



State of Florida Well Completion Report Drill Cutting Description Reference Field Guide SJ2009-FS2



This sheet is a reference for describing drill cuttings on the Well Completion Report (WCR) form, to be submitted pursuant to requirements of Chapter 62-532.900, *Florida Administrative Code*. This guide was produced by the St. Johns River Water Management District (SJRWMD) but can also be used as a reference by other Florida water management districts. An electronic version of the WCR can be found at www.sjrwmd.com. The terms used in the

pick lists of the electronic WCR are in **BOLD** below. The WCR contains four categories that relate to the description of cuttings obtained from drilling: color, material, grain size, and other features. This guide: defines the terms to use when completing a WCR; contains a color reference chart; provides a chart for identifying grain size of sands; includes representative photos of selected materials; and provides supplemental information related to Florida hydrogeology.

MATERIALS

Primary **MATERIALS** include **TOPSOIL, SAND, CLAY, LIMESTONE, DOLOSTONE, COQUINA, PHOSPHATE, CHERT, ORGANICS/PEAT/MUCK**, and **GYPSUM**. Secondary **MATERIAL** choices can be used when additional components can be identified and should be included in the **OTHER FEATURES** section of the WCR. Representative photos of the primary **MATERIALS** are provided.

- **TOPSOIL** — Composed of sediments from land surface to the base of plant root zone. Typically organic rich, brown or black sand and/or clay with plant fragments.
- **SAND** — Sample is predominately non-cemented grains with a size range from 125 µm to 2 mm (see grain size chart). Quartz grains are most common. If grains are cemented together, it may be **SANDSTONE** or, if near land surface, **HARDPAN**. If sufficient clay is present, the sample may be shaped with fingers and is called **SAND WITH CLAY**. If other components are present, the sample can be called **SAND WITH LIMESTONE; SAND WITH PHOSPHATE, SAND WITH SHELL, SAND-LIMESTONE-AND-CLAY**, or **SAND-PHOSPHATE-AND-CLAY**.
- **LIMESTONE** — Sediment composed predominately of the mineral calcite (calcium carbonate CaCO_3). Typically originates from biological activity, but other secondary processes can form limestone, such as when naturally occurring calcite “cements” grains together. Under certain conditions, limestone may recrystallize and fill in pore spaces or destroy the original texture. It may also occur as a lime mud that has been hardened with few details observable without magnification. Fossils are often very abundant and can help identify the source geologic unit. When other components can be identified, the sample can be called **LIMESTONE WITH CHERT, LIMESTONE WITH CLAY, LIMESTONE WITH FOSSILS**, or **LIMESTONE WITH PHOSPHATE**. Since caves or cavities are common in limestone strata, the WCR has an option for **LIMESTONE WITH VOIDS**.
- **DOLOSTONE** — Sediment composed predominately of the mineral dolomite (calcium-magnesium carbonate $\text{CaMg}(\text{CO}_3)_2$). Typically forms as a secondary process from the alteration of limestone. Drill cuttings may contain both limestone and dolostone pieces, or the limestone may be partially dolomitized forming **DOLOMITIC LIMESTONE**.
- **CLAY** — Predominately composed of sediments in the clay, size range (< 4 microns); may contain abundant clay minerals, but grain size is the determining factor for labeling a sample as **CLAY**. When other components are present, the sample can be called **CLAY WITH PHOSPHATE** or **CLAY WITH SHELL**.
- **CHERT/FLINT** — Microcrystalline silica (SiO_2 or quartz), often referred to as flint. Occurs as nodules, infilling in fractures, and irregular masses within limestone and dolostone. It is very hard and breaks into sharp edges, or conchoidal fractures.
- **PHOSPHATE** — In SJRWMD, phosphate occurs more as a secondary rather than a primary constituent of a sample. Most commonly seen as dark brown or black coarse sand to pebble-sized rounded grains.
- **GYPSUM** — Sample composed of the hydrated calcium sulfate; may occur as nodules, irregular masses, lenses, or beds within carbonates. Occurs more frequently in deeper carbonate zones.
- **COQUINA or SHELL** — Sample composed predominately of shell. Shell is generally bound together with calcite cement. Typically occurs in the upper 100 feet in eastern SJRWMD. Loose shell beds may produce cuttings that resemble coquina; however, shell beds typically have other material such as sand or clay mixed with them.
- **ORGANICS/PEAT/MUCK** — Mostly, remains of organic material but may contain some sand or clay. Typically, dark black or brown and often containing plant fragments. Lenses or thin beds may occur within carbonate units even at great depths.
- **CAVITY/VOIDS** — Used to denote intervals where drill rods dropped abruptly, such as when drilling into a cave.

COLORS

Place a wet sample next to color swatches, to determine which color most closely matches the dominant color of the sample.



