IMPLEMENTATION OF SLOPE STABILITY RESEARCH: GEOLOGIC PROFILES ALONG I-70 AND I-77

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Acknowledgments. The field work, which consisted of identification of the various geologic formations and members, was done by G. O. Johnson, formerly of ODOT, and R. L. Williams, formerly of OSU. Records of recent boreholes were provided by M. Stouffer of ODOT. The contact person at ODOT was E. C. Geiger, who participated in and contributed much to the earlier research projects. The drafting was done by W. J. Hartleib.
Abstract. The objective is to produce geologic profiles along interstate routes I-70, Mi. 163 to 203, and I-77, Mi. 6 to 38. These sections traverse regions where the red shales of the Pennsylvanian and Permian ages occur near the surface in many localities. Slope failures in the red shales constitute a serious maintenance problem. The geologic profiles were constructed to provide engineers with advance information as to where the red shales are likely to be encountered, so that potential problems can be anticipated and included in the planning process.

The geology was studied as a part of earlier research projects. The various geologic formations and members were identified by inspection of materials exposed in cut slopes and natural slopes. Borehole records were used to locate the formations between the exposures. This information was presented in the form of geologic profiles. Information from records of boreholes made by ODOT along these routes after 1987 was incorporated into the profiles.
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1. INTRODUCTION

Failures of cut slopes in shale and embankment slopes built of shale have occurred on many of Ohio's highways. This is particularly serious in southeastern Ohio where red shales of Pennsylvanian and Permian ages are encountered. Slope failures in red shales constitute a serious maintenance problem.

Causes of slope failures along I-70 and I-77 were studied in three research projects. The failure mechanisms and recommendations for choice of design parameters were presented in Wu (1977, 1981, and 1987) and Wu et al (1987, 1991). Two remedial measures for slope failures were evaluated and found to be successful during the period of the observation (Wu, 1995). These results provide ODOT engineers with basic information for design of slopes in the red shales. General descriptions of the red shales are given in Condit (1912) and Fisher et al (1968).

It is realized that knowing the geology of the bedrock and localities where the red shales occur near the surface will be helpful to ODOT engineers planning various construction and maintenance activities. Geologic profiles would provide engineers with advance information as to where the red shales are likely to be encountered, so that potential problems can be anticipated and included in the planning process.

2. OBJECTIVE

The objective is to produce geologic profiles along interstate routes I-70, Mi. 160 to 204, and I-77, Mi. 6 to 38. These sections traverse regions where the red shales occur near the surface in many localities.

3. DESCRIPTION OF RESEARCH

The geology along I-70, Mi. 163 to 203, and I-77, Mi. 6 to 38 were identified as a part of the earlier research described above. The geologic section along the corridor was controlled stratigraphically by Ohio Geological Survey's registered measured sections with defined stratigraphic units. These units are major limestone and coal units with regional continuity. The intervening "shale" units were defined by their positions in relation to the limestone and coal beds. Additional control was developed from waterwells registered at the Ohio Dept. of Natural Resources, Div. Of Water, and borehole records of ODOT. Observations of significant
stratigraphic outcrops exposed in cut slopes and natural slopes defined the specific stratigraphic units.

We produced the profiles with the data collected in three research projects: Stability and Performance of Earthworks in Residual Clay Soils of Southeastern Ohio, Stability of Slopes in Shale and Colluvium, and Long-term Strength of Embankments: Shale and Colluvium, to produce the geologic profiles. In addition, we obtained from ODOT records of boreholes made along these routes after 1987. This information was incorporated into the profiles.

4. RESULTS

The three formations that contain red shales are the Washington, Monongahela, and Conemaugh. The region where these formations occur close to the surface are shown in Fig. 1. A simplified stratigraphic column showing the prominent members of these formations is given in Table1. The detailed stratigraphic column by Johnson (1982) is reproduced in Appendix A.

Table 1 also shows the notations used to identify the various members in the geologic profiles. The notations are assigned according to the following system. The first few letters denote the name of the member (eg. LM = Lower Marietta, C = Creston, Wa = Washington, etc.) The last capital letter, which may be followed by a lower case letter, denote the material type: C = coal, L = limestone, S = shale, Ss = sandstone (CS = Creston Shale, LMSs = Lower Marietta Sandstone). Where a member contains more than one facies, only the first is represented in the notation for brevity (MSs = Mannington Sandstone and Shale). In this report, the term "shale" includes clay-shale, siltstone and mudstone.

