



How and when was the Amazon formed?

Project investigates the formation of the Amazon

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How and when was the Amazon formed? This is the answer that the “**Transamazonian Drilling Project: origin and evolution of the forests, climate and hydrology of the South American tropics**”, wants to discover.

With a diversity of indicators, having as fundamental materials the records of sediments and rocks, it will be possible to reconstruct the past of the Amazon since its origin, and answer fundamental questions such as, for example, how climate changes influenced the diversity of plants, the diversification of species and the formation of the Amazon River.

Studies on the origin of the Amazon are still scarce in geological data considering the continental dimension of the biome, and are generally based on more on models and hypotheses than supported by evidence, suggesting that the formation of Neotropical forests would have occurred during the Cenozoic period (geological era starting from 65.5 million years and extending until today).



“If we were to go back in time, the forest, as it is today, would have its formation in the Cenozoic period, starting 65 million years ago. So, this is the temporal dimension of our project, to reconstitute the Cenozoic history of the Amazon”, informs the geologist and Professor André Sawakuchi, from the Institute of Geosciences of the University of São Paulo (USP) and one of the Coordinators of the project in Brazil.

The Trans-Amazon Drilling Project, TADP as it is called, is funded by the International Continental Scientific Drilling (ICDP), the National Science Foundation (NSF) and the Smithsonian Tropical Research Institute (STRI). **It involves institutions from eleven countries and 60 international researchers. It is one of the largest research programs ever organized to study the origin and evolution of the Amazon and its global relevance.**

According to the description of the project, the collection of material (sediments accumulated in the sedimentary basins during the Cenozoic) for the research, the testimonies, will be carried out from drilling 800 to 2 thousand meters deep in strategically chosen locations in the states of Acre and Pará, Northern Brazil. The initial idea of the project was to drill five holes, two in the Amazon sedimentary basin, one in the Acre basin, one in the Solimões basin and another in the Marajó basin. According to Professor André, several drillings have already been carried out in the Amazon since the 1970s, but for other purposes, such as discovering coal, oil and natural gas reserves. According to the Instituto Socioambiental collection, in 1976, for example, Petrobras would have drilled 200 wells in the Amazon. These are locations that already have seismic sections that allow us to have an idea about the occurrence and thickness of Cenozoic sediments. The samples collected in these drillings, however, cannot be considered in the study, since no testimonies were collected, that is, it does not provide the rock with the integrity required for the research. Drilling operations, expected to start in the first half of 2023, will be carried out sequentially in the Acre Basins, with drilling at 2,000 meters, the Solimões, 800 meters, and the Marajó, 1,200 meters. Each perforation lasts, on average, three months of uninterrupted work.

“Probing costs have risen substantially (approximately 32%) due to several factors. The resources we have available will allow us to carry out surveys in Acre and Marajó. The Solimões basin is uncertain and will depend on the search for additional financial resources”, clarifies André.



RECONSTITUTING HISTORY

According to the Professor, the idea is to reconstruct the history of forests, climate and rivers in the Amazon using the holes. **“The sediments (sand and mud) accumulated over time in the sedimentary basins are organized in layers, which are like an archive of the past. So, the deeper we manage to drill, the more we advance our knowledge of the natural history of the Amazon”, he clarifies.** However, all the material obtained from these drillings needs to be intact for research purposes. The cores are carefully removed, stored under special conditions and sent to a repository at the University of Minnesota, in the United States, where samples will be taken for studies conducted by TADP researchers.

“With the research we hope to get answers to questions such as, for example, when the Amazon River acquired its current course and started to discharge large amounts of fresh water and nutrients into the Atlantic Ocean. Today, we know that it rises in the Andes and flows into the equatorial Atlantic, but did it at one time in the past flow into the Pacific or the Caribbean? It is still not known exactly when and under what conditions this happened, but that is what we will be able to discover through the study”, informs the Professor. In these sediments there is also pollen from plants from the past and, with this, it is possible, for example, to discover what forests were like in the past. There are also minerals and plant debris whose analyzes allow us to know how the rainfall regime was. Thus, a scenario is drawn that describes the climate, forests and rivers of the Amazonian past, including reconstructions of paleogeography and paleoclimatology (historical reconstructions) of the region.

“We have an environment whose origin and changes range from geological processes on a time scale of tens of millions of years, such as the emergence of the Andean mountain range, to plant evolution and climate change with time scales from a few million to tens of millions of years. of thousands of years. Understanding the past climate of tropical South America is another fundamental issue of the project, as this is closely related not only to the Amazon, but also to other Brazilian biomes such as the Cerrado and the Atlantic Forest. Therefore, we are interested in studying the origin of the Monsoon in South America, which is responsible for the rain in the Amazon and for an important part of the rain in the Cerrado and the Atlantic Forest. We are calling the period that marks the formation of this great tropical forest separated from the other great South American tropical forest, the Atlantic, the “Origin of the Amazon”, informs the Professor.



In his report, the Professor informs that the Amazon is generally presented to society as a large dense tropical forest that is more or less uniform, but, in fact, it has a great diversity of environments that include dense upland forests, areas of vegetation open vegetation, adapted to the lower temperatures of the higher areas in the Andes and the Guiana plateau, in addition to the largest seasonally flooded forests in the world, the floodplains and igapós, and the immense variety of aquatic environments in the great rivers amazonians. All these habitats are products of the interaction between geological, climatic and forest elements that will be researched. **“When we look at the Amazon, we shouldn't just look at the closed forest on dry land, because otherwise we'll lose other habitats”, clarifies André.** This great diversity of environments found in the Amazon is also associated with an enormous diversity of species.

