Itinerant exhibition

Five hundred million years and one day

Exhibition booklet

GÉOPARC MONDIAL UNESCO BEAUJOLAIS

unesco Global Geopark

Syndicat mixte du BEAUJOLAIS

Illustrated by : Syndicat Mixte du Beaujolais and Eléonore Ampuy

«Forty million years. These figures don't take my breath away like they used to, when I tried to build a time scale on the floor of my bedroom, one match for a thousand years, and I was horrified to realise that my outstretched arms couldn't reach both the present and the birth of the mountains. To do that, I would have needed arms that reached all the way to the barn. And even further, to the peach orchard, to touch a diplodocus.»

« Quarante millions d'années. Ces chiffres ne me coupent plus le souffle comme autre-fois, quand j'essayais de construire une échelle du temps sur le sol de ma chambre, une allumette pour mille ans, et que je me rendais compte avec effroi que mes bras écartés ne parvenaient pas à toucher à la fois le présent et la naissance des montagnes. Il au-rait fallu pour cela avoir des bras qui allaient jusqu'à la grange. Et bien plus loin encore, jusqu'au verger des pêches pour effleurer un diplodocus ».

Jean-Baptise Andréa
(Cent millions d'années et un jour, L'Iconoclaste 2019)

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QUARTZ

1 - Introduction

Talking about science often means stating surprising facts, telling stories shrouded in uncertainty, explaining the «whys and wherefores» and deconstructing ideas. The geology of the Beaujolais lends itself particularly well to these different approaches. Its geology is sufficiently unknown to be full of surprises, complex enough to leave no room for certainty, diverse enough to be an example of many natural phenomena and, last but not least, we also hear approximations about it.

Given the spread of museums across the region and the fact that the geosites are only partially equipped with mediation tools, the itinerant exhibition is proposed as a solution for disseminating knowledge equally throughout the Beaujolais region. The aim of the exhibition's tour of the region is to familiarise local people with the «UNESCO Global Geopark» label awarded to the Beaujolais region in 2018, which has been renewed in 2022, and with the reasons for this label, namely the region's high level of geodiversity and the many uses associated with these rocks.

The exhibition aims to convey the messages of both the Beaujolais Geopark and the Global Geoparks Network. The former's message is based on demonstrating the geological, cultural and ecosystem wealth of the Beaujolais region, while the latter's is based on raising awareness of the environmental challenges of the 21st century.

2 - Audiences

The exhibition is aimed at the general public who are not specialists in the subjects covered, from children (aged 9 and over) to adults. This choice to open up the exhibition means that the content has to be adapted to different visitor profiles and, consequently, different reading levels have to be used. The boundaries between each reading level are permeable, and visitors can easily move from one level to another depending on their affinity with the subject or the mediation tools used.

3 - Scientific validation

A scientific committee has been set up to prepare the Beaujolais region's application to become a UNESCO Global Geopark. On request, this scientific committee ensures the relevance of the information conveyed by the educational content developed by the Beaujolais Geopark.

4 - Guiding thread

Given the diversity of the rocks that give shape to the Beaujolais bedrock, chronology is an obvious way of interpreting the geology of the Beaujolais Geopark. This is the theme chosen for this exhibition, based on material relics (rocks, minerals, fossils) from the major stages in the region's geological history.

The media tools (panels, labels, games) are based on scientific observation, with the exhibition inviting visitors to use geological objects to construct an image of the past.

The chronology leads up to the present day, which is also the source of geological evidence. The final part of the exhibition focuses on these contemporary marks, and in particular on the global and local imprint of mankind.

A second theme emerges from the geological objects selected, namely their historical and current uses. The lithological diversity of the Beaujolais region leads to a vast range of uses for the mineral world. The most common functions are as building materials, notably through emblematic rocks such as the «Pierre Dorée» and the red Reins microgranite. The other main function is that of mining, essentially for the production of copper and lead in the Beaujolais region. By focusing on a number of uses for geological materials, this second theme of the exhibition aims to raise awareness of the importance of the geosciences in everyday life.

1 : Two micas gneiss – Rivolet

2 : Diorite – Saint-Laurent d'Oingt

3 : Gryphae limestone – Region of the Pierres Dorées

4 : Hornfels – Mont Brouilly

5 : Metamorphosed trachyte – Rivolet

6 : Diorite – Vauxrenard

7 : Ossicle limestone « golden stone » – Region of the Pierres Dorées

8 : Oolithic limestone « Lucenay stone » – Region of the Pierres Dorées

9 : Carboniferous bioclastic limestone – Thizy-les-Bourgs

10 : Rhyodacite – Saint-Didier-sur-Beaujeu

11 : Granite « from Fleurie » - Odenas

12 : Microgranite – Saint-Julien

13 : Gneiss – Saint-Julien

14 : Ignimbrite « Picard tuff » - Grandris

15 : Arkosic sandstone – Avenas

16 : Ignimbrite – Amplepuis

17 : Microgranite – Reins valley

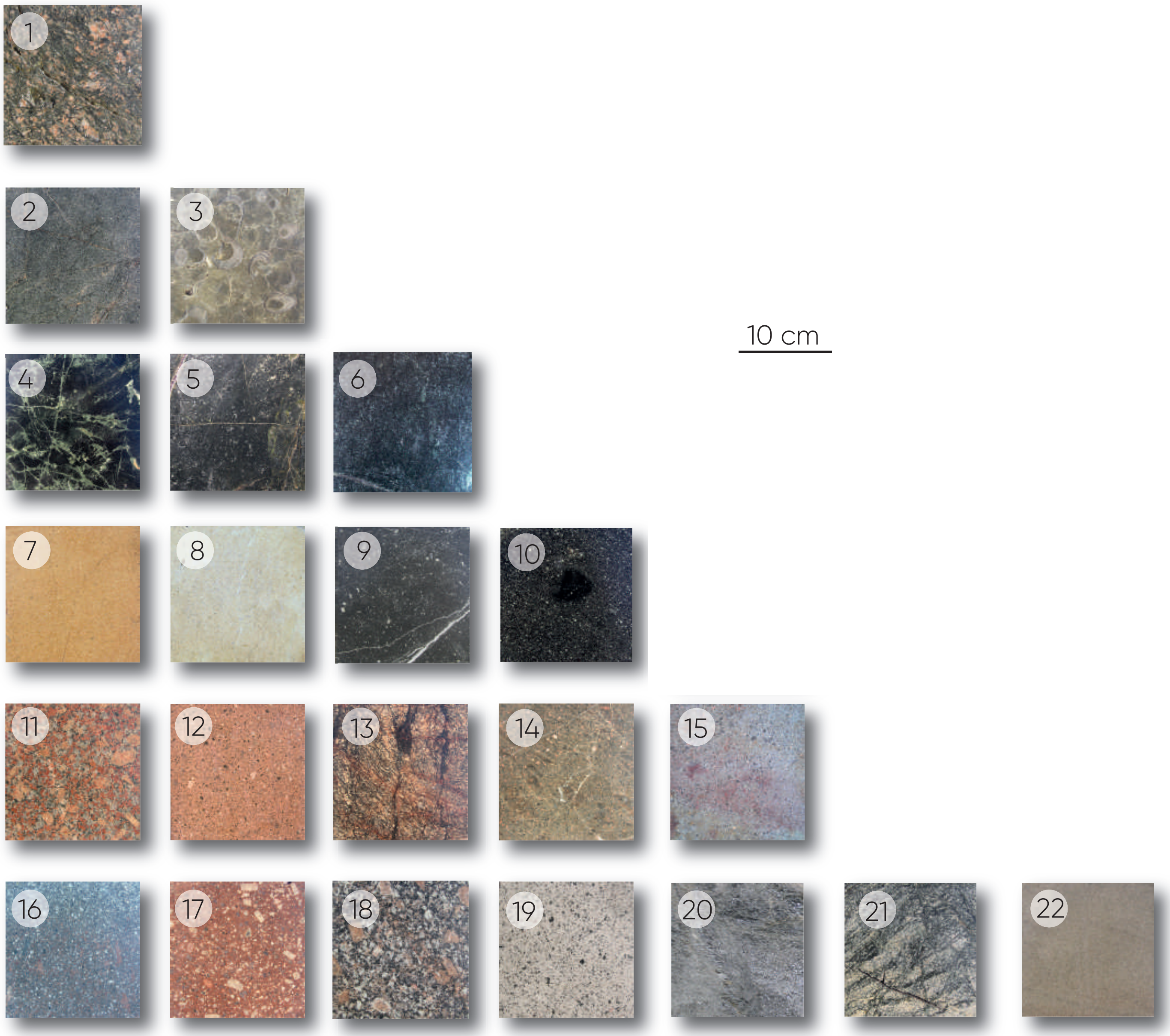
18 : Granite, porphyritic facies – Saint-Étienne-des-Oullières

19 : Aplitic granite – Les Ardillats

20 : Marl – Oingt

21 : Gneiss – Dareizé

22 : Fine sandstone – Châtillon-d'Azergues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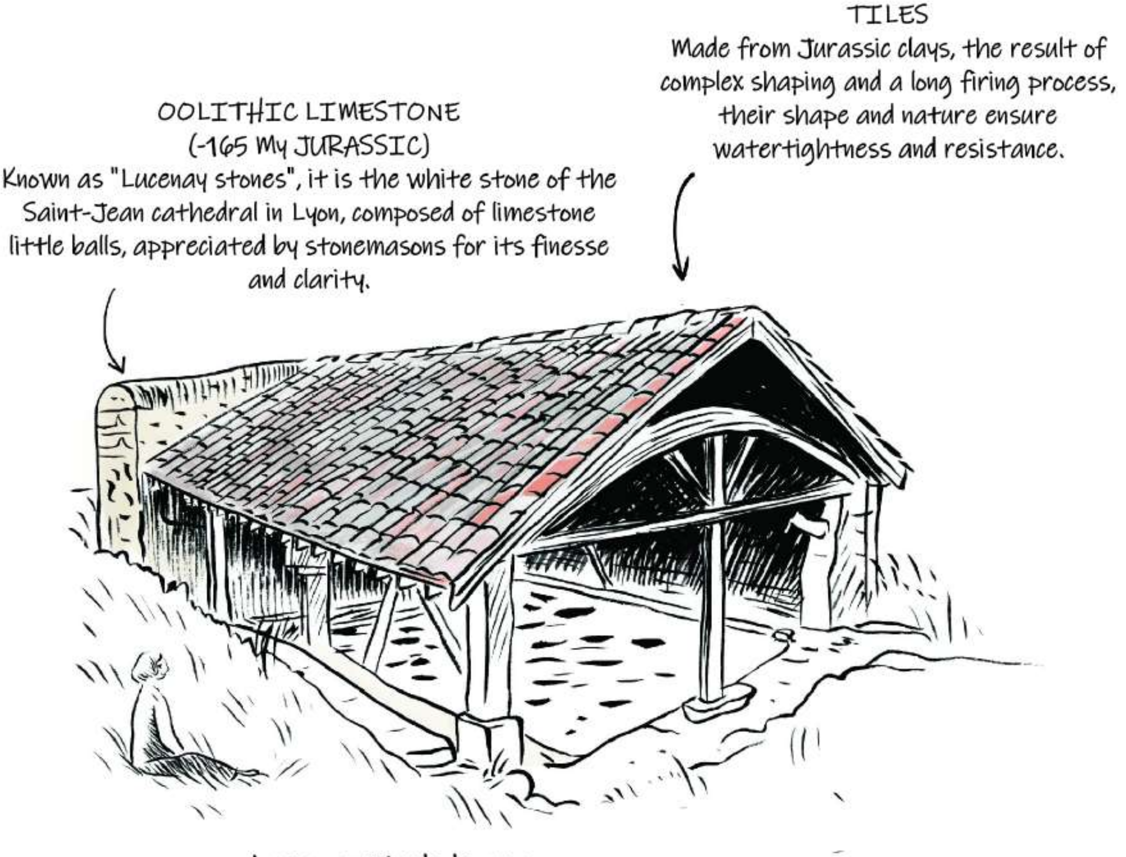


Lucenay Wash-house

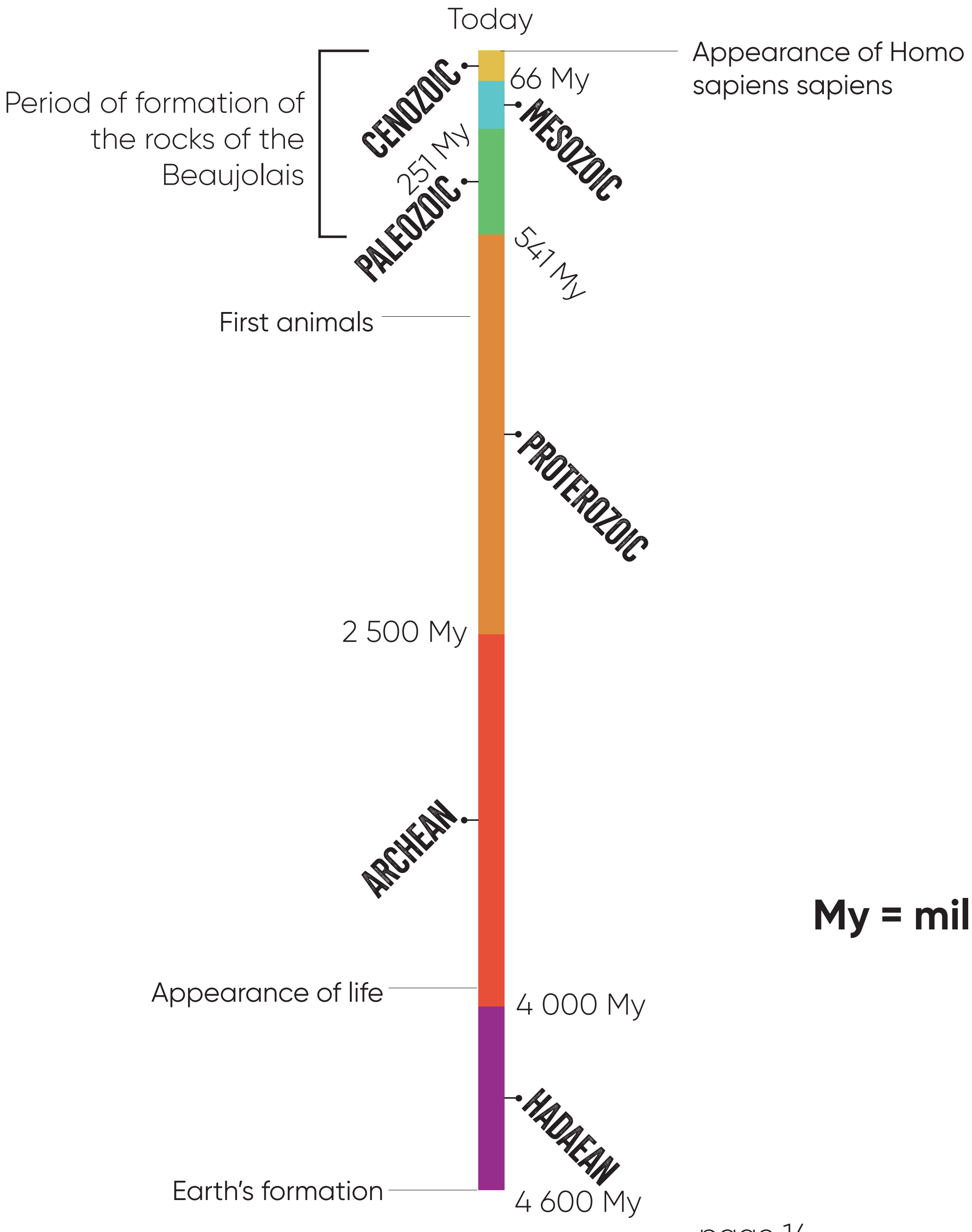
An example of the classic use of geological materials in buildings...