The geologic profiles are shown in Appendices B and C. In the profiles, thick formations are assumed to be continuous, whereas thin layers, primarily sandstone and limestone, that are known to be of limited extent, are shown as discontinuous. Unconsolidated materials (colluvium and alluvium) and unidentified materials are shown as blank spaces.

The user should note that the profiles are simplifications, based on extrapolation between observation points, that are located far apart. Therefore, continuity of formations as shown
Fig. 1. Outcrop of Washington, Monongahela and Conemaugh Formations
Table 1. Simplified Stratigraphic Column

(a) Members of Washington Formation.

<table>
<thead>
<tr>
<th>Jollytown Coal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Washington Limestone and Shale</td>
<td></td>
</tr>
<tr>
<td>Upper Marietta Sandstone</td>
<td></td>
</tr>
<tr>
<td>Washington &quot;A&quot; Coal</td>
<td></td>
</tr>
<tr>
<td>Creston Shale</td>
<td>CS</td>
</tr>
<tr>
<td>Lower Marietta Sandstone</td>
<td>LMSs</td>
</tr>
<tr>
<td>Washington Coal No.12</td>
<td>WaC</td>
</tr>
<tr>
<td>Washington Sandstone and Shale</td>
<td>WaSs</td>
</tr>
<tr>
<td>Mannington Sandstone and Shale</td>
<td>MSs</td>
</tr>
<tr>
<td>Waynesburg &quot;A&quot; Coal</td>
<td>WAC</td>
</tr>
</tbody>
</table>

(b) Members of Monongahela Formation

| Waynesburg Coal No.11                  | WC     |
| Gilboy Sandstone                       | GSs    |
| Waynesburg Limestone                   | WL     |
| Uniontown Sandstone and Shale           | USs    |
| Uniontown Coal                         | UC     |
| Arnoldsburg Limestone and Shale        | ArL    |
| Benwood Limestone and Shale            | BL     |
| Sewickley Sandstone and Shale          | SSs    |
| Meigs Creek Coal No. 9                 | MCC    |
| Fishport Limestone                     | FL     |
| Pomeroy Sandstone and Shale            | PmSs   |
| Redstone "Pomeroy" Coal                | RC     |
| Pittsburgh Sandstone and Shale         | PSs    |
Table 1 (continued)

(c) Members of Conemaugh Formation

<table>
<thead>
<tr>
<th>Pittsburgh Coal No. 8</th>
<th>PC8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bellaire Sandstone and Shale</td>
<td>BeSs</td>
</tr>
<tr>
<td>Lower Little Pittsburgh Coal</td>
<td>LLPC</td>
</tr>
<tr>
<td>Summerfield Limestone</td>
<td>SuL</td>
</tr>
<tr>
<td>Connellsville Shale</td>
<td>CoS</td>
</tr>
<tr>
<td>Connellsville Sandstone and Shale</td>
<td>CoSs</td>
</tr>
<tr>
<td>Clarksburg Limestone and Shale,</td>
<td>CL</td>
</tr>
<tr>
<td>Morgantown Sandstone and Shale</td>
<td>MoSs</td>
</tr>
<tr>
<td>Elk Lick Limestone</td>
<td>ELL</td>
</tr>
<tr>
<td>Birmingham Shale</td>
<td>BiS</td>
</tr>
<tr>
<td>Duquesne Shale</td>
<td>DS</td>
</tr>
<tr>
<td>Gaysport Limestone</td>
<td>GL</td>
</tr>
<tr>
<td>Ames Limestone</td>
<td>AL</td>
</tr>
<tr>
<td>Round Knob Shale</td>
<td>RKS</td>
</tr>
<tr>
<td>Harlem Coal</td>
<td>HC</td>
</tr>
<tr>
<td>Saltsburg Sandstone and Shale</td>
<td>SSs</td>
</tr>
<tr>
<td>Ewing Limestone</td>
<td>EL</td>
</tr>
<tr>
<td>Cowrun Sandstone and Shale</td>
<td>CrSs</td>
</tr>
<tr>
<td>Anderson Coal</td>
<td>AC</td>
</tr>
<tr>
<td>Cambridge Limestone</td>
<td>CaL</td>
</tr>
<tr>
<td>Wilgus Coal</td>
<td>WiC</td>
</tr>
<tr>
<td>Buffalo Sandstone and Shale</td>
<td>BuSs</td>
</tr>
<tr>
<td>Brush Creek Shale</td>
<td>BCS</td>
</tr>
<tr>
<td>Mason Coal</td>
<td>MC</td>
</tr>
<tr>
<td>Upper Mahoning Sandstone and Shale</td>
<td>UMaSs</td>
</tr>
<tr>
<td>Lower Mahoning Sandstone and Shale</td>
<td>LMaSs</td>
</tr>
<tr>
<td>Upper Freeport Coal No.7</td>
<td>UFC</td>
</tr>
</tbody>
</table>

