The coral reef of the Yonne valley

When rocks tell us about Earth's History

Réserve Naturelle
BOIS DU PARC

Conservatoire
d'espaces naturels
Bourgogne

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Welcome to the Yonne valley

The landscapes, the rocks, the fossils... are witnesses of planet Earth's history. In the valley, the river erosion and various phenomena revealed several outcrops that are real geological time machines. Fossilized remains of a coral reef that existed 4 to 5 million years ago can still be seen today.

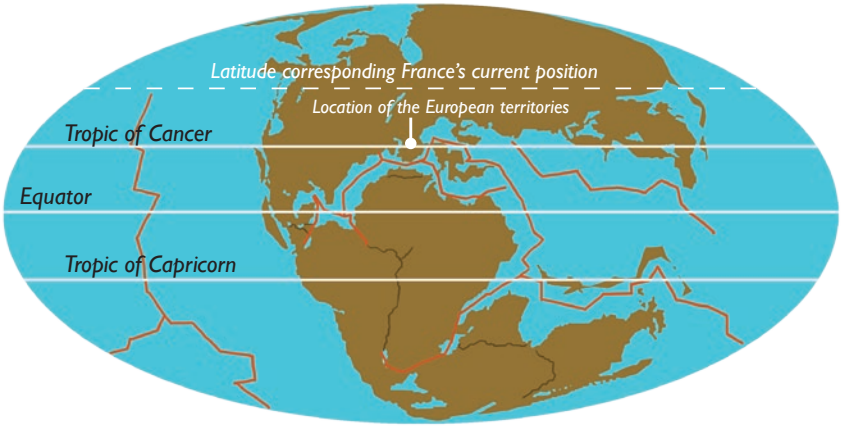
This guide will help you learn about the reef through its story, its wildlife, how it grew and lived. It will also introduce you to the geology of various sites of the Yonne valley.
Each site recounts a specific time period through several layered "slices of life". The oldest evidence comes from the deepest horizons.

A different world

160 million years ago, the placement of the continents and sea levels were very different than they are today. Bourgogne was then located in the intertropical zone of the globe, its climate hot and humid.

During the **Jurassic age**, the current Yonne county was beneath a **warm and shallow sea**.

Since then, the plate tectonics have moved Europe towards more temperate latitudes. The fossilized reef of the "Bois du Parc" is a vestige of that tropical period.



Placement of the continents during the Jurassic age

The lands, until then forming one giant continent, Pangaea, started drifting apart during that time period and oceans like the Atlantic were born. The continental drift at the end of the Triassic period was what determined the positions that these lands have today.

Based on lesdinos.free

Coral formations can still be seen in today's landscape, on the reserve cliffs.

Today
+ 2000 years

CENOZOIC : QUATERNARY ERA

The climate alternates between very cold and temperate episodes. During the temperate episodes, the erosion of the rivers, the Yonne included, causes the carving of today's valleys.

- 1,8 Ma

CENOZOIC : TERTIARY ERA

The period is tectonically active, causing geological changes : emergence of Bourgogne, formation of the Alps and the Bressan trough

- 65 Ma

CRETACEOUS

The sea retreats from the Bourgogne region.

- 145,5 Ma

The coral reef of the current Yonne valley grows for 4 to 5 million years, during the late Jurassic period.

MESOZOIC : SECONDARY ERA

The sea partly retreats to return again.

JURASSIC

The sea floods the majority of the current French territory.

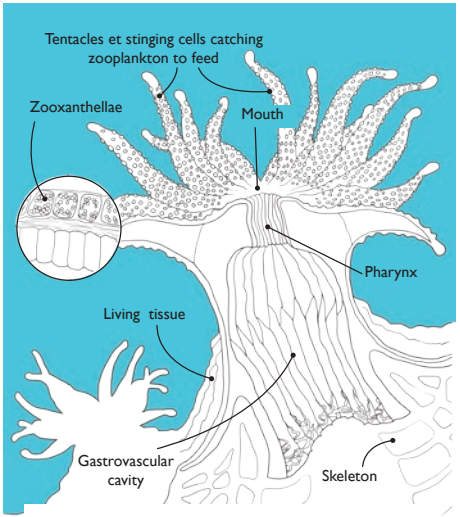
- 200 Ma

TRIASSIC

- 250 Ma

PALEOZOIC PRIMARY ERA

The coral is an animal usually living in large colonies of individuals called "polyps", attached to a base. Belonging to the cnidarian group, corals share the same sac-like body structure of the jellyfish, made of two distinct layers of tissue, and with a single opening surrounded by a ring of stinging cells



