Calcareous rocks

The most distinctive characteristic of our Geopark is, without doubt, the karst phenomena it contains. Its caves, chambers and sinkholes are clearly associated with a particular type of rock: limestone. Limestone itself forms part of a much larger group, known as carbonate rocks. It would be helpful to have a description and understanding of both.

The types of carbonate rocks and their composition

They are made up of calcium carbonate, in the case of limestones, or of calcium magnesium carbonate in the case of dolomite rocks. They are commonly formed either by the diagenesis (hardening of sediment into rock) of tests (shells and various limestone debris from marine life), or by reef-building organisms such as corals. In the field, they are well stratified (figure 1), i.e. in successive layers, except in the case of former reefs in situ, which are known as bioherms. Depending on the level of impurities they contain, they may be categorised as argillaceous limestones, calcareous sandstones, etc. There will be no mention of dolomite rocks here, since virtually no examples are to be found in the Geopark.

Figure 1. Stratified limestone formation (Fond des Vaulx quarry, Wellin). Here the strata are tilted by 80° by the folding caused by tectonic stresses during the Variscan (or Hercynian) orogeny. This range is responsible for the structures visible in the rocks of Upper Belgium

Limestone consists of calcium carbonate (CaCO3), the same chemical compound as the lime scale that obstructs up percolators or damages washing machines. This calcium carbonate is often accompanied by other substances, albeit in very small quantities: clays, silica sand, other minerals such as sulphides (pyrite: FeS2), and sometimes carbonates of other metals such as copper (malachite: CuCO3).

When the clay content reaches appreciable levels (over 10 %), it is known as c*alcschist* or argillaceous limestone (figure 2). This type of rock can play an important role in hydrogeology, since it is less permeable than the purer forms of limestone.

Figure 2. Argillaceous limestone or calcschist formation (Resteigne quarry, Tellin). The strata are much less clearly delineated than in Figure 1. This type of rock is also known as "cannonball limestone". At certain points, it is interleaved with shale strata.

The origin of limestones and their texture

An examination of figures 3 & 4 leaves no room for doubt: calcareous rocks are marine in origin, containing many traces of marine life: shells or fragments of shells (known as tests), ball-shaped, bush-forming or branched corals. In the Givetian stage, (some 390 million years ago, see the section on "Stratigraphy"), midway through the Primary or Palaeozoic Era, a tropical sea occupied the area that is now the Geopark. This sea was only shallow, rather similar to the Great Barrier Reef off Australia.

