STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL SPECIFICATIONS FOR ROADWAY DESIGN

June 29, 2011

APPENDIX 3. - STANDARD GUIDE FOR THE DESCRIPTION OF SURFACE AND SUBSURFACE GEOLOGICAL ROCK FORMATIONS OF OKLAHOMA

This guide provides standard methods of describing geologic rock formations as required by the Materials Division of the Oklahoma Department of Transportation (ODOT). These descriptions shall be of such quality and quantity as to provide complete and accurate rock type information useful to ODOT.

This guide is to be used to describe various sedimentary and igneous consolidated rock formations, henceforth called "units," in the State of Oklahoma. Such units are exposed at the earth's surface as well as in borings. These rock units may lie exposed naturally, undisturbed by man or be present in man-made cuts, pits, ditches, or similar features. Loose uncompacted earth materials, such as alluvium, are considered unconsolidated and are not included in this guide.

In addition, this guide applies to descriptions of rock types as recovered from drill bit cuttings, or as observed in cores. It is structured such that the description of rock characteristics most pertinent to the construction or repair of ODOT facilities is emphasized. Other more detailed terms may be used to describe obvious features of the rock units; i.e. carbonaceous, veins, mottles, or fissures, but they must be defined in the "Glossary of Geology" (1). The person or persons using this guide to describe rock types must be a geologist, geological engineer, civil engineer, or a trained, experienced, qualified individual that has been certified by the ODOT Materials Division or other approved designated authority.

Geographic locations of the geological log or outcroppings must be described from plans by Station to the nearest foot and tenth, when such information is available. A minimum of a legal description accurate to the nearest 100 ft. is required when plans or other detailed location information is not available. Global Positioning System (GPS) locations are acceptable. All locations shall be referenced to plan station and offset. Elevations of the ground surface to the nearest tenth of a foot are required for all borings. As a minimum, all boring logs shall include the following ancillary information:

1. Stratigraphic location, to nearest 0.1 foot, of any sample(s) or tests taken.
2. Name of contractor
3. Name of logger
4. Core or hole diameter, in inches
5. Boring number
6. Date drilled or logged
7. Bit type
8. Method of drilling

When cores are taken, identify the Rock Quality Designation (RQD) according ASTM D 6032. For continuous core sampling, use the Rock Mass Ratings (Geomechanics Classification) procedure identified in ASTM D 5878. The following is a list of the rock characterization elements to be used in describing the rock units. The elements describing the character of rock types are to be presented in the report in the order listed.

1. Rock Type (Lithology)
2. Color
3. Thickness
4. Gradation
5. Texture
6. Pores
7. Cementation
8. Hardness
9. Layering (or bedding)
10. Joints

Not all of the above elements will be present at a given site. The type of construction being considered, the character of the rock encountered, and the method of investigation are examples of situations that will dictate the elements used to describe the rock (unit(s) in the report.

Types and Descriptions of Rock

The term lithology pertains to the rock type being observed and described. The following rock descriptions represent the rock types or lithologies commonly found in Oklahoma. They occur as outcroppings or as recovered in cores. These example descriptions are to be included in the Geotechnical Report. The most common rock types are listed first.

1. **Shale.** Shales are fine grained sedimentary rocks consisting of compacted and hardened clay, silt or a combination of the two particle sizes. Shales normally contain at least 67% clay, with the remainder being silt with a chemical or crystalline material acting as a cementing agent. Shales are by far the most common of the sedimentary rocks. They are usually identified in the field by their laminated or fissile appearance. Shales can be any color. They are usually gray, brown, olive, or black in the eastern half of Oklahoma and shades of red often with greenish-gray spots or layers in western Oklahoma. The reddish shales of western Oklahoma commonly do not exhibit strong laminations but are more massive or blocky in appearance. They usually exhibit a smooth, sometimes waxy feel.

