

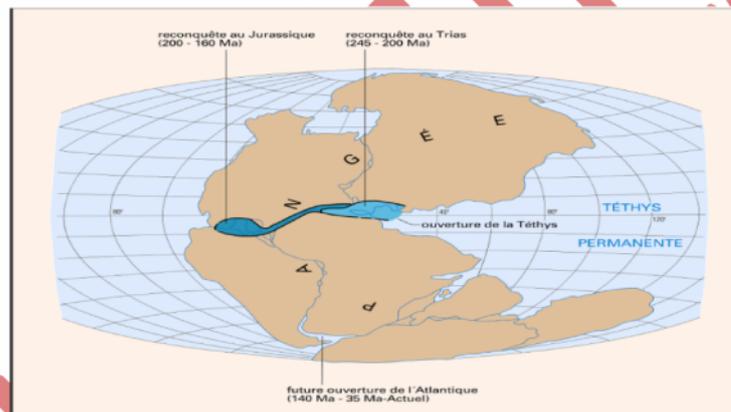
Chapter 3: The orogenic phase of the Lower Miocene (Alpine phase): The Maghrebides chain

The orogenic phase of the Lower Miocene (Alpine phase) : The Maghrebides chain

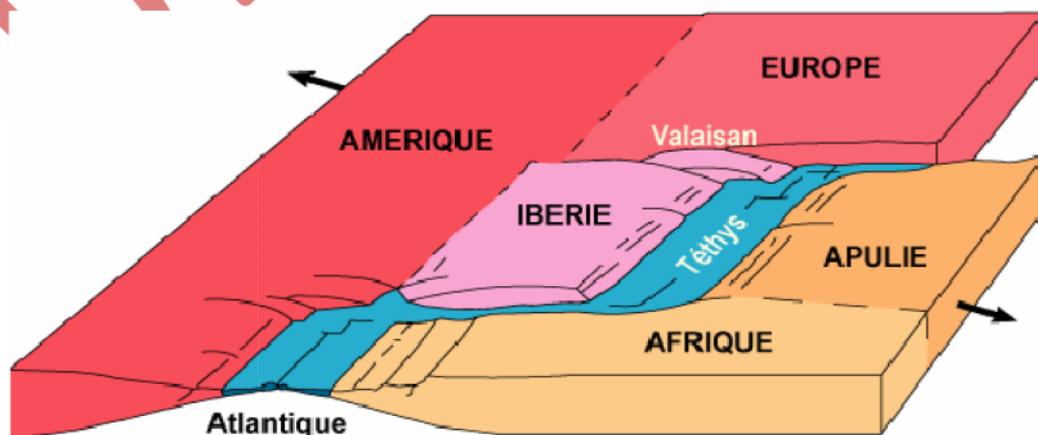
The orogenic phase of the Lower Miocene (Alpine phase) is a period in geological history, often associated with the deformation of the Alps, marked by processes of tectonic plate convergence that shaped the mountain ranges. This phase is part of the overall Alpine orogeny, characterised by the accumulation of sediments (turbidites) and the uplift of mountain ranges resulting from the collision between Africa, Arabia, and Eurasia.

The formation of the Alps:

The history of the Alpine chain is the result of plate tectonics, about 250 million years ago. At that time, Pangaea, a vast and unique continent on the Earth's surface, fragmented, and Europe was gradually separated from Africa by the birth of the Tethys Ocean, which has now disappeared. Thus, during the Secondary era, most of our regions were located under the sea.



A little over 100 million years ago, the plate movements reversed and Africa began to move towards Europe. The relatively heavy oceanic crust of Tethys sank deep into the Earth until Europe and Africa collided. In fact, microcontinents (Iberia and Apulia) and an additional small ocean (the Valaisan) found themselves caught between these two continents, as shown in the block diagram below.



Block diagram showing the different pieces of the future Alpine puzzle, about 150 million years ago. At first, Pangaea broke up with the appearance of the Tethys Ocean and the

Central Atlantic between Europe, still associated with America, and Africa. Then Iberia separates from Europe, giving rise to the narrow Valaisan Ocean. Apulia, which corresponds to the Adriatic Sea and the eastern half of Italy, only separated from Africa much later.

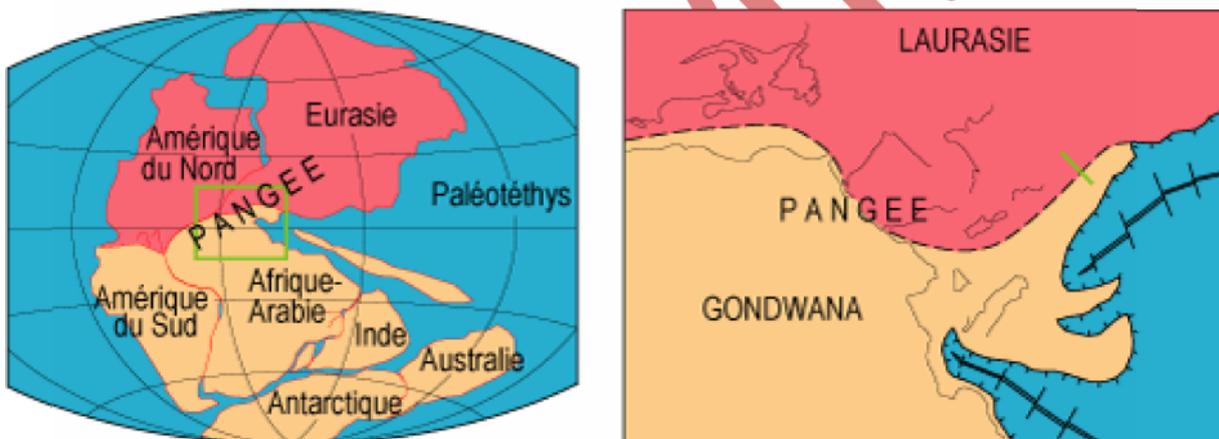
This collision of continents led to the formation of the Alpine relief. This relief was subsequently shaped by the passage of glaciers, resulting in the landscapes that are so familiar to us today. But the movement of tectonic plates continues, and our landscapes are thus in perpetual change on the scale of geological time.

