Geophysical investigation aims revealing how vegetation responds to climate change

September 26 2017

Researchers from five countries analyze remnants trapped in rainforest sediment to reconstruct 1 million years of Atlantic rainforest history. Credit: Daniel Antônio / Agencia FAPESP

In early August 2017, a team of scientists from the University of São

Paulo (USP), the University of Campinas (UNICAMP) in Brazil and France's Development Research Institute (IRD) began drilling boreholes and analyzing sediment removed from the Colônia Crater, a depression located in southern skirts of São Paulo City, with a diameter of 3.6 km, depths of up to 450 m and an area of 10.2 km^2. Their aim was to reconstruct the past 1 million years of the biosphere and Atlantic Rainforest biome in that area.

"Accumulation of sediment was possible throughout the Quaternary [the past 2.6 million years] because of the bowl shape. The 50 m of sediment we're sampling will contain records of the last 800,000 to 1 million years," said André Oliveira Sawakuchi. Sawakuchi is a member of the project team and heads the Gamma Spectrometry & Luminescence Laboratory at USP's Geoscience Institute.

Equipment for the lab was purchased with São Paulo Research Foundation (FAPESP) support, and this lab is one of the facilities where the materials will be analyzed. "The analysis will be done in labs at USP and in countries like Switzerland, France, the United States and Germany," said Marie-Pierre Ledru, a researcher at IRD, who shares the coordination of the project with Sawakuchi.

The researchers are analyzing the cores for any microbes, pollen, isotopes, greenhouse gases and algae, as well as for other items trapped in the sediment. All this is evidence of the variations in the amounts of sunlight received by the planet that caused the many glacial-interglacial cycles in the history of the planet and the impacts of the wet and dry periods on the Atlantic Rainforest.

"The questions we try to answer have to do with these natural cycles that are part of the Earth's climate. In the past 800,000 years, there have been glaciations roughly every 100,000 years. Our research project has several fronts, and we will obtain a wide-ranging analysis of this period," said

Patricia Roeser, another member of the project team and a researcher at the European Center for Environmental Geoscience Research & Education (CEREGE) in France.

The sediment samples collected from the Colônia Crater are very rich with information concerning what occurred in the area and how the Atlantic Rainforest biome responded to climate change. By analyzing the organic compounds and isotopes (forms of chemical elements) in the sediment, the researchers can determine a great deal about the type of plant cover and even the composition of the rain that fell thousands of years ago.

"Plants absorb isotopes of hydrogen from rainfall, so the vestiges of plants trapped in the sediment represent a kind of climate archive," Sawakuchi said. Another source of information about the past of the Atlantic Rainforest is the pollen found in sediment cores, from which the scientists can draw conclusions regarding flora diversity.

Analysis of the gases trapped in the pores of the sediment enables the investigation of the subsoil communities of microbes, which produce greenhouse gases such as carbon dioxide and methane.

"Research of this kind has been done for temperate forests, but very few tropical areas have been studied in this way," says Ledru. "The information obtained relates not just to the forest itself but also to the amount of rainfall and to the periods of more intense drought and rain."

The project is being carried out in three stages. The first is drilling and core sample collection. The second is the analysis of greenhouse gases and microbiology. "The drilling site is 100 m from our mini-laboratory. The material comes to the mini-lab, where the samples are divided up into smaller subsamples. We must do this fast to avoid contamination. The samples are then shipped to researchers in several countries," said

Roeser, who is responsible for in situ analysis.

This third stage involves the analysis of remnants such as isotopes, pollen and algae by experts at research centers in several different countries. "After that, the cores will be returned to Brazil for storage in USP's archive," said Ledru. "It's an interdisciplinary project with 17 researchers who specialize in different areas."

The research project, called Tropicol, is not the first to study the vegetation in the Colônia Crater. The area has been studied since the 1960s, but the initial focus was on how the crater was formed, probably by a meteorite. Studies focusing on climate and vegetation began in the 1980s.

"There isn't a lot of research of this kind in the world," Roeser said. "Continental deep drilling to study microbial activity, as opposed to oceanic surveys, began less than ten years ago. The first results showed a link between glacial-interglacial cycles and types of microbial communities. We're curious to see the results of the analyses, which will show whether this is also the case for the Colônia Crater."

Drilling in 2014, as part of the Thematic Project "Dimensions US-BIOTA São Paulo", produced 14 m cores of sediment, recording the past 250,000 years. In this case, the scientists discovered that there was a lake in the crater for a long period. They estimated that the change from a lake to a marsh occurred approximately 120,000 years ago.

"We know the sediment is rich in pollen and organic matter, all of which is good material to study the evolution of the Atlantic Rainforest," Sawakuchi said. "Another interesting fact is that at depths below 11 m, we find lake-bottom sediment layers. Most of the crater's sedimentary infill is of this kind, meaning that the crater was a lake for a large proportion of its lifetime."

The crater is also known to have a maximum thickness of 450 m of accumulated sediment. "The future goal is to drill down to collect cores from these 450 m," Ledru said. "It will then be possible to sample the basement rock at the bottom of the crater in order to define whether it really was caused by a meteorite impact. Satellite images of the crater leave no doubt, but this study will bring confirmation from the rock," Ledru said.

She added that the material that has been collected from the crater can be used in new studies concerning climate change and the Atlantic Rainforest.

"For future research, we're interested in studying how changes in solar energy affect biodiversity, creating processes of extinction and species emergence. These processes are still poorly understood. We don't have answers about the natural extinction processes, and we're currently experiencing a mass extinction largely caused by humans," Ledru said.

The planet is undergoing a new phase of the solar cycle, wherein the Sun's activity becomes more intense at intervals of approximately 11 years, while at the same time, greenhouse gases are at high levels. "It will be important to determine the effects of these variations in solar energy on the tropical forest underlayer," Ledru said. "We can then know how energy variations may impact future extinctions and specie emergences, making a link between the past and the present era in which human activity is creating something completely new on Earth. It's still only a new research possibility. Studies of climates, paleoclimates and paleobiology need several indicators, such as those captured in the Colônia Crater."

Provided by FAPESP