2. **Sandstone.** Sandstones are medium grained, consolidated, sedimentary rocks composed primarily of 85-90% quartz grains and 10-15% of a cementing agent such as

calcium carbonate which will fizz upon the application of a hydrochloric acid solution (HCL, 1 part concentrated hydrochloric acid in three parts distilled water) or more commonly, silica. The cementing medium commonly contains minor amounts of silt and/or clay. The quartz grains are sand sized and can be seen with the naked eye. Sandstones are commonly reddish in western Oklahoma. In eastern Oklahoma, sandstone is most commonly brown to yellowish but many are gray. They usually exhibit a gritty feel.

3. **Limestone.** Limestones are sedimentary rocks consisting of more than 95% of the mineral calcite (calcium carbonate). The remaining 5% is commonly dolomite. They occur in beds or layers. They may contain minor amounts of chert (silica), clay, pyrite, feldspar, and siderite. They will fizz upon the application of a hydrochloric acid solution. They may be massive or contain visible fossils. They may increase in fossil content to the point of being composed entirely of fossil shells of various types and sizes. These are common in southeastern Oklahoma. Limestones are most commonly whitish or cream in color but range through brown and red, to black. Limestones are commonly hard but may be soft and chalky.

4. **Gypsum.** Gypsum is a rock composed of the mineral gypsum, which is hydrous calcium sulfate. Gypsum occurs as massive layers or beds. It normally does not contain any particles of sand, silt, or clay. It is white in color and may occasionally contain streaks of reddish brown. Gypsum is softer than limestone and will not fizz upon the application of a hydrochloric acid solution. Gypsum is found in the western half of Oklahoma.

5. **Anhydrite.** Anhydrite is a rock similar to gypsum. It occurs in beds or layers. It is composed of calcium sulfate without the water of hydration, which is present in gypsum. Anhydrite is slightly harder than gypsum but still a soft rock. Anyhydrite generally has the same appearance as gypsum and occurs associated with gypsum in western Oklahoma.

6. **Siltstone.** Siltstones are consolidated sedimentary rocks that contain at least 70% silt sized particles with the remainder being clay size particles. They can be any color. They usually appear flaggy to thin bedded but are not as fissile as shales. Siltstones are usually soft but may occasionally be hard.

7. **Conglomerate.** Conglomerates are consolidated sedimentary rocks that contain rounded to subangular fragments larger than sand size (2mm). They appear to be a “gravelstone”. Often the particles range up to small boulder (12 inch) size. The particles are usually rounded to subrounded. The matrix is commonly silt and sand

cemented by calcium carbonate (which will fizz upon the application of a hydrochloric acid solution), iron oxide, silica, or clay. Conglomerates are usually brownish to reddish in color. They are usually found in massive beds and associated with sandstones. Conglomerates are usually hard but range from soft to hard. They are named by the composition of the "gravel" fragments. For example, if the gravel-sized material is mostly limestone, the rock is described as a limestone conglomerate.

8. **Dolomite.** Dolomite is a sedimentary rock that contains more than 50% of the mineral dolomite, which is a calcium/magnesium carbonate, CaMg(CO3). Dolomite commonly contains more than 90% dolomite with the remaining percentage being calcite. It will not fizz upon the application of a hydrochloric acid solution. However, it will fizz if powdered (e.g. with knife scratches or similar techniques). Dolomite commonly occurs with limestones or interlayered with limestones. Most Oklahoma dolomite is white, ranging to light gray or sometimes slightly pinkish. Dolomite is commonly hard, durable rock. Dolomite occurs in all areas of Oklahoma except the panhandle.

9. **Caliche.** Caliche is a rock-like soil deposit of the high plains of northwestern Oklahoma. It is calcareous and will fizz upon the application of a hydrochloric acid solution. It may contain various amounts of gravel, sand, silt, and clay locally. Caliche occurs as a 2 to 3 ft thick bed or layer at or near the soil surface. Sometimes the caliche is degraded and soft, being easily dug with a knife. Caliche is usually whitish or light gray.

10. **Granite.** Granite is an igneous rock (not bedded) that is hard, dense and crystalline. The rock is composed of crystals of quarts, feldspar, and a minor amount of dark minerals. Feldspar gives granite its color. Colors range from salmon in the Wichita Mountains of southwestern Oklahoma, light reddish purple in the Tishomingo area, to grayish in the Arbuckles. Weathered granite is usually whitish and soft.

