Carbonate Sedimentary Rock Identification

Carbonate rocks make up 10 – 15% of sedimentary rocks and are the most abundant type of chemical/biochemical sedimentary rock. They can be divided, based on mineral composition, into limestones and dolestones (dolomites).

1. **Limestones** are composed mostly of calcite ($CaCO_3$) or high Mg calcite [$(Ca,Mg)CO_3$]
2. **Dolostones** are composed mostly of dolomite [$CaMg(CO_3)_2$]

Because carbonate minerals in general are soluble in slightly acidic waters, they often have high porosity and permeability. Limestone in hand specimen or outcrop will fizz with a drop of HCl (forming CO_2) because of its high solubility. Dolestone will not fizz unless powdered and tends to weather to a brownish color. Limestones tend to weather to white or gray.

Limestone textures

Allochems are defined as composite grains in carbonate rocks. In other words, these are grains that occur as aggregates (or clusters) of carbonate minerals.

- **Skeletal particles** may range in size from gravel to fine sand, depending on the organism and the degree to which the grains are broken by waves or during transport.

- **Ooids** are spherical sand sized particles that have a concentric or radial internal structure. The central part of each particle consists of a grain of quartz or other carbonate particle surrounded by thin concentric layers of chemically precipitated calcite. The layers or coatings are formed in agitated waters as the grain rolls around. (< 2 mm), **Pisoids** (2 – 10 mm) – sometimes irregular in shape

- **Pellets** are spherical aggregates of microcrystalline calcite of coarse silt to fine sand size. Most appear to be fecal pellets (poop) from burrowing benthic organisms. The peloids are much easier seen in thin section than in hand specimen because of their small size. (0.01mm – 0.1 mm)

- **Oncoids** biogenic concentric, irregular laminae that surround a nucleus of some sort, which are generally 2-10mm

- **Intraclasts** are fragments of earlier formed limestone or partially lithified carbonate sediment, originating within the basin of deposition. Clusters of grains are bonded together by welding, cement or lime mud. (fine sand – granule) **Aggregate grains**

Matrix/cement

- **Micrite (or limey mud)** is microcrystalline calcite**,** a carbonate mud composed of very fine grained calcite crystals, texturally similar to siliciclastic shale. In modern environments this mud consists of needle-shaped aragonite crystals. (1.0 – 4.0 μ)

- **Sparry calcite** consists of larger crystals of calcite. Sparry calcite is distinguished from micrite on the basis of size. Individual sparry calcite grains are visible on the microscope, but micrite microcrystalline grains are not distinguishable. (0.02 – 1.0 mm)

Dolomite textures

Planar dolomite consists of rhombic, euhedral (well-formed crystal shape) to anhedral (poorly formed crystal shape) crystals.

Nonplanar dolomite consists of non-rhombic, commonly anhedral crystals.

Formation of carbonates

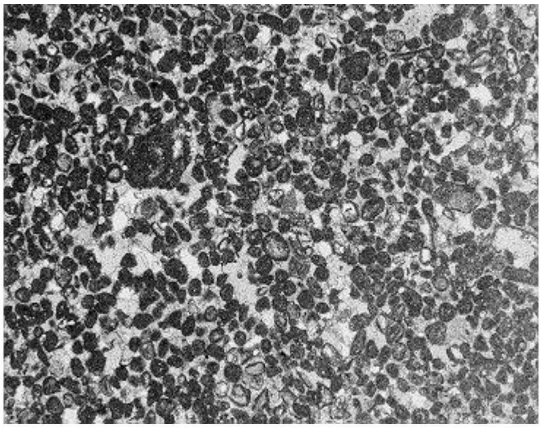
Chemical and biochemical rocks originate by precipitation of minerals from water. Carbonates form from calcium (Ca^{2+}), magnesium (Mg^{2+}) and carbonate (CO_3^{2-}) ions. Modern carbonate sediments are composed of **aragonite** ($CaCO_3$), a metastable polymorph (having the same chemical composition but different crystal structure) of calcite ($CaCO_3$). Sediments from the early Paleozoic to the late Cenozoic time were composed mostly of calcite due to different ocean chemistry. Over a relatively short time, aragonite dissolves and is replaced by calcite. Dolomite is usually formed through diagenesis.