5 - Geological history of the Beaujolais

Geology on the scale of an area, whatever its surface, from a single vineyard parcel to an entire natural region, is inseparable from large-scale geology. To understand the geology of a given area, it is necessary to observe neighbouring areas, as the rocks form complexes that go far beyond the climatic, topographical, biological and administrative frameworks. The term «narrative» conveys an idea of continuity. However, this idea does not sit well with geology as it is presented by the rocks available to the geologist. Rocks provide information about precise moments in time, about the period of their formation and their transformations, if they have undergone any. Linking this information together results in an incomplete story, with many gaps.

The Beaujolais region is no exception, and the rocks found there are relics of ancient periods that feed into a partial geological narrative, alternating highly detailed episodes with genuine geological silences.

Geological time scale



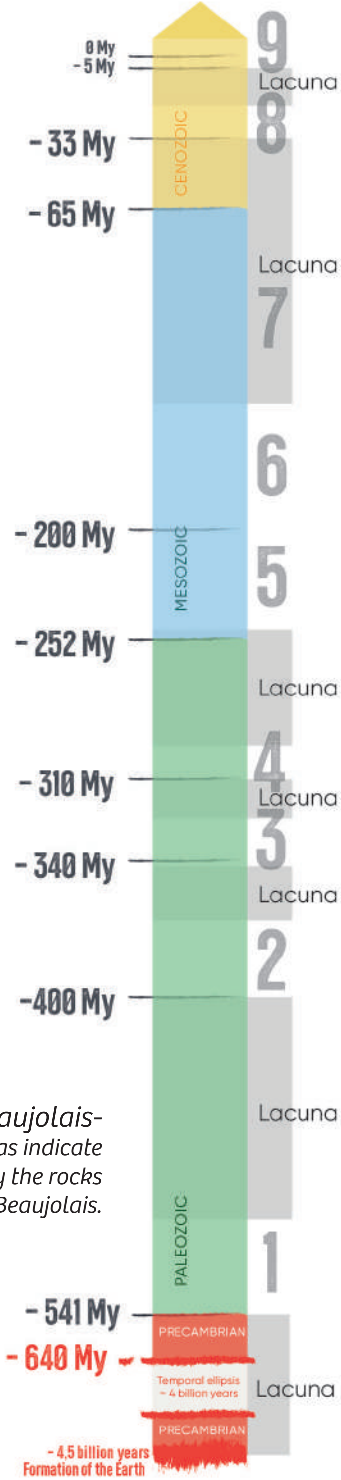
My = million years

The oldest rocks in the Beaujolais region are around 500 million years old. On our human time scale, and even on the scale of the animal kingdom, such an age may seem remote, but on the scale of the planet Earth, 500 million years is a relatively recent age.

Considering the geology of the globe, of all continental surfaces, the Beaujolais region is classified as young. The bedrock of the Beaujolais region reveals a short but very eventful history. This history can be broken down into nine major stages, with gaps and chronological hollows full of uncertainty in between.

The nine major stages in the geological history of the Beaujolais region are detailed in the following pages.

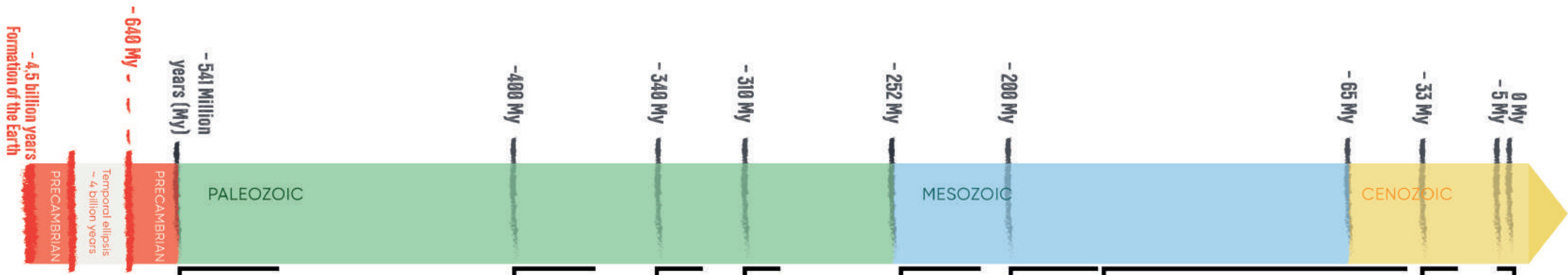
1 : The first witnesses
2 : Ephemeral sea
3 : Ash and water
4 : High mountains & plutons
5 : Erosion
6 : Ebb and flow
7 : Silence
8 : The echo of the Alps
9 : Quaternary



Geological chronology of the Beaujolais- The grey areas indicate periods not represented by the rocks of the Beaujolais.

The exhibition presents the geological history of the Beaujolais region in nine tableaux. Each tableau illustrates one of the key stages in the geology of the region. Geological objects, mainly rock samples, provide physical evidence of these stages. At the same time, the exhibition aims to show the human uses to which some of the rocks on display have been put - uses that are also indicated by physical objects. For example, ossicle limestone (known locally as «golden stone») is linked to the various products of its quarrying: cement bags, lime bags, automotive plastic (calcite-enriched plastic) and flint arrows (from the flint banks of ossicle limestone).

A special place is given to the ninth and final tableau, devoted to the «Quaternary». The objects selected give shape to two distinct histories: that of the last great Quaternary ice ages, and that of the 'present day'. This second theme, «present day», aims to provide food for thought about the geological traces left by mankind. The objects used are anthropic objects that mark the «Anthropocene».



Cambrian – First witnesses

Orthogneiss of Saint-Julien
Paragneiss of Joux
Gneiss, impregnated with pyrite
Bottle of the Vignerons des Pierres Dorées (« Gneiss »)
Muslin

1

Devonian – Ephemeral sea

Green schist
Gabbro
Serpentinite
Diorite (Mt Brouilly & Légny)
Basalt from the Azores UGGp
Marble
Sulphide cluster
Sulphuric acid
Bottle of the domaine Joncy (« Le Volcan »)

2

Viséan – Ash and water

Conglomerate
Pebble with cupule
Rhyolite
Pyroclastic tuff & cinerite
Tuff from the Azores UGGp
Fossilised plants
Volcanic bomb
Asphalt

3

Moscovian – High mountains

Granite of the crus & grey granite
Barium fluorine vein
Fishing sinker
Dentifrice
Contact granite/hornfels
Pyromorphite & galena
Quartz from Beaujeu
Bottle of the domaine Forest (« Granitic »)

4

Trias – Erosion

Current ripples
Sandstone wheel
Reptile footprints

5

Jurassic – Ebb & flow

Ossicle limestone with flint bed
Gryphae limestone
Marls
Ammonite with bite marks
Tile
Sculpture in oolithic limestone
Cut flints
Cement Lafarge
Oolithic sand
White paper & automotive plastic

6

Upper Jurassic & cretaceous

No rock

7

Oligocene – Echo of the Alps

Azurite
Calcite
Romanechite
Copper roll
Porcelain
Sandstone block, impregnated with azurite

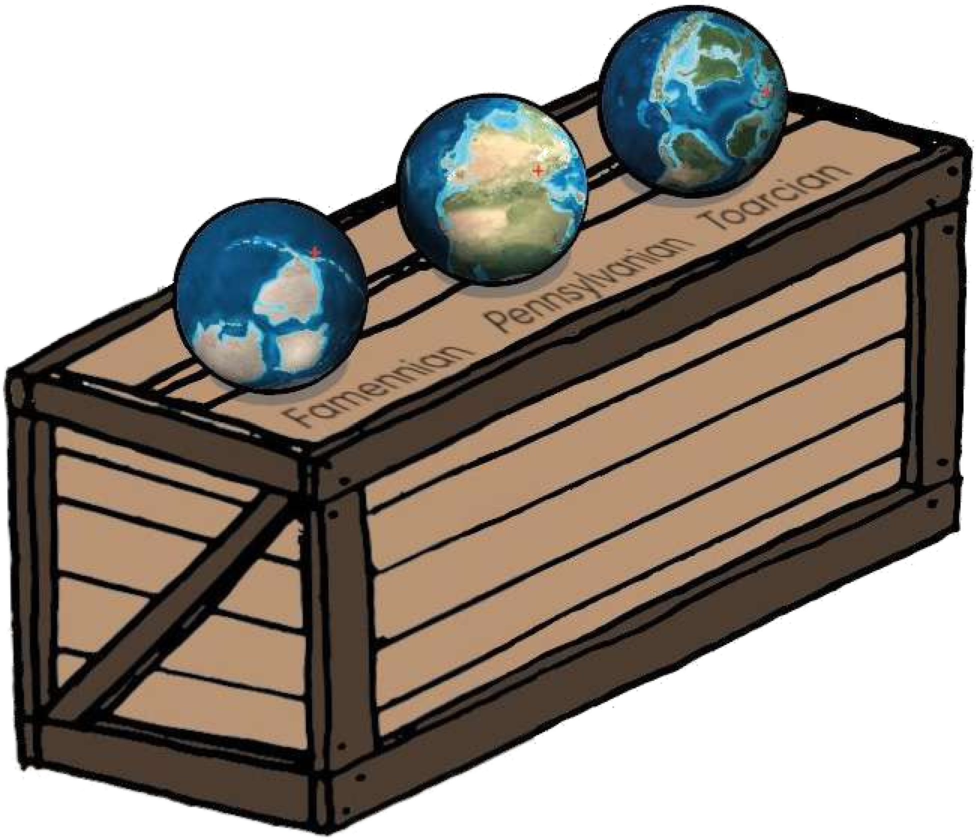
8

Quaternary – Ice ages

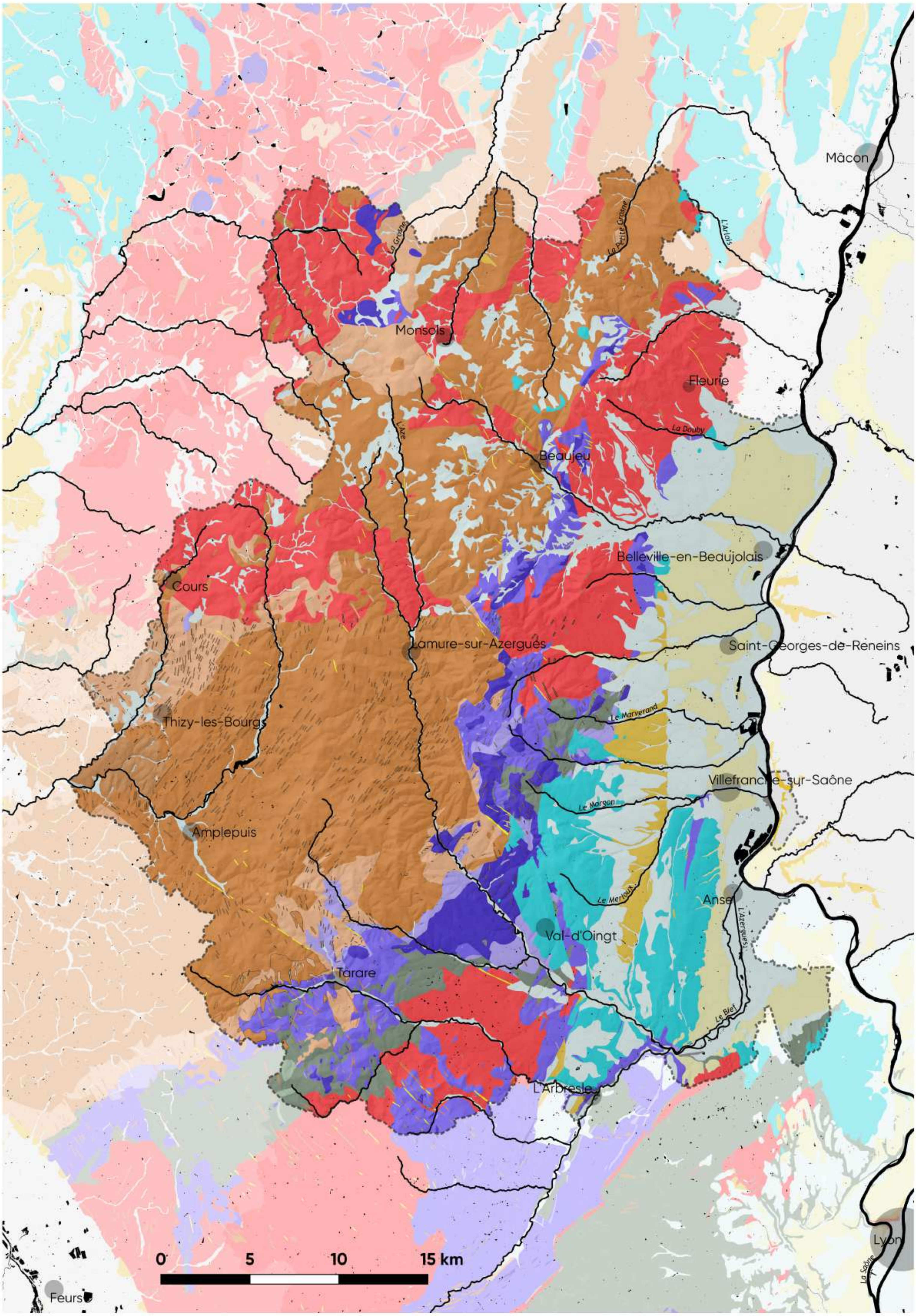
Glacial block
Alluvial deposits of the Saône river
Slag
Plastiglomerate
Cement pebble
Box of «Cristal Tupic»

9

The nine major tableaux in the exhibition are supported by elements that encompass the entire chronology. This is the case with one of the montages designed for the exhibition, which shows the evolution of geography on three globes. Each globe represents the distribution of the continents at key moments in the geological history of the Beaujolais region. The three periods concerned are the Famennian, Pennsylvanian and Toarcian.


