the Geological Landscape of Emilia-Romagna

01 Western Peaks

Cretaceous-Paleocene Flysch

Some sectors of the Apennine ridge, which marks the boundary between Emilia-Romagna and Liguria and Tuscany to the west, are characterized by a landscape dominantly rocky relief, including M. Molinatico, M. Gottero and M. Lesima, with significant differences in elevation and "geomorphological" appearance. Although the ridge is characterized by a rocky relief in many sectors, being only slightly marked by the thick vegetation hiding the geological substrate in less extensive and more classy, the landscape is marked by saddles, and here we find the main mountain passes leading to Liguria (Bre Cisa, Cento Croci and Bocca passes).

The unit is formed by **Cretaceous-Paleocene Flysch** deposits consisting of alternating, highly deformed layers of marls and sandstones, with a significant presence of clayey-marly layers and complex systems of folds, joints and faults. These rocks were deposited between 100 and 60 million years ago (between the Upper Cretaceous and Lower Paleocene). Peaks vary from 600 to 1720 metres above sea level and, due to this relatively modest altitude, even on the highest peaks it is rare to find morphologies shaped by glaciers during the last ice age.

02 Mid-Eastern Peaks

Oligo-Miocene sandstones

The Apennine ridge between Parma and Bologna plus some sectors of the Piacenza and Bologna ridge are characterized by a landscape dominated by impressive mountain, with steep forest-covered slopes that include the region's highest peaks: M. Cimone (2165 m), M. Cusna (2120 m) and Alto Scale (1945 m). In proximity to the principal ridge, we can observe spectacular morphologies, with steep slopes and pointed peaks, which are the result of glacial modelling. Further down the valley, morainic deposits cover these areas reached by the glacial tongues.

The landscape unit comprises **Oligo-Miocene** Macigno-type **sandstones**. These consist of well stratified turbidite sandstones (turbiditites) with Bouma, very well cemented with layers several metres thick intercalated with thin beds of clay. In some areas the stratification highlights the morphological structure, with sandstone layers that form the ridge and steep slopes. These turbidite sandstones were deposited in a period between 28 and 20 million years ago (Upper Oligocene-Lower Miocene). Peaks vary from 800 to over 2000 metres a.s.l.

03 Mountains, Landslides and Badlands

Cretaceous-Paleocene Flysch and Eo(Upper)-Miocene sandstones

"Argille Scagliose"

This vast territory includes the majority of the medium-altitude mountains and hillslopes, as well as the Marecchia Valley in Romagna, with peaks varying from 150 to 800 metres a.s.l. The considerable geological and morphological complexity of this area gives rise to a composite landscape defined by striking contrasts. Gentle, often cultivated slopes alternate with badland erosion areas, with steep, bare slopes, with a significant presence of clayey-marly lithotypes, which are darker in colour and formed by aphitalus, and imposing rocky relief, almost covered with thick forest. This territory is distinguished by a particularly high density of landslides (the typical earth-flow type referred to as *lame* (both active and dormant, which cover over 50% of the territory, making this the most landslide-vulnerable zone in Italy.

The rocks which make up this unit are **Ophiolites**, a name which derives from the Greek word ophis (snake), and lithos (rock), in reference to their brilliant surface and colour, reminiscent of the skin of a snake. These are rocks of oceanic origin, characterized by a typical "Ophiolite Sequence" (bottom forming the oceanic crust). Ophiolites outcropping in the Emilia-Romagna Apennines formed approximately 175 million years ago (Middle Jurassic) and thus testify to the presence of an ancient ocean which underlies long ago the Ligurian-Piedmont Ocean. These large ophiolite rocks are almost always associated with **ophiolitic breccias and clays**. The ophiolitic substrate provides a habitat for a particular flora, which is well-adapted to the presence of heavy metals (nickel, chrome and iron), and, where present, a very thin layer of soil with high levels of heavy metals (nickel, chrome and iron).

04 Ophiolitic Crags

Ophiolites

Ophiolitic breccias and clays

The Ligurian-Emilian ridge and some sectors along the valleys of the rivers Taro, Ceno, Nure, Arda and Trebbia are characterized by a wholly unique landscape, strongly shaped by the ophiolitic substrate. The highest peaks are M. Maggiorasca (1790 m) and M. Ben (1172 m) imposing mountains offset by smaller peaks further down valley. The landscape of the ophiolites is always very striking and prominent, with steep slopes and pointed peaks, which are the result of glacial modelling. Large quarries, typically ground-cover. These are tremendously inhospitable environments, as we can deduce from the almost complete absence of agricultural activity and the very rare presence of dwellings.