From 270 to 190 million years ago:

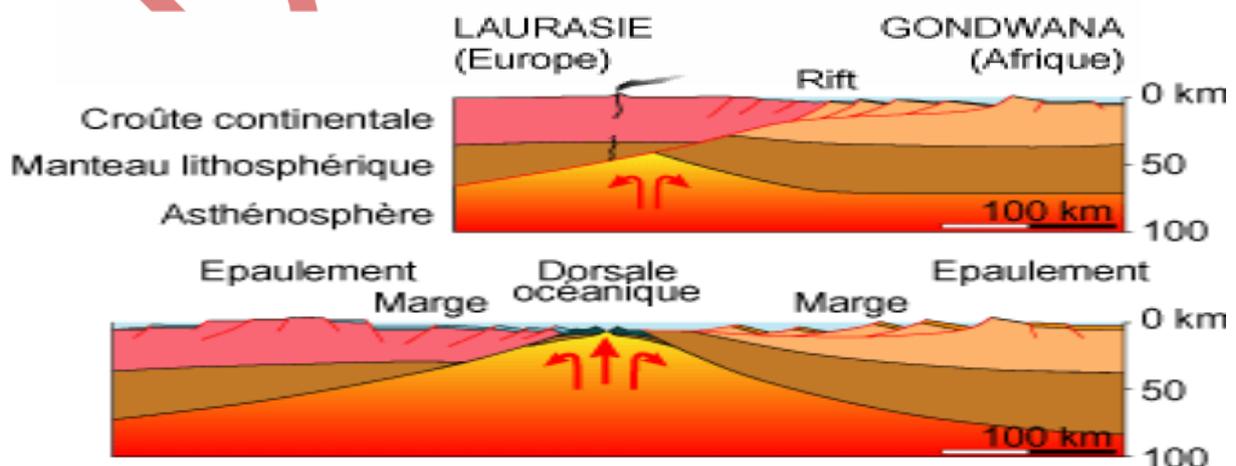
The single continent Pangaea, which had formed towards the end of the Primary era, breaks into two parts, Gondwana and Laurasia, giving rise to the Tethys Ocean and the Central Atlantic.

At first, a collapse trench (or rift) forms in the Lias between these two continents. Then, during the Dogger, the ocean floor of the Tethys begins to form through underwater volcanism along the mid-ocean ridge.

On the edge of the thinned continental margins, an uplift is caused by thermal warming, creating two emerged zones: the shoulders.



Global and regional maps at the beginning of the Triassic (250 million years ago). The green rectangle indicates the extent of the regional map, and the green line indicates the position of the sections below.



Coupes des futures Alpes au Lias (175 millions d'années) et Dogger (160 millions d'années).

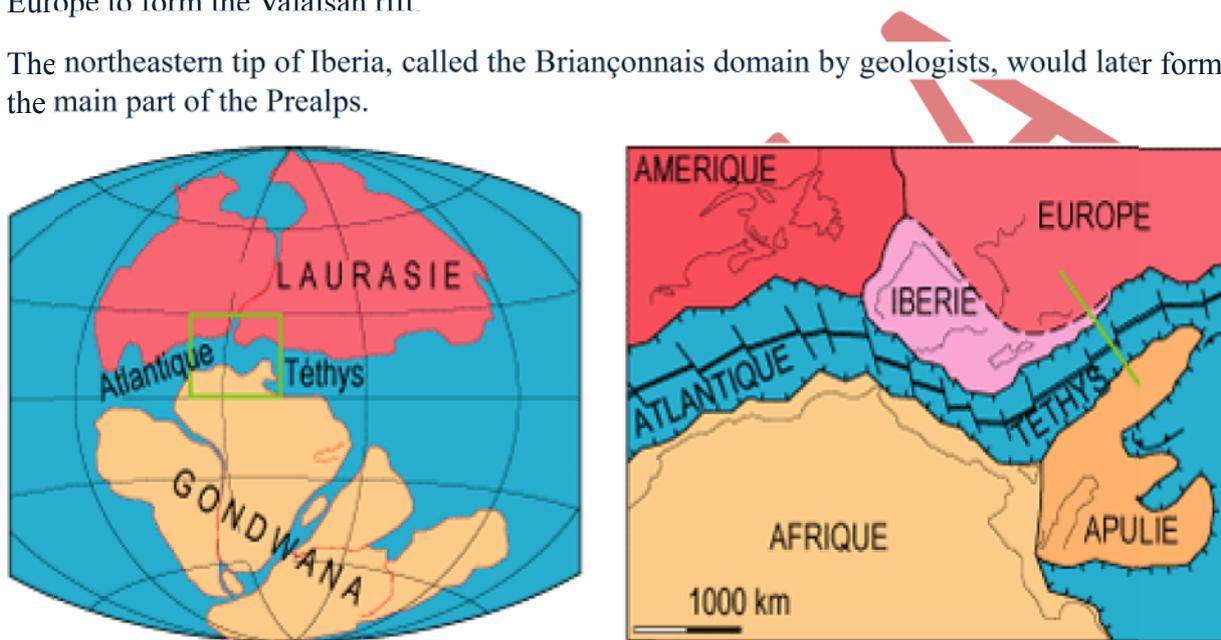
From 190 to 120 million years ago:

The Tethys Ocean continues to widen between Europe and Africa with its promontory formed by the Apulian microcontinent, as well as the Central Atlantic between Africa and North America.

