

APPENDIX A

SOIL AND BEDROCK CLASSIFICATION

APPENDIX A.1 - ODOT Quick Reference for Visual Description of Soils

1) STRENGTH OF SOIL:

| Non-Cohesive (granular) Soils - Compactness | |
|---|---------------|
| Description | Blows Per Ft. |
| Very Loose | ≤ 4 |
| Loose | 5 – 10 |
| Medium Dense | 11 – 30 |
| Dense | 31 – 50 |
| Very Dense | > 50 |

2) COLOR :

If a color is a uniform color throughout, the term is single, modified by an adjective such as light or dark. If the predominate color is shaded by a secondary color, the secondary color precedes the primary color. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term “mottled”

3) PRIMARY COMPONENT

Use **DESCRIPTION** from ODOT Soil Classification Chart on Back

Cohesive (fine grained) Soils - Consistency

| Description | Qu (TSF) | Blows Per Ft. | Hand Manipulation |
|--------------|----------|---------------|---|
| Very Soft | <0.25 | <2 | Easily penetrates 2” by fist |
| Soft | 0.25-0.5 | 2 - 4 | Easily penetrates 2” by thumb |
| Medium Stiff | 0.5-1.0 | 5 - 8 | Penetrates by thumb with moderate effort |
| Stiff | 1.0-2.0 | 9 - 15 | Readily indents by thumb, but not penetrate |
| Very Stiff | 2.0-4.0 | 16 - 30 | Readily indents by thumbnail |
| Hard | >4.0 | >30 | Indent with difficulty by thumbnail |

4) COMPONENT MODIFIERS:

| Description | Percentage By Weight |
|-------------|----------------------|
| Trace | 0% - 10% |
| Little | >10% - 20% |
| Some | >20% - 35% |
| “And” | >35% |

5) Soil Organic Content

| Description | % by Weight |
|--------------------|-------------|
| Slightly Organic | 2% - 4% |
| Moderately Organic | 4% - 10% |
| Highly Organic | > 10% |

6) Relative Visual Moisture

| Description | Criteria | |
|--------------|---|---|
| | Cohesive Soil | Non-cohesive Soils |
| Dry | Powdery; Cannot be rolled; Water content well below the plastic limit | No moisture present |
| Damp | Leaves very little moisture when pressed between fingers; Crumbles at or before rolled to 1/8”; Water content below plastic limit | Internal moisture, but no to little surface moisture |
| Moist | Leaves small amounts of moisture when pressed between fingers; Rolled to 1/8” or smaller before crumbling; Water content above plastic limit to -3% of the liquid limit | Free water on surface, moist (shiny) appearance |
| Wet | Very mushy; Rolled multiple times to 1/8” or smaller before crumbles; Near or above the liquid limit | Voids filled with free water, can be poured from split spoon. |



CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart. The first classification that the test data fits is the correct classification.)