How do carbonate deposits generally form? Some marine organisms form tests (shells) or skeletal structures by removing dissolved carbonate from ocean waters. The most commonly formed hard parts are $CaCO_3$ (calcite). When these organisms die, their hard parts collect on the ocean floor and may be lithified to form limestone. These organisms include many mollusks, calcareous algae, stromatoporoids, corals, annelids (worms), echinoids, crinoids, forams, red algae, coccoliths (chalk), and brachiopods. Less commonly, calcite may be inorganically precipitated directly from aqueous solution. In both cases, *limestone formation most commonly occurs in shallow, warm, and calm marine environments*.

The dissolution and precipitation of calcite and aragonite is controlled by pH, which is a function of partial pressure of dissolved CO_2 in the water. Carbon dioxide and water react to form carbonic acid. Calcite and aragonite are readily dissolved in a carbonic acid solution. ***What does that mean?*** If there is more carbon dioxide dissolved in water, the pH decreases and more calcite and aragonite will dissolve. If there is a loss of carbon dioxide from the water, the pH increases and calcite or aragonite precipitates out of the solution. Loss of CO_2 can be caused by an increase in temperature or a decrease in pressure (salinity also affects CO_2 concentration).

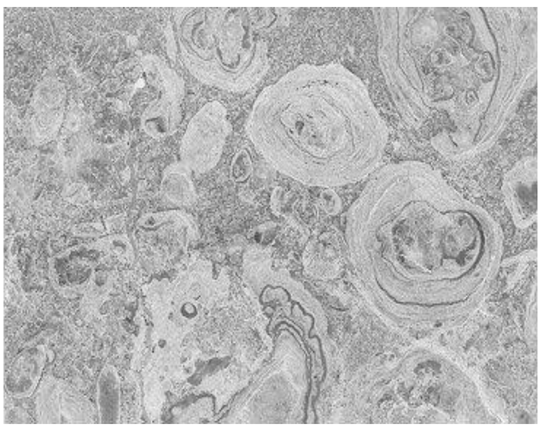
Pellets

(biogenic)



Pellets

Those grains composed of **micrite** and **lacking any recognizable internal structure** are called 'peloids'. This photograph shows a limestone in which the allochems are mainly peloids, circular to elliptical in cross-section and averaging about **0.1mm** in diameter. Such peloids are generally interpreted as **faecal** (**biogenic**) in origin and are called '**pellets**'. The photograph shows pellets at the lower end of the size range for typical pellets, which extends up to 0.5mm.

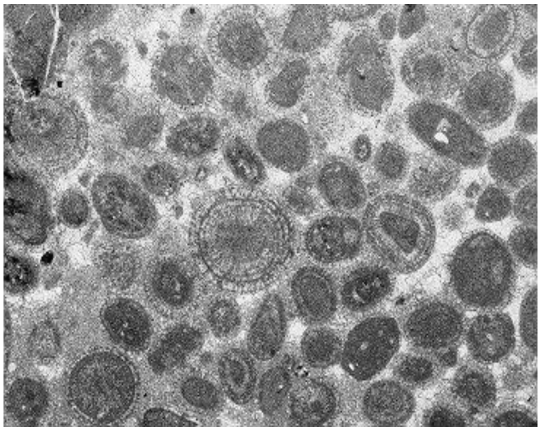


Oncoids

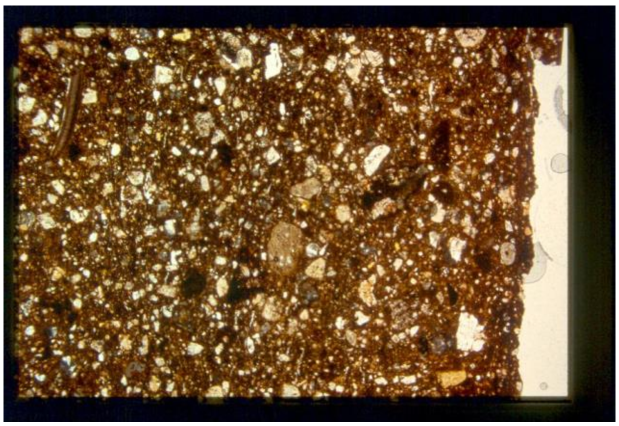
This is a photograph of a polished rock surface showing oncoids. Oncoids are presumed to be **biogenic**, **blue-green algae** on the grain surface, trapping and binding fine sediment particles. Note the **size*** of the grains, the **asymmetrical** growth and the **wavy** nature of many of the laminae, all features characteristic of oncoids. The bluish-grey areas are sparry calcite and the orange-brown areas are stained with iron oxides.
*(photograph, not thin section – **actual size**)