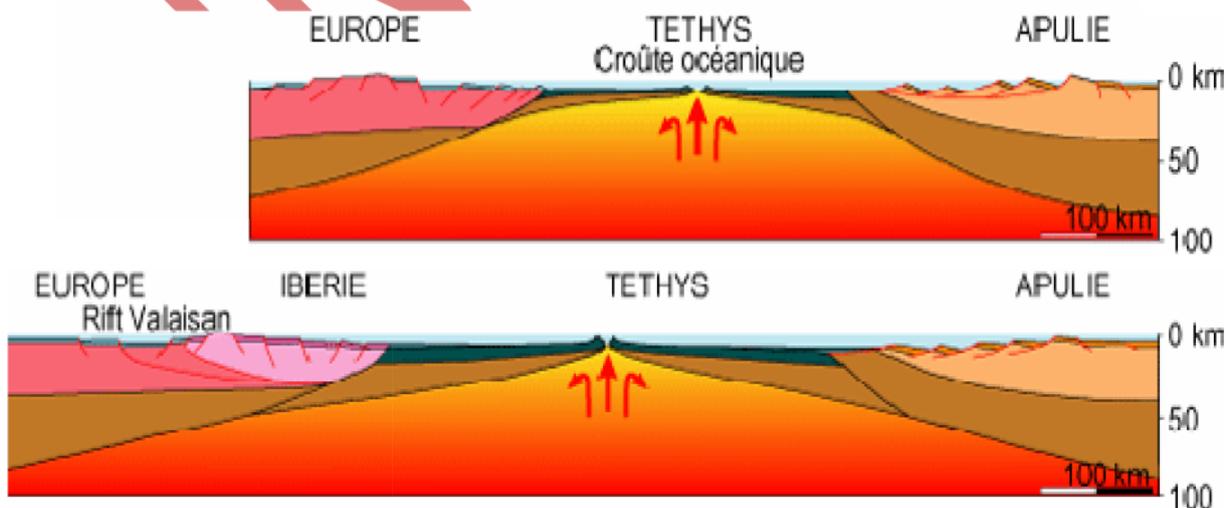
Then, during the Malm, a rift formed between Europe and North America, which would give rise to the North Atlantic.

This plate movement causes a rotation of the Iberian microcontinent, which separates from Europe to form the Valaisan rift.

The northeastern tip of Iberia, called the Briançonnais domain by geologists, would later form the main part of the Prealps.



Global and regional maps in the Upper Jurassic, or Malm (150 million years ago). The green rectangle indicates the extent of the regional map, and the green line indicates the position of the sections below.



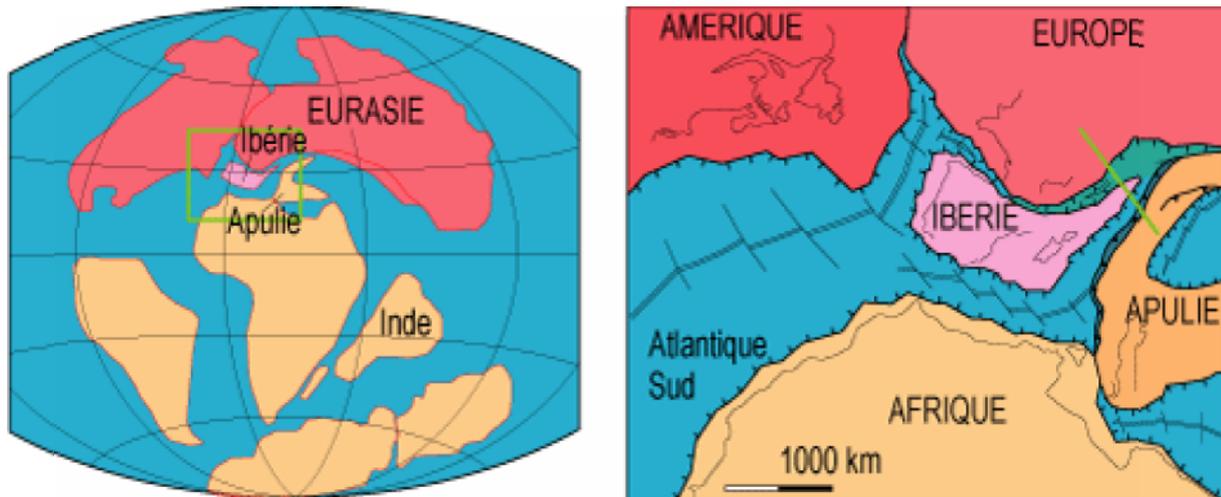
Cross-sections of the future Alps during the Malm (150 million years ago) and the Lower Cretaceous (120 million years ago).