| SYMBOL | DESCRIPTION | Classification | | LL _O /LL × 100* | % Pass #40 | % Pass #200 | Liquid Limit (LL) | Plastic Index (PI) | Group Index Max. | REMARKS |
|--|--|----------------|------------------------------|-------------------------------|------------------|-------------------|-------------------------|--------------------------|------------------------|--|
| | | AASHTO | OHIO | | | | | | | |
| | Gravel and/or Stone Fragments | A-1-a | | | 30 Max. | 15 Max. | | 6 Max. | 0 | Min. of 50% combined gravel, cobble and boulder sizes |
| | Gravel and/or Stone Fragments with Sand | A-1-b | | | 50 Max. | 25 Max. | | 6 Max. | 0 | |
| | Fine Sand | A-3 | | | 51 Min. | 10 Max. | NON-PLASTIC | | 0 | |
| | Coarse and Fine Sand | -- | A-3a | | | 35 Max. | | 6 Max. | 0 | Min. of 50% combined coarse and fine sand sizes |
| | Gravel and/or Stone Fragments with Sand and Silt | A-2-4 | | | | 35 Max. | 40 Max. | 10 Max. | 0 | |
| | | A-2-5 | | | | | 41 Min. | | | |
| | Gravel and/or Stone Fragments with Sand, Silt and Clay | A-2-6 | | | | 35 Max. | 40 Max. | 11 Min. | 4 | |
| | | A-2-7 | | | | | 41 Min. | | | |
| | Sandy Silt | A-4 | A-4a | 76 Min. | | 36 Min. | 40 Max. | 10 Max. | 8 | Less than 50% silt sizes |
| | Silt | A-4 | A-4b | 76 Min. | | 50 Min. | 40 Max. | 10 Max. | 8 | 50% or more silt sizes |
| | Elastic Silt and Clay | A-5 | | 76 Min. | | 36 Min. | 41 Min. | 10 Max. | 12 | |
| | Silt and Clay | A-6 | A-6a | 76 Min. | | 36 Min. | 40 Max. | 11 - 15 | 10 | |
| | Silty Clay | A-6 | A-6b | 76 Min. | | 36 Min. | 40 Max. | 16 Min. | 16 | |
| | Elastic Clay | A-7-5 | | 76 Min. | | 36 Min. | 41 Min. | ≤ LL-30 | 20 | |
| | Clay | A-7-6 | | 76 Min. | | 36 Min. | 41 Min. | > LL-30 | 20 | |
| | Organic Silt | A-8 | A-8a | 75 Max. | | 36 Min. | | | | W/o organics would classify as A-4a or A-4b |
| | Organic Clay | A-8 | A-8b | 75 Max. | | 36 Min. | | | | W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6 |
| MATERIAL CLASSIFIED BY VISUAL INSPECTION | | | | | | | | | | |
| | Sod and Topsoil | | Uncontrolled Fill (Describe) | | Bouldery Zone | | Peat | | | |
| | Pavement or Base | | | | | | | | | |

* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

APPENDIX A.2 – ODOT Quick Reference Guide for Rock Description

1: ROCK TYPE: Common rock types are: Claystone; Coal; Dolomite; Limestone; Sandstone; Siltstone; & Shale.

2: COLOR: To be determined when rock is wet. When using the GSA Color charts use only Name, not code.

3: WEATHERING

| Description | Field Parameter |
|-----------------------------|--|
| Unweathered | No evidence of any chemical or mechanical alteration of the rock mass. Mineral crystals have a bright appearance with no discoloration. Fractures show little or no staining on surfaces. |
| Slightly weathered | Slight discoloration of the rock surface with minor alterations along discontinuities. Less than 10% of the rock volume presents alteration. |
| Moderately weathered | Portions of the rock mass are discolored as evident by a dull appearance. Surfaces may have a pitted appearance with weathering “halos” evident. Isolated zones of varying rock strengths due to alteration may be present. 10 to 15% of the rock volume presents alterations. |
| Highly weathered | Entire rock mass appears discolored and dull. Some pockets of slightly too moderately weathered rock may be present and some areas of severely weathered materials may be present. |
| Severely weathered | Majority of the rock mass reduced to a soil-like state with relic rock structure discernable. Zones of more resistant rock may be present, but the material can generally be molded and crumbled by hand pressures. |

4: TEXTURE

| Component | | Grain Diameter |
|-----------|-----------|----------------|
| Boulder | | >12” |
| Cobble | | 3”-12” |
| Gravel | | 0.08”-3” |
| Sand | Coarse | 0.02”-0.08” |
| | Medium | 0.01”-0.02” |
| | Fine | 0.005”-0.01” |
| | Very Fine | 0.003”-0.005” |

5: RELATIVE STRENGTH

| Description | Field Parameter |
|--------------------------|---|
| Very Weak | Core can be carved with a knife and scratched by fingernail. Can be excavated readily with a point of a pick. Pieces 1 inch or more in thickness can be broken by finger pressure. |
| Weak | Core can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure. |
| Slightly Strong | Core can be grooved or gouged 0.05 inch deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch maximum size by hard blows of the point of a geologist’s pick. |
| Moderately Strong | Core can be scratched with a knife or pick. Grooves or gouges to ¼” deep can be excavated by hand blows of a geologist’s pick. Requires moderate hammer blows to detach hand specimen. |
| Strong | Core can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen. |
| Very Strong | Core cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer. |
| Extremely strong | Core cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer. |