Black



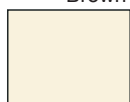
Blue



Bluish green



Brown



Cream



Gray



Green



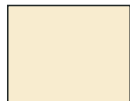
Olive



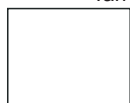
Orange



Red



Tan



White



Yellow

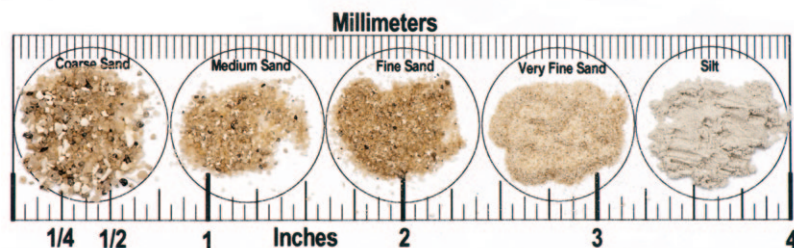
TIPS

- Use a 10x magnifying lens to identify individual components of a sample.
- Use a kitchen strainer to allow the fine material to wash out of a sample so that the remaining material can be better observed. If most of the sample is gone, it may be an indication the MATERIAL is CLAY or material with grain size smaller than FINE SAND.
- Use dilute (10% or less) laboratory hydrochloric acid (HCl) or use dilute muriatic acid from a hardware or swimming pool store to help differentiate limestone from dolostone. Limestone will react (fizz) more vigorously than dolostone. Be aware that calcite cement will also fizz, so a calcite-cemented sandstone may fizz like a limestone. Caution: Follow all safety precautions on acid label.
- When deciding the primary MATERIAL in a sample, identify the predominate (> 50%) material in the sample. Use the OTHER FEATURES category for additional features or less abundant materials.
- When deciding the COLOR of a sample, identify the dominant color of the whole sample when wet. Samples will not match the color swatches exactly, so make the closest color choice. For example, the silt size material in the grain size scale below would be called TAN, whereas the fine sand would be called ORANGE.
- Clay-rich material can be shaped into a ribbon by squeezing the material between your thumb and fingers. Clay can also be rolled or otherwise shaped.
- Dolostone is often darker and appears more dense and finer than limestone. Edges may be sharp when broken.
- Cementation refers to a naturally occurring process of binding grains together by deposition or recrystallization of minerals, such as calcite, dolomite, iron compounds, or quartz, resulting in a more consolidated and harder material. Calcite or quartz cement may look like clear or milky "glue" between grains. Iron cements may impart a reddish or brown color to the material. Calcite cement "fizzes" when dilute acid is applied.

GRAIN SIZE

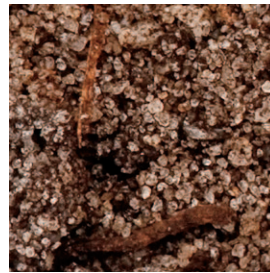
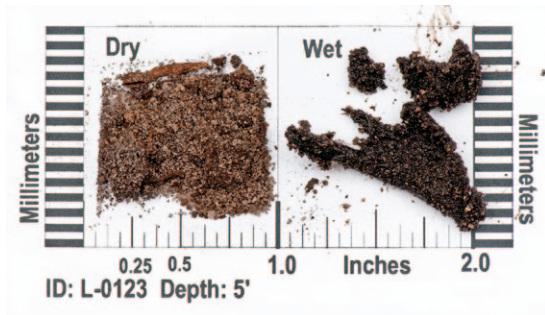
Use this chart to estimate the relative size of grains that make up SAND in a sample. Clay particles are too small to see even with a hand lens. Grain size names conform to the 1922 Udden-Wentworth size chart. Scale at bottom of the page is actual size unless this sheet has been distorted during printing.

φ scale	Size range (metric)	Size range (approx. inches)	Aggregate name (Wentworth Class)
< -8	> 256 mm	> 10.1 in.	Boulder
-6 to -8	64–256 mm	2.5–10.1 in.	Cobble
-5 to -6	32–64 mm	1.26–2.5 in.	Very coarse gravel
-4 to -5	16–32 mm	0.63–1.26 in.	Coarse gravel
-3 to -4	8–16 mm	0.31–0.63 in.	Medium gravel
-2 to -3	4–8 mm	0.157–0.31 in.	Fine gravel
-1 to -2	2–4 mm	0.079–0.157 in.	Very fine gravel
0 to -1	1–2 mm	0.039–0.079 in.	Very coarse sand
1 to 0	0.5–1 mm	0.020–0.039 in.	Coarse sand
2 to 1	0.25–0.5 mm	0.010–0.020 in.	Medium sand
3 to 2	125–250 μm	0.0049–0.010 in.	Fine sand
4 to 3	62.5–125 μm	0.0025–0.0049 in.	Very fine sand
8 to 4	3.90625–62.5 μm	0.00015–0.0025 in.	Silt
> 8	< 3.90625 μm	< 0.00015 in.	Clay

