Studying the climate

Core boring

Core boring is a sampling technique used to research mineral resources in the subsoil by boring wells in order to analyze the ground, and for other digging activities for civil engineering purposes. In core boring a cylinder shaped sample of rock or ice is extracted, which is known as a core. From these cores it is possible to obtain a large amount of information on the climate variations of the past, thanks to what remains imprisoned in the ice, such as : gas bubbles, chemical elements that form the ice, sediments, fossils and many other elements. These traces are true witnesses of past periods, and are useful in order to reconstruct the climatic history of the Earth. Ice cores, in fact, maintain the chemical and isotopic characteristics obtained from the snow in the atmosphere at the time of condensation and precipitation, characteristics that remain mostly unaltered in the ice. Ice core boring is possible in the internal areas of Greenland and the Antarctic as the temperature always remains below zero and therefore the is no surface fusion, and the snow that accumulates each year forms a regular and continuous stratigraphic succession of layer upon layer of snowfall. With the passing of time the snow is compacted and the empty spaces are decreased and the snow is transformed first into firn or névé and then into ice, the pores become occluded and the air bubbles are trapped and therefore provide samples of the atmosphere in the past.

Fossil pollens

The study of pollens can reconstruct the history of vegetation in the past, and therefore of climate changes in time. For example we can imagine a fossil lake, preserved in different sediments, just like a filing cabinet with many drawers: each layer is a drawer containing the pollens of all the plants that grew at that particular time in the surrounding area. There are plants, in fact, that are considered climatic indicators – in other words they live in a particular region only if the climate is suited to their needs. For example oaks, hazel trees and linden trees which are all broadleaf trees, only live in temperate-warm climates and will never be found in regions with a rigid climate. Fir trees and beech trees instead, live in regions with a fresher, humid climate. In regions with a cold continental climate, only some types of grasses can be found, which form ecosystems such as the tundra or the steppes. If the climate of a particular region changes in time, obviously also the vegetation shall change and shall follow the various climatic oscillations very closely. This is exactly what we can see when we study the evolution of vegetation in a fossil lake or in any other deposit of sediments. Once a suitable area is identified, samples are obtained by drilling and core boring. Once the samples are extracted they are taken to a laboratory and treated with chemical agents in order to eliminate any excess organic and inorganic fraction, and finally the pollens are obtained.
Subsequently, with the help of a microscope, a detailed analysis will help to recognize the various species of plants that were present in the area and therefore reconstruct the climatic oscillations of the past. The data that are collected, are then summarized in diagrams that visually represent the vicissitudes of the various historical periods. The next steps of the analysis consist in attributing a relative age to each climatic phase, and following the sequence of the events that have taken place over the centuries.

Isotopic stratigraphy

Isotopic stratigraphy is based on the study of isotopes, especially carbon and oxygen isotopes. This technique can be used to study variations in temperature, salinity and volume of masses of ice in time. Generally, planktonic and benthonic foraminifera living in the surface layers of the sea or in sea sediments, are studied. After treating the organisms with the help of a specific instrument, the isotopic ratio of “heavy” oxygen-18 and normal oxygen-16, contained in the calcite shells of the foraminifera, is measured. If the calcite shows an isotopic equilibrium with the sea water, the ratio of the two oxygen isotopes varies with the precipitation temperature of the calcite. Therefore an increase in the isotopic equilibrium of the oxygen in a carbonate indicates a drop in the temperature, while a decrease in the same indicates a rise in temperature. Simplifying, it is therefore possible to trace the periodic fluctuations of the climate in time.

Geological traces

In certainly is no easy task to retrace all the sea level variations that have happened in thousands of years. Several different geological techniques which focus on studying specific areas near the coastlines have been used to trace these variations.

- the sea digs a horizontal crevice at water level at the base of a cliff which becomes deeper as time goes by. When the sea level decreases, it makes a new etching. Sea level variations can be discovered by measuring the height difference between these two marks
- speleothem: if near the sea there is a cave with stalactites, one can discover sea level variations by studying these stalactites. When the sea level is below the cave the stalactite grows because the water that seeps into the cave causes calcium carbonate to deposit, whereas its formation stops when the sea invades the cave but some organisms carry on with the stalactite's concretion. These animals which are called serpulides have a calcium carbonate outer shell which therefore can be given an age with the radiocarbon technique and thus enable us to discover when the sea came into contact with the stalactite
- when the sea level rises and encounters a specific land conformation it will form a very shallow inland lagoon called "paleolagoon". This lagoon is where sediment and fossil shells will deposit. Then when the sea level diminishes, one will find organic deposits at different heights on the hills. The age of these deposits is analyzed in order to find out when the sea was at that specific level
- when the sea level rises and meets a shelf made of soft rock which is easily eroded, it creates a terrace shaped platform known as "marine terrace" and a sort of slope. At the flex point between the abrasion platform and the beginning of the slope, a place called the "inner edge", one can measure the sea level of the past.

Climate variations

If we have many geological markers we can draw a eustatic graph which traces the different sea levels over the millennia. For instance, 220,000 years ago the sea was 3 meters below its current level and about 140,000 years ago it was as much as 140 meters below its level nowadays. Right after that, during the Tirrenian period about 125,000 years ago it rose suddenly to 7 meters above today's level.

That was a very warm period, much warmer than it is today and with a much higher concentration of carbon dioxide. Obviously, if the sea level was 7 meters above what it is today, many of the current coast areas, such as Venice, did not exist.

At a much more recent time, about 22,000 years ago, there was the last glacial acme, which is the coldest moment of the last glacial era which had lowered the sea level by approximately 120 meters. At this time half of the Adriatic was dry land, Corsica and Sardinia were joined together, Elba was part of the peninsula, and Sicily was joined both to Italy and to Africa. Thanks to these dry lands, many African animals were able to migrate and settle in Italy (i.e. rhinoceros and elephants). Once the islands became separated from Italy, these species adjusted to the new environment, spawning new characteristics such as dwarfism. In fact, fossil remains were found in Sicily of a dwarf elephant that was no more than 1 meter tall. It was much smaller than its African relatives because on the island there were no predators that it would have needed to protect itself from but there was also little food available. With this great a decrease in sea levels, man found new fertile lands and hunting territories. After the glacial acme, the sea level started rising again until the present day.

Therefore, at the end of the Glacial Era, a new warm phase began and the ices have melted making the sea rise very quickly (about 10 meters in 100 years). In fact we find both historical and religious references to this period which became known as the Deluge.

The plains that were inhabited by man were flooded by the sea which forced man to move several times in a lifetime, specially in the areas surrounding the Black Sea which are rather flat. About 10,000 years ago the sea was 50 meters

below today's level, then there was a global warming trend so the sea level rose suddenly about 5,000 years ago. This phase peaked approximately between 7,500 and 4,600 years ago, when Earth reached its highest temperatures in the past 10,000 years. About 6,000 years ago the Sahara had a very humid climate and was covered with grass lands that were inhabited by highly civilized populations.