6: BEDDING

| Description | Thickness |
|-------------------------|-------------|
| Very Thick | >36” |
| Thick | 18” – 36” |
| Medium | 10” – 18” |
| Thin | 2” – 10” |
| Very Thin | 0.4” – 2” |
| Laminated | 0.1” – 0.4” |
| Thinly Laminated | <0.1” |

7: DESCRIPTORS

| |
|---|
| Arenaceous – sandy |
| Calcareous - contains calcium carbonate |
| Conglomeritic - contains rounded to subrounded gravel |
| Feriferous – contains iron |
| Friable – easily broken down |
| Siliceous – contains silica |

| |
|--|
| Argillaceous - clayey |
| Carbonaceous - contains carbon |
| Crystalline – contains crystalline structure |
| Fissile – thin planar partings |
| Micaceous – contains mica |
| Styolitic – contain stylotites (suture like structure) |

| |
|--|
| Brecciated – contains angular to subangular gravel |
| Cherty- contains chert fragments |
| Dolomitic- contains calcium/magnesium carbonate |
| Fossiliferous – contains fossils |
| Pyritic – contains pyrite |
| Vuggy – contains openings |

APPENDIX A.2 – ODOT Quick Reference Guide for Rock Description

8: DISCONTINUITIES

a: Discontinuity Types

| Type | Parameters |
|----------------|--|
| Fault | Fracture which expresses displacement parallel to the surface that does not result in a polished surface. |
| Joint | Planar fracture that does not express displacement. Generally occurs at regularly spaced intervals. |
| Shear | Fracture which expresses displacement parallel to the surface that results in polished surfaces or slickensides. |
| Bedding | A surface produced along a bedding plane. |
| Contact | A surface produced along a contact plane. (generally not seen in Ohio) |

b: Degree of Fracturing

| Description | Spacing |
|-----------------------------|----------------|
| Unfractured | > 10 ft. |
| Intact | 3 ft. – 10 ft. |
| Slightly fractured | 1 ft. – 3 ft. |
| Moderately fractured | 4 in. – 12 in. |
| Fractured | 2 in. – 4 in. |
| Highly fractured | < 2 in. |

c: Aperture Width

| Description | Spacing |
|---------------|--------------------|
| Open | > 0.2 in. |
| Narrow | 0.05 in. - 0.2 in. |
| Tight | <0.05 in. |

d: Surface Roughness

| Description | Criteria |
|----------------|--|
| Very Rough | Near vertical steps and ridges occur on the discontinuity surface. |
| Slightly Rough | Asperities on the discontinuity surface are distinguishable and can be felt. |
| Slickensided | Surface has a smooth, glassy finish with visual evidence of striation. |

11: RECOVERY

| | |
|--|--|
| $Run\ Recovery = \left(\frac{R_R}{L_R} \right) * 100$ | $Unit\ Recovery = \left(\frac{R_U}{L_U} \right) * 100$ |
| L _R = Run Length R _R – Run Recovery | L _U = Rock Unit Length R _U – Rock Unit Recovery |

9: GSI DESCRIPTION

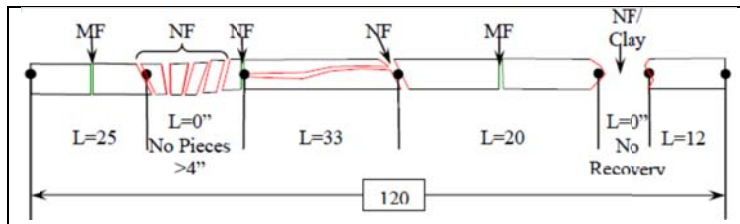
a: Structure

| Description | Parameters |
|-------------------------------|--|
| Intact or Massive | Intact rock with few widely spaced discontinuities |
| Blocky | Well interlocked undisturbed rock mass consisting of cubical blocks formed by three interesting discontinuity sets |
| Very Blocky | Interlocked, partially disturbed mass with multi-faceted angular blocks formed by 4 or more joint sets |
| Blocky/Disturbed/Seamy | Angular blocks formed by many intersecting discontinuity sets, Persistence of bedding planes |
| Disintegrated | Poorly interlocked, heavily broken rock mass with mixture of angular and rounded rock pieces |
| Laminated/Sheared | Lack of blockiness due to close spacing of weak shear planes |

b: Surface Condition

| Description | Parameters |
|-------------|---|
| Very Good | Very rough, fresh unweathered surfaces |
| Good | Rough, slightly weathered, iron stained surface |
| Fair | Smooth, moderately weathered and altered surfaces |
| Poor | Slickensided, highly weathered surface with compact coatings or fillings or angular fragments |
| Very Poor | Slickensided, highly weathered surfaces with soft clay coating or fillings |