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05 Sandstone Spurs

Eo(Upper)-Miocene and Pliocene sandstones

This unit extends over a vast section of the hill and mountain zones of Emilia and upper Romagna with elevations ranging from 150 to 1000 metres a.s.l. It includes rocks of different ages which create a landscape defined by relief, often with tabular morphology or crags, bordered by steep slopes and rock faces (spurs). These landforms are a product of the low erodibility of the rocks which make up the unit. The rocks in question are stratified sandstones, with substratified marls and conglomerates, separated by erosion, forming the typical "spur and valley" morphology of the Apennines. Along the current mountain series, intermediate plains and small plateaus are to be found at the summit of isolated relief, and between mountain groups. Some steeply striking formations such as the *Gessi gallerie Pliocene* and Pliocene layer (Bologna Apennines) and the *Pietra di Bismantova* and Bismantova Rock (in the province of Reggio Emilia) give rise to escarpments with these shapes of over 100 m.

The rocks which make up this unit are **Eo(Upper)-Miocene** and **Pliocene sandstones**, i.e. Oligo-Miocene formations, prevalently arenaceous, belonging to Epiligurian Units (Marnoso, Fortuna and Cigarello U). These stratified rocks measure very in colour from grey to beige and yellow. The rocks forming this unit were deposited between 35 and 2.5 million years ago (Oligocene-Pliocene). Slopes are wooded, while summit plateaus are home to arbusticated areas surrounded by cultivated areas. Although these rocks are well-known for their resistance to erosion, they are in fact the most clayey formations outcrop anthropic, for instance in the Bologna valley, they have a large impact on the landscape. Landslides are a rare occurrence, but extremely hazardous given the precipitous slopes.

06 Windows on the Deep Apennines

Marnoso-Arenacea

Oligo-Miocene turbidites

This unit includes the territory between Modena and Forlì of Romagna Apennines as well as the Marecchia Valley in Romagna, with peaks varying from 150 to 1000 metres a.s.l. It is a landscape shaped by complex geological dynamics that have determined the exposure of rocks which, despite lying in the deepest parts of the Apennine belt, are actually more recent than the overlying rocks. The term used to describe this geological phenomenon is tectonic window.

In terms of the landscape, tectonic windows appear as mountain and hill sectors which seem to be characterized by a particular "softness" of the landscape, due to the low resistance to erosion and the intensity of erosion processes involved. A prime example is the meanders of the Sant'Eufemia south of Bobbio, unique landscape features in this region. The rocks that make up this unit are turbidite sandstones: those of Arenaceous belong to the *Marnoso-Arenacea* Formation (see **Lamo** Unit; **Lanzi**, within Bobbio we find outcrops of **Oligo-Miocene turbidites** (see **Mio-Eocene Flysch**). These rocks were deposited between 28 and 20 million years ago (Upper Oligocene-Lower Miocene). The "tectonic window" are either thickly wooded or rocky. Thanks to a gentle morphology and clear proximity to the plain, in the area of Salsomaggiore woodland, built-up areas and farmland alternate.

07 Triassic Gypsum

Gypsum and anhydrites

It is characterized one of the red and upper Sercchio valley (Reggio Emilia province) we can observe an extraordinary Triassic gypsum outcrop carved out by the course of the River Secchia. The broad bed of the Secchia (as wide as 500 metres in places) flows in a straight course for 6 kilometres between towering rock faces of white, pink and light grey gypsum, rising up 200 metres in some points. The morphology of the gypsum is very "rocky" with steep slopes and pointed peaks, and, in the case of the Secchia, we can observe phenomena there are many sinkholes, particular karst springs, and spelaeologic caves. The continuity of the gypsum is interrupted by lateral valleys with large clay flows which outgoingly broke off from the distant slopes of the rock of Bismantova and from M. Venerio. Moving towards the centre pass, a distinguishing feature of the landscape is the wide front of the "Riserva Quara" with its "Gypsum Gallery" and the "Gypsum Cathedral" (Reggio Emilia Apennines).

Triassic gypsum contains a number of different lithotypes: **gypsum, anhydrites**, dolomite and quartzite, which form a distorted rock structure with fragments of layers that present rupture and folding, where all original stratification has been erased by powerful tectonic forces. The rocks which make up the unit were deposited during the Middle-Upper Triassic (245-202 million years ago) and, therefore, the oldest rock outcrops of the Emilia-Romagna Apennines. The steep gradients, coupled with instability brought about by karstic phenomena, make this a highly vulnerable area, with thickly wooded or rocky slopes.