Pisoids

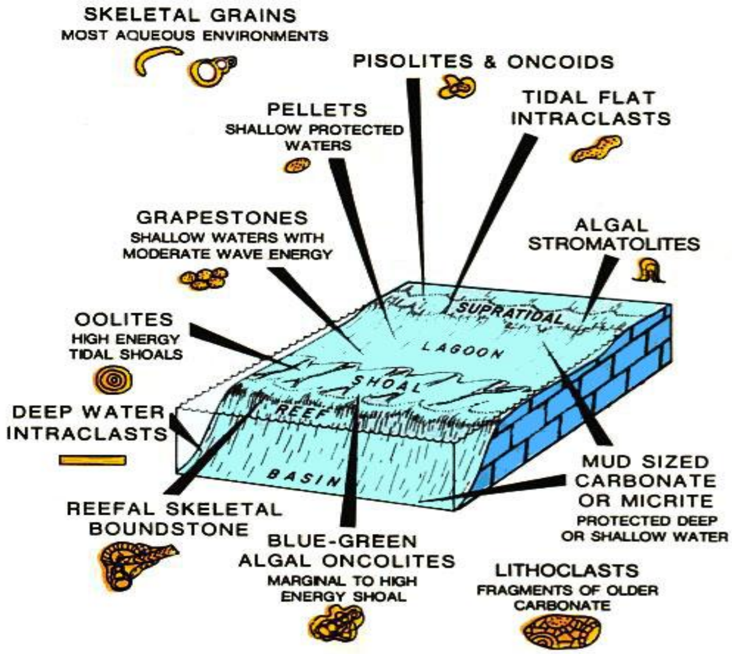
This photograph shows grains with a regular, well-defined concentric layering, in grains **up to 5mm** in diameter. This is typical of **inorganic** growth and these grains may be pisoids. Pisoids are commonly fractured or broken. Broken pieces can be seen towards the top right of the photograph.



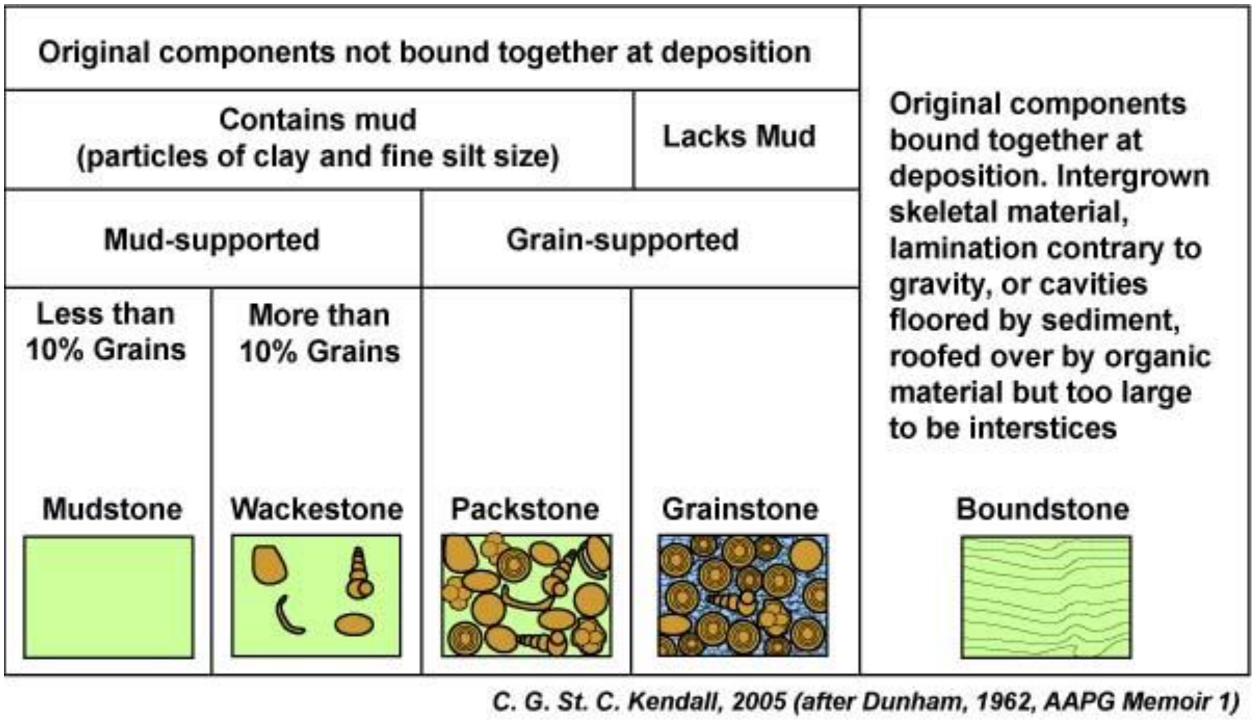
Ooids
This photograph shows ooids with well-developed radial and concentric structures. (Ooids are **spherical** or ellipsoidal grains**, less than 2mm** in diameter, having **regular concentric laminae** developed around a uncleus.) The nuclei are micritic carbonate grains. The matrix between the ooids is a mixture of carbonate mud and sparry calcite cement. (**inorganic**)