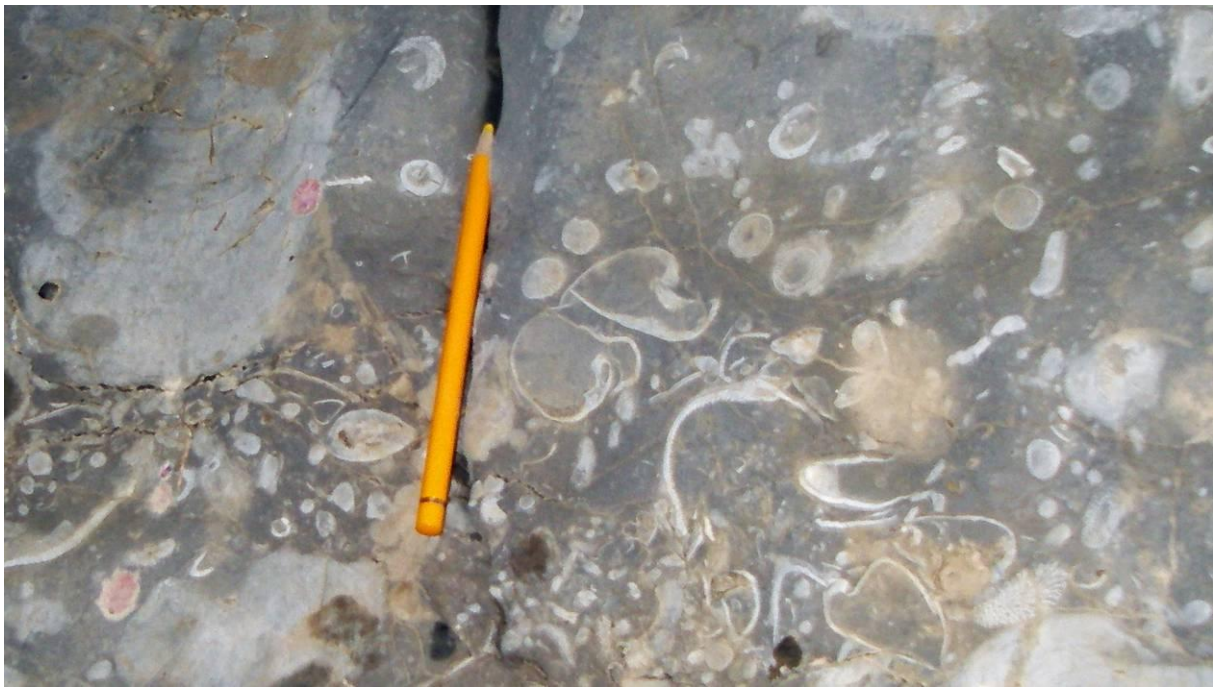


Figure 3. Limestone wall in the Cave of Lorette (Rochefort). The white areas are fragments or cross-sections of the shells of a brachiopod, *Stringocephalus Burtini*, which existed only during the Givetian stage and is therefore easily dated. Top left is a Stromatopore, a sessile reef-building organism belonging to the sponge family. The fossils are also clearly cemented to the rock by a darker brown paste, also calcareous.

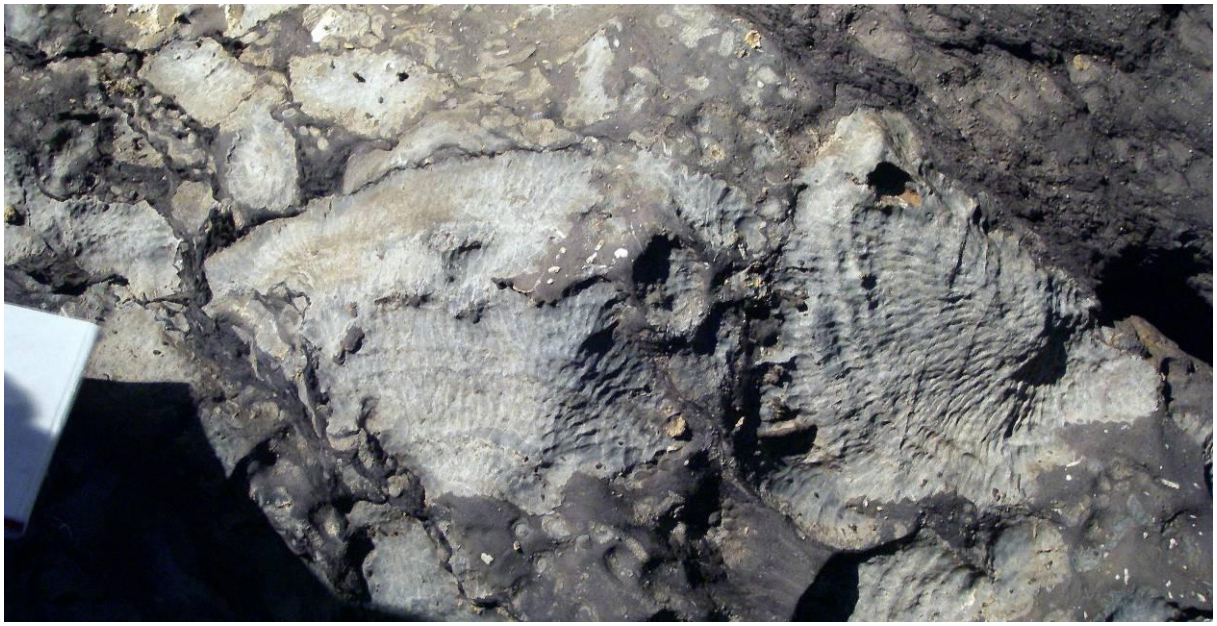


Figure 4. Fossil corals in the Cave of Lorette (Rochefort). This wall features two bush corals, known as *hexagonaria*. Once again, these fossils are cemented in place by a brownish calcareous cement.