Polyp anatomy

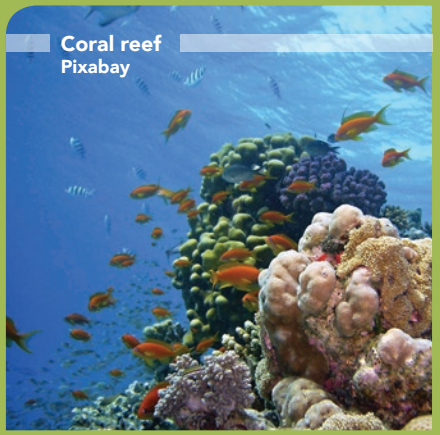
Based on Encyclopaedia Britannica Inc. 2010

The polyps of some species can secrete their own external skeletons called coral-lite. There are hard corals with limestone skeletons, soft corals with horny-whip like skeletons and soft corals without any real skeleton.
The accumulation of the limestone skeletons are the bedrock of a coral reef formation when the hard corals die.
The living corals then keep growing on top of it.

Inside a coral reef, many coral species - nearly 300 species on the Reunion island for example - coexist, with many different shapes and colours. A specific species can adopt different shapes depending on the environmental conditions - depth, light, water currents…

Colours stemmed from a pact

Many corals live symbiotically* with tiny algae, mostly zooxanthellae*, responsible for their specific colour. Taping light energy, these algae produce organic molecules essential to the growth of the polyp and its limestone skeleton. In return, the coral provides the algae with a stable environment and the elements required for their survival.



Coral reef
Pixabay

The different types of coral

Branching coral colony

The colony displays an architecture of more or less fused main branches, with short or slender sub-branches.

Table or tabular coral colony

The colony forms broad flat surfaces commonly referred to as table-shaped corals. It can be side-attached or rest on a central leg.

Lamellar coral colony

The colony grows in multiple horizontal layers. The thinner layers can look like a stack of plates.

Massive coral colony

The colony is characterized by a thick spherical shape. It allows the coral to be more resistant to ocean currents.

Encrusting coral colony

The layers of the colony cover the substrate and adhere to it firmly, forming a crust that sometimes has a few lumps.

Pillar coral colony

The colony grows upward in cylindrical forms that have been compared to candles.

The coral reefs

Coral reefs are **mineral structures essentially built by animals.** They are primarily associated with warm seas, and are mainly made of hard corals. Their growth is controlled and **optimized** by :

- the **water temperature** between 18 and 29 °C ;
- an **adequate salinity** nearing 35 grams of salt per litre of water ;
- a **depth not exceeding 165 ft** and clear waters allowing light to penetrate the surface, which is essential to the algae living in symbiosis with corals ;
- **ocean currents** guaranteeing a good water oxygenation and food supply, though if they're too violent, the risk of the colonies being destroyed is high ;
- marine waters with low phosphate and nitrate levels.

The reefs serve many roles, such as catering to a considerable biodiversity. Even if they only take up 0.2% of the ocean floor, the reefs host more than 25% of marine species, plants and animals.

Shape and organisation of a reef

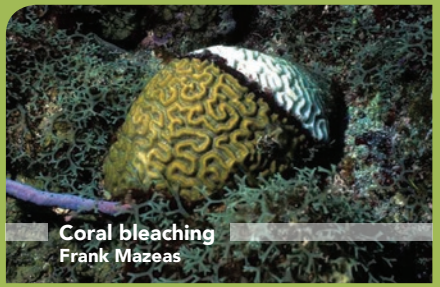
The various shapes of coral colonies are determined by the necessity to both build a structure able to resist water currents, and maximize the light-capturing surface. In wave-battered areas, the corals have massive "dome" morphologies. In calm waters, they can settle for a thinner and more branch-like skeleton to better capture light.

A coral reef
J.P. Quod

Threatened ecosystems

For the last few decades, **the coral populations have been decreasing at an alarming rate**, for multiple reasons :