11. **Gabbro, Anorthosite, Prophyry, and Basalt.** These rocks are igneous and similar in physical properties and mode of occurrence to granite. These are all hard dense rocks that are not bedded, except basalt, which appears as a lava flow atop Black Mesa in the extreme northwestern tip of Cimarron County in the panhandle. The other rocks occur in association with granite. Gabbros are hard, dark to black colored rocks occurring in masses or veins. Anorthosites are composed primarily of feldspar. In Oklahoma They are hard, dark grayish and also occur in masses or veins. Porphyry is a hard, coarsely crystalline rock with the same mineral content as granite or any other igneous rock.

12. **Chert.** Chert (sometimes called flint) is a very hard, dense, siliceous sedimentary rock. Chert consists of interlocking invisible microcrystalline or cryptocrystalline quartz

crystals of less than 30 µm. Chert has a splintery fracture. It commonly occurs as nodules or concretions in limestones. Chert only occasionally occurs in beds. It will not fizz upon the application of a hydrochloric acid solution. This is commonly medium to dark gray but due to impurities, may be brown, black, reddish, or whitish. Chert is more commonly found in northeastern Oklahoma.

These rock types are not always pure. For example: Sandstones may contain more than just sand grains. If it contains a calcareous matrix or cementing agent, then it should be called limy or calcareous sandstone. If limestone is composed mostly of whole or broken fossils, it should be described as a fossiliferous, etc.

Descriptions for the rock types should be based on the following:

1. **Color:** Describe the color using Munsell rock color chart notations and symbols

2. **Thickness:** Record the thickness of each rock type either in an outcropping or in a log should to the nearest 0.1 foot. The elevation in feet and nearest tenth is required on all logs or other appropriate or designated reports.

3. **Texture:** The term texture refers to the arrangement of grains, particles, or crystals on a freshly exposed rock surface, as easily seen by the naked eye. Texture indicates the appearance as megascopic or microscopic as seen on the surface of mineral aggregate. The following describes the texture of geometrical aspects of the rock grains.

    a. **Grain Size:** There are two major grain size classes:

        - Coarse grained. This texture is one in which the large crystals or grains can be seen easily by the naked eye.

        - Fine grained. This texture is one whose grains cannot be seen without magnification.

    b. **Grain Shape:** There are six grain shape classes:

        - Very angular
        - Angular
        - Subangular
        - Subrounded
        - Rounded
        - Very rounded

    c. **Grain Arrangement:** From a morphological standpoint, rock texture is grouped into three main groups.

        - Homogenous
        - Nonhomogeneous (or Hetrogeneous)
        - Layered

For example: a rock may be described as, "coarse grained, subrounded, homogeneous, etc."

4. **Cementation:** Cementation is a term used to describe the natural cementing agents surrounding the grains and binding the grains together making a rigid and compact mass. They may include the following:

   a. **Siliceous:** A granular rock with the mass cemented by silica. It is hard and cannot be scratched by a knife blade. It will not fizz upon the application of a hydrochloric acid solution. It is usually shades of gray but may be any color.

   b. **Calcareous:** A rock with calcareous or limy cement. It is not as hard as the siliceous cement. It ranges from fairly hard to soft. It will fizz upon the application of a hydrochloric acid solution. It is usually whitish but may be any color.

   c. **Ferruginous:** A rock cemented by iron. It is usually hard to very hard. It is dark red in color; sometimes it will show yellowish streaks or pockets.

   d. **Argillaceous:** A rock cemented by clay. It is usually soft and can be any color.