Famennian
Pennsylvanian
Toarcian

- Old and recent alluvium and colluvium
- Würm glacial and periglacial formations
- Sedimentary formations and tertiary colluvium
- Triassic and Jurassic sedimentary formations
- Granitic plutons (Pennsylvanian)
- Viséan sedimentary formations (& Upper Carboniferous)
- Pyroclastic deposits, microgranite lavas and veins associated with Upper Viséan collisional volcanism
- Volcanic rocks and Devonian ophiolithic complex
- Devonian hypovolcanic massifs
- Devonian sedimentary formations
- Ante-Devonian metamorphosed sediments
- Ante-Devonian metamorphic bedrock
- Vein-bearing rocks: quartz
- Vein-bearing rocks: **rhyolite**


Mâcon
L'Arlois
La Petite Grosne
La Grosne
Monsols
Fleurie
La Douby
L'Aze
Beaujeu
Belleville-en-Beaujolais
Cours
Lamure-sur-Azergues
Saint-Georges-de-Reneins
Thizy-les-Bourgs
Le Marverand
Villefranche-sur-Saône
Le Morgon
Amplepuis
Le Merloux
Anse
L'Azergues
Val-d'Oingt
Tarare
Le Bief
L'Arbresle
Lyon
La Saône
Feurs
0
5
10
15 km

5.1 -500 My Cambrian

First witnesses

In the south of the Beaujolais region, rocks with a very tortured appearance and many undulations come to the surface. One of these rocks, called micaschist, breaks up into very thin sheets; another, called gneiss, breaks up into grains of sand.

These are the oldest rocks in the Beaujolais region, dating back some 500 million years. 500 million years is a favourable period for the transformation of these rocks, by exposure to great variations in temperature and pressure. This is known as metamorphism.

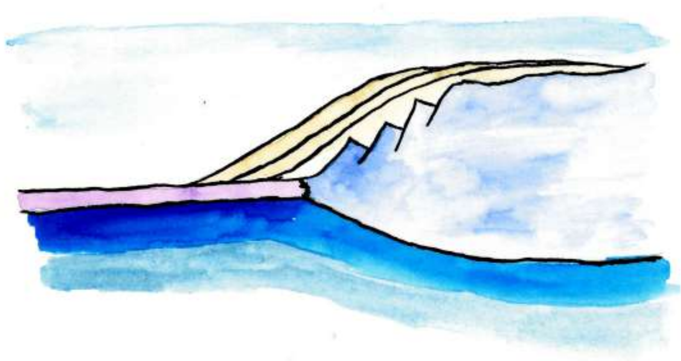
The ancient rocks of the Beaujolais, dating from before 310 million years ago, are all metamorphosed. The initial rock that undergoes metamorphism is called a «protolith». By analogy, we could refer to bread dough as the protolith of bread, which, once baked, differs in texture and structure from the initial dough. In the case of most of the gneisses found in southern Beaujolais (Éveux, Montmelas), the protolith is a granite. As for the micaschists visible in the vicinity of the gneisses, their protolith is a sedimentary rock.

All these clues lead us to imagine the context in which these rocks were formed, in this case a place combining granite, sedimentary rocks and a geological phenomenon leading to the transformation of these rocks.

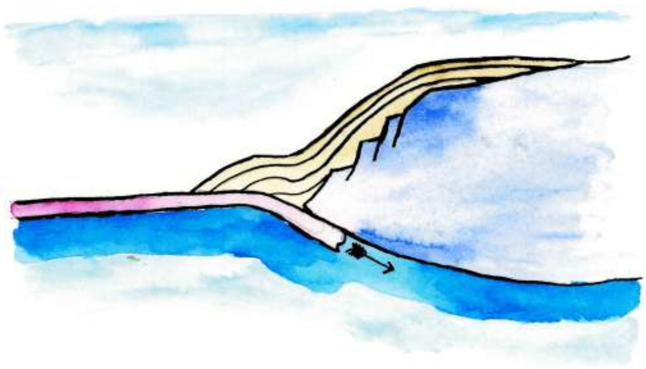
At that time (Cambrian), the early Beaujolais was probably on the edge of tectonic plates. Subduction (the sliding of one tectonic plate under another) was taking place at these boundaries, generating stresses conducive to metamorphism. In this type of context, certain rocks come together and stresses favourable to the formation of gneiss and micaschist are exerted.

Understanding the movement of continents over time allows us to model the location and morphology of continents over the last 600 million years. Models place the Beaujolais not far from the South Pole in the Cambrian.

Cross-section of a continental slope



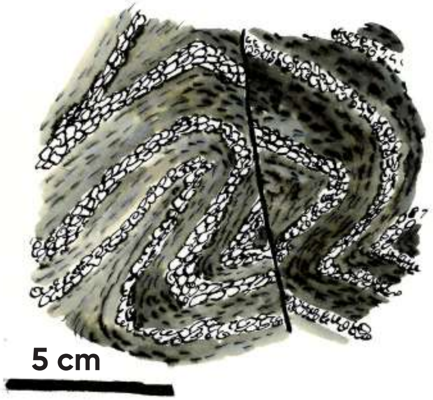
Cross-section of a subducted continental slope



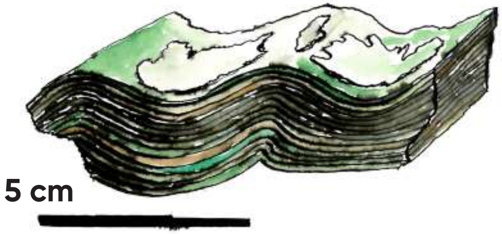
Gneisses and schists are the most representative Cambrian rocks in the Beaujolais. The exhibition includes an orthogneiss (Dareizé gneiss) and a paragneiss (Joux gneiss), one illustrating a metamorphic rock of magmatic origin, the other a metamorphic rock of sedimentary nature. Another facies of the Joux gneiss, impregnated with pyrite, is selected for this tableau.

In the southern half of the Beaujolais region, gneiss forms one of the vineyard terroirs. A bottle of Gamay planted on gneiss (cuvée «Pépites» from the Vignerons des Pierres Dorées cooperative) marks this cultural relationship and underlines the winegrowers' approach to making the most of the local geology.

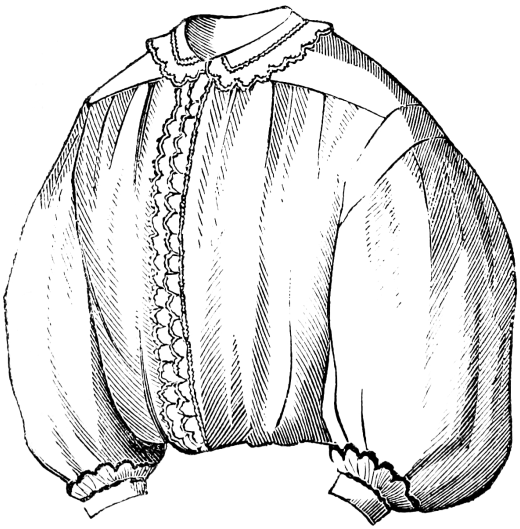
The fabric industry is partly linked to geology, as textile processing requires water that is acidic and relatively free of dissolved elements. The waters of the Trambouze and Turdine basins, which only flow through old mountain ranges, meet this requirement. A muslin garment, a fabric whose production was industrialised in Tarare for the first time, provides an example of the impact of the subsoil on the location of industrial production.



Gneiss « from Dareizé » - Saint-Loup. The white bands are mainly composed of quartz and felsdpaths, while the dark bands tend to contain ferromagnesian minerals (pyroxenes, amphiboles, micas, etc.).



Micaschist - Montmelas



Engraving of a 19th century muslin suit

5.2 -370 My Devonian

Ephemeral sea

150 million years separate us from the first stage of our story. During this gap, which is not covered by the rocks of the Beaujolais region, we know from examining the rocks of neighbouring regions that Western Europe found itself in the middle of a series of collisions between several micro-continents. We also know that subduction was underway, leading to the collision of two continents.

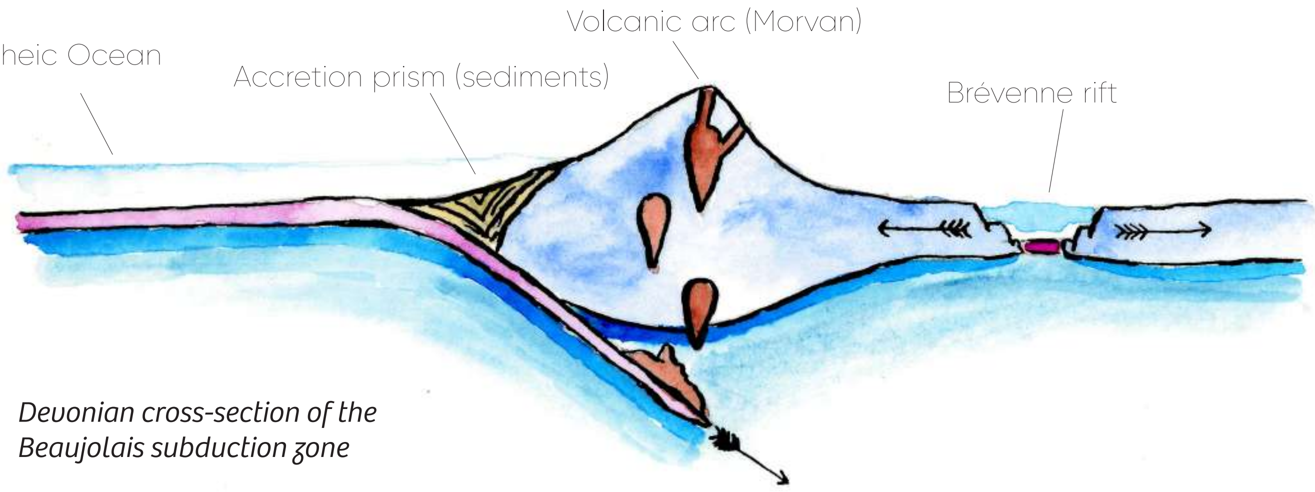
During the Devonian, the land that would become the Beaujolais was located behind a subduction zone. Similar to the Andes mountain range today, the subduction zone formed a highly active volcanic arc on the surface, traces of which can be seen today in the Morvan mountains. The Beaujolais region is also volcanically active, but in a very different way. Subduction causes continents to stretch. Like an overstretched pizza dough, the continents tear apart, creating micro-oceans. These embryonic seas are known as «rifts», and the Beaujolais Sea, created by subduction, is known as the «Brévenne rift». The bottom of these seas is an area of volcanic activity. This is evidenced by the pillow lavas that can be seen on the roads around l'Arbresle. Pillow lavas only form when magma cools on contact with water.

As with all oceans and seas, the Brévenne rift is a basin subject to sedimentation. Rivers probably flow into this sea, bringing with them their baggage of sand and clay. Thick accumulations of sediment in the form of shales can be found around Ternand and Létra. The shales even include lenses of limestone (close to marble).

During the Devonian period, the rocks that make up the rich subsoil of the Beaujolais region also come together. Lying on the seabed, natural chimneys were created by the action of water circulating in the rocks of the oceanic crust.

On its way, the water picks up metals that it releases into these chimneys after heating up. 370 million years later, these metals (copper and iron in particular) were mined in the Beaujolais region.

«Black smokers» (underwater chimneys), the variations in colours can be explained by fluctuating concentrations of sulphur, ferro-magnesium minerals, non-ferrous metals, etc.
The ensemble measures two to three metres in height.



Devonian cross-section of the Beaujolais subduction zone

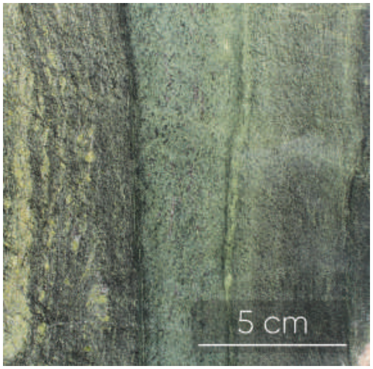
The Devonian is the period that left the most complex remains in the Beaujolais. It includes volcanic facies, plutonic facies and sedimentary horizons. All of the Devonian geological units in the Beaujolais are metamorphosed, making a brief summary of this geological stage even more complicated. The exhibition presents the relics of a few Devonian geological facts.

The Devonian sub-unit known as the «Brévenne» is detailed through four rocks: the green schist (l'Arbresle), the gabbro (Rivolet), the serpentinite (Légny) and finally the sulphide cluster (Saint-Pierre-la-Palud). The first three form an ophiolitic suite, a sample of oceanic crust. The last, the sulphide cluster, is a special feature linked to this same procession. The sulphide cluster, composed mainly of pyrite, has found industrial use in the manufacture of sulphuric acid (a bottle of acid is also on display).

In comparison, the green schist (metabasalt) from l'Arbresle is presented alongside a contemporary basalt from the Azores Geopark.

The Devonian era in the Beaujolais region produced a large number of plutonic rocks, in particular major dioritic massifs (often metamorphosed). Winegrowers call these diorites «Pierres Bleues» (blue stones), and some Beaujolais crus, such as Côte de Brouilly, reflect this magmatic past. A block of metadiorite from Mont Brouilly is placed next to a bottle of «Le Volcan» (Domaine de Joncy). This underlines the essentially plutonic/hypovolcanic nature of the rocks on Mont Brouilly.