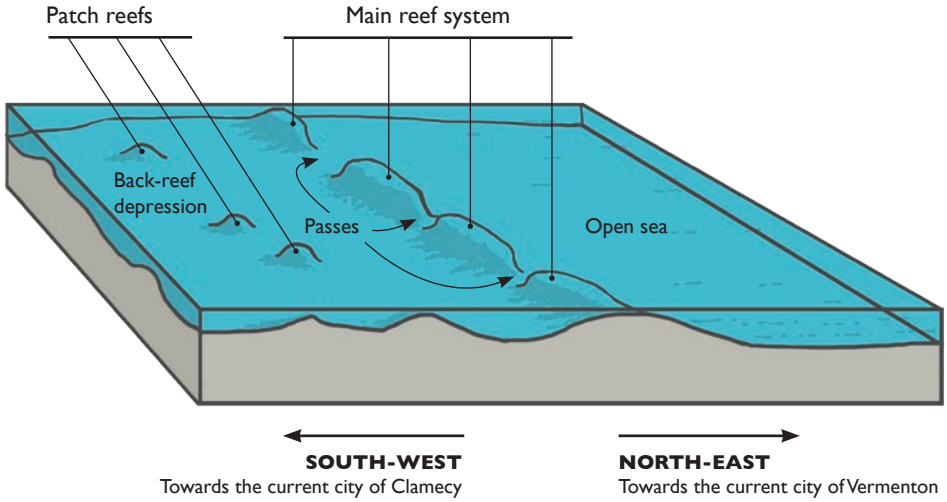
- **coastal urbanization**, clearing and intensive farming causing reefs to be covered by sediments,
- **chemical pollution**,
- **overfishing, poaching** and the **introduction of exotic species** upsetting the natural biological balance,
- **climate change**, about to become the main issue. The temperature variations of the oceans lead to coral bleaching that can kill the reefs.



Coral bleaching
Frank Mazeas

The reef formation of Yonne

Today, this reef formation is spread out over 47 miles between the Loire and the Cure rivers. Its outcrop width is but a few miles, though its true distance can't be determined to the North or East due to its erosion during the Cenozoic era. The thickness of the reef formation ranges from 197 to 328 feet.
The reef formation developed on a large platform, a vast and shallow marine expanse that used to host a complex network of channels and passes where the reefs grew. This spatial distribution can still be observed today in diverse places on the planet.



Based on http://planet-terre.ens-lyon.fr/

Representation of the environmental conditions of the Yonne valley coral reef development.

Fossil formations

Coral skeletons, shells of numerous organisms but also the soft parts of certain organisms can be preserved through time under specific conditions :

• the dead organism must be quickly protected from degradation by a layer of sediment (no oxygen or degrading organisms)

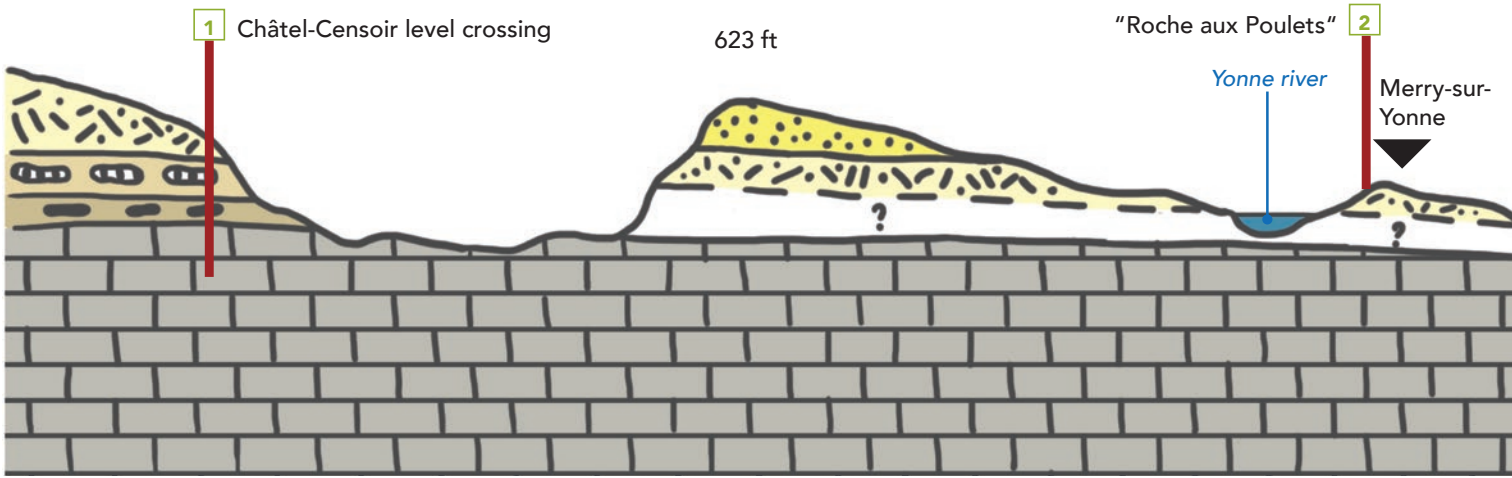
• the protective sediment layer must be thin and light enough so as not to crush the remains of the dead organism.