08 Layer upon Layer

Inner Marnoso-Arenacea

Outer Marnoso-Arenacea

This unit comprises much of the hill and mountain territory of Romagna, with peaks ranging from 50 metres above sea level to over 1000 metres a.s.l. It is a landscape shaped by complex geological dynamics strongly almost exclusively to one formation, the *Marnoso-Arenacea* formation, whose name indicates the two principal lithological components which are sandstones and marls. This is a complex and expressive turbidite formation, composed of a rhythmic, repetitive sequence of pelitoarenaceous layers of sandstone and grey coloured marly layers, based on the predominance of one lithological type or the other. The rocks which make up this unit were deposited during the Upper Oligocene-Lower Miocene (**Marnoso-Arenacea**). In the upper Apennines, the landscape is defined by the tenacious nature of the Inner *Marnoso-Arenacea*, organized in thick sandstone layers which predominate over the marly partners, resulting in steep, wooded slopes, scarcely straight furrows with sudden meanders, bends, saddles and locally, pathales. In the central and lower Apennines the landscape is somewhat softer thanks to the greater presence of marls, which are more easily eroded, and the greater frequency of sandstone combinations, in terms of both the thickness of layers and the ratio of sandstone to marl.

The pattern of stratification shapes the landscape, its position determining the ridge profiles. Long, gently pitched slopes form where the layers lie parallel to the slope, while, beyond the ridge, crests dipping into the slope result in steep escarpments. This asymmetry, which is to be found above all in the Romagna Apennines, is the result of differential erosion between the steep and gentle slopes of the ridge, with gentler slopes covered with woodland, meadowland and farmland, while steeper gradients are often stripped of vegetation, sparsely wooded or reforested. The easternmost peaks are home to the region's only rolling-hill forest, located in the Sasso Fratino nature reserve, within the *Parco delle Foreste Casentinesi*. The rocks that make up this unit were deposited during the Lower-Middle Miocene (21-13 million years ago).

09 Foothills

"Italian garlic"

"Argille Azzurre"

This landscape unit extends along the entire pede-Apennine margin, from the area of Piacenza to Rimini, with peaks varying from 50 metres above sea level to over 500 metres a.s.l. It is a landscape defined by a gentle morphology expressed in long terraces sloping down towards the valley, which are also find ancient paleosols. Local erosion of the secondary hydrographic network has resulted in quite shallow valleys, separate from ridges with large summits where the "yellow sands" that comprise the rocky substrate outcrop.

The rocks which make up this unit are where it meets extensive badland bluffs, where grey-blue Pliocene clays outcrop. In some cases the badlands cover a vast area, as in the valleys of Romagna, Modena, Reggio Emilia and Piacenza. The rocks that comprise this unit belong to the **Argille Azzurre** (Blue Clays) and **sabbie gialle** (yellow sands) or Imola Sands formations which were deposited between 5.3 and 0.01 million years ago (Pliocene - Pleistocene). Among the Pliocene clay found in the Emilia-Romagna area, there are also the "Italian garlic" (Italian Pleistocene) outcrops in the Po Valley, which is responsible for a landscape of cliffs and high hills which develop along a sinuous narrow strip straddling the valley. This area, with its very gentle landscape, has always attracted man and today it is heavily farmed, with fruit orchards and vineyards the preferred cultivations.

10 Vena del Gesso

Messinian gypsum

This unit extends along a narrow strip of territory which runs parallel to the Apennic margin through the territories of Reggio Emilia, Bologna, Imola-Faenza and the hill area of Cesena. The most visible aspect of this unit in terms of the landscape occurs in Romagna, where it substantes in a long and very impressive ridge, clear grey in colour, which interrupts the gently rolling hills. The ridge, which can be seen from a great distance despite the fact that it measures just 1500 metres at its broadest point, is home to a series of peaks which are the highest in the Romagna Apennines: Monte Mauro (Mount Mauro), Gypsum Hill) rises up over 500 metres above the surrounding clayey slopes and is divided into strata, often up to 30 metres thick, separated towards the top by clay beds which support the vegetation. To the north, the ridge rises up with a steep yet more gradual flank, dotted with dolines and caverns lines, the majority of which are covered by woodland. There are numerous karst landforms and caves, which are home to a rare fauna, which is well-adapted to the presence of heavy metals.

The gypsum outcrops to the west (Bologna and Reggio Emilia hills) are less striking in terms of morphology, but still form unique, remarkable environments. The gypsum forming this unit, known as **Messinian gypsum**, was deposited between 7.2 and 5.3 million years ago during the Messinian, the last age of the Upper Miocene. These environments are home to rare species of flora and fauna, which are well-adapted to the presence of heavy metals. The gypsum forms steep, wooded cases, with tunnels and white-stepped escarpments, in the gypsum rock between Emilia (Vezzano sul Crostolo) and Romagna (Val Senio).