cannot be assured. In addition, the user should be aware of the variability of natural materials.

The material characteristics may vary considerably even between two points that are not very far apart.

5. CONCLUSIONS AND RECOMMENDATIONS

The profiles make the geologic information readily available to engineers in a user-friendly format. The information would alert engineers to probable presence of red shales and allow them to take the potential problems into account in planning and design.
6. IMPLEMENTATION

The implementation of the results will consist of the use of the geologic profiles by ODOT engineers when planning various construction and maintenance activities. The geologic profiles would provide engineers with advance information as to where the red shales are likely to be encountered, so that potential problems can be anticipated and included in the planning process.

7. REFERENCES


APPENDIX A. STRATIGRAPHIC COLUMNS
(from Johnson, 1982)
Jollietown "A" Coal
Upper Washington Limestone and Shale: fresh water, white to blue, fossiliferous.
Hundred Sandstone and Shale: medium to coarse grained with pebbles, light brown, massive to ripple marked, lime cemented, micaceous.
Upper Marietta Sandstone and Shale: medium grained, light brown to gray, massive to laminated, micaceous (black).
Washington "A" Coal
Middle Washington Limestone and Shale: fresh water, light-brownish gray with orange hue, massive, fossiliferous.
Creston-Reds Shale and Mudstone: dusky red to dark red or dark olive with limestone nodules.
Lower Washington Limestone and Shale: fresh water, medium to olive gray, contains clay and silt, conglomeratic.
Lower Marietta Sandstone and Shale: med-fine gr. cross bedded
Washington Coal No. 12
Bristol Limestone: fresh water, yellowish gray, clayey, conglomeratic.
Washington Sandstone and Shale: fine gr., lt. gray, micaceous.
Little Washington Coal
Wannington Sandstone and Shale: fine grained, gray to greenish gray, massive to laminated, micaceous, fossiliferous.
Waynesburg "A" Coal No. 11a
Mount Morris Limestone and Shale: fresh water, clayey, gray.
Waynesburg Sandstone and Shale: fine to coarse grained with pebbles, gray, massive cross bedded to thin bedded, micaceous.
Wegge Limestone and Shale: fresh water, silty, conglomeratic.
Elm Grove Limestone: marine, dark bluish gray, laminated.
Callville Shale: medium blue gray, fossiliferous.
Waynesburg Coal No. 11
Waynesburg Coal No. 11
Gilboy Sandstone and Shale: shale, sandstone, gray to olive gray, thin bedded.

Little Waynesburg Coal
Waynesburg Limestone and Shale: fresh water, olive gray, silty to clayey, conglomeratic.

Uniontown Sandstone and Shale: fine to medium grained, light gray to tan, massive to shaley, micaceous, fossiliferous, may contain Annabelle Shale.

Uniontown Coal No. 10
Uniontown Limestone and Shale: fresh water, medium gray, brecc.
Arnoldsburg Sandstone and Shale: fine grained, gray, mica.

Arnoldsburg Coal
Arnoldsburg Limestone and Shale: fresh water, light brownish gray, silty to clayey, conglomeratic.

Fulton Shale: green to bluish green, graded to siltstone.

Hemwood Limestone and Shale: fresh water, light to olive gray, argillaceous, upper portion is sedimentary breccia, lower basal layers are conglomeratic.

Sewickley Sandstone and Shale: fine grained to siltstone, laminated, greenish gray, glauconitic, lenses of medium to coarse grained sandstone in lower unit.

Meigs Creek Coal No. 9
Lower Sewickley Sandstone and Shale: fine grained, light tan gray, clay bonded, thin bedded to massive.