Mineral salts replace the organic matter of the animal or plant trapped in the rocks.

Through time, organic debris and sediments settle and form successive strata. Sometimes, some fossils allow one of the strata to be dated.

Spatial organisation

South-West



Based on J.C. Menot - 1991

This diagram is not to scale.

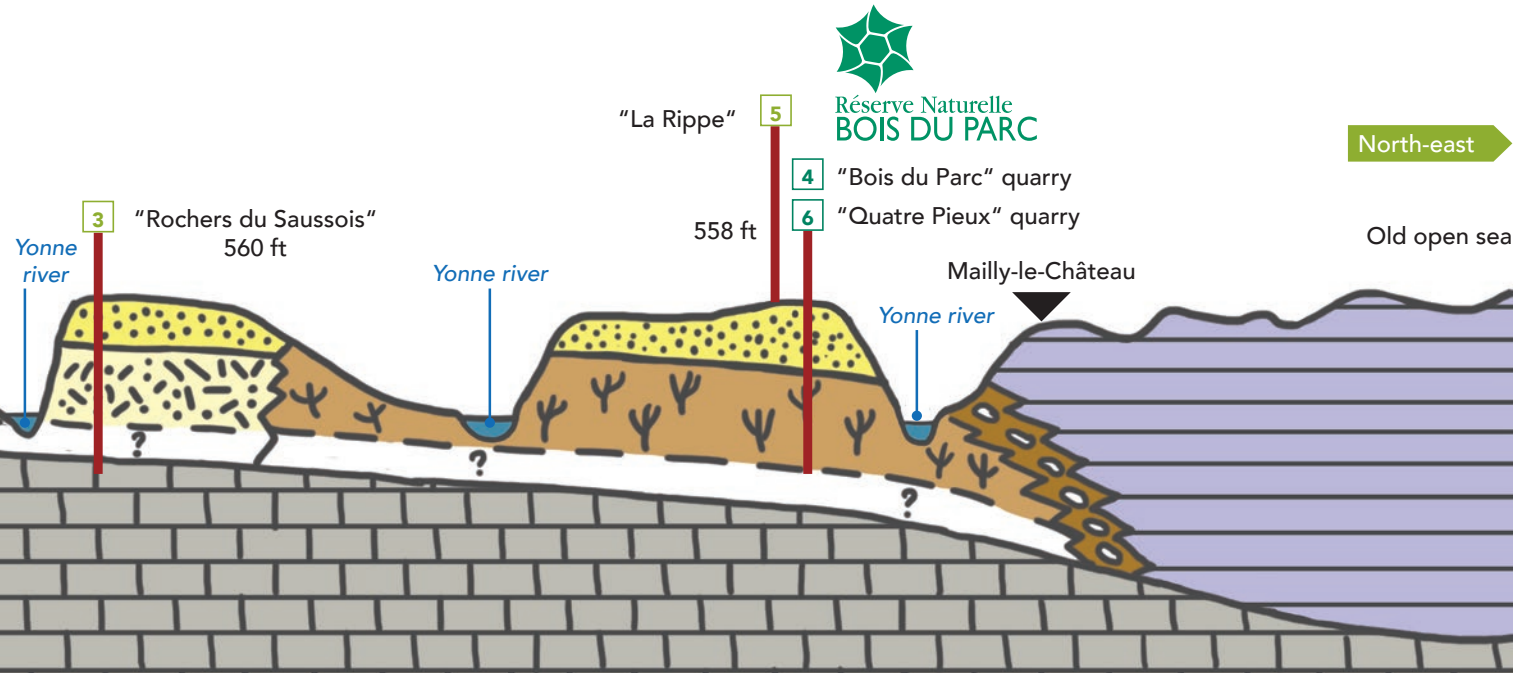
Callovian limestone substratum

Lower reef slope >

Upper reef slope >

Building arena

Fore reef



Colonization area

Reef bedrock : structure and size unknown

Main reef or " heart of the reef "