5. **Hardness:** The rock hardness* classes most pertinent to engineering are as follows:

   a. **Soft:** The rock can be worked with a shovel, friable, can be broken by hand in a dry to moist hand specimen, easily carved with a knife when moist. The red clay shales and mudstones of western Oklahoma are usually soft.

   b. **Moderately Hard:** The rock cannot be worked with a shovel. It can be worked with a geology hammer, or pick. It can be scratched with a penny. Examples of such rocks are the gypsums, anhydrites, and caliches of western Oklahoma. Many sandstones and siltstones are among this class, as well as some black shales in the Quachita Mountains of southeastern Oklahoma.

   c. **Hard:** The rock cannot be worked with a pick. It has a ring when struck with a hammer. It cannot be scratched with a penny but can with a knife. Most competent rocks are within this category. Most limestones, sandstones, and dolomites are examples.

   d. **Very Hard:** The rock has a distinct ring when struck with a hammer. Cannot be scratched with a knife. Examples include the siliceous limestones of eastern Oklahoma and the granites and other igneous rocks of the Witchitas and Arbuckles.

*These are hammer tests. They should be made with a 2 lb hammer on a 4 inch or so diameter specimen lying on a flat hard surface. Friable hand specimens should also be

about 4 inches. The hammer soundness test on rock outcrops should be on layers at least 1 ft thick.

6. **Layering:** Most of the rocks of Oklahoma occur as beds or layers. The exceptions are the granites and other ingenious rocks of the Wichitas and Arbuckles. Include a description of the character of the beds or layers from the list below in the Geotechnical report.

    a. **Fissile:** Splits easily along closely spaced plains of 1/16 inch or less. Many shales of eastern Oklahoma are fissile.

    b. **Very Thin Bedded:** Beds of 1/16 to 2 in. (known as stringers)

    c. **Thin Bedded:** Beds of 2 inches to 2 feet.

    d. **Thick Bedded:** Beds of 2 to 4 feet. Beds in excess of 4 feet are described as "very thick bedded".

    e. **Massive Bedded:** Beds exceeding 4 feet. Usually describes homogeneous beds that have little or no evidence of minor joints, laminations, or imperfections. Gypsums are commonly massive bedded.

7. **Joints, Faults, and fractures:** A Joint is defined as a surface of a fracture or a discontinuity in a rock mass, without displacement (faulting). If displacement of the sides of the rock, relative to one another, can be observed along the discontinuities, then the feature is by definition a fault. Sedimentary rocks will usually have two sets of parallel joints. All the features defined above are considered discontinuities within a rock mass. Note: Unusual conditions where rocks are observed exhibiting closely spaced (measured in inches or fractions thereof) joints and faults may be described as fractured or highly fractured. Their rating classes are as follows:

    a. **Very Low Jointing.** A distance of more than 6.5 ft between discontinuities.

    b. **Low Jointing.** A distance 2.0 to 6.5 feet between discontinuities.

    c. **Medium Jointing.** A distance of 8 inches to 2.0 feet between discontinuities.

    d. **High Jointing.** A distance of 2.5 to 8 inches between discontinuities.

    e. **Very High Jointing.** A distance of less than 2.5 inches between discontinuities.

8. **Pores:** The open spaces in a rock or soil. Pores are to be observed with the unaided eye. Measure, describe, and report where there are obvious features in a hand specimen or length of core. Use the following class sizes:

   a. **Very Fine.** Less than 1.0 mm.
   b. **Fine.** 1 to 2 mm
   c. **Medium.** 2 to 5 mm
   d. **Coarse.** 5 to 10 mm*
   e. **Very Coarse.** More than 10 mm*
   f. **Vugs.** 5 to 30 mm

   **If irregular shaped coarse and very coarse pores are present in limestones, dolomites, or gypsums, they may be described as having vugs or vuggy (small cavity in a rock).*

References:

a. **Jackson, J.A. "Glossary of Geology," America Geological Institute, Fourth Edition, 1997.**
b. **Geological Society of America, "Rock Color Chart, Munsell," 8th Printing, 1995.**
c. **Jumikis, A.R., "Rock Mechanics," Second Edition, Trans. Tech Publs., Federal Republic of Germany, 1983.**
d. **Compton, R.R. "Geology in the Field," John Wiley and Sons, 1985.**
e. **American Association of State Highway and Transportation Officials, "Particle Size Analysis of Soils," T-88, 1999.**
f. **"Standard Field Descriptions of Sedimentary Rocks," Research Section, Materials Division " 1961**
g. **Schoeneberger, P.J. et al., "Field Book for Describing and Sampling Soils," Version 1.1, USDA, NRCS, Lincoln NE, 1998.**

Other Relevant Publications:

"Engineering Classification of Geologic Materials," Vols. 1-8 Research and Development Div., ODOT, Curtis Hayes, Principal Investigator, 1965 to 1972.