Fishpot Coal
Fishpot Limestone and Shale: fresh water, light brownish to olive gray, laminated fine grained limestone, breccia, fossiliferous.

Pomeroy Sandstone and Shale: coarse grained, light bluish gray.

Redstone "Pomeroy" Coal
Redstone Limestone and Shale: fresh water, medium gray to light olive, brecciated and shrinkage cracks, sideritic, Pittsburgh Sandstone and Shale: coarse to fine gr, light gray.

Pittsburgh Coal No. 8
Pittsburgh Coal No. 8
Pittsburgh Limestone and Shale; fresh water, black to bluish gray, Dolomitic, amorphous, brecciated.
Lower Little Pittsburgh Coal
Bellaire Sandstone and Shale; coarse grained to fine grained.
Upper Little Pittsburgh Coal
Summerfield Limestone and Shale; fresh water, light to medium gray, amorphous, conglomeratic, interbedded clay.
Lower Little Pittsburgh Coal
Connelleville Sandstone and Shale; coarse grained, yellowish gray, crossbedded to laminated.
Clarksburg Coal
Clarksburg Limestone and marly Shale; fresh water, bluish gray.
Morgantown Sandstone and Shale; coarse to fine grained, bluish gray, massive, arkosic.
Elk Lick Coal
Elk Lick Limestone and marly Shale; fresh water, nodular.
Birmingham Shale, marine, gray to red shale, fossiliferous, hematite nodules, facies to Morgantown Sandstone.
Kelley Limestone; marine, blue to greenish gray, fossiliferous.
Duquesne Coal
shale
Gaysport Limestone; marine, nodular, light to dark gray, impure with sand and silt.
Ames Limestone; marine, crinoidal, light brownish gray, crystalline.
Harlem Coal
Round Knob Shale, red, clay stone, calcareous, fresh water limestone nodules and beds.
Saltburg Sandstone and Shale; fine grained, thin bedded, gray.
Sorton Coal
Ewing Limestone; fresh water, light gray, ferruginous.
Cowrun Sandstone and Shale; coarse grained, massive, light yellowish gray.
Portersville Limestone; marine, black, fossiliferous, pyritic.
Anderson Coal
Bloomfield Limestone; fresh water, light gray, nodular.
shale
Cambridge Limestone, marine, light yellowish gray, flinty, fossiliferous.
Wilgas Coal
Buffalo Sandstone and Shale; coarse grained, light yellowish gray, massive to thin bedded.
Brush Creek Limestone and Shale; marine, medium bluish gray, cherty, hard, fossiliferous.
Brush Creek Coal
shale
Moson Coal
Upper Mahoning Sandstone and Shale; fine grained to shaley.
Mahoning Coal
Thornton Clay, mottled green and red claystone.
Mahoning Limestone; fresh water, bluish gray, ferruginous.
Lower Mahoning Sandstone and Shale; coarse grained with pebbles, massive to cross bedded, light gray.
Upper Freeport Coal No. 7
APPENDIX B GEOLGIC Profiles, I-70
BuSs = Buffalo Sandstone and Shale; BCS = Brush Creek Shale; MC = Mason Coal; CL = Brush Creek Limestone; UMaSs = Upper Mahoning Sandstone and Shale; LMaSs = Lower Mahoning Sandstone and Shale; UFC = Upper Freeport Coal No.7
AL = Ames Limestone; HC = Harlem Coal; RKS = Round Knob Shale; CrSs = Cowrun Sandstone and Shale; AC = Anderson Coal; WiC = Wilgus Coal; BuSs = Buffalo Sandstone and Shale; BCS = Brush Creek Shale; BCL = Brush Creek Limestone; LMaSs = Lower Mahoning Sandstone and Shale
PC8 = Pittsburgh Coal No. 8; BeSs = Bellaire Sandstone; SuL = Summerfield Limestone; CoS = Connellsville Shale; DS = Duquesne Shale; GL = Gaysport Limestone; AL = Ames Limestone; HC = Harlem Coal; RKS = Round Knob Shale; CrSs = Cowrun Sandstone and Shale; AC = Anderson Coal