Back reef

Emerging terminal facies

Lateral non-reef sediments

Sites of the Yonne valley

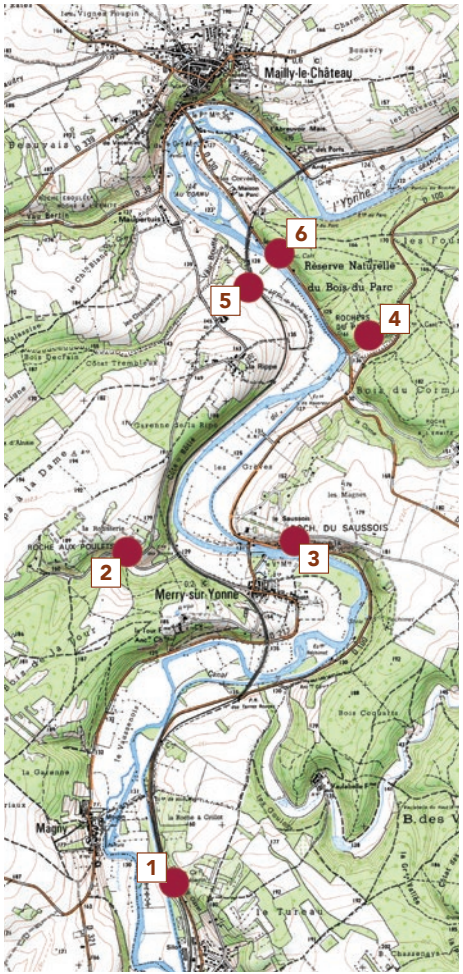
1. Châtel-Censoir level crossing (no public allowed)
2. " Roche aux Poulets "
3. " Rochers du Saussois "
4. " Bois du Parc " quarry (restricted area, access can be requested)
5. " La Rippe " (no public allowed)
6. " Quatre Pieux " quarry

For safety reasons and lack of access to private plots, a few sites are not open to the public. Please be respectful of this restriction.

These sites have been developed to allow you to discover this geological heritage. They're accessible to all.

Coral fossils and other organisms are common heritage. Please show some respect, and do not harvest them.

The definitions of the starred terms can be found in the lexicon at the end of the document



Châtel Censoir 1

No public allowed

Accessibility : no public allowed

Localisation : reef bedrock

Intérêt

The site provides insight on the construction of a reef complex, with fossils as old as the coral colonisation era (Middle Oxfordian).

Description

• Due to an abundance of vegetation, the substratum* isn't visible. It's composed of limestone as well as bivalve, ammonite and brachiopod* fossils.
• Lower reef slope :
– building area of reef formations, rich in lamellar polyparies ;
– colonisation facies : thin and irregular horizon, made of lamellar polyparies ;
• back reef facies : massive or branching polyparies filled with a mixture of sands, coming from marine animal debris and limestone mud.

Lamellar polypary
M. Jouve - CENB

Construction of a reef structure

The first corals (lamellar polyparies) grow around a base made of various fossils, in a calm and shallow sea. As several species of corals develop, the colonisation grows denser to form a building area, the skeleton of a coral reef. These corals look like stack of plates or saucers. In an environment modified by the emergence of a more offshore main reef, other kind of corals develop over time. Châtel-Censoir, at the time, is in the back reef depression.

"Quatre Pieux" quarry

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On site, you'll find signs detailing the different visible levels

Parking and access

The Conservatory has set up a parking area at the quarry site. The site is a free access area.

Localisation

Upper reef slope and emerging terminal facies near the main reef.

Curiosity

This old quarry shows the site's evolution, from a marine environment to a beach, by material accumulation.

Description

In this old quarry, the limestone is massive and without distinct stratification. However, if you look closely, three levels can be seen :

- calcareous polyparies[1] : skeletons of diverse coral species are present in a variety of morphologies;
- *Diceras*[2]* limestone inside which polyparies have nearly disappeared ;
- emerging terminal facies[3].

Diceras shell
M. Jouve - CENB

From calm to rough sea

The coral reef at the bedrock of the cliff is constantly under water, in a calm and shallow environment.

As time passes, the area is carved by the tides and more turbulent waters, causing the polyparies* to disappear, destroyed by the waves. Inside the rock is the debris of corals that lived at a prior period, as well as other organisms such as bivalve molluscs : the *Diceras**.

In this high temperature sea water, extremely shallow and very turbulent, a chemical reaction around the debris eventually generated the formation of oolite*. These little spheres accumulated to form a rock.

"Bois du Parc" quarry

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Restricted area, access may be requested - On site, you'll find signs detailing the different visible levels

Accessibility

The site is closed for security reasons and to preserve the geotope.
Access may be requested by groups.

Localisation

Upper reef slope near the main reef.