The scenario for the formation of limestone is easily imagined. A multitude of organisms, sessile (fixed) or free-swimming, live in the sea. When they die, they fall to the seabed and any hard

parts, the tests, remain. As these are over time, they are bonded together by mud, also calcareous in nature. As the pressure and temperature increase the deeper it is buried, this sediment hardens. Any fluids, such as seawater still contained in the pores, are expelled in a series of chemical reactions, in particular the crystallization of calcium carbonate that finally bonds the calcareous rock together.

Chemical composition alone, however, is not enough to distinguish all the different types of limestone. Texture is another factor to be taken into account. This depends on the various elements making up the rock, such as the fossils seen above, and it is on this basis that the various types of calcareous rocks are classified. Without going into too many details here, further information on the type of classification widely used in the oil and gas industry is provided in the box at the end of this section, for those keen to find out more. Here, we will confine ourselves to just a few examples.

Detritic limestones. Formed exclusively from particles transported by the currents and cemented together.
Chemical limestones. Formed exclusively by chemical processes. Though continental rather than marine in origin, examples include the stalactites and stalagmites found in caves, formed by the chemical precipitation of limestone in solution (in the form of calcium bicarbonate, $Ca(HCO_3)_2$) in seepage water.
Biodetritic limestones. These are the most common forms, examples of which are shown below. They are formed by the cementation of debris from the tests of living organisms: molluscs, brachiopods, corals, stromatopores, etc. When the shell content is very high, the limestone is known as coquina (figures 5 & 6).

Figure 5. Coquina in the Givetian Trois-Fontaines formation (Resteigne quarry). The stratum containing the fossilised shells of *Stringocephalus Burtini* is indicated by the red lines

Figure 6. Coquina in close-up (Fond des Vaulx quarry, Wellin).

Reef limestones may be one of two types. The first does not present successive layers but consists of mounds created by reef-building organisms, and thus of different types of reef. This type belongs to the category of bioherms (figure 7). The second is also formed from reef-building organisms but is stratified: this type is known as a biostrome (figure 8).

Figure 7. The Givetian bioherm (Fonds des Vaulx quarry, Wellin). It is whiter than the surrounding layers and interrupts the strata, tilted by 80°, but shows no stratification.

Figure 8. Biostromes in the Lannoy gallery (Caves of Han-sur-Lesse). We have marked out two biostromes with red lines. Although composed primarily of reef-building organisms, these biostromes are stratified because the organisms were for the most part broken up by storm action.

For those who want to know more…

Carbonate rocks play a fundamental role in applied geology. They constitute valuable reservoirs (of oil, gas or water) , largely because they have the potential for karstification. They are used intensively as a source of aggregates and decorative stone and in the manufacture of cement. One commonly used and very thorough system for classifying them is the Folk classification. It is based on the nature of the cement and of the elements (shells, corals, aso.), then combining the two characteristics to give the name of the limestone.

THE CEMENT is either a ***micrite*** matrix, a lime mud made up of particles of between 1 and 4 µm (formed in calm waters), or a ***sparite***, crystals of between 20 and 100 µm filling the pores of pre-formed elements (in choppy, highly dynamic shallow waters). Microsparite (crystals of between 5 and 10 µm) is often formed by recrystallisation of a micrite.

THE ELEMENTS CONSIST OF 4 TYPES.