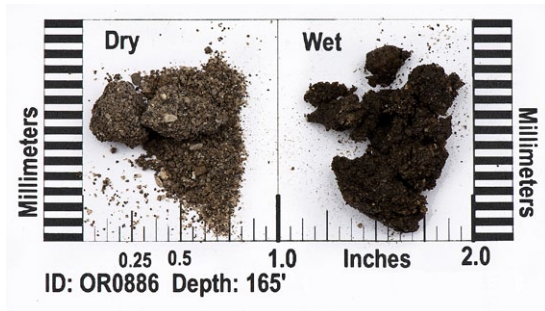


EXAMPLES OF PRIMARY MATERIALS CATEGORIES

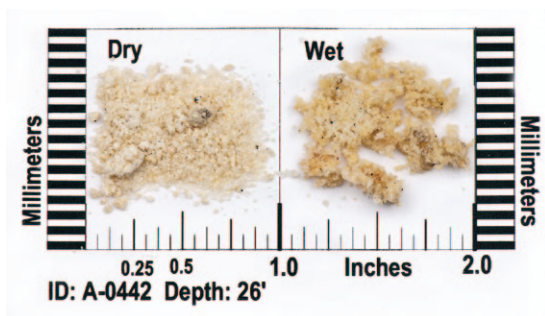
Terms used on the WCR are in **BOLD**. Enlarged views are shown with a variety of scales.



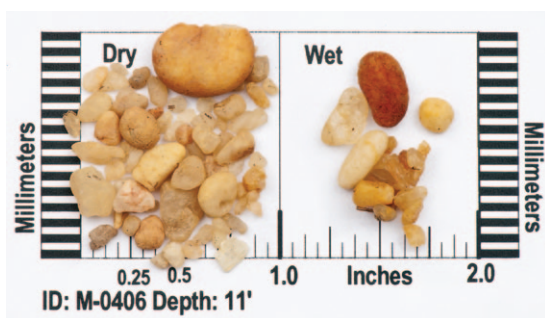
TOPSOIL — BLACK, BROWN, GRAY. Typically sand, organics, clay, or plant fragments located within the root zone near land surface. **HARDPAN** may form when sediment is cemented (calcite or iron cement).



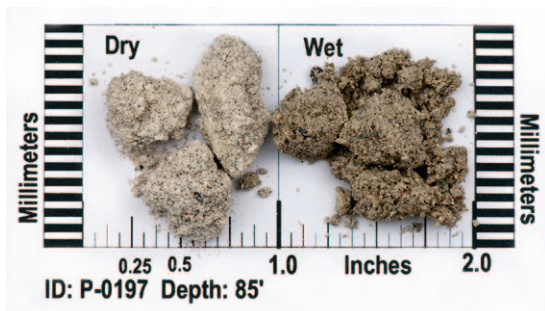
ORGANICS/PEAT/MUCK — Composed of decayed plant or other organic matter. Generally BLACK or BROWN. May occur as beds up to tens of feet thick or as thin lenses within limestone or dolostone. Often includes sand, silt or clay grains and may have visible plant fragments. Generally will break apart easily.



SAND — Can be most any color. Grains generally composed of quartz or calcite. If grains are cemented together, it may be **SANDSTONE**. Often found with **CLAY**, **LIMESTONE**, or **PHOSPHATE**. Use the grain size chart on page 2 to estimate size.



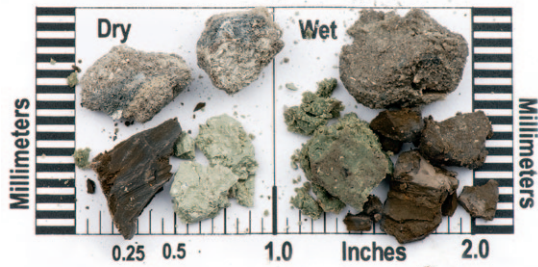
QUARTZ PEBBLES — Generally WHITE, clear or milky, but iron staining can give an orange hue. Often seen in Putnam and Clay counties above the Hawthorn Group, but may be seen elsewhere.



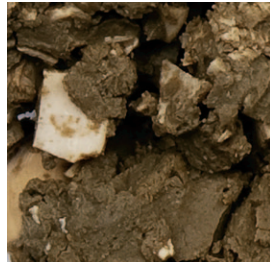
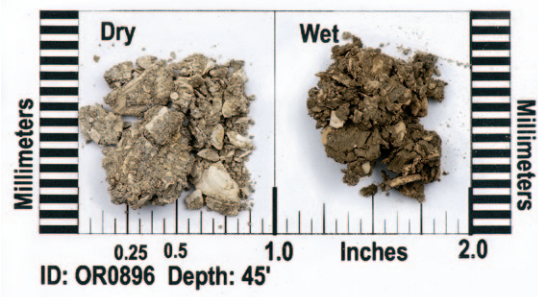
SAND WITH CLAY — Sand-sized grains held together with clay. Sample easily crumbles or can be shaped if sufficient clay-sized material. Grains are limestone, phosphate, shell pieces, and quartz in this sample.