From 120 to 60 million years

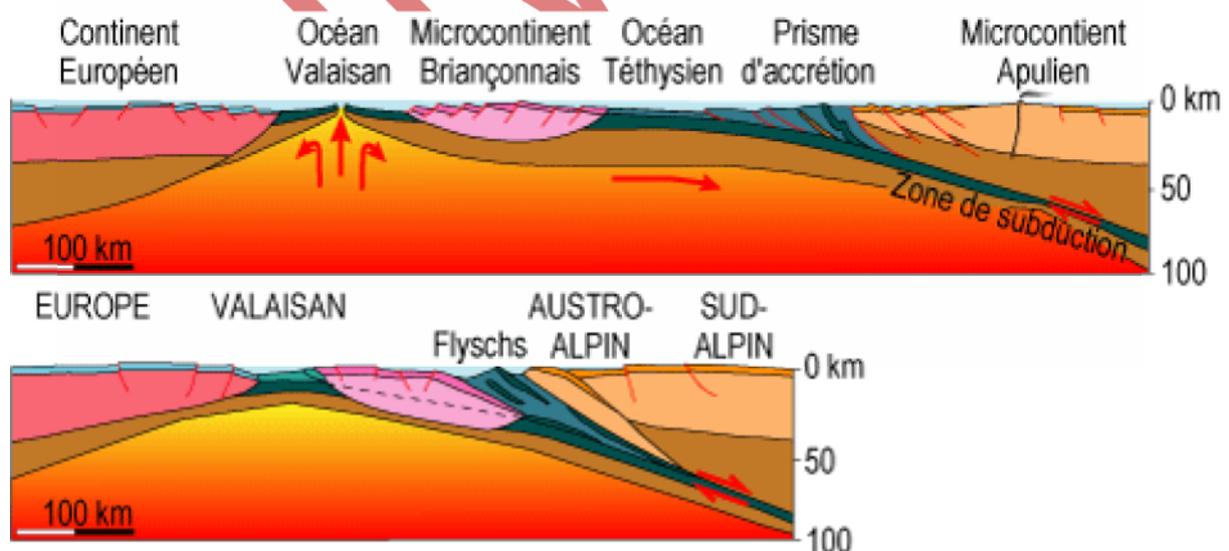
The birth of the South Atlantic, separating Africa from South America, reverses the movement of Africa, which begins to move closer to Europe, dragging the Tethys Ocean deep beneath Apulia through the subduction process.

In front of the Apulian microcontinent, an accretionary prism gradually forms by tearing off large chunks of Tethyan sediments and oceanic crust, which thus escape subduction.

Iberia separates from Europe, thus creating a narrow oceanic basin: the Valaisan, which separates Europe from the Briançonnais microcontinent.



Global and regional maps in the Lower Cretaceous (110 million years ago). The green rectangle indicates the extent of the regional map, and the green line indicates the position of the sections below.



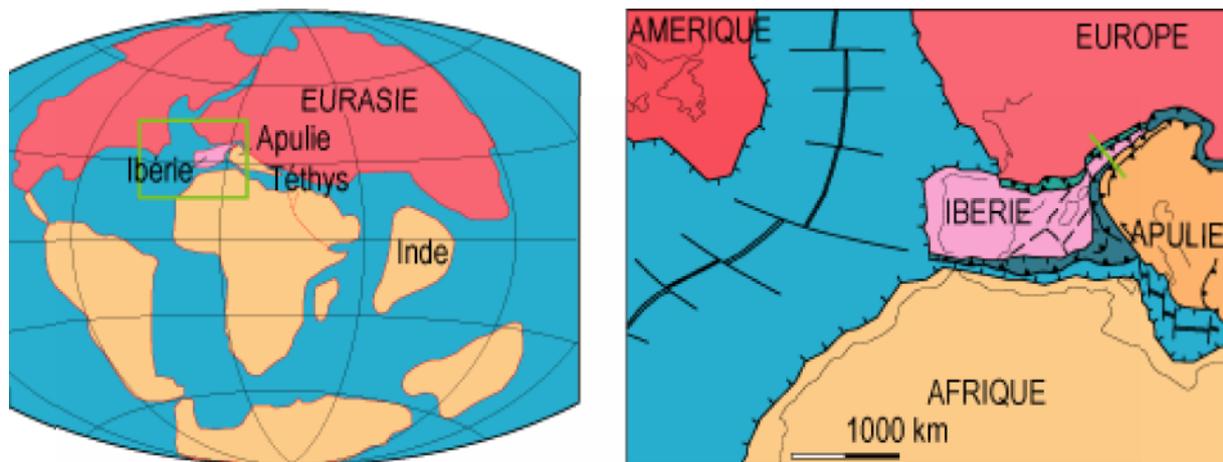
Cross-sections of the future Alps during the Lower Cretaceous (110 million years ago) and the Upper Cretaceous (80 million years ago).

From 60 to 20 million years

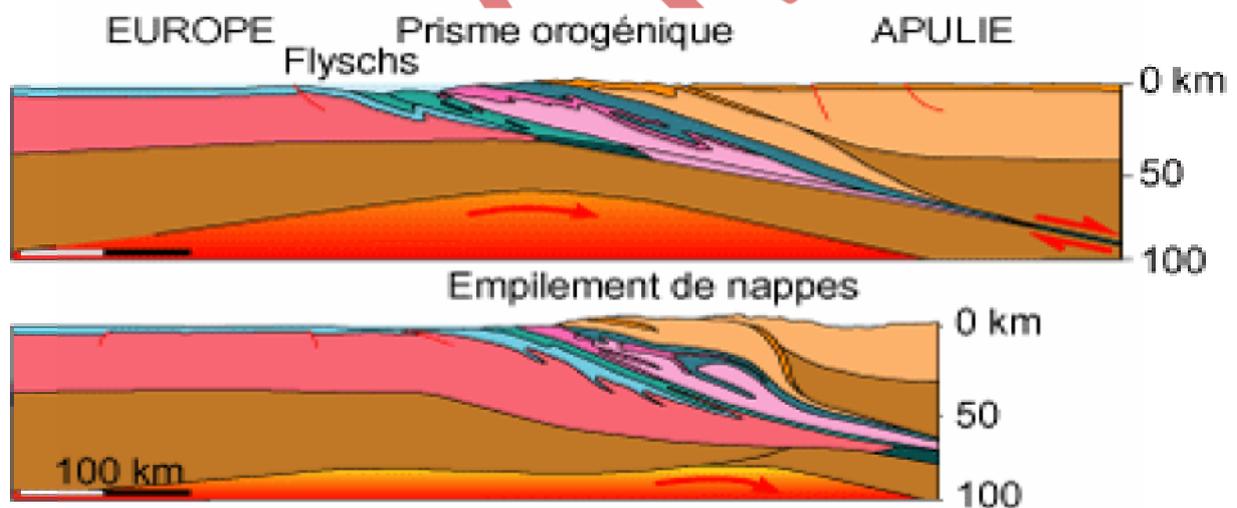
After the Tethys Ocean, it was the Briançonnais microcontinent's turn to plunge deep beneath Apulia along the subduction zone. Subsequently, it is the Valaisan Ocean and the edge of the European Plate that are dragged deep down.