EXAMPLES

The features listed in the above Guide are to be noted in the report or log as observed in cuttings, cores, and outcroppings. The most current versions of Rock Quality Designations (ASTM D6032), Rock Mass Ratings (ASTM D5868), and Diamond Core Drilling for Site Investigation (ASTM D2113) are to be used. When coring, NX Core sizes are preferred; a minimum of NQ is required.

The following is an example of core log from a bridge boring:

Surface Elevation _____ ft Station _____ + _____, feet left or right

0.0 – 3.3	Fine sand (2.5 Y8/6), alluvium, not covered
3.3 – 13.5	Shale – Red (10R5/8), sandy, mottled with yellow (5Y8/6), soft, fissile
13.5 – 15.5	Siltstone – Gray (10YR3/1), mod. Hard, thin bedded.
15.5 – 23.0	Sandston – Red (10R6/6), mottled with yellow (5Y7/8), mostly fine ranging to coarse grains, becoming coarser with depth, med graded, mod. hard, massive, calcareous, many fine pores.
23.0 – 23.7	Limestone Conglomerate – Reddish – brown (5YR5/4), limestones are light gray (10YR7/1), mod. hard, particle sizes range from clayey matrix up to about 4 in gravel, well graded, calcareous cement, few coarse pores, thin bedded.
23.7 – 30.1	Limestone – Gray (10YR7/1), hard, thick bedded, contains two thin zones (1/2 in) of broken fossil shells at 28.6 and 29.1
30.1 – 33.6	Dolomite – Pinkish gray (5YR6/2), sandy, hard, thin bedded, occasional, large pores, vuggy
33.6 – 39.3	Interbedded dolomite and shale – Dolomite; pinkish gray (5YR6/2), shale; very dark gray (5YR3/1), dolomite is thin bedded, hard; shales range from thin to thick bedded, minor small pyrite, mod. hard, becomes predominantly shale @ 37.0
39.3	TD, shale – very dark gray, (5YR3/1), as described above.

Logged by:	Bit Type, Size, Design:	Date of Start, Finish:
Contractor:	Ground Water Level, Dates:	Other ASTM 2113 Boring Items as Appropriate
Hole Diameter (core):	Project Identification:	

The following is an example of a description of an outcropping along a proposed roadway alignment:

Station 139 + 50, from centerline 12 ft right.