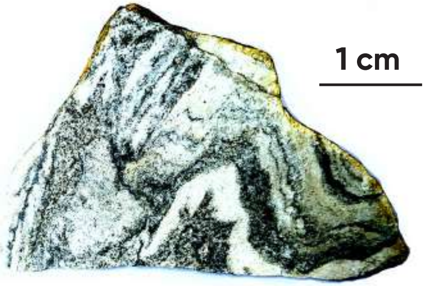
A final rock completes the Devonian picture, the «Ternand marble» (quartzite limestone), a marker of sedimentary activity.



Green schist (metabasalt)

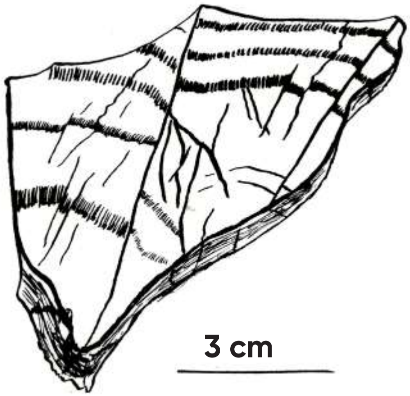
Current Azores basalt

Gabbro - Rivolet



Sulphide cluster sample - Chessy

Serpentinite - Légny



«Ternand marble (siliceous limestone) - Mont Jonc quarry

5.3 -335 My Lower Carboniferous

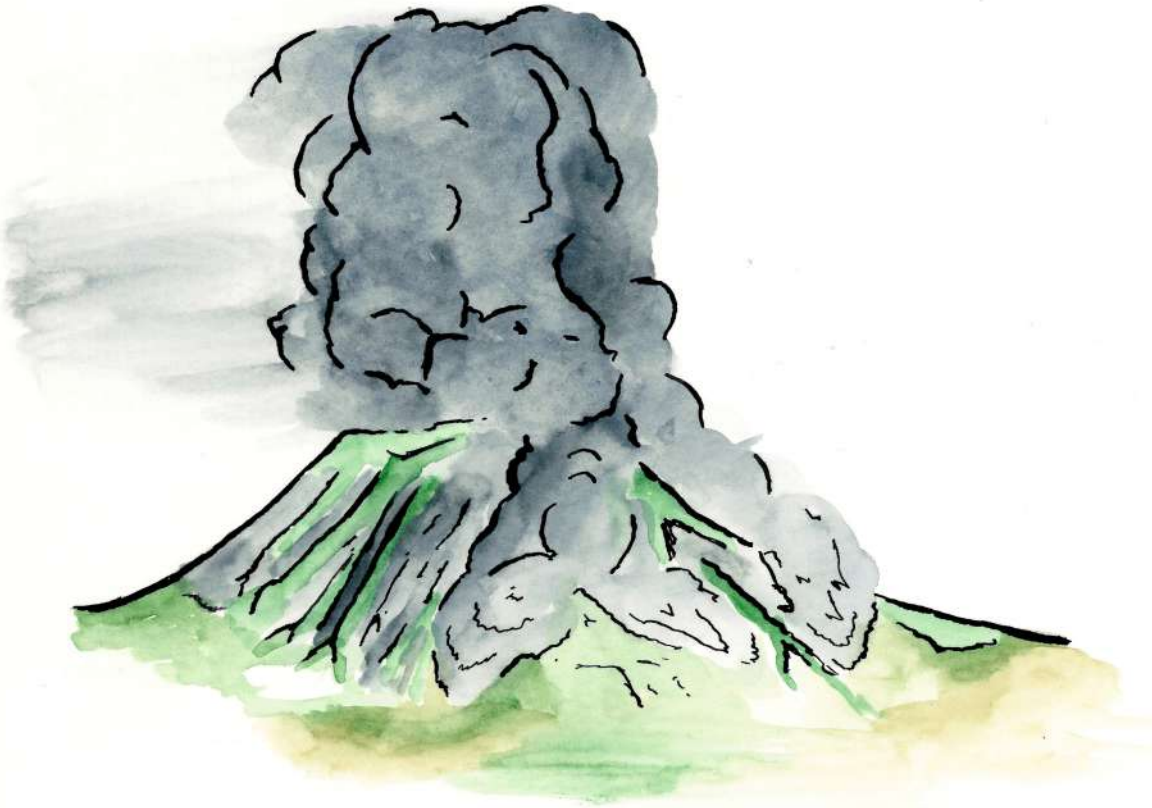
Ash and water

During the Carboniferous period, from 346 My to 300 My, subduction culminated in the meeting of two continents, bringing to a close a series of continental collisions that shaped early Europe. This meeting between the two continents resulted in the closure of the Brévenne Sea, the formation of a mountain range known as the Hercynian or Variscan chain and the onset of volcanism typical of collision zones.

The Beaujolais landscape at the beginning of the Carboniferous period resembled the shores of large lakes (or inland seas) bordered by volcanoes. These lakes or inland seas, like all natural basins, filled up with sediment. The north and west of the Beaujolais region are partly underlain by accumulations of sand and silt deposited in this context (which have since consolidated into rock). Some layers even show traces of the vegetation of the time, in the form of coal seams.

Carboniferous sediments are omnipresent over a large part of the Beaujolais region. However, they are obscured on the surface by a blanket of volcanic rock.

Collision volcanism involves very acid magmas (acid meaning rich in quartz) and therefore very viscous. Today's volcanoes releasing this type of magma allow us to imagine violent eruptions in the Carboniferous. The eruptions are triggered by an increase in pressure in the magma chamber until a certain threshold is reached, at which point the volcanic edifice finally explodes, spewing large quantities of ash and other incandescent particles into the atmosphere. When they fall back, this «pyroclastic» debris (ash, volcanic bombs, lapilis, etc.) can weld together depending on their residual heat. The fallout from the volcanoes of the Beaujolais region piled up over several hundred thousand or even several million years, forming deposits more than 300 m thick. These deposits are known as «pyroclastic tuffs».



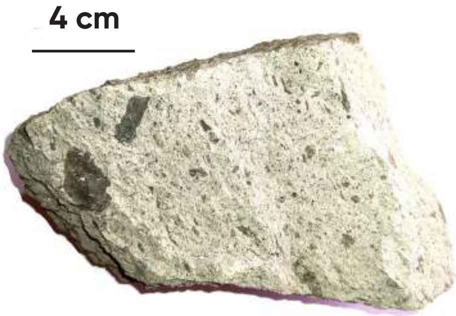
Cross-section of the collision zone at Beaujolais level in the Lower Carboniferous

The Carboniferous, and more specifically the Viséan (-340 My), is the geological period that has had the greatest impact on the geology of the Beaujolais region. Two-thirds of the Beaujolais surface is underlain by Viséan rocks.

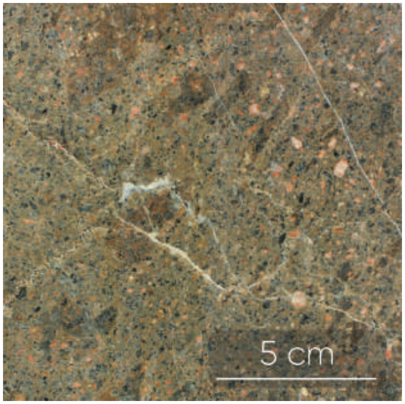
In chronological terms, the Viséan period began with major sedimentary deposits. One rock from this period is a pudding containing large limestone pebbles. A cup-shaped pebble is also on display, bearing the scars of tectonic disruption during the Carboniferous period. Samples of fossilised plants (ferns, calamites and horsetails) highlight the sedimentary nature of the early Viséan formations.

Most of the formations in question are volcanic. Three objects illustrate this: a block of pyroclastic tuff, a block of rhyolite and a volcanic bomb. As the tuffs are relatively metamorphosed, a current block of fiamed tuff (from the Azores Geopark) is on display.

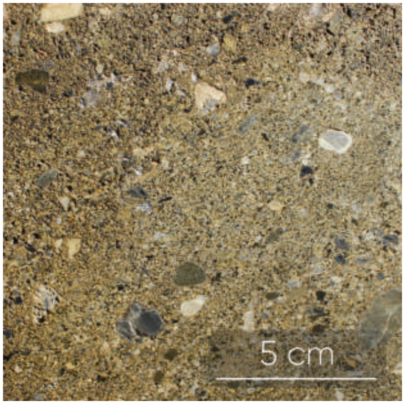
In terms of the uses to which man has put the rocks in question, the Carboniferous tableau refers to the production of aggregate. Tuffs and rhyodacites were indeed used as aggregate in roadworks (a block of asphalt is on display).



Current Azores tuff



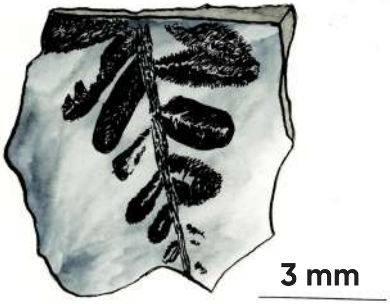
Viséan tuff from the Beaujolais



Beaujolais Viséan micro-conglomerate

Carboniferous rhyolite (acid lava) - Tarare

Beaujolais Viséan volcanic bomb



Fossil leaf - hamlet of Glaizé, commune of Sainte-Paule

Asphalt incorporating volcanic tuff aggregates

UK anthracite block

5.4 –310 My
Upper Carboniferous

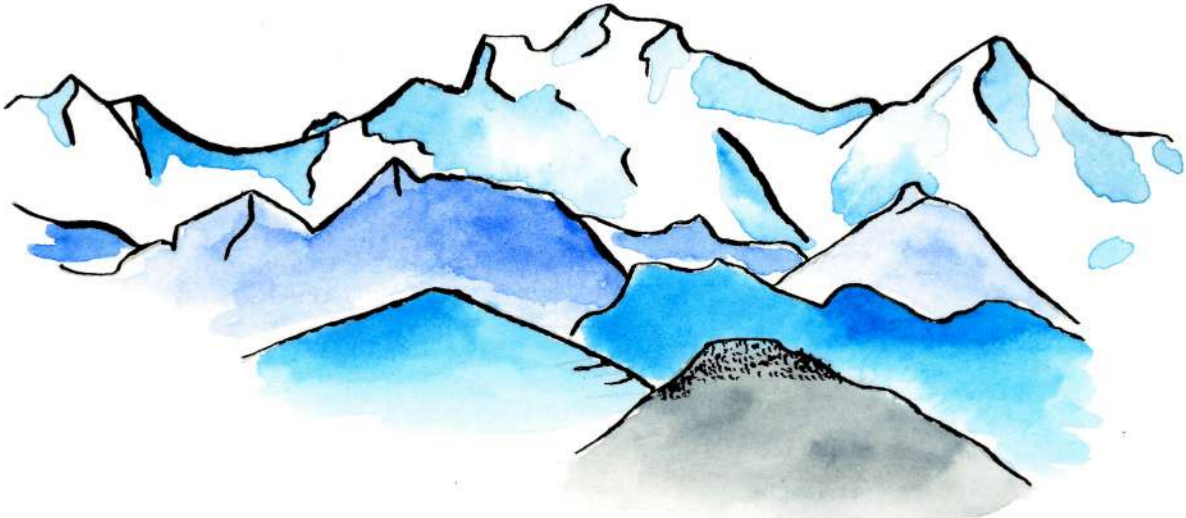
High mountains & plutons

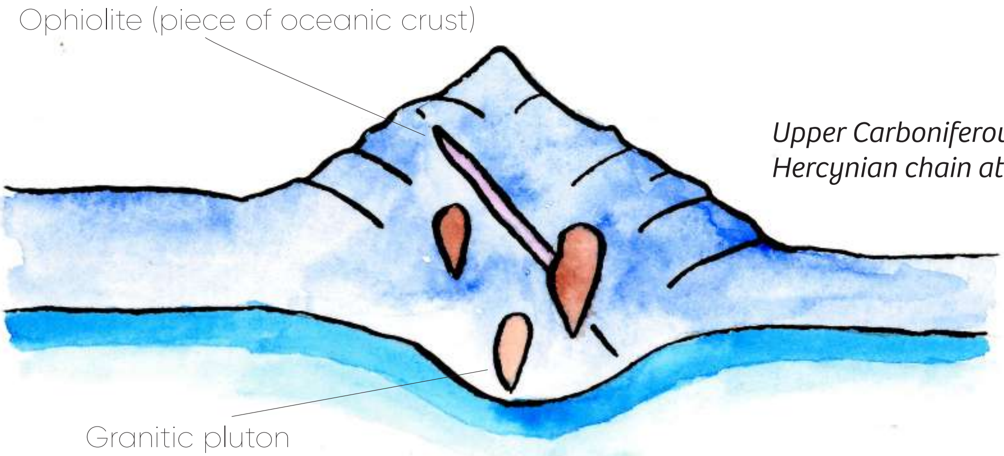
During the Carboniferous, the continents continued to move closer together and volcanism faded. Pressure continued to build up between the continents, resulting in a thickening of the mountains. The Hercynian chain emerged as a vast mountain range comparable to today's Himalayas.

Deep down, masses of magma cool down very slowly. Geologists call these large pockets of magma trapped in the Earth's crust «plutons». It takes several hundred thousand or even several million years for plutons to cool completely. Granite is the rock formed in these plutons. During this long cooling phase, the plutons affect the rocks they intersect. With temperatures approaching 1,000°C, a halo of heat is released around them, baking the rocks they encounter. This is known as contact metamorphism. Such high temperatures can restructure rocks and create new minerals. Garnet is one such mineral formed when certain rocks are exposed to heat.