10: RQD



$$RQD = \left(\frac{\sum \text{Length of Pieces} > 4 \text{ inches}}{\text{Total Length of Core}} \right) * 100$$

$$RQD = \left(\frac{25 + 33 + 20 + 12}{120} \right) * 100 = 75\%$$

APPENDIX A.3 - ODOT Rock Type

GENERAL AND GLOSSARY:

The following terms are use in describing the rock types found within Ohio. The following listing is presented in alphabetical order.

Amorphous: Does not contain crystalline structure with shapeless appearance.

Anhydrous: Does not contain water within the crystalline structure.

Bioturbated: Evidence of past organisms, such as filled burrows, within the rock mass.

Conchoidal Fracture: A curved fracture plane with a rock mass.

Concretion: A solidified mass of concentrated material, usually of a single or multiple mineral composition.

Dilute HCl: A liquid composed of a 10% Hydrochloric Acid solution.

Hydrous: Contains water within the crystalline structure.

Hardness: When describing rock and minerals, the hardness of the material is commonly referred to. The hardness is the ability of the material to resist scratching. The easier the material is scratched, the lower the hardness, and the more resistant the material is to scratching, the higher the hardness. The following table list hardness of common items to aid in field determinations:

| Object | Hardness |
|----------------------------|----------|
| Fingernail | 2.5 |
| Copper Penny (pre 1982) | 3.5 |
| Knife Blade/Nail | 5.5 |
| Window Glass | 5.5 |
| Hardened Steel (File) | 6.5 |

Indurated: Partially lithified (hardened) sediment.

Lithified: Process during which unconsolidated sediments are formed into sedimentary rock.

Luster: The ability of the material to reflect light resulting in a surface appearance.

Vitreous: Description referring to a glassy luster.

ROCK TYPES:

The following are descriptions of the basic rock types found within Ohio. It should be noted that when referencing a percentage of composition the percentage is based on volume not weight.

| ROCK TYPE | DESCRIPTION |
|---------------------|---|
| ANHYDRITE | A rock or mineral consisting of anhydrous calcium sulfate (CaSO ₄) which is common to massive evaporite beds and readily alters to gypsum. Anhydrite is white, has a vitreous or pearly luster, and a hardness of 3.5 |
| BRECCIA | A coarse-grained sedimentary rock comprised of more than 25% subangular to angular gravel, cobbles and/or boulders. These grains are supported by either inter-grain contact or a matrix of sands, silt and/or clay and cemented by calcite, dolomite, hematite, silica or hardened clay. Color depends on the cementing agent with white, gray, yellow, orange, brown, and red colors common. |
| CHERT | A hard dense sedimentary rock consisting of very fine quartz crystals and may contain amorphous silica or silica replaced fossils. Chert varieties in color, but commonly is white or ranges from brown to black, has a semi-vitreous to dull luster, and a hardness of 7. When broken it commonly produces conchoidal fractures. These fractures are smooth with sharp edges. Chert forms as oval or irregular nodular or concretionary segregations, or as layered deposits in limestone and dolomite. Also referred to as flint. |
| CLAYSTONE | A fine-grained rock formed of at least 75% clay sized particles. Claystone is comprised of lithified clay having the texture and composition of shale, but lacking the laminations and fissility of a shale. Generally has a blocky, thick to massive appearance. Claystone may range in color from red, gray, olive, yellow, or brown with multiple colors typical. Slickensides are commonly found within claystone. |
| COAL | A combustible substance containing more than 50%, by weight, and more than 70%, by volume, of carbonaceous material; formed from the compaction and lithification of plant remains. Colors of coals range from brown to black. It is generally light weight with a shiny appearance on fresh surfaces. |
| CONGLOMERATE | A coarse-grained sedimentary rock comprised of more than 25% rounded to subrounded gravel, cobbles, and/or boulders. These grains are supported by either inter-grain contact or a matrix of sands, silt and/or clay and cemented by calcite, hematite, silica or hardened clay. Color depends on the matrix and cementing agent with white, gray, yellow, orange, brown, and red colors common. |
| DOLOMITE | A sedimentary rock of which more than 50% consists of the mineral dolomite (calcium magnesium carbonate – CaMg(CO ₃) ₂) and less than 10% is comprised of the mineral calcite. It is commonly interbedded with limestone, and the magnesium can be replaced with ferrous iron. Dolomite typically has a hardness of 3.5 to 4, colors ranging from white to light gray and will weakly react with cold dilute HCl on fresh or powdered surfaces. |
| FIRECLAY | See Underclay for description. The preferred use is Underclay. |