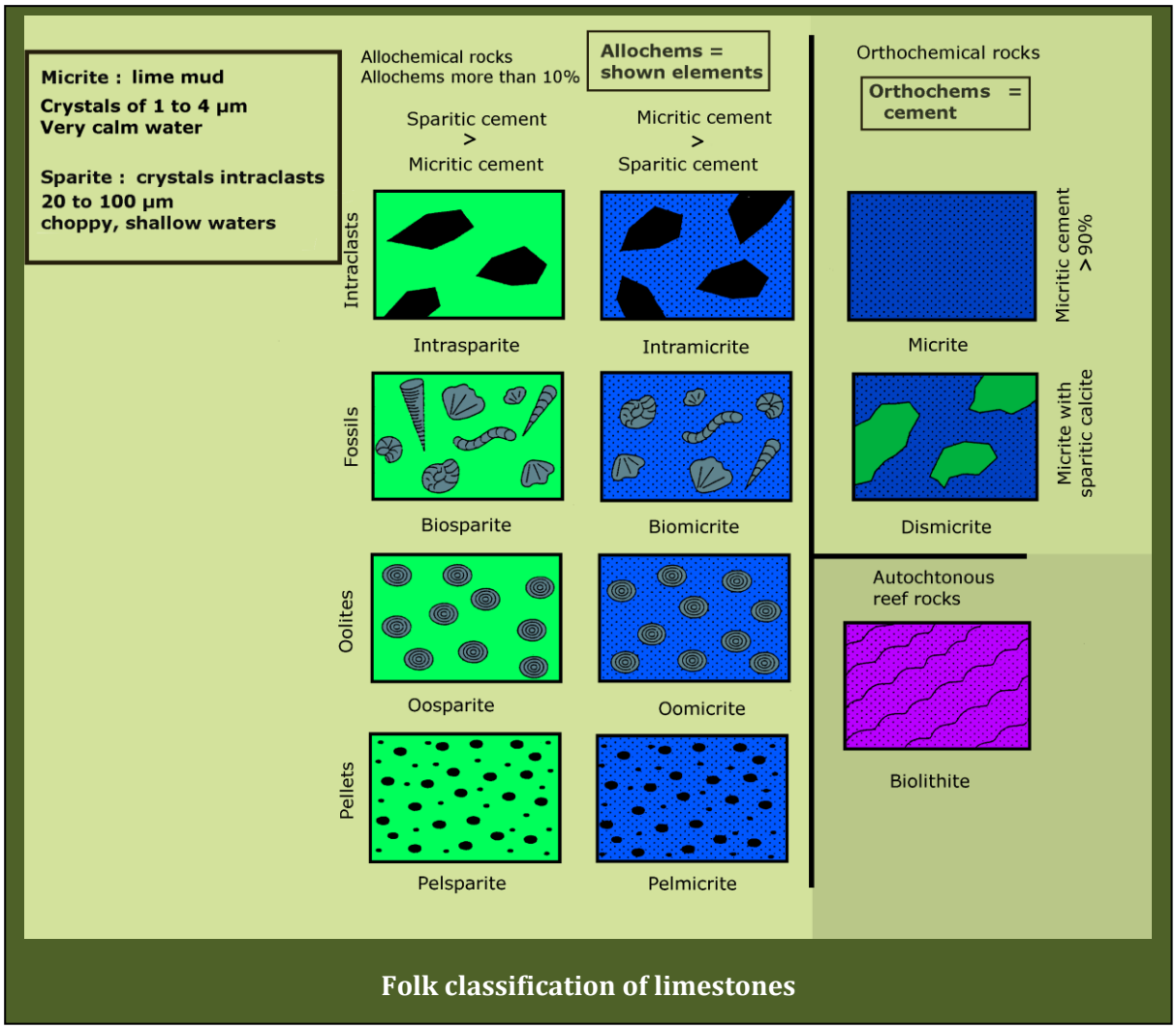
Intraclasts are angular fragments from a poorly consolidated neighboring sediment with little transport. Theoretically, these should be distinguished from true pebbles, which are detritic in origin.

Oolites are small spheres ranging from 0.5 to 2 mm in size, formed around a tiny piece of debris at their centre, surrounded by concentric layers. Pisoliths also belong to this group but the spheres are over 2 mm in size.

Fossils may be either whole or broken (bioclasts). Reef-building organisms are not included here.

Pellets are small ovoid masses of between 40 and 80 µm, microcrystalline muds rich in organic matter of faecal origin.

The naming system is based on combining the names of the two types of elements. An intrasparite is made up of intraclasts bound together by a crystalline cement. A biomicrite is made up of fossil fragments bound in a fine crystalline matrix. Lastly, there is biolithite, a limestone formed by reef-building organisms. Lastly, the limestone must be classified as dolomitic or otherwise. Fully dolomitised rocks constitute a distinct group.



Folk classification of limestones