11 Alluvial Plain of the Apennine Rivers

Fluvial channels

Fluvial terraces and overbank

Interfluvial plain

This includes the inter-valley sectors of the Apennines, valley mouths along the Apennine margin and the large plain stretching all the way to the river Po and the coast. Elevations are generally between 100 metre a.s.l. in the upper plain area, with the exception of inter-valley sectors and sea level in coastal areas. The landscape owes its primary characteristics to the dynamism of the rivers which flow from the Apennines and the sea. The rivers which flow from the Apennines, when they flow into the plain (upper plain), depending their coarse load of gravel and sand, and forming sedimentary bodies: the alluvial fans, characterized by a system of **fluvial channels**. The middle and lower plain is associated with decreasing slope gradients (around 0.1-0.2 %) and smaller sediment grain size. In this sector, river dynamics are characterized by repeated deviation of the rivers, the transport of large quantities of sediment and consequent deposition of the sediment, which results in an elevated above the surrounding land, formed by the current clay and ancient courses of rivers formerly repeated overflowing (**channel-levee and overbank deposits**). In those areas farthest from the fluvial systems we find **interfluvial plain** areas consisting of large depressions, "valleys" or marshlands, the majority having been reclaimed during the last century, where overflowing rivers have left behind a thick layer of clay, which, in the past, gave rise to swamps and marshlands, today land reclamation works. The plain is a fully anthropized territory where, for over 2000 years, man has shaped the landscape through a combination of artificial embanking and rectification of rivers, reclamation of valleys and immense urbanization: these actions have doubled the natural evolutionary dynamics of the floodplain. Today the plain is fully formed and presents a level of industrialization which, along the via Emilia, is one of the highest anywhere in the world.

12 Po Plain

Fluvial meanders

Delta channels and levees

Delta valleys

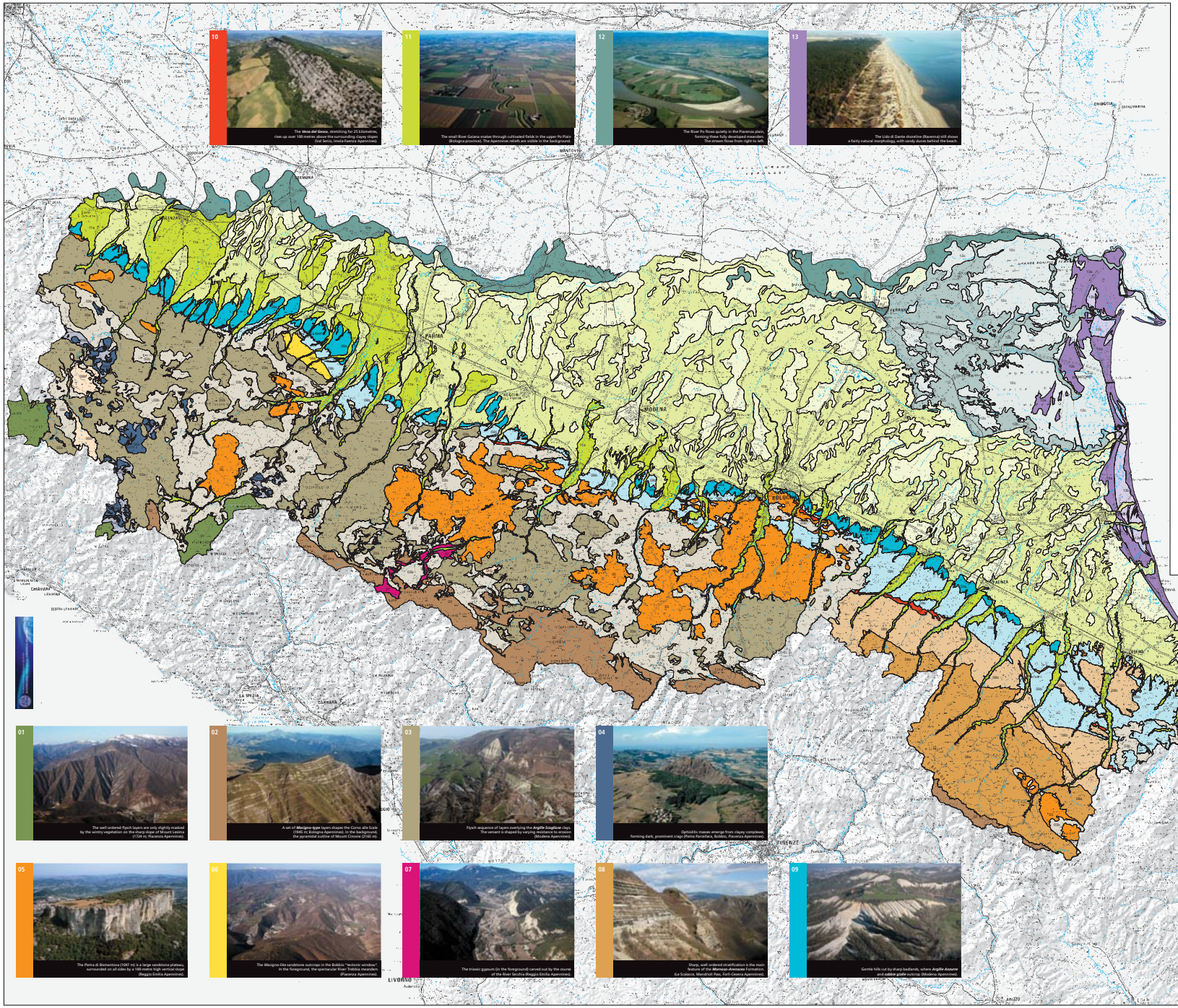
This area includes the land occupied by the corridor of the great river by the mouths of its various tributaries, and the delta area. The Po Plain is a fluvial landform which, from Piacenza to the sea, covers 2000 km2 in the province of Ferrara. Elevations reach 70 m with frequent values in excess of 100 m in the west, dropping to below sea level in the lower-lying areas of the delta coastal plain. Due to its very slight gradient, the river corridor, which marks the northern boundary of Emilia-Romagna, has sinuous, twisting trend which defines the typical **fluvial meanders** of the Po. Just before it flows into the sea, the river splits into a series of branches, which, in the past, have given rise to a complex of distributaries (distributary channels) from Ferrara, the river leaves the alluvial plain and constructs the delta coastal plain. The main morphological elements of the delta coastal plain are the **delta channels and levees**, corresponding to the distributary channels of the Po over the ancient branches of the Po di Primaro, Po di Goro and other minor branches), and the **delta valleys**, depressions which are home to lagoons and marshlands, which are fed by the sea and by the rivers and streams. Along the river mouth, salt water, carried up the river during high tide. Originally, in these areas of the delta, farthest inland, lakes of no more than a few metres in depth, or marshland, stood where now there are valleys. Towards the sea, meanwhile, there were lagoons and bay of shallow water. Today, on the other hand, the area has been almost completely drained as a result of monumental land reclamation works, which have allowed for the transformation of many parts of the lagoon into farmland or reclaimed areas (where, with time, they provide wetlands providing clues to the past.