“Few know that the Amazonian biodiversity, the greatest on the planet, has such an ancient origin. The genetic and paleontological data available so far indicate that several lineages of Amazonian plants and animals showed high rates of diversification shortly after the extinction of the dinosaurs, approx. of 65 million years. In addition, we also observed high rates of diversification, corresponding to the emergence of a high number of lineages, during the Oligocene and Miocene, periods with significant climate changes and great tectonic activity. On the other hand, despite the Amazon biota having such ancient roots with many species (today fossils) that inhabited this region since the beginning of the Cenozoic (or even earlier), most of the species that live in the Amazon today are relatively recent. For example, many species of butterflies, birds, primates and plants originated during the Pliocene and Pleistocene, that is, during the last 5 million years, although some species are more ancient, with origins circa 10 million years ago” comments Lúcia Lohmann,

professor at the Institute of Biosciences at the University of São Paulo (USP), member of the project team.



“Unraveling the history of the Amazon is not a trivial matter. It depends on highly multidisciplinary teams prepared to study different aspects associated with the origin of the Amazon. Partnerships between biologists, geologists, paleontologists and climatologists are extremely important for us to unravel the complex history of this exceptionally diverse biome,” adds Lúcia.

The research

The research, titled “**Trans-Amazon Drilling Project (TADP)**”, is carried out under the International Continental Scientific Drilling Program (ICDP), one of the largest research programs ever organized to study the origin, evolution of the Amazon and its global relevance, being responsible for US\$1.5 million in funding and the rules of cooperation. The resources were granted by ICDP and US-NSF – National Science Foundation, represented by researchers Paul Baker (Duke University), Sherilyn Fritz (University of Nebraska), Cleverson Silva (Fluminense Federal University) and Anders Noren (University of Minnesota). Two other institutions that also contributed with financial support were the Smithsonian Tropical Research Institute, through researcher Carlos Jaramillo, and FAPESP, under the coordination of Professor André Sawakuchi, with the aid of R\$6,856,626.00 and US\$88,090.00, in addition to four postdoc fellowships and one technical training fellowship. They are institutions from eleven countries and 60 researchers, 30 of whom are nationals of different specialties.



According to the coordinator of the project in Brazil, this will be the first time that the Cenozoic sedimentary strata of the Amazon will be continuously drilled and sampled through cores for scientific purposes. The project will make it possible to carry out systematic analyzes of the geological and climatic history of the Amazon since the beginning of the Cenozoic, a period considered key to understanding the initiation and consolidation of the Neotropical forest and the Amazon River Basin.



In order to carry out all this research, some specific scientific questions were outlined that the project seeks to answer, such as:

What is the history of the rise and erosion of the Andes? How has the climate evolved in tropical South America from the Cretaceous to the present? When was the hydrological connection established between the Amazon basins and the Equatorial Atlantic Ocean? What was the composition and diversity of plants like in the Amazon and how does this correlate with the history of vertebrate diversification? Whether methane (CH₄) and carbon dioxide (CO₂) generated by the biodegradation of buried organic sediments are relevant to the carbon balance in the Amazon, and whether the magmatism that occurred during the opening of the central Atlantic Ocean caused climate change responsible for the mass extinction of the end of the Triassic period.

The forecast for starting the survey is April 2023, in Acre, in a job that takes place 24 hours a day, 7 days a week. The material collected will begin to be studied in this project, but it will require several other research projects and will probably take decades to carry out detailed studies.

So far, two scientific workshops have been held, which should be periodic as the project progresses. One of these events is already confirmed at the University of Minnesota (USA) as soon as the first testimony arrives at the institution, which will open and curate the collection of samples and planning of laboratory analysis.



Risks

One of the risks of the project is in the financial part. When the project was prepared and submitted with all the necessary cost estimates, in 2018, drilling services were worth around three million dollars. At the time, the dollar was at R\$3.80. The contract took place in April/2019. Then came the COVID-19 pandemic which, for two years, prevented field work, redirecting studies during this period to analyze surface materials collected in previous projects. With the resumption of work in 2022 and with the dollar already at around R\$ 5.00, it was therefore impossible to carry out the three surveys. In June 2022, however, FAPESP granted an amendment, so that now the resources for drilling total R\$5,500,000.00, which is equivalent to around US\$1 million, as requested in 2018.

Another point of attention of the project is the logistical and operational complexity of the drilling. The locations were selected from seismic studies and drilling carried out for oil and natural gas exploration by Petrobras in the 1980s and 1990s. This allowed selecting locations where the sediments and rocks of interest to the project occur. Although Petrobras has not found oil or gas in these places, it is not possible to exclude the risk of drilling reaching an accumulation of gas. Therefore, drilling must be carried out using techniques used in oil and gas exploration and by a specialized company. The logistics of transporting the rig between the drilling sites is also challenging, as it will require transport through rivers whose navigability can be complicated during the dry season. For this reason, the project requires logistical planning, from obtaining environmental licenses to transporting tons of cores for opening and taking samples in the USA.

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