Large slabs of crust from different origins are thus stacked and folded, forming an orogenic prism made up of nappes.

Some of them will descend to several tens of kilometres deep where they will undergo metamorphism: a recrystallisation due to temperature and pressure.



Global and regional maps at the Eocene (50 million years). The green rectangle indicates the extent of the regional map, and the green line indicates the position of the sections below.



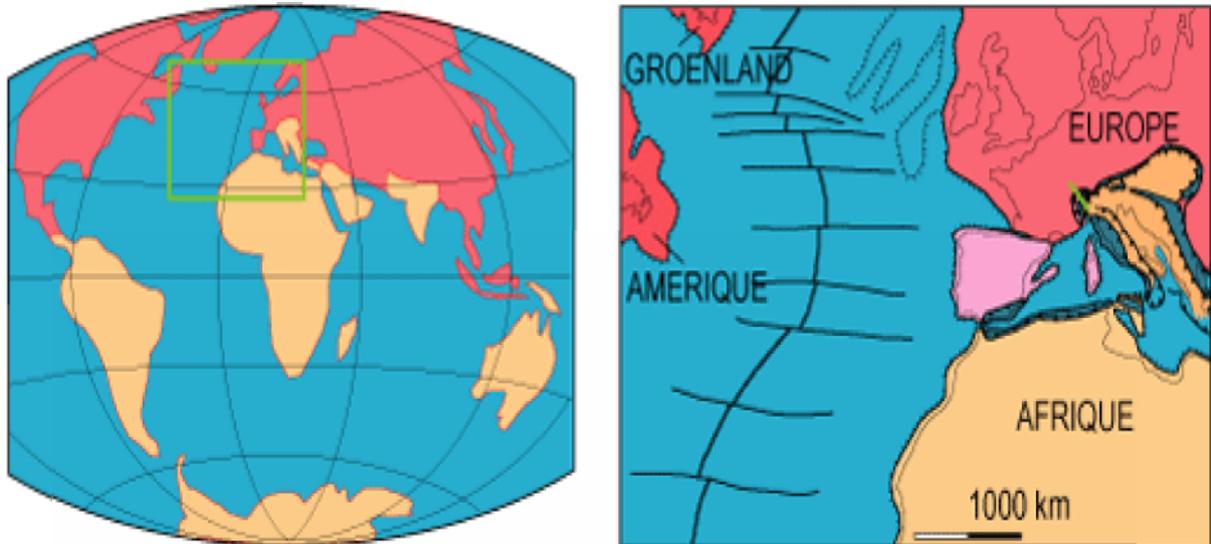
Cross-sections of the future Alps during the Eocene (50 million years ago) and the Oligocene (30 million years ago).

From 20 million years ago to today

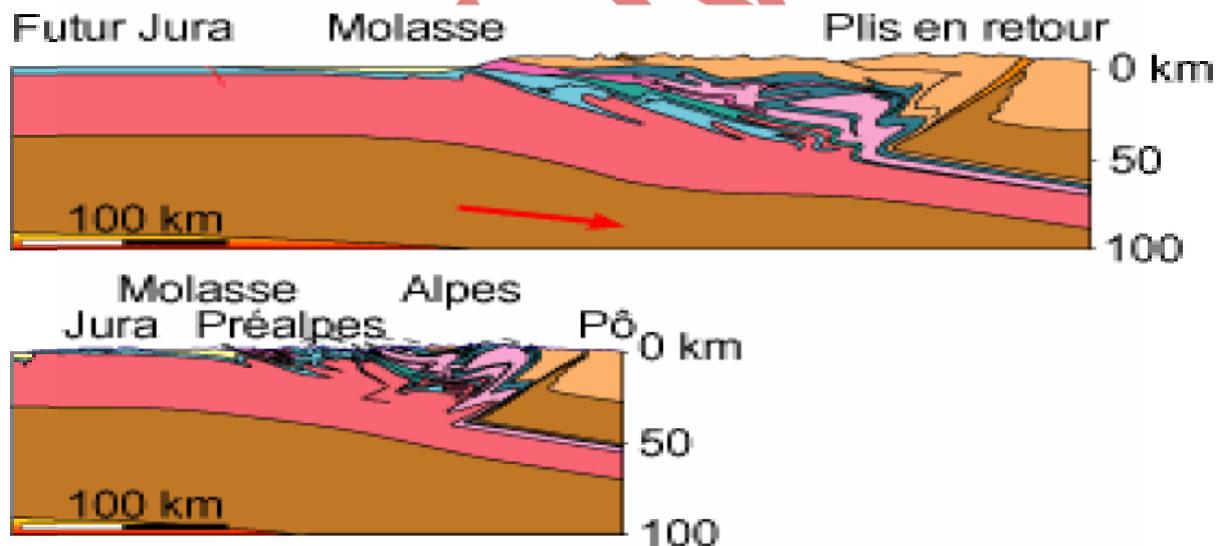
Due to the accumulation of nappes that overload the European plate, it is folded and thus forms a foreland basin at the front of the Alps. This basin fills with sediments from the erosion of the future Alpine chain. These sediments are sometimes marine, sometimes continental: it is the Molasse, which also covers a large part of the Jura.