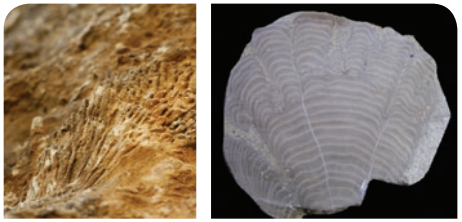
Curiosity

This site highlights the composition and the structure of the heart of the reef.

Description :

In the quarry, two levels are visible, showing the reef's appearance at two different time periods :

- calcareous polyparies* : colossal branching polyparies, and massive spherical polyparies form the main reef, or "the heart of the reef". Fossilised, these polyparies were trapped in their living state in a limestone matrix* ;
- limestone mixing polyparies and algae



Branching polypary (*Calamophylliopsis flabellum*) and *Solenopora japonica*
M. Jouve - CENB / B. Martin-Garin

Morphologies dictated by their living environment

Many coral species form the "heart of the reef". The predominantly branching polyparies indicate a calm and always submerged environment. This main reef was most likely interrupted here and there by patch reefs, linking it to the sea and a back-reef depression.
Red algae, mixed with the polyparies, are present at the top of the outcrop. Their presence is a testimony to the evolution of this environment : at the time, the site is just under the surface, close to temporarily emerge.

"Rochers du Saussois" 3

Accessibility
Please park your car in the car park along the Yonne canal.

Localisation inside the reef complex
Lower reef slope, back-reef depression.

Curiosity
These cliffs show the variations of the water dynamics, and how a back-reef depression works.

Description
This cliff, 165 feet high, is made of white limestone marked by undulations. Yet, the composition is very different between the multiple zonations :

• The rock displays both recessed and protruding areas, due to an unequal resistance against external impacts.

The protruding areas are in fact full of branching and spherical polyparies trapped in their living state, whereas the recessed areas contain jumbled broken coral

• The top of the cliffs is rich in polyparies, mostly spherical.

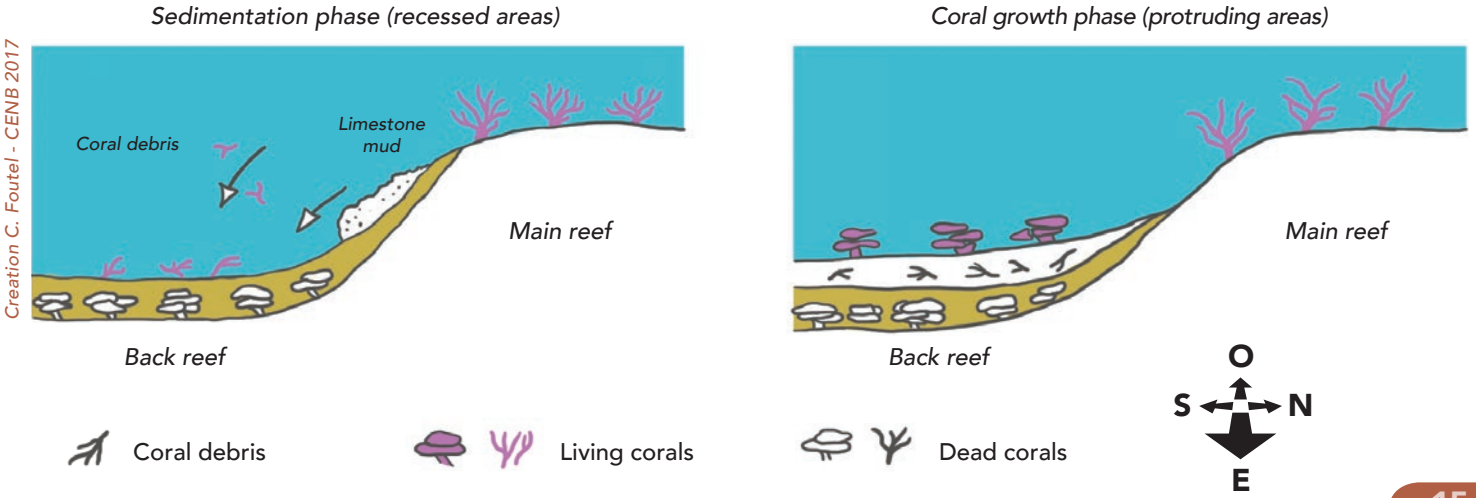
Branching colony of *Aplosmilia* growing on an *Isastrea*
B. Martin-Garin

Currents, tides and sediments

The cliff structure reflects an evolution of the currents in the back reef depression over the years.
In the recessed areas, the rock displays a sedimentation of different particles at the bottom of the sea. The rock thus formed is made up of :

- fragments of, or entire polypary colonies toppled over, urchin debris and similar organisms coming from the barrier reef and its turbulent waters;
- limestone mud that filled the cracks. These deposits were possible because of the low currents, sheltered by the barrier reef.