| ROCK TYPE | DESCRIPTION |
|------------------|--|
| FLINT | A common name for chert, generally used by archaeologists. See Chert for a description. |
| GYPSUM | A rock or mineral consisting of hydrous calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). It forms thick extensive beds in Silurian aged rock commonly associated with halite and anhydrite in evaporative deposits. Gypsum may be white, translucent or transparent with a vitreous to pearly luster and a hardness of 2.0. Does not react with dilute HCl. |
| HALITE | A rock or mineral occurring in massive, granular compact or cubic-crystalline forms associated with evaporite beds. It is comprised of sodium chloride (NaCl) and is commonly known as salt. Halite is colorless to white with a hardness of 2.0 to 2.5. Fresh samples will have a salty flavor. |
| IRONSTONE | <p>A sedimentary rock that is heavy and compact, containing primary components of iron oxides, carbonates, clay, and/or sand. Fresh surfaces generally are gray which weathers (oxidizes) to yellowish brown (limonite) to deep red (hematite) depending on the type and amount of oxide/hydroxide formed. It is very distinct in that its density is greater than a typical sedimentary rock.</p> <p>Purer forms of ironstone occur as concretionary forms within shale, sandstone and limestone or dolomite layers, or at bedding contacts. Generally these concretionary forms are composed of goethite ($\text{Fe}(\text{OH})$, hardness 5.0-5.5), limonite ($\text{FeX}(\text{OH})$, hardness 4.0-5.5), or siderite (FeCO_3, hardness 3.5-4.5) and can be called “kidney ores” for their kidney shapes. Colors of these concretions vary between gray, yellowish brown, brown, brownish red or black depending upon the composition and degree of weathering.</p> |
| LIMESTONE | <p>A sedimentary rock consisting of the mineral calcite (calcium carbonate – CaCO_3). Impurities may include chert, clay and minor mineral crystals. It may be crystalline (hard, pure, fine to coarse texture) with very fine grains not visible to the naked eye and/or fossiliferous (contains remains of organisms). Limestone is typically white to dark gray in color with a hardness of 3.5 to 4.0 and reacts vigorously with cold dilute HCl.</p> <p>Descriptions based on Folk or Dunham Carbonate Classification systems are not needed.</p> |
| MUDSTONE | A fine grained sedimentary rock comprised of mud (silt and clay) sized particles. Mudstone can be used as a generic term incorporating the rock classes of siltstone, claystone, and shale with Ohio. Although this term was widely used on past projects, the three previous descriptions are preferred for current projects. For a detailed description see Claystone. |
| SANDSTONE | A sedimentary rock comprised of grains of angular or rounded sand in a matrix of silt and/or clay cemented together by silica, iron oxides, or calcium carbonate. Sandstones may be composed of up to 25% of particles of gravel, cobbles, and/or boulders sizes. Color depends on the cementing agent with white, gray, yellow, orange, brown, and red colors common. |

| ROCK TYPE | DESCRIPTION |
|------------------|--|
| SHALE | A fine-grained sedimentary rock formed by the lithification of clay, silt or mud (predominate particle size is less than 0.002 mm). Shale has a laminated structure, which gives it fissility along which the rock splits readily. Shale is commonly interbedded with sandstone or limestone. Carbonaceous shale often grades into coal. Typical colors may be red, brown, black, green or gray. |
| SILTSTONE | A fine-grained sedimentary rock formed from particles finer than sand, but coarser than clay. Siltstone is comprised of lithified silt and lacks lamination or fissility. Typical colors may be gray, olive, or brown. Generally, siltstone has a fine grit feeling when rubbed against teeth. |
| UNDERCLAY | A layer of clay lying immediately beneath a coal bed or carbonaceous shale. This layer may be bioturbated and indurated or lithified. It is chiefly comprised of siliceous or aluminous clay capable of withstanding high temperatures without deformation, and may have a high shrink/swell potential. |