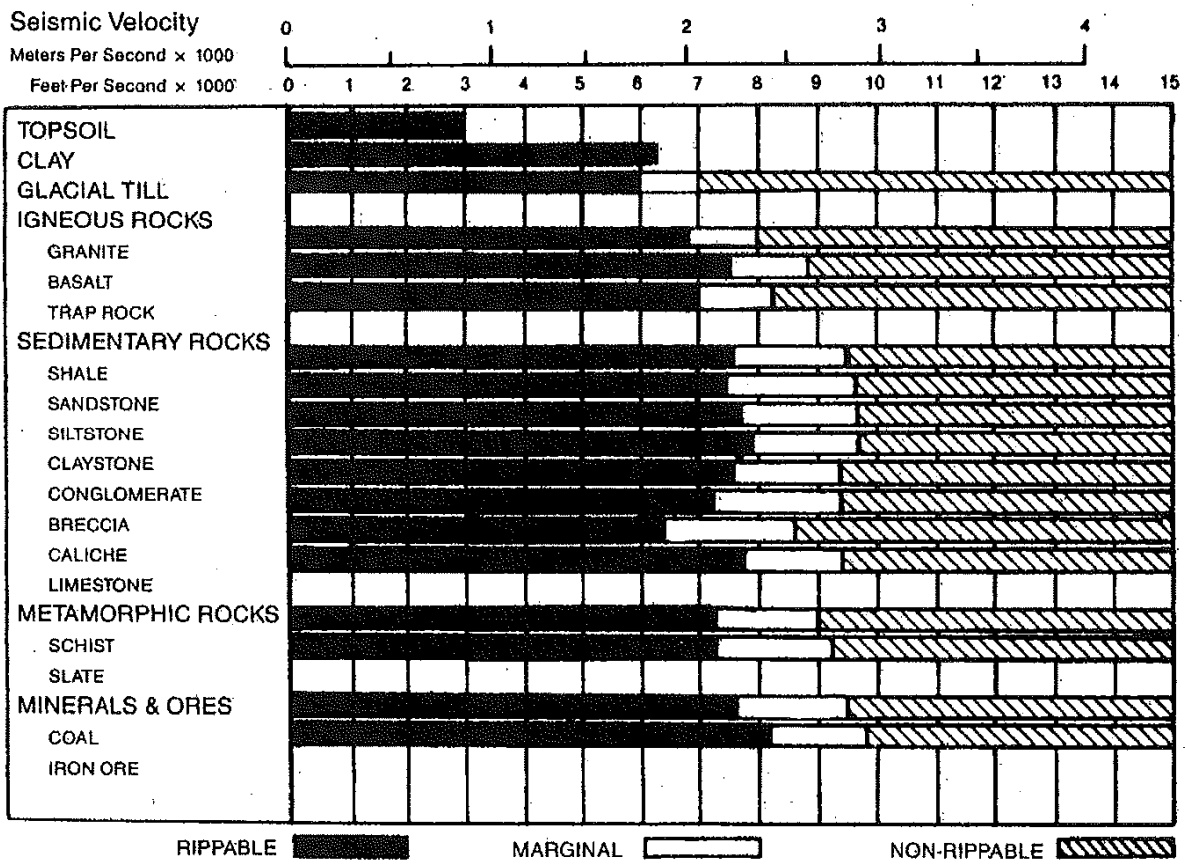
Layer	**Thickness (ft.)**	**Description**
1	0 – 10.3	Sandstone, brown (10YR5/3), fine, poorly graded, moderately hard, mostly thin bedded, high jointing; one thick bed at 5.3 to 7.8 ft. Sandstone contains thin stingers of brown sandy shale near the base and grades to
2	10.3 - 15.5	Interbedded sandstone and sandy shale, brown (10YR5/3), mostly soft ranging to mod. hard, very thin bedded ranging to thin bedded, high jointing, becoming more shale-like at the base.
3	15.5-26.6	Shale, very dark grayish brown (10YR3/2), soft fissile, contains veins of reddish yellow (7.5YR6/8) going at all angles.
4	26.6	Elev. Of roadway grade

Seismic Velocity Charts for Estimating the Rippability of Various Soil and Rock Formations