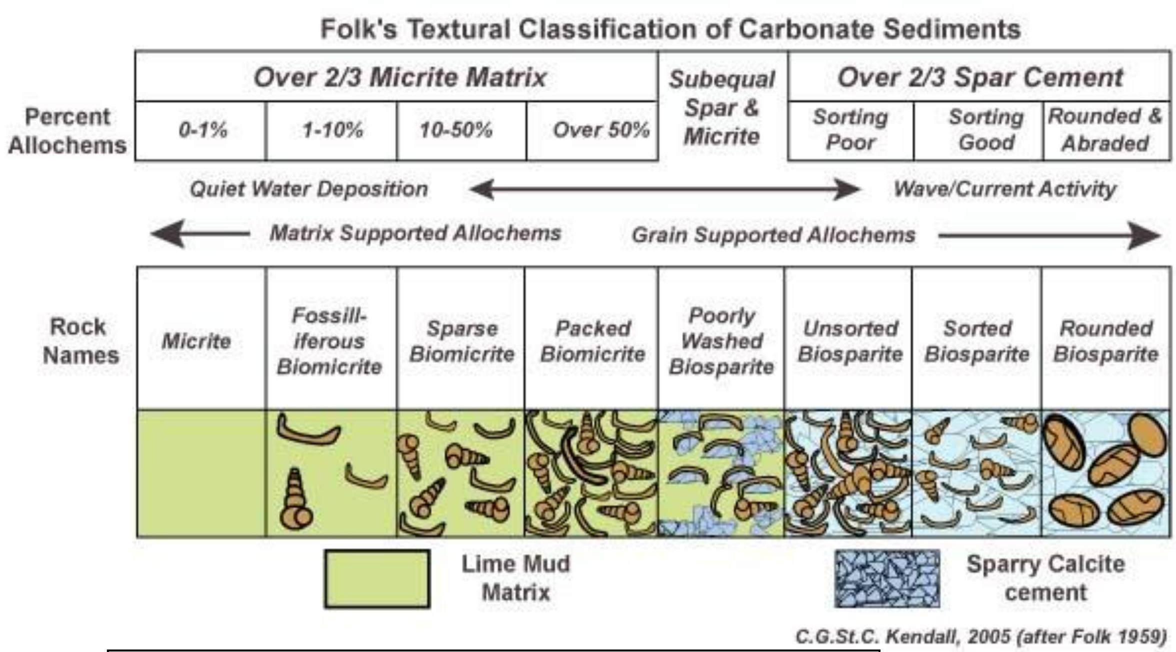
Intraclasts
Lithic clasts originating from the same depositional environment as they are deposited in. They are analogous to lithic clasts in siliciclastic rocks.