EXAMPLES OF PRIMARY MATERIALS CATEGORIES

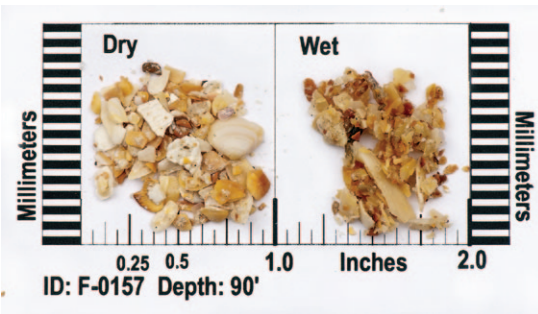
Terms used on the WCR are in **BOLD**. Enlarged views are shown with a variety of scales.



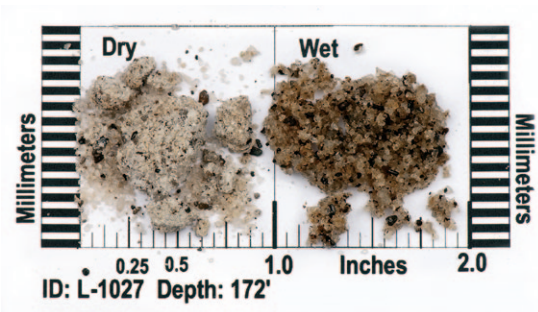
CLAY — Can be most any color. GREEN, OLIVE, GRAY, BLUISH-GREEN, and BLUE are most common in the Hawthorn Group. WHITE, RED, ORANGE, and BROWN are more common in other units. Clay can be squeezed into a ribbon or rolled into shapes (shown in the photo on right). Dried samples may become quite hard and difficult to break apart. Individual grains cannot be seen even when magnified and cannot be felt when rubbed between fingers. Often mixed with sand, shell, or phosphate.



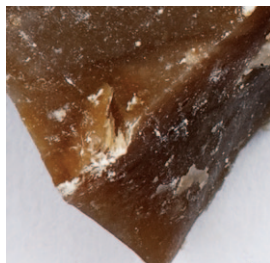
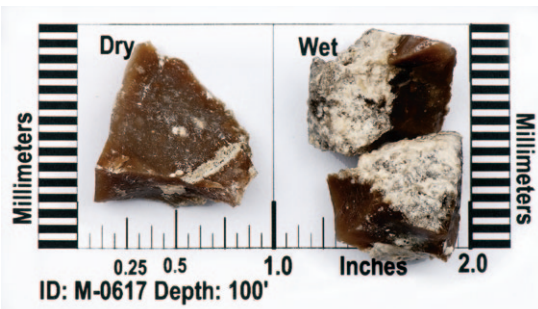
CLAY WITH SHELL — Same colors as above, but may appear lighter because of shells. Clay-sized sediment is dominant constituent.



COQUINA or SHELL — Coquina is composed primarily of shell hash that has been cemented together. Somewhat harder drilling than an unconsolidated shell bed and has very little clay or silt content. Though most often found along the eastern coast of SJRWMD within the upper 100 feet; occurrence at depth within limestone units is also possible. Shell beds look similar in drill cuttings, but may have more clay and sand.



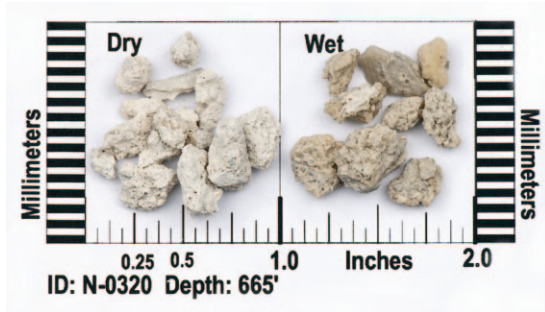
SALT AND PEPPER — BLACK AND WHITE. Generally, a sand with quartz and PHOSPHATE (black or brown grains in photo) or heavy minerals (titanium-based), such as those mined from the Trail Ridge in Clay County.



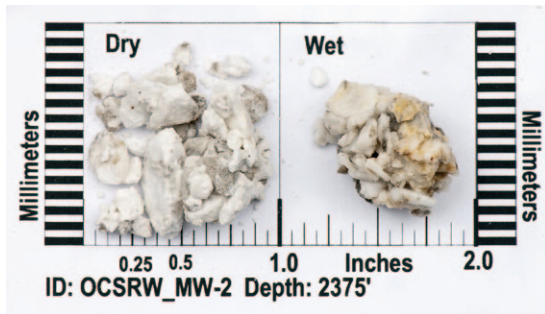
CHERT — Can be most any color. Rock is very hard and breaks with sharp edges or conchoidal fracture. Occurs as nodules, lenses, beds, or within fractures or voids. Often called flint.