Rippers

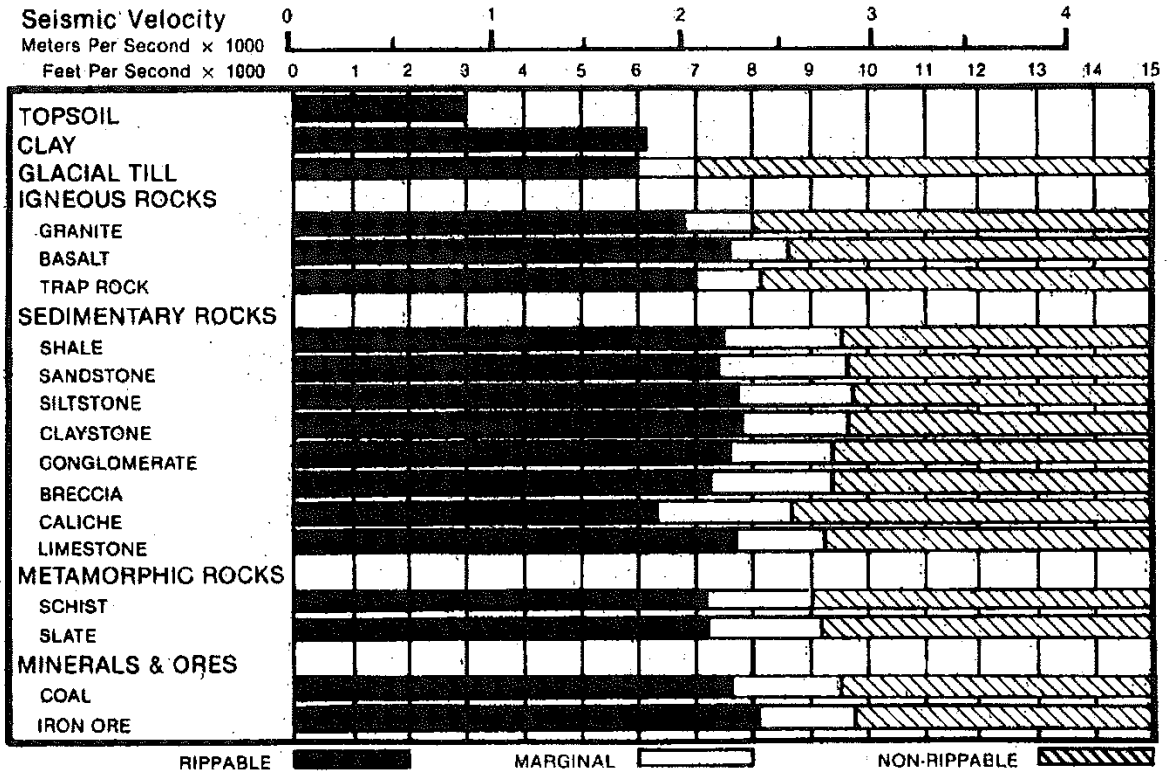
D8L Ripper Performance

- Multi or Single Shank No. 8 Ripper
- Estimated by Seismic Wave Velocities



D9N Ripper Performance

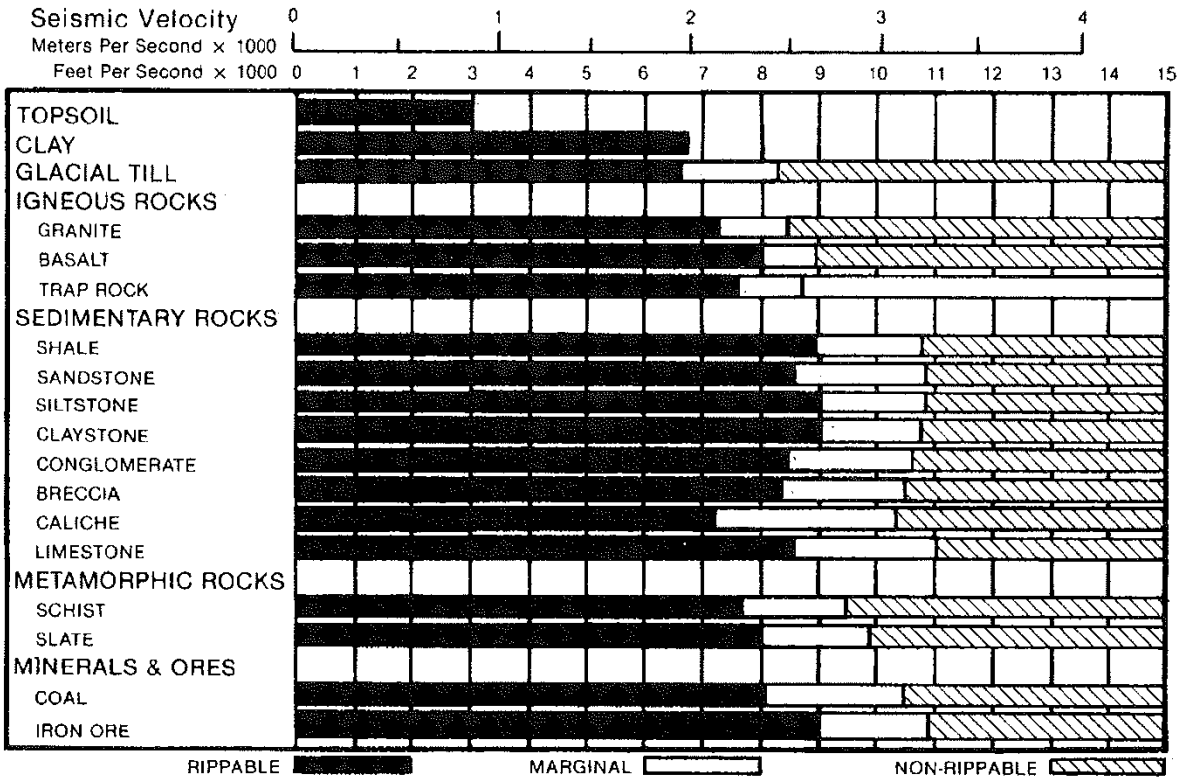
- Multi or Single Shank No. 9 Ripper
- Estimated by Seismic Wave Velocities