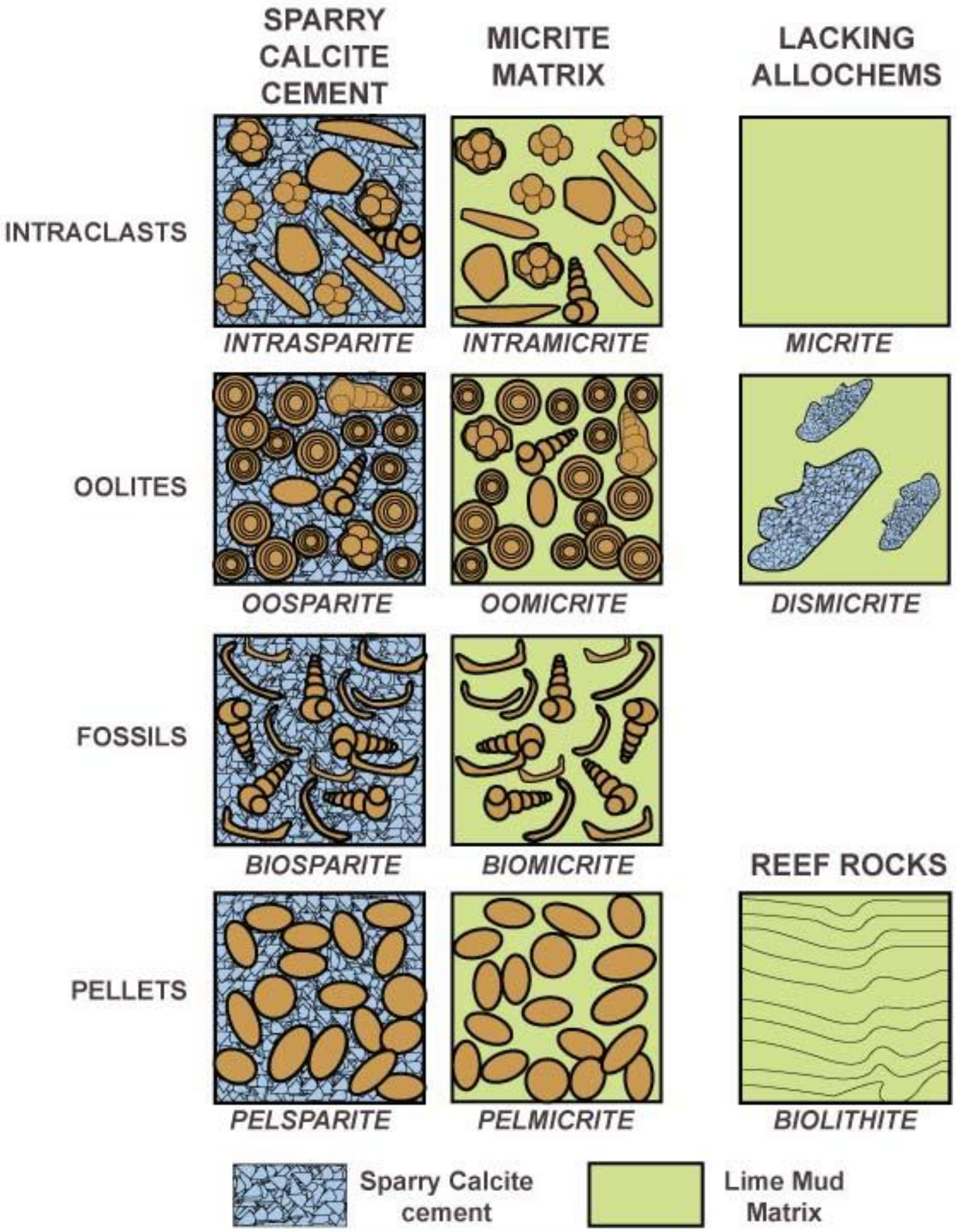
Dunham Classification



Folk Classification



A rock with >2/3 spar cement and no allochems is a **sparite**



C.G.St.C. Kendall, 2005 (after Folk 1959)