In a final convulsion, the northwest thrust of the Alpine front caused the Jura to fold 12 to 5 million years ago.

Even today, the Alps continue to grow, by one to two millimetres per year, due to the slow northward movement of the African plate.



Current global and regional maps. The green rectangle indicates the extent of the regional map, and the green line indicates the position of the sections below.

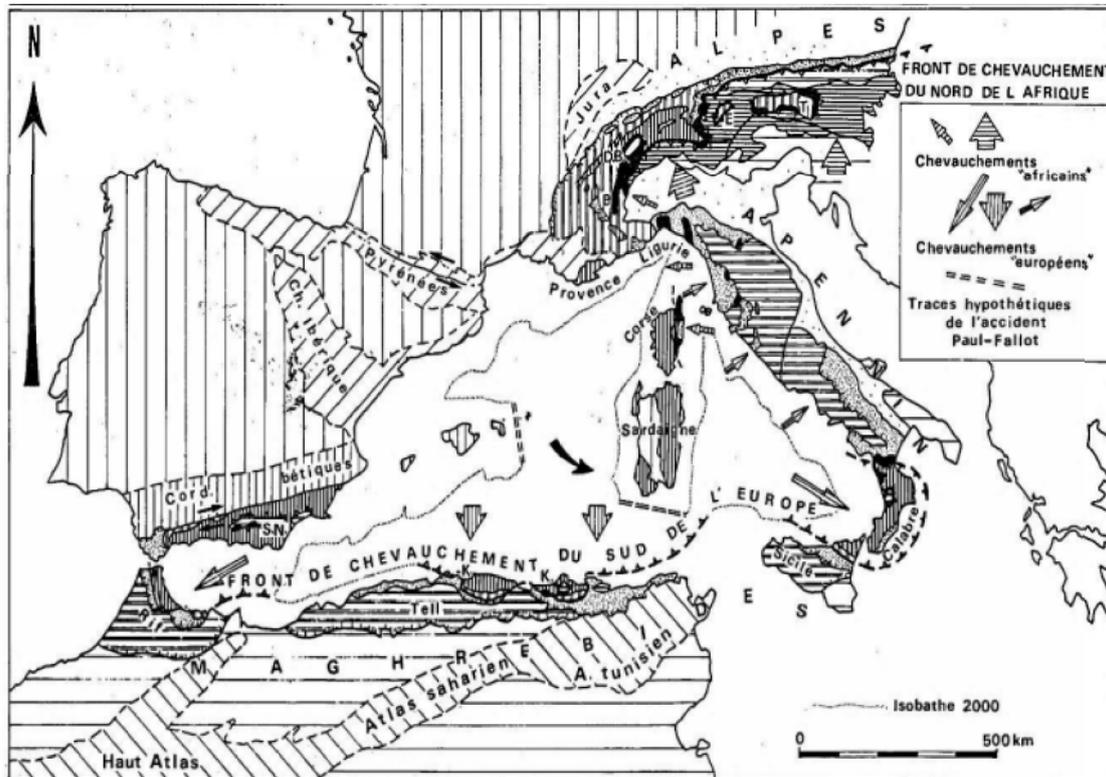


Cross-sections of the future Alps in the Miocene (25 million years ago) and the Alps as they are today.

General conclusion:

Plate tectonics has thus allowed for a conceptual renewal in the study of mountain ranges. However, there remains a major problem regarding ancient mountain ranges. Is the concept of plate tectonics usable? It seems established that the Paleozoic chains, formed between -600 and -200 Ma (Caledonian and Hercynian), can be explained within this framework. The major features of recent chains seem to be present there (ophiolites, high-pressure/low-temperature metamorphic belts, subduction zone magmatism, large crustal

overthrusts). For the chains between -600 and -2000 Ma, the question remains open (the Cadomian chain is beginning to be understood). For the Archean chains (prior to -2600 Ma), the thermal regime of the earth was warmer, magmatism must have been more intense, and it is thought that the convection cells were more numerous, resulting in a system of many small plates whose geometry and functioning remain obscure. It is not established under these conditions that large overthrusts could have initiated in this low-resistance crust.