Rippers

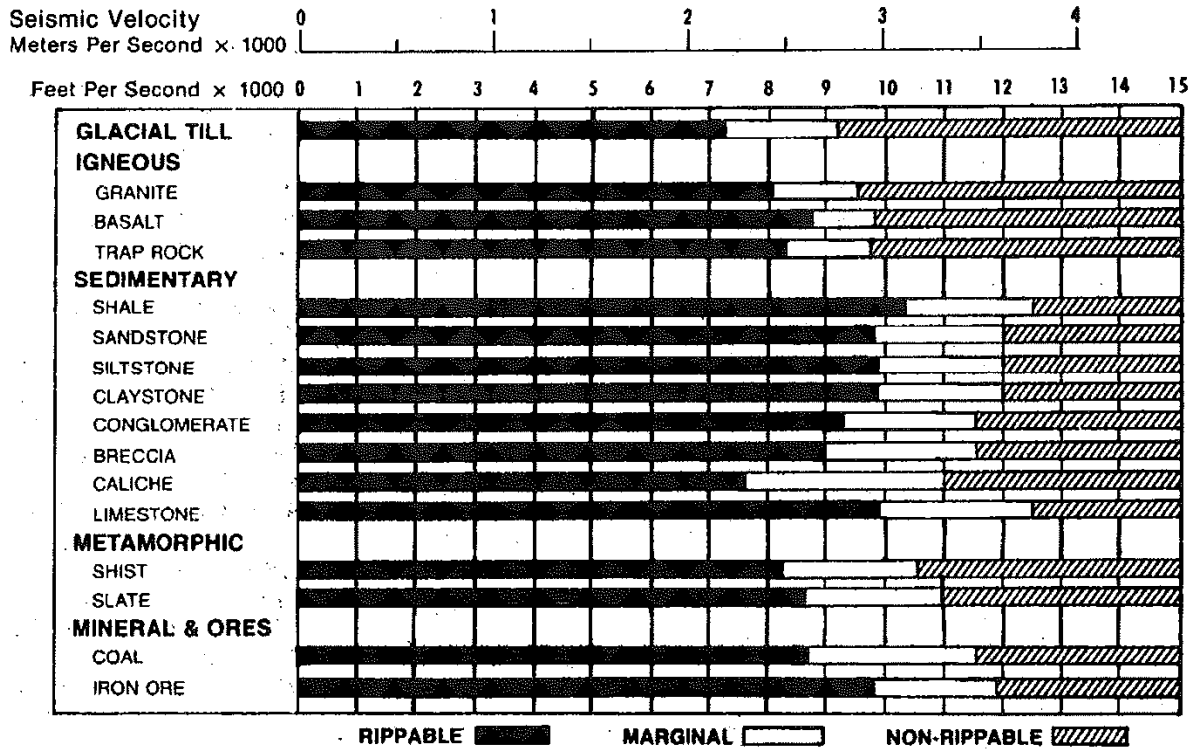
D10N Ripper Performance

- Multi or Single Shank No. 10 Ripper
- Estimated by Seismic Wave Velocities



D10N Impact Ripper Performance

- Single Shank Impact Ripper
- Estimated by Seismic Wave Velocities



Rippers

D11N Ripper Performance

- Multi or Single Shank No. 11 Ripper
- Estimated by Seismic Wave Velocities