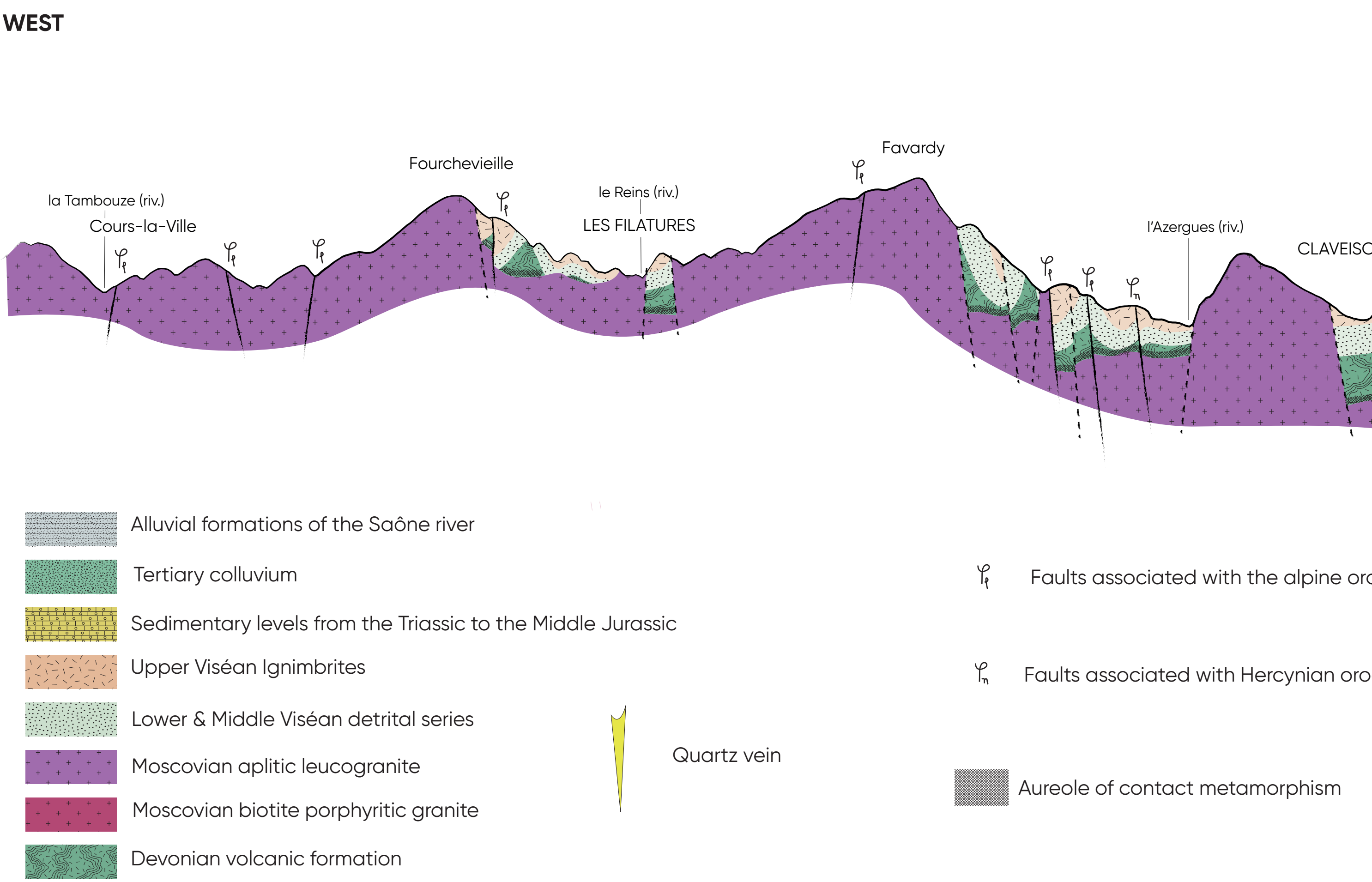
The rocks in the Hercynian chain, particularly those buried several kilometres below the surface, undergo transformations in response to the very high pressures generated by continental collision. Most of the ancient rocks in the Beaujolais (pre-Carboniferous) acquired their metamorphic character during the Hercynian orogeny (the term «orogeny» refers to the formation of mountains).

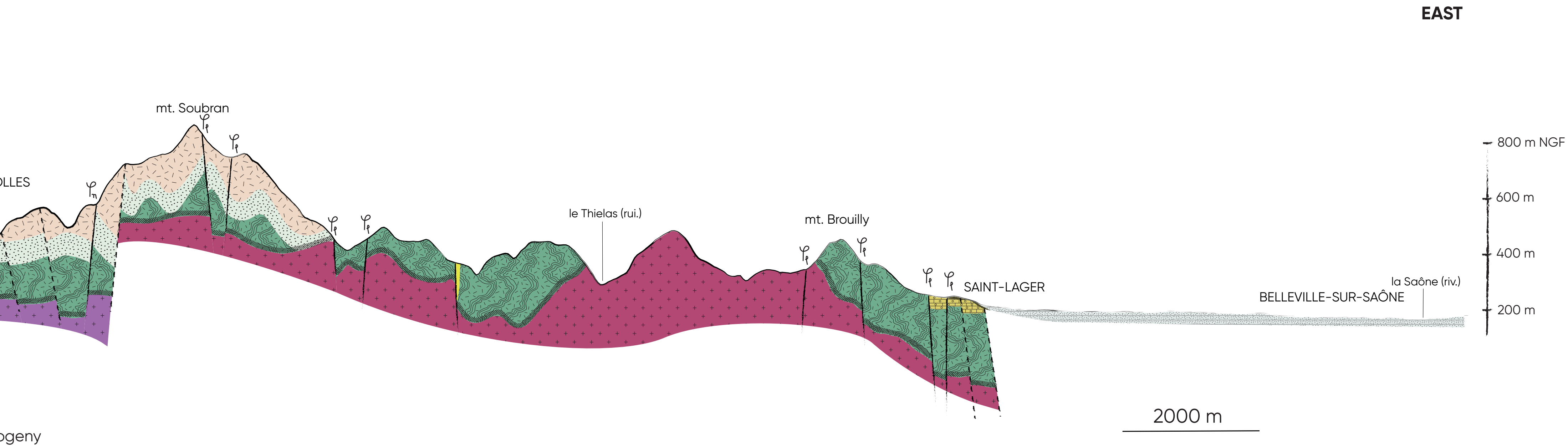
By acting as veritable reactors, the plutons set in motion «hydrothermal» fluids (literally hot water). These fluids, made up of water and quartz, are loaded with chemical elements as they circulate within the plutons and surrounding rocks. The fluids travel through the dense network of fissures created by the plutons and the orogeny, covering their path with quartz deposits. All these fissures eventually fill up with quartz and other minerals, such as barite and fluorite, forming veins that Beaujolais miners have been exploiting since Antiquity.





Upper Carboniferous cross-section of the Hercynian chain at Beaujolais level


WEST
la Tambouze (riv.)
Cours-la-Ville
Fourchevieille
le Reins (riv.)
LES FILATURES
Favardy
l'Azergues (riv.)
CLAVEISC
Alluvial formations of the Saône river
Tertiary colluvium
Sedimentary levels from the Triassic to the Middle Jurassic
Upper Viséan Ignimbrites
Lower & Middle Viséan detrital series
Moscovian aplitic leucogranite
Moscovian biotite porphyritic granite
Devonian volcanic formation
Quartz vein
Faults associated with the alpine oro
Faults associated with Hercynian oro
Aureole of contact metamorphism



ogeny

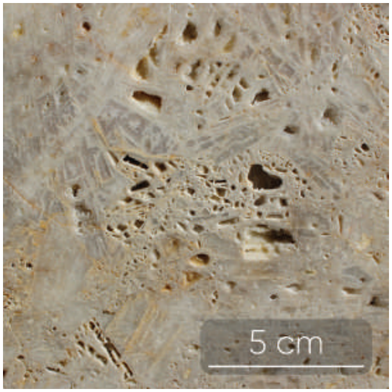
geny

Geological section of the Beaujolais region near Claveisolles

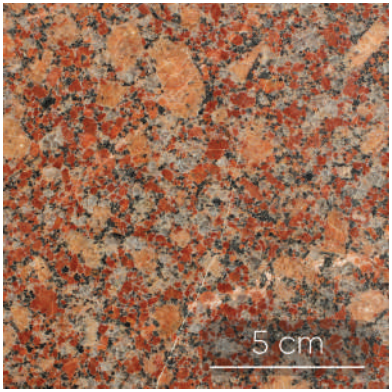
The vast Hercynian chain shaped the Beaujolais once again in the Carboniferous period. In the second half of this period, granitic plutons penetrated the earth's crust and profoundly affected the substratum. The emblematic Upper Carboniferous rock of the Beaujolais is granite. Two types of granite are widespread in Beaujolais, both in the subsoil and in old buildings. The red granite known as «Odenas-Fleurie» and the grey granite known as «Saint-Étienne-des-Oullières» are on display. A bottle of «Granitic» from the Fabien Forest estate illustrates a granite terroir, granite being the most common rock in the Beaujolais crus vineyards.

The formation of granite plutons gives rise to numerous veins of mineralised and non-mineralised quartz. The exposure incorporates two blocks from veins in northern Beaujolais, one purely quartzite, the other baryto-fluorite. A mineralogical sample of galena represents the other type of vein (BPGC type) typical of this period.

The minerals extracted from these veins had many uses. For the exhibition, parallels are drawn between, on the one hand, the baryto-fluorinated vein and dentrifrice (rich in fluorine) and, on the other, pyromorphite/galena and a fishing sinker.



Hydrothermal quartz



« Odenas/Fleurie » granite

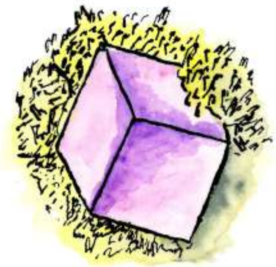
« Saint-Étienne » granite

4 cm

Galena

3 cm

Barite



1 mm

Fluorite cube - Lantignié

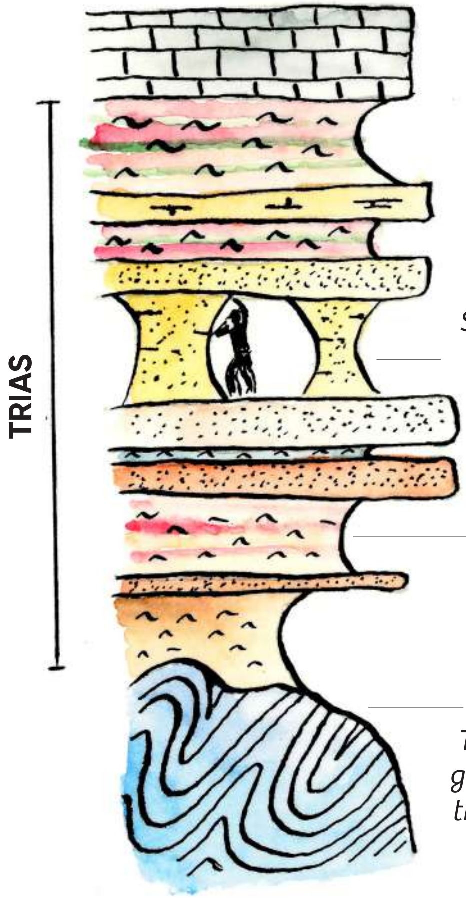
5.5 -250 to 201 My Trias

Erosion

This stage in the geological story of the Beaujolais region takes us 70 million years after the surrection of the great Hercynian massif, 70 million years during which the agents of erosion (rain, wind, frost) dismantled the mountains. In the Beaujolais region, thick layers of indurated sandstone are a reminder that it only took a few tens of millions of years to reduce one of the largest mountains on Earth to dust.

Sandstone, which can be more than twenty metres thick, is a sedimentary rock composed of grains cemented together. The Beaujolais region is home to a wide variety of sandstones, differing in grain size and cement composition (limestone, silica, clay, etc.). Whatever the type of sandstone, it was deposited in a coastal or estuarine environment (possibly a delta). Coarse sandstones (with large grains) indicate strong hydrodynamic conditions (areas with currents and wave action), while fine-grained sandstones indicate a more tranquil depositional context. It is on these fine sandstones that protodinosaur footprints can be found, preserved thanks to the covering by another layer of sand.

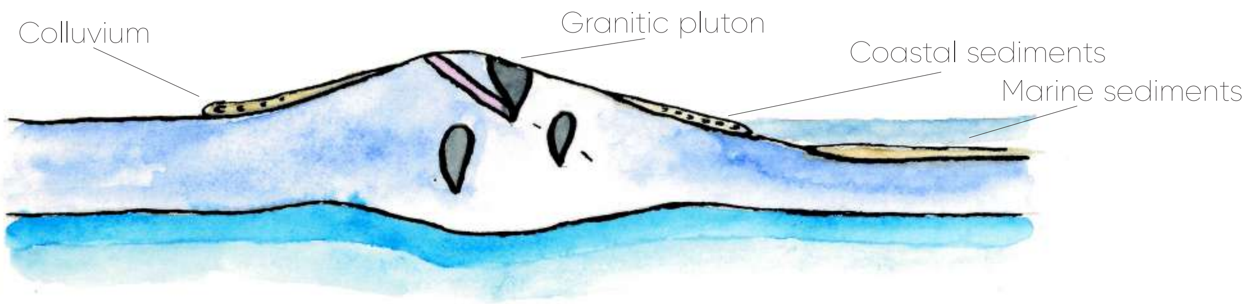
The location of the deposition zone on the coast is confirmed by the recurrent observation of «ghosts» of salt. When puddles of water evaporate on the sand, salt crystals (sodium hydroxide) form. Over time, these crystals are replaced by limestone, silica or other elements, leaving a visible negative of the salt crystal.



Some levels of sandstone are very weakly consolidated, easily crumbling. People have exploited these sandstones in underground quarries (known as «morguières») to extract sand for mixing with lime to make mortar.

Among the rocks of the Triassic period are the bari-coloured clays (highly coloured). They mark a context of very low hydrodynamics (coastal lagoon).

Crystalline bedrock. The Triassic deposits rest on the ancient Beaujolais bedrock. The contact between the basement and the first Triassic sediments has a very irregular morphology, synonymous with a period of erosion between the formation of the basement and these sediments (the terms «erosion surface» and «stratigraphic unconformity» are used to designate this type of surface).

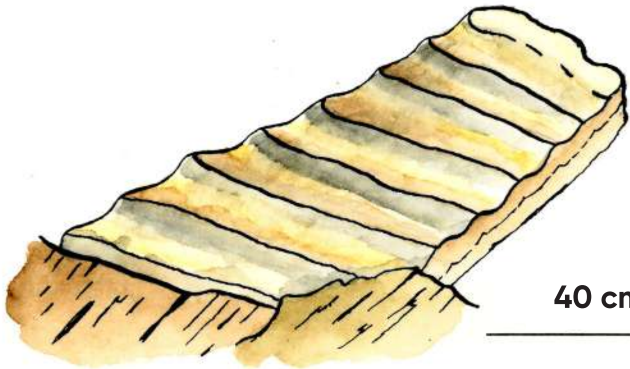


Cross-section of the Hercynian chain being eroded, near the Beaujolais region

The Triassic marked the end of the Hercynian period in the Beaujolais region. The mountain ranges underwent intense erosion, which began in the Carboniferous period. The Triassic period in the Beaujolais is best seen in the sandstones and variegated clays.