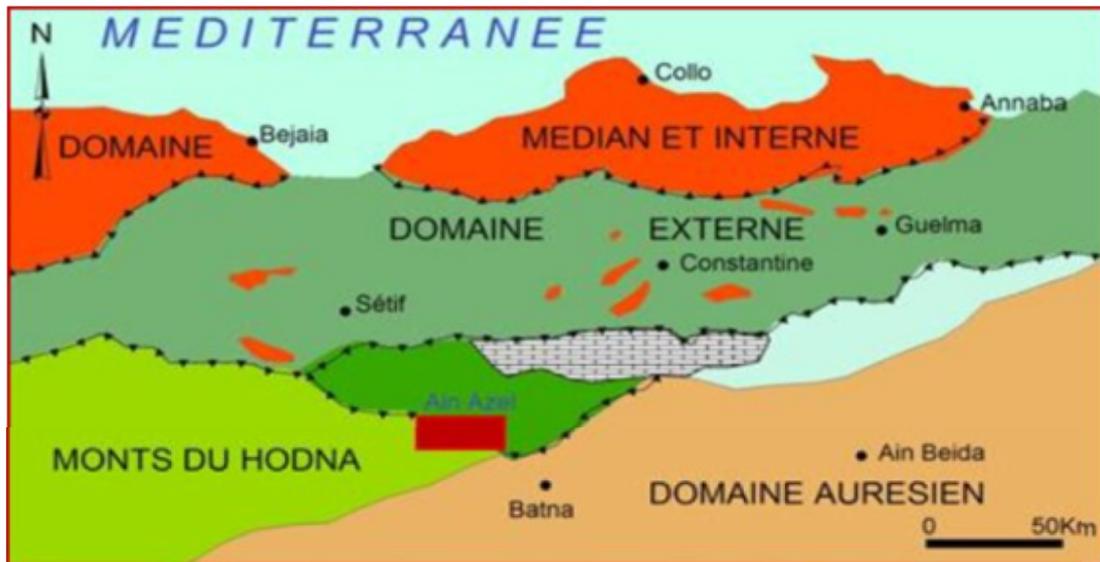
The Maghrebides chain

The North African Alpine chain or Maghrebide chain is part of the peri-Mediterranean Alpine orogeny (Durand-Delga, 1969) of Tertiary age, which extends from West to East over 2000 km from Southern Spain to the Calabro-Sicilian arc.

In this highly flattened ring-shaped area, we classically distinguish between the internal zones, located inside the ring and represented today by various massifs, scattered along the Mediterranean coast, and the external zones located on its periphery.

The Maghrebide chain domain experienced Meso-Cenozoic deformation phases resulting in the establishment of thrust sheets. This is the nappe domain or allochthonous domain.

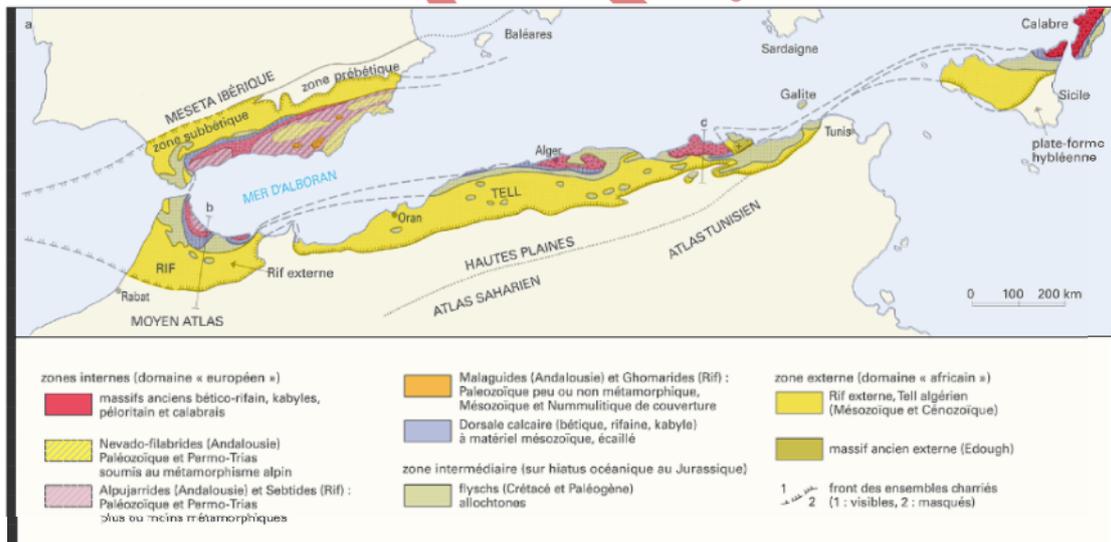
In Algeria, the Maghrebides chain shows the following domains from north to south:

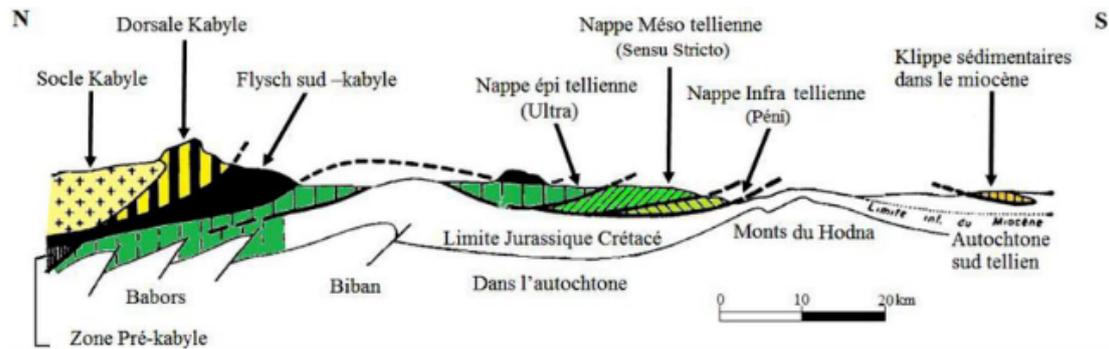


1. an internal domain:

The units of the internal domain include:

- the Kabyle or Kabyliide basement, composed of metamorphic crystalline massifs (gneiss, marbles, amphibolites, micaschists, and schists)
- and a Paleozoic sedimentary sequence (Ordovician to Carboniferous) with low metamorphism.