13 Coastal Plain

Beaches and dunes

Lagoons and marshes

This strip of land lies parallel to the coast, running along side the sea for approximately 130 km from the Po di Goro mouth to the Gabicce headland. Low-lying, with elevations generally between 0 and 5 m, it is home to a series of landforms which are the result of the interaction between waves, clear evidence of ancient shorelines, interrupted here and there by bodies of palustrine waters and by river levees. Along the stretches of coastline which still retain some natural aspects, the **beaches** widen out back to the coastal **dunes**, formed by the onshore wind sweeping the grains of sand. Inland, traces of fossil dunes have been found, once common, these have virtually disappeared because of land reclamation. Behind the dunes, there are lagoons and marshes, the former being on the shores of Mesoneritico, or the protected area of a regional nature reserve, which stand over it in above the surrounding plain, marking the Copper Age shoreline. The large wetlands near the coast provide important geo-morphological clues to the past: they may be part of ancient delta **lagoons and marshes**, like the Comacchio Valley, and the Bertuzzi Valley, or lowlands which indicate the presence of ancient lagoons, such as the Valle Mandriole, the Valle Pega, the Valle Santa Giustina and the Venice of Bellocchio. Over the last fifty years the area has been highly urbanized, beachfront bathing establishments, ports, wharfs and coastal defence works (breakwaters, groins) have been built, altering the natural morphodynamic characteristics of the beach. There are increasingly fewer areas today where we can still observe typical beach morphology, with sandy dunes behind the beach, or a river outlet unconfined by man-made banks.



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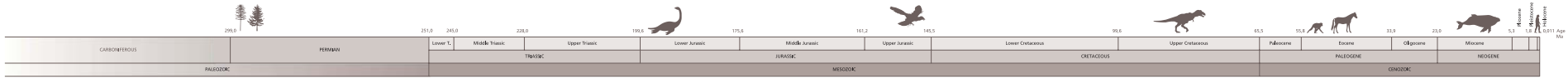
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