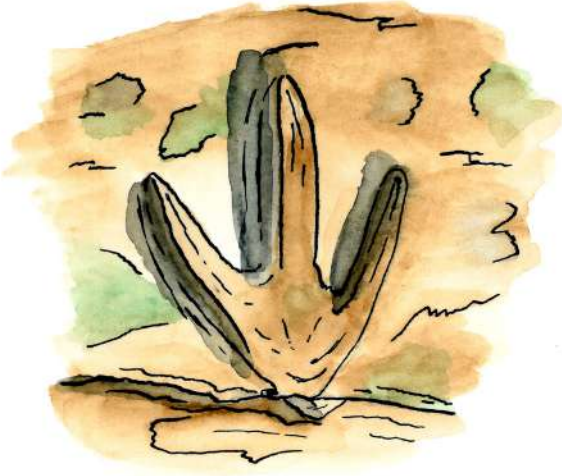
The exhibition features a sandstone block with beach wrinkles, a more clayey sandstone facies and a reptile footprint cast from the Avenas sandstone in northern Beaujolais.

Sandstones are used in construction, but also because of their abrasive nature. A piece of a grinding wheel embodies this characteristic of sandstone.



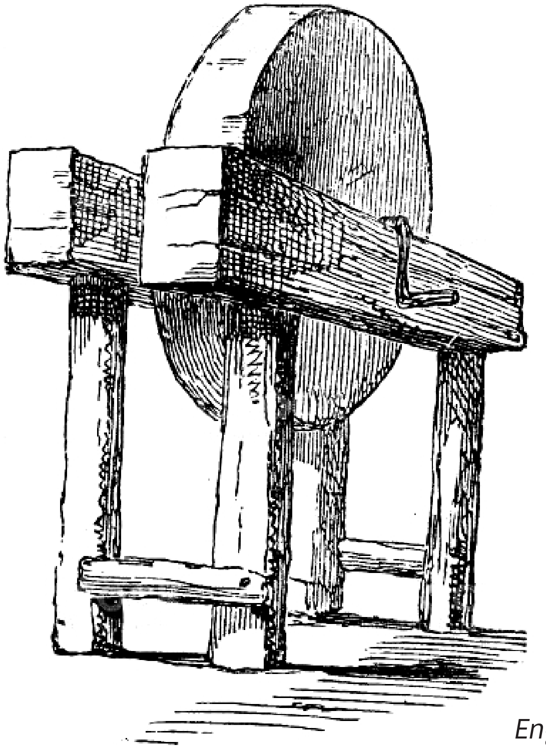
40 cm

Current ripples on a sandstone slab - Chasselay.
Some sandstone slabs show current ripples, reminiscent of the patterns seen on today's beaches.



2 cm

Tridactyl reptile footprint - Avenas



Engraving of a grinding machine incorporating a sandstone wheel

5.6 -201 to 160 My Jurassic

Ebb & flow

From the Lower Triassic to the Middle Jurassic, sea levels change, with some periods experiencing transgressions (rise in sea level) and others regressions (fall in sea level). Variations in eustatic level (a term synonymous with sea level) have two possible origins: climatic and geodynamic.

In the short term, that of a few million years, the climatic origin is the most obvious. As land ice melts, it increases the volume of the oceans, logically raising global sea level. These variations are of the order of a maximum of a hundred metres. This phenomenon of transgression caused by melting ice is accentuated by the expansion of the oceans (in warm periods, the oceans swell slightly).

In the long term, that of several tens of millions of years, the geodynamic cause predominates, with variations in sea level of up to 300 metres. Such large variations are made possible by the shape of the seabed. The oceans are criss-crossed by ridges, dynamic mountain ranges where the oceanic crust is formed. These mountain ranges are responsible for the opening and widening of the oceans. A so-called «fast» ridge, meaning that an ocean opens up faster, represents a much larger mountain range than a «slow» ridge. These differences in volume, and therefore in the speed at which the oceans open up, have an impact on global sea levels.

In the Lower Jurassic, the North Atlantic Ocean opened up rapidly, causing sea levels to rise. The Jurassic rocks of the Beaujolais region record these variations through various sedimentary horizons, such as the oolithic limestones typical of shallow areas, or the marls typical of deep areas.

During the Triassic period, the Beaujolais region was on the coast. The Jurassic, which followed the Triassic, marked the transition to a more open marine environment, producing a wide variety of limestones and marl levels.

During the Sinemurian (195 My), one of the earliest ages of the Jurassic, a limestone mud very rich in gryphae shells (relatives of oysters) accumulated over part of the Beaujolais and Monts d'Or regions. The very puffy structure of the limestone indicates turbulence caused by wave action. Based on these marks, we can estimate a depth of deposition of between 5 metres and several dozen metres.

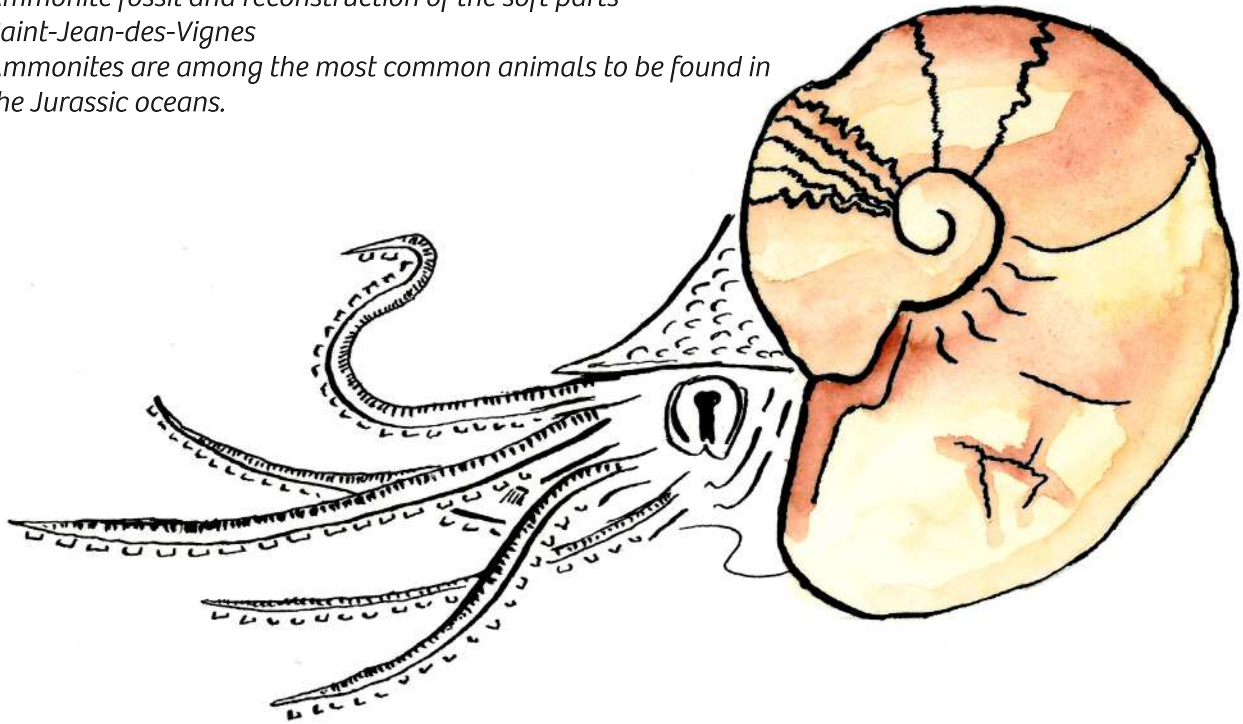
Over time, the mud consolidates, giving rise to solid limestone (this is diagenesis, the transition from sediment to sedimentary rock). Gryphae limestone's tendency to be cut into slabs and its high resistance to wear make it the material of choice for doorways and stair treads in old buildings.

Cross-section of the continental shelf at Beaujolais level during the Lower Jurassic period

The rocks of the next stage, mainly marl, symbolise a strong marine transgression. The Pliensbachian (-186 My) left around sixty metres of grey marl. The fineness of the sediment leading to the marl (a mixture of limestone and clay) is only possible in a very calm depositional context, not subject to waves or currents. Only deep environments meet these sedimentation conditions, and we can therefore assume a depth of between 100 and 200 metres.

Some geological periods saw transgressions, while others saw a return to a more coastal context. This is the case of the Aalenian (-174 My), the geological stage during which the famous «golden stone» was formed.

This is a limestone composed mainly of ossicles of crinoids, animal debris (star-shaped or circular). This is known as «ossicle limestone». The predominance of bioclasts (debris from organisms) indicates sedimentation in a very turbulent environment, with a tendency to break up the shells. The stratifications visible in this limestone are evidence of strong currents. The stratifications are very often oblique, themselves truncated and covered by other levels with oblique strata. These strata are characteristic of underwater dunes shaped by currents.

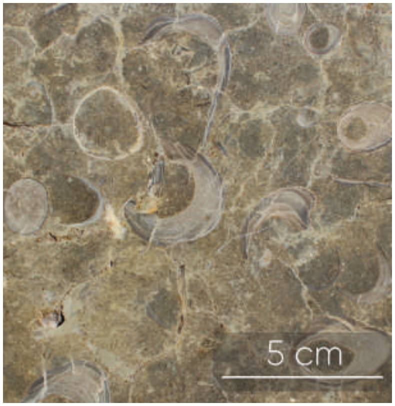


Ammonite fossil and reconstruction of the soft parts
Saint-Jean-des-Vignes
Ammonites are among the most common animals to be found in the Jurassic oceans.

The rocks of the Jurassic record a coastal and marine past. Depending on their composition, structure and the fossil fauna they contain, these rocks tell us about the evolution of the coastal environment in the Beaujolais region. The exhibition includes four rocks from the Beaujolais Jurassic: gryphae limestone, marl, oolithic limestone and ossicle limestone.

Each of these rocks is associated with one or more uses. White oolithic limestone (known as «Lucenay») is highlighted for its ornamental qualities alongside sculpture. The marl is associated with a traditional terracotta tile from Oingt. Ossicle limestone is used for a number of purposes: cement bags, paper reams and automotive plastics (where calcite is used as an additive) and, finally, Palaeolithic carved flints (the flint banks in the limestone provide a material suitable for making tools).

The exhibition also features fossils representative of the Jurassic fauna of the Beaujolais region.