EXAMPLES OF PRIMARY MATERIALS CATEGORIES

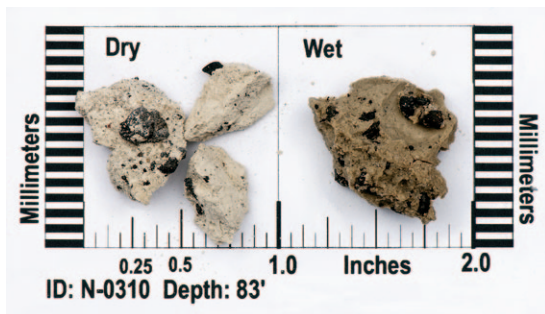
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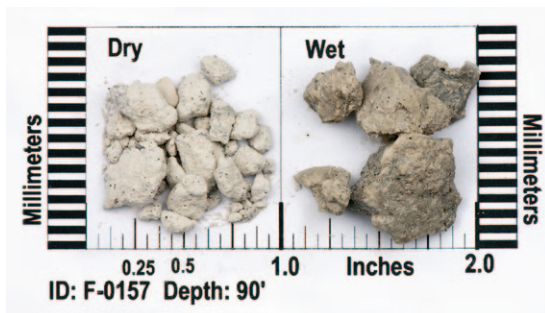
LIMESTONE — Colors tend to be CREAM, TAN, BROWN, WHITE, YELLOW, ORANGE. Fizzes vigorously when dilute acid is poured on the sample. May contain many fossils or other materials. Individual grains may be too fine to see or consist of large pieces of shell or rock. May be soft enough to crumble with fingers or require a hammer to break. Can be encountered from land surface to thousands of feet depth.



LIMESTONE — Component grains form a framework held together by calcite cement, which appears as clear to milky white between the grains. This sample is mostly limestone grains (white), but brown dolostone can also be seen. Grain size is variable as is overall color.

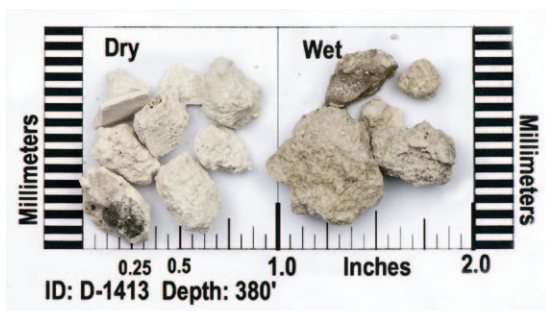


LIMESTONE WITH PHOSPHATE — Black phosphate pebbles can easily be seen against the white background of the limestone matrix. Phosphate grains vary in size and are generally rounded. Phosphate occurs similarly in clay, sand, and shell units of the Hawthorn Group units.



LIMESTONE — This sample has calcite cement (clear and milky) with sand grains and fossils casts. In the enlarged view, an impression of a shell can be seen (lower left), but the original shell material is missing. Brown dolostone grains are present.

shell imprint

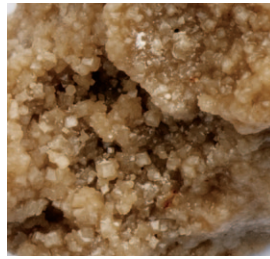
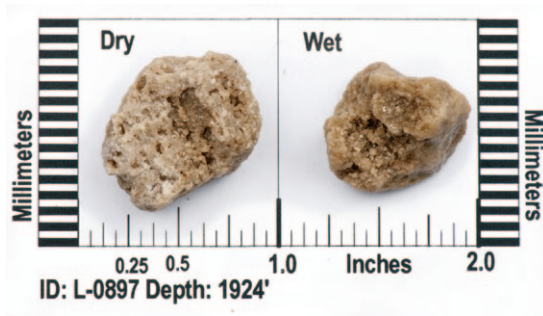


LIMESTONE WITH FOSSILS — Similar to the above in that grains comprise the majority of the rock and the inter-granular space is filled with hardened lime mud. Enlargement shows that a portion is fossil coral with mud infilling.

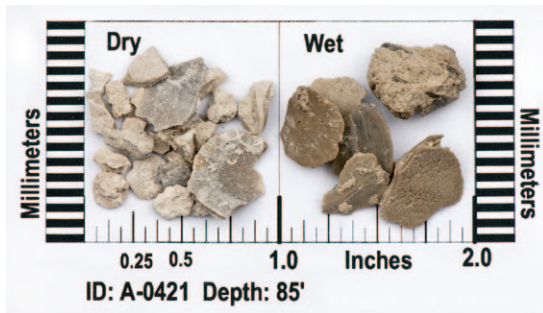
coral

EXAMPLES OF PRIMARY MATERIALS CATEGORIES

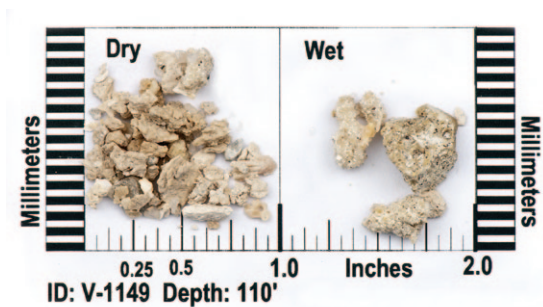
Terms used on the WCR are in **BOLD**. Enlarged views are shown with a variety of scales.