2. the flysch domain:

Is made up of Cretaceous-Paleogene flysch sheets that outcrop in coastal areas over 800 km long, between Mostaganem and Bizerte (Tunisia). These are essentially deep-sea deposits laid down by turbidity currents. It is unanimously accepted that the Kabyle flyschs are allochthonous. These flyschs appear in three ways:

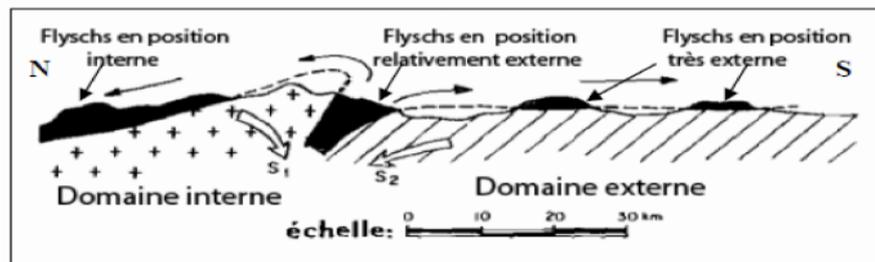


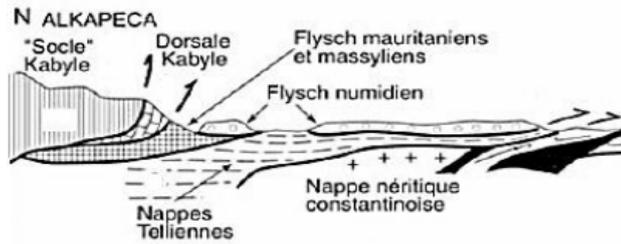
Figure 3 : Position des nappes de flyschs par rapport aux unités de la chaîne des Maghrébides

(i) . in an internal position

Tectonically superimposed on the Kabyle massifs (flyschs located on the mass or north of the the ancient Kabyle cores). In this situation, they have been described as "north Kabyle," "supra-Kabyle," or "ultra-Kabyle" flysch (Durant Delga, 1955; Mattauer, 1959, 1963; Andrieux, 1971).

(ii). in a relatively external position

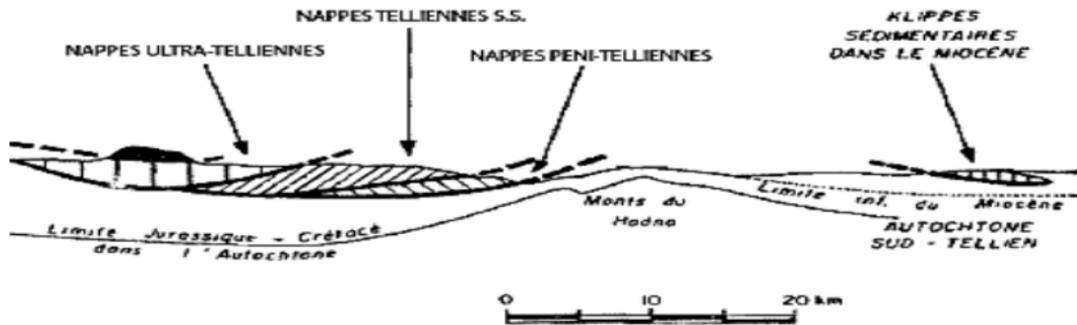
In this position, they have been described as "south-Kabyle," "infra-Kabyle," or "cis-Kabyle" flysch (Durant Delga, 1963, Bouillin, 1977). From North to South, two main groups of flyschs are distinguished: the Mauritanian flyschs and the Massylian flyschs, to which a third, more recent group of flyschs is added, the Numidian flyschs of Upper Oligocene – Lower Burdigalian age.



3. an external domain:

Or tellian domain consisting of a set of thin allochthonous sheets mainly composed of marls of Middle Cretaceous to Neogene age and which were transported over a hundred kilometres to the South. From North to South, we distinguish:

- (i) the ultra-tellian nappes
- (ii) the tellian nappes
- (iii) and the peni-tellian nappes



4. The foreland domain

Whose external domain consists of even more external units and notable, but lesser, allochthony, structured in the Middle Miocene, called the allochthonous or Tellian foreland series and are located between the Tellian nappes in the North and the autochthonous or para-autochthonous Atlasic in the South.

We thus distinguish from west to east:

- (i) the southern-Setifian allochthonous complex
- (ii) the "Constantine neritic sheet"
- (iii) the "Sellaoua scales" unit

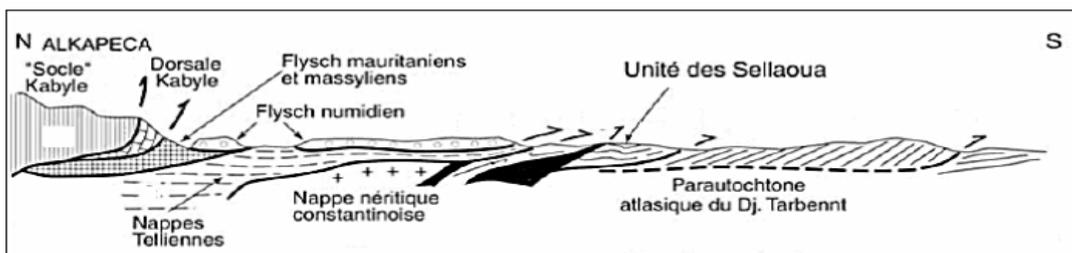


Figure 4 : Coupe générale synthétique des Maghrébides de l'Est algérien (région du Constantinois)