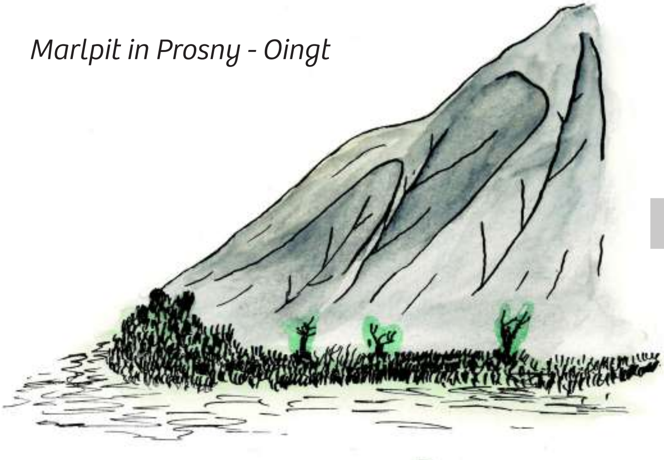


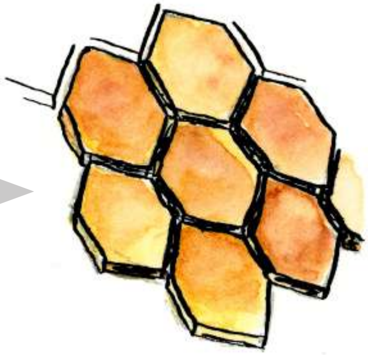
Gryphae limestone

Toarcian ammonite fragment with bite marks

Oolithic limestone

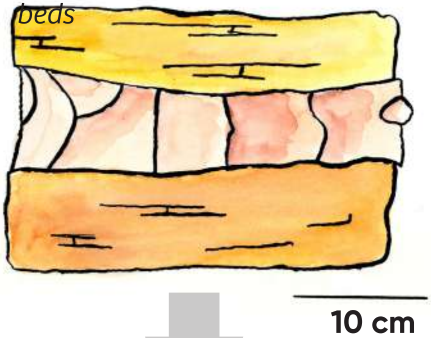
Marlpit in Prosny - Oingt



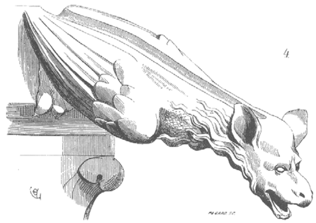


Terracotta tiles

Limestone with ossicles of crinoids and flint beds



Cut flint



5.7

-157 to -33 My

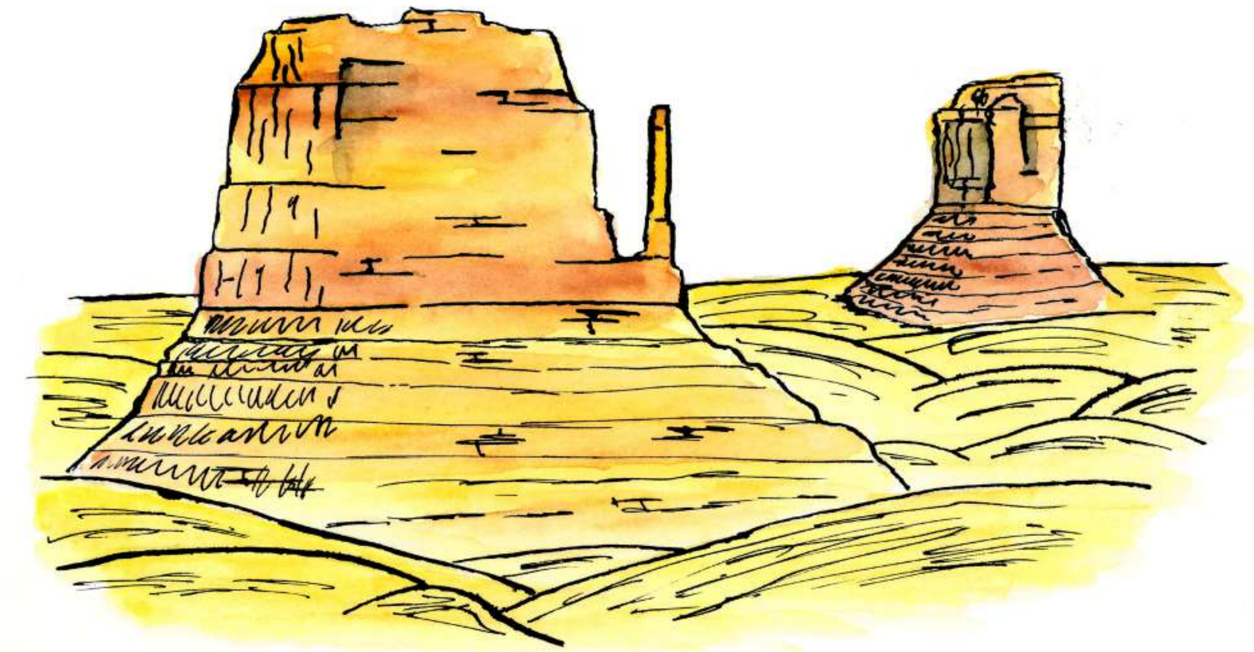
Upper Jurassic & Cretaceous

Silence

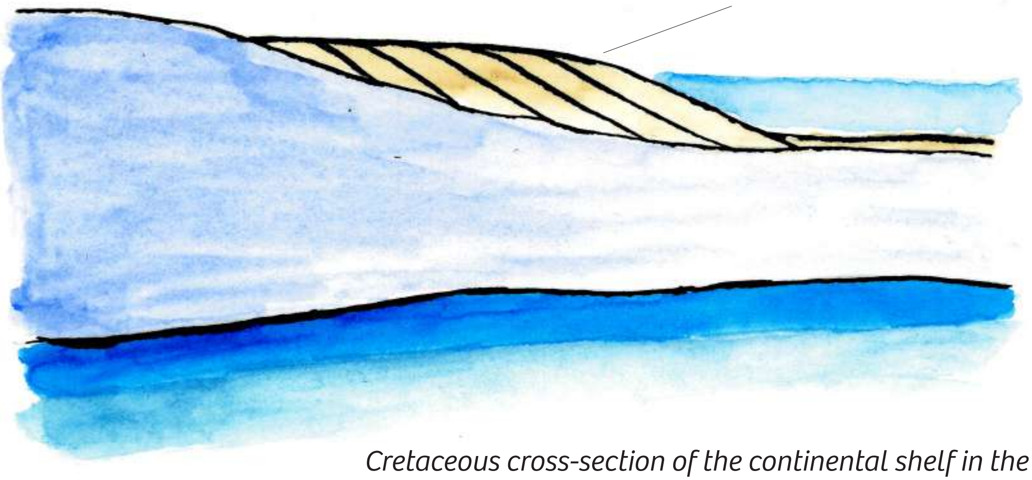
The geology of the Beaujolais alternates between evidence of past eras and stratigraphic silences. The most recent Jurassic rocks were followed by a gap of 120 million years, 120 million years during which no rocks were found to bear witness to the Beaujolais landscape. There are two possible explanations for this: either the land was out of the water during this period (and therefore no sediments were deposited), or the land was underwater but the sediments subsequently disappeared.

In the Cretaceous, the second period of the Second Era, the global sea level continued to rise. There were significant drops, but the general trend was upwards. Despite this marine transgression, involving sedimentary deposits, the Beaujolais region has not preserved the slightest trace of these sediments.

The absence of Cretaceous sedimentary rocks could be explained by erosion. From 65 million years ago, when the dinosaurs disappeared, the global sea level dropped. The sediments accumulated during the Cretaceous period were exposed to the open air and consequently became subject to erosion. In just a few tens of millions of years, the agents of erosion destroyed all the sedimentary deposits of the Cretaceous period.



In the Cretaceous, the Beaujolais region probably resembled a plain punctuated by scattered landforms, the remains of eroding sedimentary massifs. Monument Valley in the United States provides a good example of landforms that bear witness to ancient sedimentary deposits.



Cretaceous cross-section of the continental shelf in the Beaujolais

5.8 -33 to -3 My

Oligocene

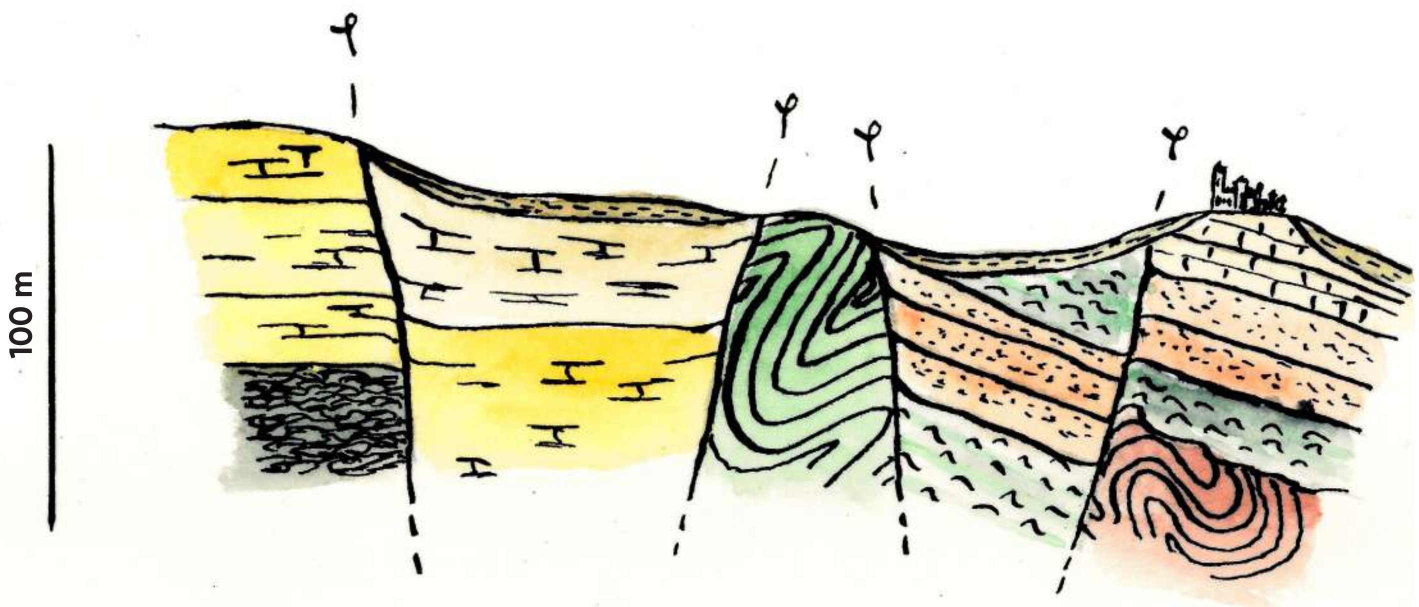
Echo of the Alps

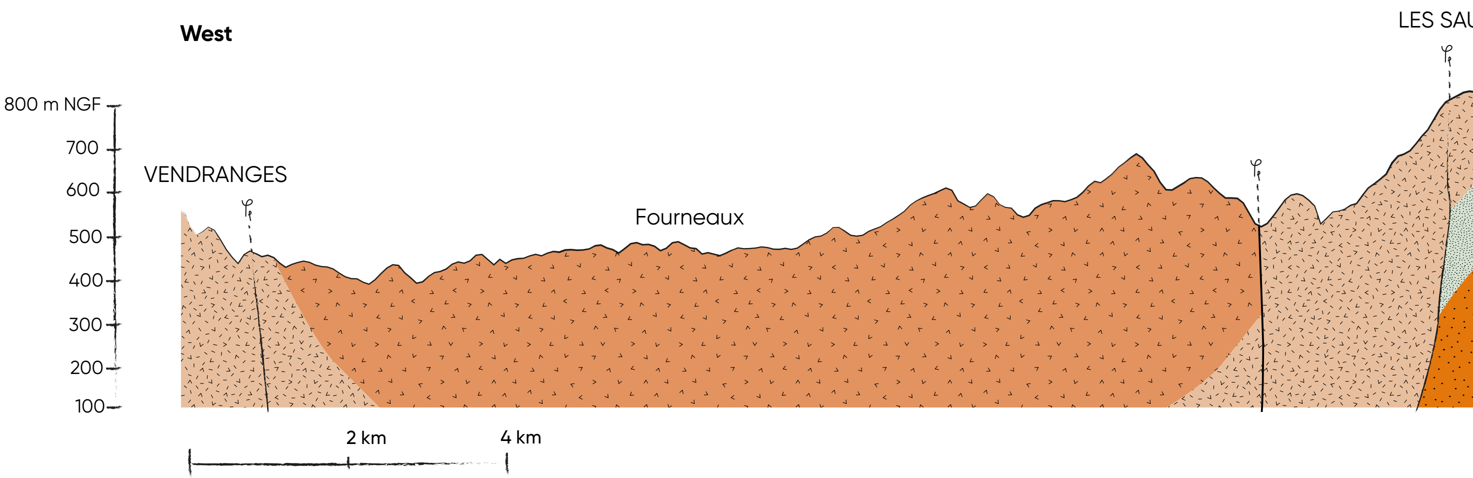
This is the stage that largely shapes the current morphology of the Beaujolais region. The Alps and the Pyrenees rose almost simultaneously, producing a whole series of deformations in the surrounding regions.

The Massif Central still bears the scars of the thrust of the Alps. Indeed, as the Alps grew on one side, blocks the size of entire regions collapsed on the other. This is the case of the Limagne plain, the Forez plain and the Dombes plain. In other words, the Beaujolais mountains did not rise, but the surrounding regions collapsed.

It was also during this period that pebble-rich sediments were piled up in the Pierres Dorées and Arbresle areas. These pebbly rocks are known as «puddingstone» and are found at the bottom of watercourses in turbulent environments.

Typical geological section of the Pierres Dorées area.
The repetition of collapse basins generates a vast network of fractures, particularly visible in the Pierres Dorées area. The complex interplay of faults brings rocks of different ages into contact with each other and contributes to the morphology of the landscape.





Alluvium and colluvium — **Quaternary**

Limestone and clayey-siliceous limestone — **Dogger**

Limestone & marl — **Lias**

Sandstone, carbonate sandstone and clay — **Trias**

Pink Ignimbrite («Brou» unit)

Ignimbrite («Picard tuff» unit)

Volcanic tuff and rhyolite («Brou» unit)

Upper Viséan

Detrital series: arenite and siltstone

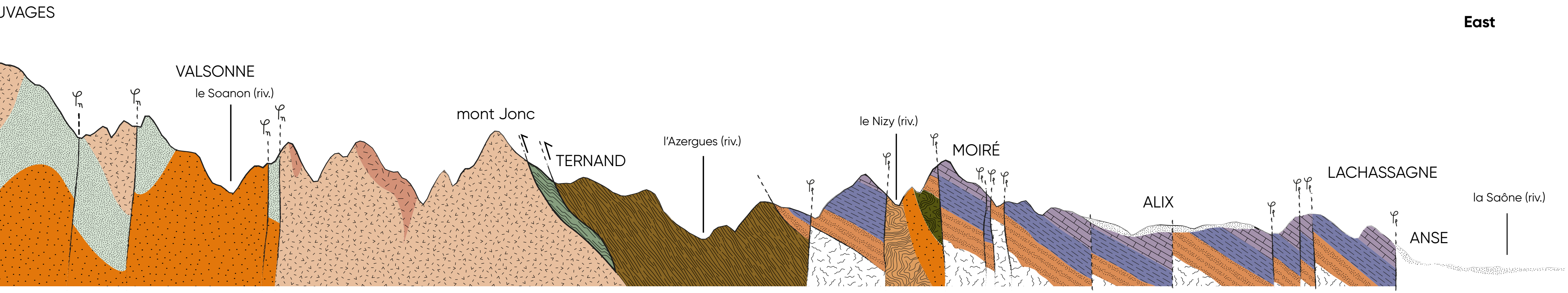
Ophiolithic series: amphibolites, gab

Diorite and dolerite veins («Saint-Vé

Metapsammite with multi-decamet

Graywackes and basic lavas («Valsc

Gneiss (known as «from Affoux»)



bbro, basalt, etc.

erand» unit)

tric marble lenses («Ternand-Cruizon» unit)

onne» unit)

Lower Viséan

Silurian-Dévonian

Cambrian-Ordovician

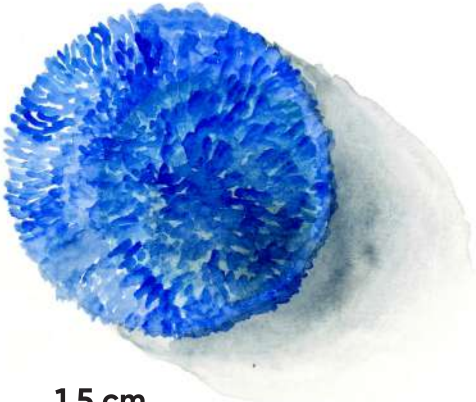
Faults associated with the alpine orogeny

Faults associated with Hercynian orogeny

Geological section of the Beaujolais region near Anse

The formation of the Alps was accompanied by profound tectonic disruptions across the Massif Central. The very morphological structure of today's Beaujolais is inherited from the Alpine orogeny. This morphology can be summed up as a set of normal faults forming a staircase descending eastwards towards the Saône river.

The faults are privileged interfaces in the genesis of certain minerals. Water flows easily through these faults, allowing exchanges between a wide variety of rocks. Two of the minerals that are emblematic of the Beaujolais region were formed near these faults: azurite from Chessy (or chessylite) and romanechite from Romanèche-Thorins. The first of these minerals was used to produce copper, while the second, a manganese oxide, was used for a number of purposes, including in steelworks (anti-corrosion treatment), glassmaking (glass whitening) and ceramics (pigmentation of porcelain).