During low sedimentation times, coral colonies grow in the back-reef depression, becoming gradually covered by debris coming from the main reef. These layers form the protruding ridges.
The top of the cliffs are rich in shattered polyparies. This characteristic is typical of areas exposed to waves and currents. The nature of the cements* present in between the polyparies is also a testimony to hydrodynamics. Some parts of the seabed were, at the time, just below sea level at low tide, and in rare occasions, fully emerged during spring tides.



"Roche au Poulets" 2

Accessibility
Please park on the roadside. The site is a free access area.

Localisation : Lower reef slope, back-reef depression and reef patches

Curiosity
The site shows the top layers of the lower reef system, formed just below sea level.

Description
On a 148 feet high surface, the slope of the small valley shows a succession of cliffs. The bare bedrock belongs to the same part of the reef as the "Saussois", but within a higher layer; a clear indication of a latter period. The outcrop presents three distinct layers :
• the lower layers, made of :
- limestone of polyparies of various shapes, trapped in their living state (branching, spherical, lamellar).
- limestone rich in various shells (Diceras, Nerineas…), but rather poor in massive polyparies ;

***Stylina* (polypary, common during the Oxfordian era)**
B. Martin-Garin

• the median mass, made of limestone rich in polyparies of various shapes. The cements* between them, because of their structure and composition, are evidence of the shallow seas they grew in ;
• the upper layers, located above the road leading to "Mailly-le-Château", are typical beach formations. The limestone is made of organism and fossil debris.
The site shows the upper parts of the coral reef. The lowest layer of this outcrop matches the upper layer of "Rochers du Saussois". The lower and median layers were formed in a sedimentary environment, during the time close to the emergence of the reef, and match the lower reef slope.

Back-reed depression

The median layers are read as sediments in the back-reef depression, where small and isolated coral structures (reef patches: polyparies in their living state), as well as sediments coming from the dismantlement of the reef through the passes (bent polyparies) can be found. This structure shows that the back-reef depression is organised into a network of channels and small reef structures.

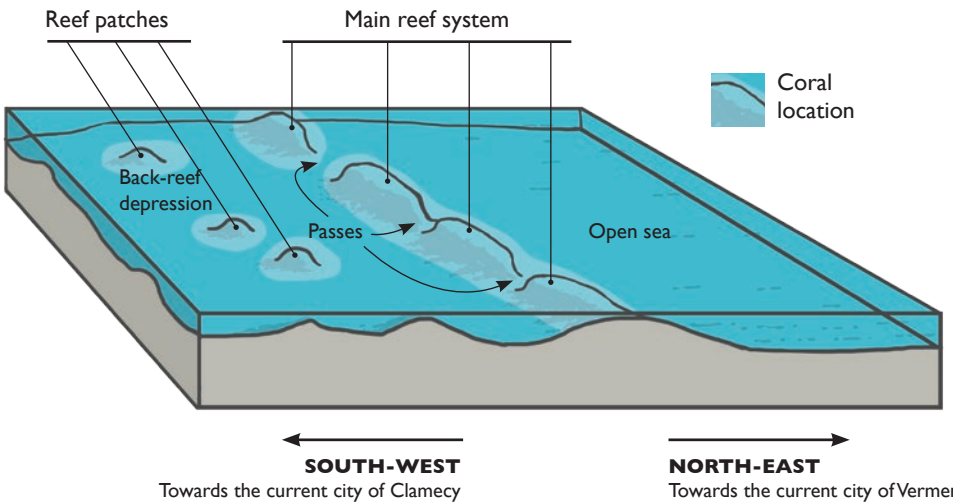
Tidal influence

The upper layers match the emerging terminal facies. The sediments settled when the site was just below sea level during the low spring tides, in a typical beach facies. Polypary, shellfishes and thick shell gastropod fossils (Diceras*) debris can be found in the bedrock, but water movements modified those elements :

- by causing the erosion of the debris through friction,
- by granulometric sorting, modifying their spatial distribution.

The depth of the water and the frequency of the emergence influence as well the structure of the cement* between the debris.