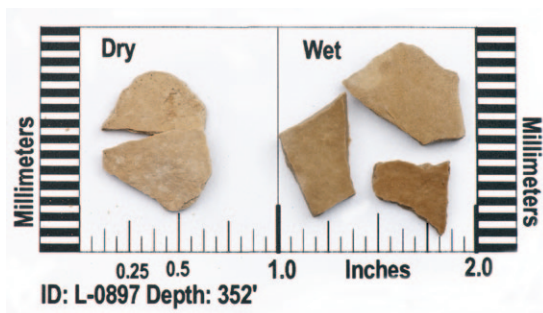
DOLOSTONE — Recrystallized dolostone. In this sample, rhombohedral-shaped dolomite crystals can be seen in the enlargement. Acid reaction may be barely perceptible when applied. A hammer was needed to break the sample.



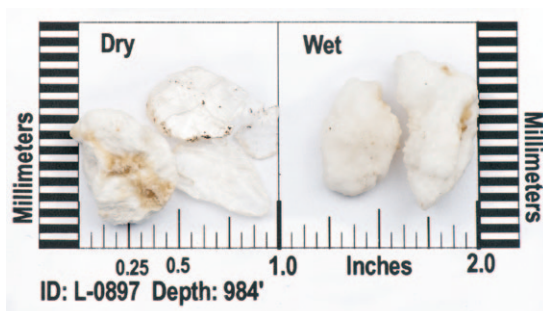
DOLOSTONE — Colors tend to be CREAM, TAN, BROWN, WHITE. It may be harder to identify grains or fossils in the rock, as they are often too small to see or destroyed during the process of dolomitization. It will not “fizz” as vigorously as limestone when dilute acid is applied.



DOLOSTONE — Similar to above, except grains are supporting the rock. This sample has limestone, dolostone, and chert grains with some fossil pieces. The limestone grains will fizz more vigorously than the dolostone or chert.

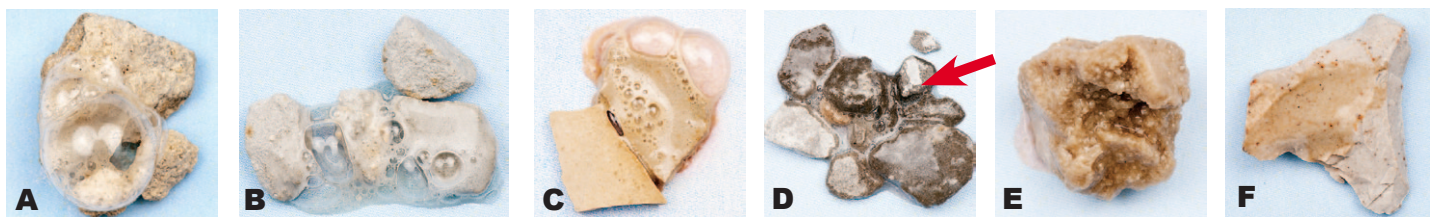


DOLOSTONE — This BROWN dolostone is composed of silt-sized particles bound together with a limestone cement. Acid will react slowly until the cement is dissolved, leaving the dolomite grains.



GYPSUM — Generally WHITE but may have bluish tint or brown staining. Soft – can scratch with fingernails. Occurs as nodules, beds, or infilling in voids or fractures. Flat faces of crystals may be seen. Anhydrite looks similar to gypsum but cannot be scratched with a fingernail. Neither will dissolve in acid.

ACID TEST TO IDENTIFY LIMESTONE



These photos illustrate how to determine if a sample is composed of calcium carbonate (LIMESTONE). The length of reaction time and how vigorous a reaction occurs are an indication of the relative amount of calcium carbonate present. A 10% solution of hydrochloric acid (HCl) was poured on each dry sample. Muriatic acid that is purchased from a hardware store is the same acid but at a higher concentration (31.45% HCl). Sample A is pure limestone and reacts (fizzes) immediately and vigorously, forming large bubbles. Sample B also reacts but not as vigorously. Sample C is

composed of silt-sized dolomite with a calcium carbonate cement. It took a much longer time to begin reacting than A or B. Sample D is dolostone with traces of limestone. There is a mild reaction from the limestone. Traces of gypsum (see arrow) do not react at all. Sample E has crystals of dolomite and reaction is almost imperceptible. Sample F is a fine-grained dolostone and reaction with acid is very slow and almost imperceptible. Though not pictured, quartz, clay, and gypsum would have no reaction, like sample F.