1,5 cm

Azurite - Chessy

3 cm

Azurite-impregnated sandstone - Chessy

Copper pipe

5 cm

Romanechite

Porcelain

3 cm

Manganese calcite - L'Arbresle

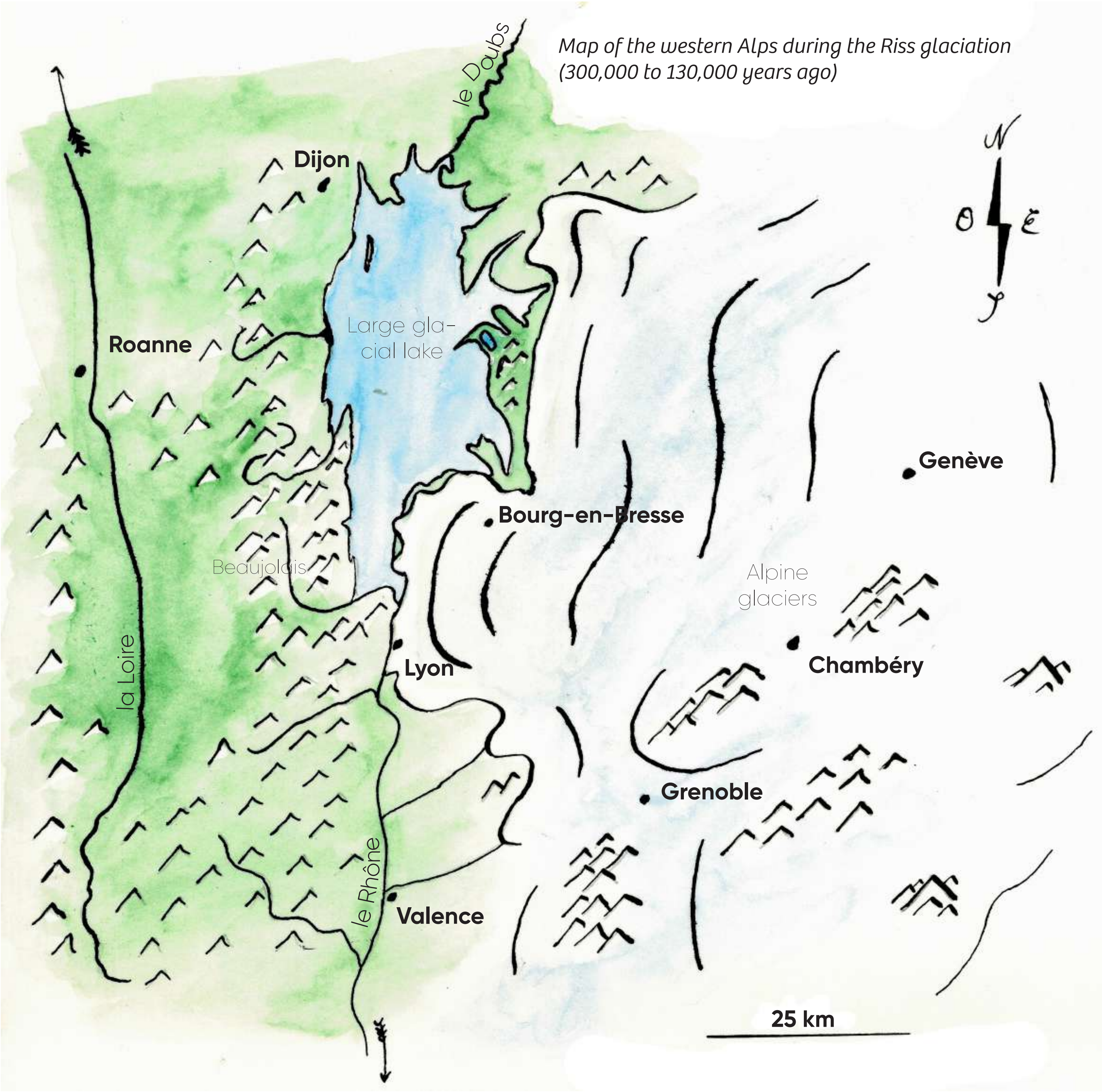
5.9 -3 My to -10 000 years Quaternary

Ice ages

In the Quaternary, Europe underwent a phase of alternating cold periods, known as «glacials», and warm periods, known as «interglacials». During glacial periods, climatic conditions were conducive to glaciation, in this case the extension of ice-covered surfaces.

When Neanderthal man lived in the Beaujolais region between -300,000 and -130,000 years ago, he wandered through a landscape that was occasionally covered in ice and bordered by a large lake. From the Monts d'Or to the Dijon region, a vast lake stretched over several thousand km^2. Such a large flooded area is made possible by a natural dam, that of a glacier descending from the Alps and blocking the Saône river near the Monts d'Or.

In the Beaujolais region, the soils bear witness to this glacial episode. In some villages on the Saône plain, the subsoil reveals thin layers of sediment (deposited at the bottom of the lake). In other communes, this time at higher altitudes, the soil contains imposing blocks of rock, sandstone in particular, moved several kilometres from the heights of the Beaujolais region. Their presence far from their original environment seems to indicate the passage of glaciers.



Map of the western Alps during the Riss glaciation (300,000 to 130,000 years ago)

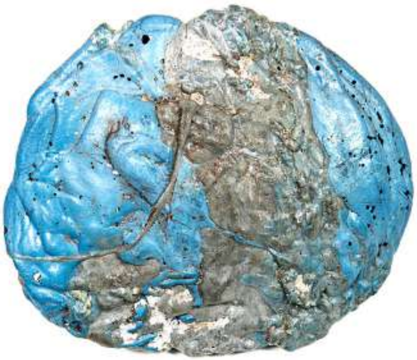
The «Quaternary» section focuses primarily on the great ice ages. These left numerous relics in the Beaujolais region, such as the large rounded blocks of sandstone. Smooth blocks of Triassic sandstone can be found all over the eastern part of the Beaujolais. Many of them bear the marks of glacial grazing. The exhibition incorporates one of these marked blocks.

Secondly, the «Quaternary» tableau addresses the theme of the Anthropocene. This neologism is regularly used to designate the age of mankind, the suffix -cene being usually reserved for the names of geological eras. According to this definition, the «age of man» is a geological stage, meaning that in 500 million years or more, the Earth will still have visible traces of human activity.

The notion of the Anthropocene is often parodied by the expression «waste age», pointing to the most visual marker of human activity: waste. It floods the beaches with each new tide, it covers part of the ocean floor (as shown by the images brought back from underwater missions discovering plastic bottles at a depth of 2,000 m). They abound in our soils, providing archaeologists with a rich source of information about past populations.

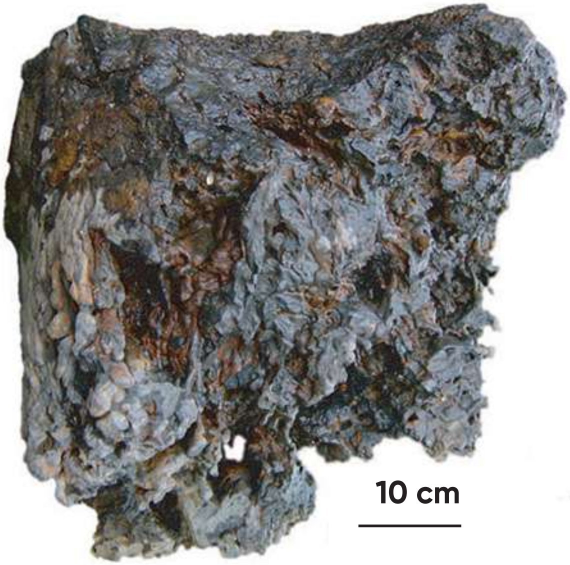
The exhibition presents some of the 'mineral waste' produced by human activity: slag and concrete pebbles collected from the Azergues river, terracotta sand and plastiglomerate from Hawaii.

The Bourdon Tower - Régnié-Durette



3 cm

Plastiglomerate



10 cm

Slag

Although glass and plastic bottles are abundant everywhere today, their construction does not allow them to be preserved over the very long term (several million years). We need to look elsewhere for the lasting marks of the Anthropocene! To distinguish it from other geological layers, chemists have proposed two markers: lead and POPs.

Since ancient times, humans have been releasing lead into the atmosphere through metallurgy, and this lead is found in the «natural archives» (ice and sediments in particular). The age of man is thus marked by an enrichment of sediments in lead. However, this enrichment is local.

The division of geological time requires markers that can be measured across the globe. POPs are therefore a good candidate. These are Persistent Organic Pollutants, such as PCBs and lindane. They are found all over the world, are difficult to degrade and are strictly linked to human activity.

On the «Quaternary» panel of the exhibition is an old box of the insecticide «Tupic». This insecticide contains lindane, one of the POPs classified as one of the «dirty dozen» (the most widespread organic pollutants on Earth).

Étiquette d'insecticide au lindane

6 - Bibliography

Ecology

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** Translation of the original title*

8 - Appendix

Inventory of the exhibition collection

The collection will continue to evolve.

OBJECTS OF THE ITINERANT EXHIBITION OF THE BEAUJOLAIS GEOPARK			
Object	Position in the exhi	Owner	Place of origin
Gneiss from Affoux	1 - Cambrian	SMB	Le Valletier, Joux
Gneiss from Saint-Julien	1 - Cambrian	SMB	Champey, Rivolet
Gneiss impregnated with pyrite	1 - Cambrian	Tanguy Leblanc	Le Valletier, Joux
Bottle "Gneiss"	1 - Cambrian	SMB	Vignerons des Pierres Dorées
Muslin linen	1 - Cambrian	SMB	/
Bottle "Le Volcan"	2 - Devonian	SMB	Espace des Crus du Beaujolais
Sulphide cluster	2 - Devonian	SMB	Carrière Saint-Antoine, Saint-Pierre-la-Palud
Bottle of sulfuric acid	2 - Devonian	SMB	
Marble	2 - Devonian	SMB	Mont Jonc, Ternand
Green schist	2 - Devonian	SMB	Saint-Germain-Nuelles
Serpentinite	2 - Devonian	SMB	La Poyat, Légny
Gabbro	2 - Devonian	SMB	La Fouillouse, Rivolet
Basalt from the Azores	2 - Devonian	SMB	São Miguel, Açores
Amphibolite from the Mont Brouilly	2 - Devonian	SMB	Le Pavé, Saint-Lager
Diorite from Saint-Vérand	2 - Devonian	SMB	La Poyat, Légny
Bituminous asphalt	3 - Viséan	SMB	Beaujolais
Fossilised fern	3 - Viséan	Tanguy Leblanc	Glaizé, Sainte-Paule
Sheared pebble	3 - Viséan	SMB	Le Bois Vermare, Saint-Marcel-l'Eclairé
Puddingstone	3 - Viséan	SMB	Le Serrou, Affoux
Rhyodacitic pyroclastics	3 - Viséan	SMB	La Moissonnière, Les Sauvages
Microgranite	3 - Viséan	SMB	
Rhyolite	3 - Viséan	Tanguy Leblanc	Le Bois Vermare, Saint-Marcel-l'Eclairé
Ignimbrite from the Azores	3 - Viséan	SMB	São Miguel, Açores
Pyroclastite with cinerite level	3 - Viséan	Tanguy Leblanc	La Moissonnière, Les Sauvages
Granite of the crus	4 - Pennsylvanian	SMB	Carrière du Moulin Favre, Odenas
Bottle "Granitic"	4 - Pennsylvanian	SMB	Domaine Fabien Forest
Fluorite	4 - Pennsylvanian	Tanguy Leblanc	Les Grandes Terres, Lantignié
Dentifrice	4 - Pennsylvanian	SMB	/
Garnet schist	4 - Pennsylvanian	SMB	Montagne de Thion, Beaujeu
Jaspoïd quartz	4 - Pennsylvanian	Tanguy Leblanc	Le Gonty, Beaujeu
Vein quartz	4 - Pennsylvanian	SMB	Saint-Jean, Beaujeu
Romanechite	8 - Oligocene	Musée Marius Audin	Mines de Romanèche
Granite from Saint-Étienne-des-Oullières	4 - Pennsylvanian	SMB	Pont-Mathivet, Saint-Etienne-des-Oullières
Fishing sinker	4 - Pennsylvanian	SMB	/
Galena	4 - Pennsylvanian	SMB	Beaujolais
Phased quartz	4 - Pennsylvanian	SMB	Les Grandes Terres, Lantignié
Sandstone grinder	5 - Trias	Tanguy Leblanc	Hameau de Saint-Clair, Ville-sur-Jarnioux
Proto-dinosaur impression moulding	5 - Trias	SMB	Carrière de la "Trappe aux Loups", Avenas
Sandstone with wave ripples	5 - Trias	Tanguy Leblanc	Oingt
Block with halite pseudomorphoses	5 - Trias	Espace Pierres Folles	Cimenterie Lafarge
Tile from Prosny	6 - Jurassic	SMB	Marnière de Prosny
Marls	6 - Jurassic	SMB	Marnière de Prosny
Cement bag	6 - Jurassic	SMB	/
Ream of paper	6 - Jurassic	SMB	/
Toarcian ammonites	6 - Jurassic	SMB	Pierres Dorées
Oolithic limestone	6 - Jurassic	SMB	/
Cut flint	6 - Jurassic	Musée Marius Audin	Beaujeu
Ossicle limestone with flint bed	6 - Jurassic	SMB	Les carrières, Chessy
Automotive plastic	6 - Jurassic	SMB	/
Gryphea limestone	6 - Jurassic	SMB	Pierre Folle, Saint-Jean-des-Vignes
Belemnite rostrum	6 - Jurassic	SMB	/
Nautile	6 - Jurassic	SMB	/
Piece of copper piping	8 - Oligocene	SMB	/
Chessylite	8 - Oligocene	SMB	Chessy-les-Mines
Sandstone, impregnated with azurite	8 - Oligocene	SMB	"Terril de la mine bleue", Chessy-les-Mines
Porcelain plate	8 - Oligocene	SMB	/
Glacil sandstone block	9 - Quaternary	SMB	Cimetière du Cornu, L'Arbresle
Plastite	9 - Quaternary	SMB	Hawaii
Slag	9 - Quaternary	SMB	Azergues
Alluvial deposits	9 - Quaternary	SMB	Azergues
Box of pesticide	9 - Quaternary	SMB	Garage
Concrete pebble	9 - Quaternary	SMB	Azergues

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The Beaujolais Geopark team

Syndicat mixte du BEAUJOLAIS

Itinerant exhibition

Five hundred million years and one day