Rock Descriptors:

The following listing of descriptors is for rock types found within Ohio. The following descriptors should be applied when the condition comprises 10% or more of the observed sample by volume. If the condition comprises less than 10% use “contains ---“. For example if the core contains more than 10% mica then the rock is “micaceous”, but if the rock is composed of 5% mica then the rock is “contains mica.” The following listing is presented in alphabetical order.

| Percentage Composition | | Description |
|-------------------------------|--------------------------|---|
| >10% | ≤ 10% | |
| Arenaceous | NA | Contains sand sized particles. Should not be used to describe sandstone, conglomerate, or breccia. |
| Argillaceous | NA | Contains clay and/or silt sized particles that result in the appearance having a slightly clayey texture. Should not be used to describe shale, claystone, or mudstone. |
| Brecciated | NA | Contains less than 25% angular to subangular gravel, cobbles and boulders. Typically used to describe sandstone, limestone or dolomite. |
| Calcareous | NA | Contains calcium carbonate indicated by reaction with HCl. Should not be used for describing limestone or dolomite. |
| Carbonaceous | NA | Contains a significant amount of carbon, but is not combustible. Should not be used to describe coal. |
| Cherty | Contains chert fragments | Contains chert fragments. |
| Conglomeritic | NA | Contains less than 25% rounded to subrounded gravel, cobbles and boulders. Typically used to describe sandstone, limestone or dolomite |
| Crystalline | NA | Contains crystalline structure visible with the unaided eye or a 10 power hand lens. Generally referred to by the crystal size based upon texture chart, i.e. fine grained. |

| Percentage Composition | | Description |
|------------------------|---------------------------|---|
| >10% | ≤ 10% | |
| Dolomitic | NA | Contains calcium/magnesium carbonate. Reacts slightly with dilute HCl on a fresh surface, and slightly to moderately on a powdered surface. Should only be used with limestone |
| Ferriferous/Ferric | Slightly ferric | Contains iron based minerals that are either visible, or results in an increase density. |
| Fissile | NA | Partings along closely spaced planes parallel or nearly parallel to bedding. |
| Fossiliferous | Contains fossils | Contains remains of plant and animals including carbonized fossils, silica, pyrite or other mineral replaced organisms and sand, silt, and/or clay filled cast or burrows of organisms in most sedimentary rocks. |
| Friable | NA | Can be easily broken down with hand pressure. |
| Lithic | Contains lithic fragments | Contains less than 25% rounded to angular rock fragments. Typically used to describe claystone. |
| Marine | NA | Reference made to limestone and dolomites which were deposited in a salt water marine environment. |
| Micaceous | Contains Mica | Rock mass contains mica fragments. |
| Non-marine | NA | Reference made to limestone and dolomites which were deposited in a fresh water environment. Commonly also referred to as "impure". |
| Petroliferous | NA | Contains free petroleum or petroleum staining, including natural asphalt. |
| Pyritic | Contains pyrite | Rock mass contains pyrite crystals or nodules |
| Siliceous | Contains silica | Rock mass contains very fine to fine silica material. |
| Stylolitic | NA | Contain stylotites (cranial suture like structure) within the rock mass. |
| Vuggy | NA | Contains solution cavities which may or may not contain mineral crystals. Typically used to describe carbonate rocks. |

APPENDIX A.4 - ODOT Rock Core Photo Examples



Figure A-1: Correct Method of Core Photo



Comment: Photo taken at a bad angle resulting in the inability to see details in the core and the entire length of the core is not visible.

Figure A-2: Incorrect Method of Core Photo – Obtuse Angle



Comment: Photo taken with shading over the core results in the inability to distinguish the entire characteristics of the core.

Figure A-3: Incorrect Method of Core Photo – Shading