95 Occoquan River

Rock Classification	Rock Mass Modulus Range (MPa)	Average RQD	Average UC (MPa)	Average RMR	Comments
High Quality Slate	E_m > 10,000	94	60	74	Slate bedrock, fractures infrequent
Low Quality Slate	1000 < E_m < 10,000	78	26	64	Slate bedrock, fractures, brecciated zones, and slickensides more frequent, loss of water return common during drilling
Siltstone	E_m < 1000	92	43	74	Siltstone bedrock

Design P-y Curves



Conclusions

- Rock PMT Modulus values improve lateral load design of drilled shafts in rock
- Rock PMT modulus are representative of “rock mass modulus” and do not need reduction corrections
- Rock is quite heterogeneous—Modulus design values should be average value minus “x” standard deviations—we chose 2 S.D.

Conclusions (cont.)

- Rock type is as important to modulus as RQD or RMR
- No meaningful correlation found between rock modulus and RQD
- Correlation may be possible between rock modulus and RMR—but our data was limited

Second International Dilatometer Conference

April 2 – 5, 2006

Washington, D.C.

$650 includes all meals

www.2006dmt.com