Sea level as a metronome of Earth's history

May 19 2017

A view of the Mediano anticline, strata dipping to the left into the lake waters. This large-scale fold structure is a witness of ancient deformation associated with the rise of the Pyrenees in the middle Eocene, 45 Million years ago. Excellent exposure of rocks in this dry area allow today's geologists to study the epic poem of the Earth written in its sedimentary archives. Credit: © UNIGE

Sedimentary layers contain stratigraphic cycles and patterns that precisely reveal the succession of climatic and tectonic conditions that have occurred over millennia, thereby enhancing our ability to understand and predict the evolution of the planet. Researchers at the University of Geneva (UNIGE), Switzerland and international colleagues have been working on an analytical method combining deep-water sedimentary strata observations and measuring the isotopic ratio between heavy and light carbon. They have discovered that the cycles that

punctuate these sedimentary successions are not due solely to the erosion of mountains that surround the basin, but are ascribable to sea level changes. This research, published in the journal *Geology*, paves the way for new uses of isotopic methods in exploration geology.

The area south of the Pyrenees is particularly suitable for studying sedimentary layers. Rocks are exposed over large distances, allowing researchers to make direct observations. Turbidites are found here—large sediment deposits formed in the past by underwater avalanches consisting of sand and gravel. "We noticed that these turbidites returned periodically, about every million years. We wondered what the reasons for this cyclicity were," explains Sébastien Castelltort, professor in the department of earth sciences in UNIGE's faculty of sciences.

The ups and downs of oceans regulate sedimentation cycles

The geologists focused their attention on 50 million-year-old Eocene sedimentary rocks, and undertook the isotopic profiling of the sedimentary layers. "We took a sample every 10 metres, measuring the ratio between ^{13}C (heavy carbon stable isotope) and ^{12}C (light carbon stable isotope). The ratio between the two tells us about the amount of organic matter, the main consumer of ^{12}C, which is greater when the sea level is high. The variations in the ratio helped us explore the possible link with the sea level," says Louis Honegger, a researcher at UNIGE. The research team found that the turbidite-rich intervals were associated with high ^{12}C levels, and almost always corresponded to periods when the sea level was low. It seems that sedimentary cycles are mainly caused by the rise and fall of the sea level and not by the episodic growth of mountains.

When the sea level is high, continental margins are flooded under a layer of shallow water. Since the rivers can no longer flow, they begin to deposit the sediments they carry at the continental margins. This is why so little material reaches the deep basins downstream. When the sea level is low, however, rivers erode their beds to lower the elevation at the mouth; they transfer their sediment directly to the continental slopes of the deep basins, creating an avalanche of sand and gravel. Consequently, if the variations of the sea level are known, it is possible to predict the presence of large sedimentary accumulations created by turbidites, which often contain large volumes of hydrocarbons, eagerly sought in exploration geology.

Measuring stable carbon isotopes: a new indicator of reservoir rocks

The research provides a new role for the use of carbon isotopes. "From now on," continues Castelltort, "we know that by calculating the ratio between ^{13}C and ^{12}C sampled in similar slope deposits close to continents, we can have an indication of the sea level, which means it's possible to predict the distribution of sedimentary rocks in the subsurface."

In addition, this measurement is relatively simple to perform and it provides accurate data—a real asset for science and mining companies. The study also highlights the importance of sea levels, which are a metronome of the Earth's sedimentary history. "Of course," concludes Honegger, "tectonic deformation and erosion are important factors in the formation of sedimentary layers; but they play a secondary role in the formation of turbidite accumulations, which are mainly linked to changes in the sea level."

Provided by University of Geneva