Coral spatial distribution



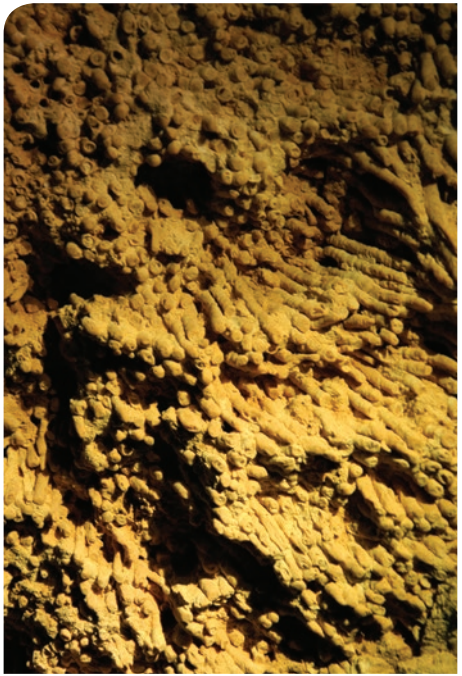
Based on http://planet-terre.ens-lyon.fr/

Nerinea

Biogéosciences Laboratory, CNRS - Bourgogne University

"La Rippe" 5

No public allowed



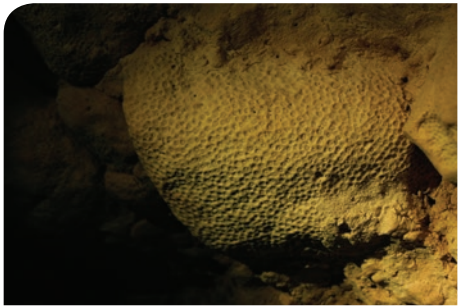
Branching polypary
M. Jouve - CENB

Accessibility
No public allowed

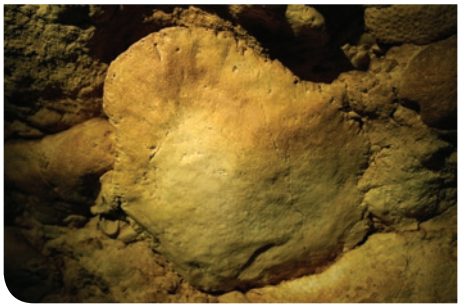
Localisation inside the reef complex
Lower reef slope, heart of the reef

Curiosity
The site, inside the heart of the main reef, is full of polyparies trapped in their living state and contains many species.

Description
The site reveals the lower reef slope, showing Oxfordian limestone on one of its face.
Only one layer is visible : the coral reef. The polypary colonies, still essentially in their living state positions, reflect perfectly the variety of coral species living in coral reefs. The facies also accurately shows the structure of a still immersed coral reef. The remarkable condition and the variety of fossils are what makes this site so appealing.



Massive polypary
M. Jouve - CENB



Other shape of polypary
M. Jouve - CENB

Lexicon

Brachiopods : marine animals. They first appeared during the Cambrian age, and survive to this day, albeit relatively rarely (400 species). Their shells have two valves.

Cement : precipitated crystals (in this case, aragonite and/or calcite) that link the grains together after the sedimentation.

***Diceras* :** dissymmetrical bivalve molluscs that lived attached to the seafloor, and belonged to the extinct rudist family. They're evidence of an old coral reef. They're relatively useless from a stratigraphic perspective though, because they don't belong to a specific stratum.

Echinoderm : marine animals that can be found at every ocean depth, from the intertidal to the abyssal zone. They first appeared during the Cambrian age. They include well- known animals such as sea urchins and sea stars. The palaeontologists have identified several thousands of extinct echinoderm species.

Subtidal : constantly immersed coastal zone.

Intertidal : zone between the tide marks.

Matrix : the matrix is the finger-grained mass of material of a sedimentary rock, in which bigger elements are embedded. The matrix is formed at the same time as the sediments of the elements.

Oolithe : spherical grain (0,5 - 2 mm) (sand or microfossil) composed of a nucleus surrounded by concentric layers; limestone in this case.

Polyp : individual of the Cnidaria animal group. Their simple appearance looks like a tiny anemone : a hollow cylindrical body with only one opening (both mouth and anus) surrounded by a ring of tentacles.

Polypary : limestone skeleton produced by polyps of numerous cnidarian species.

Bedrock : geological formation lying under a sedimentary layer.

Symbiosis : a mutually beneficial relationship between two biological organisms of different species.

Zooxanthellae : a brownish symbiotic alga living inside non-chlorophyll organisms (invertebrates, microalgae...).

For more information

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www.tourisme-yonne.com

Useful links :

L'Oxfordien de l'Yonne > http://bit.ly/Oxfordien-Yonne

Identification des scléractiniaires > http://bit.ly/identification-scleractiniaires

Photographies de corail > http://bit.ly/photos-corail

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