SuL = Summerfield Limestone; CoS = Connellsville Shale; BiS = Birmingham Shale; Al = Ames Limestone; HC = Harlem Coal; RKS = Round Knob Shale; CaL = Cambridge Limestone
LMaSs = Lower Mahoning Sandstone and Shale; UFC = Upper Freeport Coal No.7
LMaSs = Lower Mahoning Sandstone and Shale; UFC = Upper Freeport Coal No. 7; UFSs = Upper Freeport Sandstone and Shale
MoSs = Morgantown Sandstone and Shale; HC = Harlem Coal; RKS = Round Knob Shale; WiC = Wilgus Coal; BuSs = Buffalo Sandstone and Shale; LMaSs = Lower Mahoning Sandstone and Shale; UFC = Upper Freeport Coal No.7; UFSs = Upper Freeport Sandstone and Shale
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PSs = Pittsburgh Sandstone and Shale; PC8 = Pittsburgh Coal No. 8; BeSs = Bellaire Sandstone; SuL = Summerfield Limestone; CoS = Connelsville Shale; MoSs = Morgantown Sandstone and Shale; BiS = Birmingham Shale; DS = Duquesne Shale; AL = Ames Limestone; HC = Harlem Coal; RKS = Round Knob Shale
MCC = Meigs Creek Coal No. 9; FL = Fishport Limestone; PmSs = Pomeroy Sandstone and Shale; PSs = Pittsburgh Sandstone and Shale; PC8 = Pittsburgh Coal No. 8; BeSs = Bellaire Sandstone; MoSs = Morgantown Sandstone and Shale; BiS = Birmingham Shale
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MSs = Mannington Shale and Sandstone; WAC = Waynesburg "A" Coal; WC = Waynesburg Coal No.11; GSs = Gilboy Sandstone; WL = Waynesburg Limestone; UC = Uniontown Coal; ArL = Arnoldsburg Sandstone
GSs = Gilboy Sandstone; WL = Waynesburg Limestone; USs = Uniontown Sandstone and Shale; UC = Uniontown Coal; ArL = Arnoldsburg Sandstone; BL = Benwood Limestone and Shale; SS = Sewickley Sandstone and Shale, MCC = Meigs Creek Coal No. 9
UC = Uniontown Coal
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MCC = Meigs Creek Coal No. 9
PSs = Pittsburgh Sandstone and Shale
PC8 = Pittsburgh Coal No. 8
BeSs = Bellaire Sandstone
SuL = Summerfield Limestone
CoS = Connellsville Shale
BeSs = Bellaire Sandstone; LLPC = Lower Little Pittsburgh Coal; SuL = Summerfield Limestone; CoS = Connellsville Shale
MoSs = Morgantown Sandstone and Shale; BiS = Birmingham Shale
CoS = Connellsville Shale; MoSs = Morgantown Sandstone and Shale; GL = Gaysport Limestone; AL = Ames Limestone
CoS = Connellsville Shale; MoSs = Morgantown Sandstone and Shale; BiS = Birmingham Shale; DS = Duquesne Shale; GL = Gaysport Limestone; AL = Ames Limestone; RKS = Round Knob Shale
MoSSs = Morgantown Sandstone and Shale; AL = Ames Limestone; HC = Harlem Coal; RKS = Round Knob Shale; SSS = Salisbury Sandstone and Shale; EL = Ewing Limestone; CrSS = Cowhurt Sandstone and Shale; AC = Anderson Coal.
CoS = Connellsville Shale; CL = Clarksburg Limestone and Shale; MoSs = Morgantown Sandstone and Shale; BiS = Birmingham Shale; AL = Ames Limestone; HC = Harlem Coal

Elevation in Feet

Miles

Sandstone  Shale  Red Shale
Limestone  Coal

BiS  CL  I-77  CoS  MoSs  BiS

29  30  31  32

C37

800  850  900  950  1000
CoS = Connellsville Shale; CL = Clarksburg Limestone and Shale; ELL = Elk Lick Limestone; AL = Ames Limestone; HC = Harlem Coal; RKS = Round Knob Shale; CrSs = Cowrun Sandstone and Shale
AL = Ames Limestone; HC = Harlem Coal; RKS = Round Knob Shale; SSs = Saltsburg Sandstone and shale; AC = Anderson Coal; BuSs = Buffalo Sandstone and Shale
RKS = Round Knob Shale; CrSs = Cowrun Sandstone and Shale; AC = Anderson Coal; CaL = Cambridge Limestone; WiC = Wilgus Coal; BuSs = Buffalo Sandstone and Shale