Unveiling the hottest period in a million years: The MIS 11c paradox

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Limestone core samples collected Bàsura cave, northern Italy. The black-and-white alternating bands represent a scale measured in centimeters. Researchers follow the scale to extract small subsamples ranging from 0.1 to 100 milligrams for carbon and oxygen isotope analysis, trace element determination, and uranium-thorium dating. Credit: National Taiwan University

The hottest warm period in the past million years is believed to have occurred about 400,000 years ago. During this time, the Northern Hemisphere had less ice than today, and sea levels were about 10 meters higher. Surprisingly, solar radiation, a key driver of warm periods, was weak during this time, and greenhouse gas levels were lower than today. This puzzling period, known as the MIS 11c paradox, has long baffled scientists.

Dr. Hsun-Ming Hu, a postdoctoral researcher from the Department of Geosciences at National Taiwan University (NTU), along with an international team led by NTU's Distinguished Professor Shen Chuan-Chou, has uncovered the key to this mystery.

Using speleothem data from Mediterranean caves and North Atlantic ocean records, their research reveals the causes of the anomalous warmth 400,000 years ago. Their findings were published in *Nature Communications* on July 15, 2024.

Dr. Hu explains that the key to solving the MIS 11c paradox lies in understanding the sequence of reactions of Earth's ice sheets, oceans, and atmosphere to solar radiation. Due to the lack of precise dating in most ocean and land records, this issue has puzzled scientists for years. In 2014, the NTU team and their European partners collected a two-meter-long speleothem core sample from Bàsura cave in northern Italy.

Using high-precision uranium-thorium dating technology from NTU HISPEC laboratory, they provided accurate age control for geological records, reconstructing the environmental history of southern Europe from 480,000 to 360,000 years ago. By comparing solar radiation, global sea level changes, and various climate records, the team finally unraveled the MIS 11c paradox.

Dr. Shen states that over the past few years, the team discovered that the

carbonate records from Bàsura cave are closely linked to climate changes in the Atlantic and Mediterranean regions. The chronology of paleoclimate records from the North Atlantic could, therefore, be controlled accurately using the precisely dated stalagmites from the cave.

Their research shows that the extreme warm period of MIS 11c was due to a combination of factors. Around 426,000 years ago, increased summer solar radiation in the Northern Hemisphere first caused extreme warming in the mid-to-low latitude Atlantic. Coincidentally, as ocean warming occurred, Earth's tilt gradually increased to cause hot summers, allowing this warm water to persist for thousands of years.

The prolonged transfer of heat to high latitudes through ocean currents caused an unusual, long-lasting melting of ice shelves, leading to the hottest period in Earth's history over the past million years.

MIS 11c serves as an important reference for understanding global warming. Like today, this period did not have particularly strong solar radiation, but it shows that prolonged ocean warming alone can cause significant ice shelf collapse and sea level rise without requiring extremely high atmospheric temperatures or greenhouse gas concentrations. This study highlights the crucial role of oceans in driving global warming and ice shelf collapse.

More information: Hsun-Ming Hu et al, Sustained North Atlantic warming drove anomalously intense MIS 11c interglacial, *Nature Communications* (2024). DOI: 10.1038/s41467-024-50207-1

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