COMMON FOSSILS TO AID IN FORMATION IDENTIFICATION (upper Floridan aquifer system)

Ocala Limestone (upper part of the Floridan aquifer system)



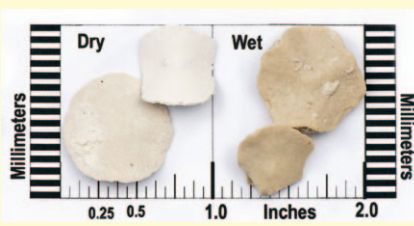
Numulites willcoxi
Heilprin, 1882
(foraminifera)

Photo by Jonathan R. Bryan (FGS)



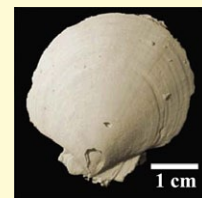
Lepidocyclina ocalana
Cushman, 1920 (foraminifera)

Photo by Jonathan R. Bryan (FGS)



Lepidocyclina sp.
(foraminifera)

Photo by Mathew O'Malley (SJRWMD)



Amusium ocalanum
Dall, 1898 (scallop)

Photo by Jonathan R. Bryan (FGS)



Asterocyclina sp.
(foraminifera)

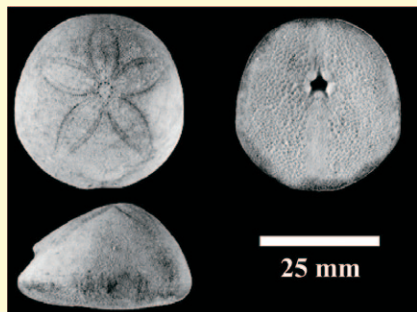
Photo by Jonathan R. Bryan (FGS)



Chlamys spillmani
(scallop)
Gabb, 1860

Photo by Jonathan R. Bryan (FGS)

Suwannee Limestone (uppermost part of the Floridan aquifer system)



Ryncholampas gouldii
Boué, 1846 (echinoderm – sea urchin)

Photo by Sean Roberts

Avon Park Formation (middle part of the Floridan aquifer system)



Dictyoconus americanus
Cushman, 1919 (foraminifera)

Photo by Jonathan R. Bryan (FGS)



Neolagnum dalli
Twitchell, 1915 (echinoid)

Photo by Roger W. Portell (FMNH)
Index fossil for the Avon Park Fm.

HYDROGEOLOGIC FRAMEWORK

The hydrogeologic framework shows the relationship between the lithostratigraphic units (defined by the rock or sediment composition) and the hydrostratigraphic units (defined by the water production capability).

Hydrostratigraphic Units*

Characterized by production or lack of production of water over a laterally extensive area. Zones that can produce a sufficient quantity of groundwater are termed aquifers, and zones that restrict the flow of groundwater are termed confining units.

SURFICIAL AQUIFER SYSTEM (SAS) —

Extends from land surface to the top of laterally extensive and vertically persistent, low permeable beds. Beds of low permeability may occur locally within the unit.

INTERMEDIATE AQUIFER SYSTEM OR INTERMEDIATE CONFINING UNITS (IAS/ICU)

— Includes all sediments that lie between and collectively retard the exchange of water between the overlying SAS and the underlying Floridan aquifer system. Locally, certain intervals may be used as production zones.

FLORIDAN AQUIFER SYSTEM (FAS) — The sequence of predominantly limestone and dolostone that functions regionally as a water-yielding hydraulic unit. It may occur at land surface (unconfined) or be buried by more than 600 feet of sediments. In many areas the aquifer is under confined conditions and water will rise above the aquifer in tightly cased wells or flow at land surface as springs. Includes multiple aquifers and confining units. Aquifers are very productive and numerous caves and dissolution features greatly enhance production locally. Drillers may lose circulation when this unit is encountered. Confining units within the FAS may isolate different zones of water quality.

Lithostratigraphic Units

Defined solely on the basis of lithology (rock or sediment type). They are geologically similar material such as limestone or sands. They can be identified and mapped over a large regional area.

Undifferentiated sand, shell, clay — Below topsoil. Sands, shells, clay lenses. Generally unconsolidated. Locally, layers may act as confining unit. Ranges from a few feet thick to several hundred feet thick.

Hawthorn Group — Highly variable composition. Includes multiple formations. Fine-grained sediments (sands, clay, or carbonates), often green, gray, bluish green, or olive. Shell beds, medium to coarse sands, and carbonates may be producing. Shark teeth and phosphate common. May contain beds of hard chert at the base. Ranges from a few feet thick to more than 600 feet thick.

Suwannee Limestone — Tan or orange limestone. Present only in southern and northwestern SJRWMD. May be difficult to distinguish from Ocala Limestone (below).

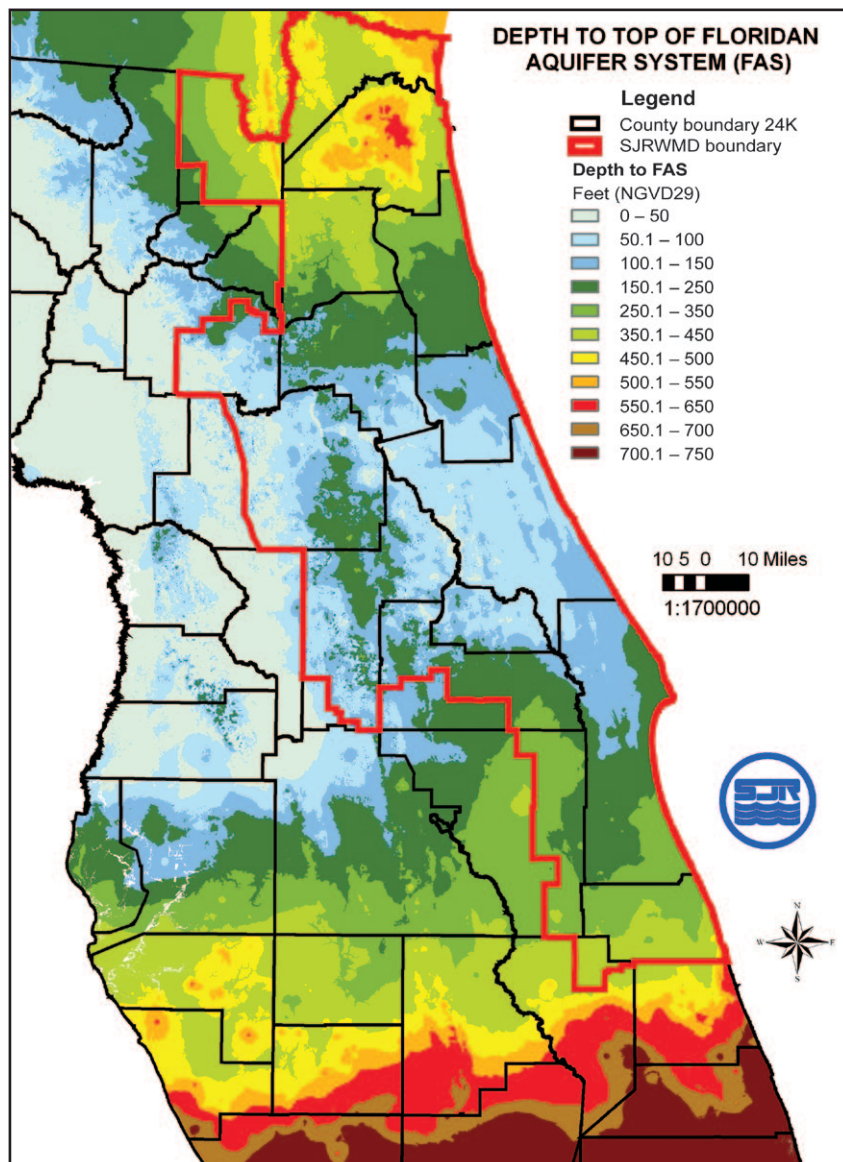
Ocala Limestone — Limestone generally white, cream, tan, or orange. Ranges from soft (can crumble with fingers) to very hard where the limestone contains dolomite, chert, or is highly recrystallized. May contain numerous characteristic fossils, chert, or sand.

Avon Park Formation — Tan, brown, hard dolostone with interbeds of white or cream limestone. Organics such as peat or lignite may be present.

Oldsmar Formation — Upper section is dolomitic, recrystallized microcrystalline limestone. May contain chert, peat, phosphate, clay, or quartz masses. Lower zone is very hard, dark brown, or gray dolostone.

Cedar Keys Formation — Dolostone, gypsum, and anhydrite.

* Note that hydrostratigraphic units may overlap lithostratigraphic units.



POROSITY



Example of low porosity (left), medium porosity (middle), and high porosity (right). Porosity, which is a measure of the void space in a sample, is more difficult to identify in individual drill cuttings than in cores or rock samples. If most of the cuttings show similar porosity characteristics such as pits, irregular surface, pinpoint holes, poor induration (hardness), or a very smooth or dense appearance, then a qualitative estimate of porosity can be determined. Permeability, or the ability of a sample to transmit fluids, is dependent on the interconnection of the void spaces of the rock matrix and other secondary features, such as connected fractures or cavities. The rate at which water is absorbed when poured on a dried sample may give some indication of permeability however clay content may increase absorption but not indicate higher permeability. Although there may be more void space (porosity) in the sample on the right, the middle sample has more connection (permeability) between voids and absorbs more water. All water poured on the sample at left flows over the surface and falls off. While a qualitative indication of porosity of drill cuttings may be useful, estimating permeability from drill cuttings should generally be avoided.

Well Completion Reports may be downloaded from each water management district's Web site (links are on the back of the WCR form). Some districts are now able to accept electronic submittals of completed WCR forms.

This publication may be downloaded from SJRWMD's Web site at floridaswater.com/permitting or floridaswater.com/technicalreports.



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