ADVERTISEMENT FEATURE

APPLYING GEOSCIENCE TO SOLVE THE BIG CHALLENGES

FROM INSIGHTS ON ANCIENT CAVE DEPOSITS to studies of monsoon intensity throughout history, researchers in China are expanding knowledge of the Earth's systems and climate.

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▲ **Erosion rates for the Loess Plateau in north-central China could be estimated using artificial intelligence and Geographic Information System data.**

Carbon dioxide levels in the Earth's atmosphere hit nearly 420 parts per million in 2021 — a level not seen in around four million years, since the mid-Pliocene Epoch, long before our own species evolved. This is why palaeoclimatological data is so crucial to understanding the impacts on our planet of rising greenhouse gas levels and temperatures.

Predicting the future effects of climate change requires a solid understanding of geoplanetary systems and also the Earth's deep history. Fresh insights from the School of Geography at the Nanjing Normal University, in China, are helping frame global challenges and shape solutions via an interdisciplinary lens.

Among the school's researchers is Yongjin Wang, a professor of palaeoclimatology, whose data collection in caves across China, studying speleothems — mineral deposits, such as stalagmites, that accumulate over time —will help predict future climate change.

"Compared to coral and ice core samples, speleothems are one of the better climate proxies for meteorological measurements, because they offer more detailed insights into historical climate variations based on the varying values of oxygen isotopes," explains Wang.

CAVE INSIGHTS

In 2001, Wang's study of Hulu Cave near Nanjing in China's Jiangsu Province, was published in *Science*[1]. He remains fascinated that five oxygen isotope records in the icicle-shaped, stalagmite mineral deposits he found here resemble those found far away in the ice cores of Greenland.

"Our results suggest that the East Asian Monsoon intensity changed in concert with Greenland's temperatures between 11,000 and 75,000 years ago," he says. "This data links the North Atlantic climate with the transport of heat and moisture from the warmest part of the ocean where the summer East Asian Monsoon originates. This helps us understand climate cycles and trends."

His team has been investigating the mechanisms and events of the East Asian Monsoon using speleothems. From these they have been able to determine rain or precipitation records with a resolution of just three years over the past two millennia, which is important to the projection of future precipitation. They reported the findings in *Quaternary Science Reviews*[2] in June 2022.

However, isotope levels are also subject to the complex interplay of geochemical mechanisms and environmental processes. Wang is studying the processes at play here, hoping to find solid evidence behind isotope levels and monsoon intensity.

"Narrowing data discrepancies has been central to our research," he says. "Its credibility lies in consistency between experiment samples and modelling results."

MODELING POWER

Wang says that it could take many years to continue testing and then verifying the data with climate modelling done elsewhere, and international monitoring data collected by the Global Network of Isotopes in Precipitation (GNIP) of the International Atomic Energy Agency (IAEA). Among Wang's colleagues at the School of Geography also collecting data to understand Earth systems is Guonian Lü, a geographic modelling and simulation scientist.

To Lü, the future of geographic analysis tools — such as Virtual Geographic Environments (VGE) and Geographic Information Systems (GIS) — will be in greater data sharing and model resources sharing. As he detailed in *Nature Reviews Earth & Environment*[3] in 2023, these technologies combine artificial intelligence and human knowledge with GIS data and models, enabling geospatial applications in geological studies.

"For example, to calculate the latest annual erosion volume of the Loess Plateau in China, an automated process can help geologists locate all the available data sources to come up with a reliable estimate," says Lü.

Understanding erosion can help scientists predict how the terrain of the Earth will change over time, and this kind of analysis can help expedite the research process.

BIG DATA

Lü is also applying mathematics to geological data to generate insights. "With 'geometric algebra', we hope to describe our world with data modelling that remains consistent across multiple dimensions," he says.

This could have applications for future smart cities, allowing both human and environmental data to be captured and used to create real-time maps and charts that capture what is going on in urban environments in a dynamic way.

Another geographic modelling scientist, Zhaoyuan Yu, adds that assigning those data values is akin to the organization of the elements in a periodic table.

"Our philosophy of modelling comes down to a framework for a big data model that incorporates scattered information in a dynamic system, such as the OpenGMS platform," explains Lü.

Developed by the school's Min Chen, OpenGMS is the first open geo-simulation project originating from China. It encourages sharing of modelling and simulation resources for geographic research and applications.

"We have trained more than 5000 researchers from around 20 regions of the world over the past three years," says Chen. "Gathering a community from diverse branches of earth system sciences, ranging from geology to atmospheric science."

That community, says Chen, and the OpenGMS platform, will be instrumental in helping address pressing global challenges, such as climate change. ■

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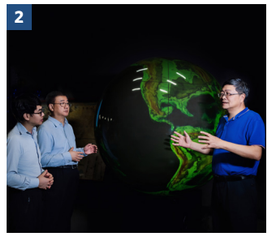

▲ **1. Mineral deposits such as stalagmites provide insight into climate change.**
2. Min Chen (left), Guo'an Tang (middle) and Guonian Lü (right) of Nanjing Normal University in front of a geo-modelling device.
3. Zucong Cai (left), Jian Liu (middle) and Yongjin Wang (right) of Nanjing Normal University discuss ancient climate records.

A MELTING POT OF BIG IDEAS

The School of Geography at Nanjing Normal University was the first school focused on geographical research in China. Officially inaugurated in 1997, it traces its history back to 1902. It has been led by meteorologist Coching Chu, population geographer Huanyong Hu and human geolographer Xudan Li.

The school continues to combine diverse research endeavours. Together with geographic modelling and simulation scientist Guonian Lü, geomorphologist Guoan Tang, leads the school's efforts in a project called Deep-Time Digital Earth (DDE). Initiated by the International Union of Geological Sciences, DDE promotes data harmonization and knowledge sharing on the geological evolution of the Earth. Tang is also known for contributions to digital terrain analysis, which offers more realistic and accurate imaging of the Earth's surface.

Dedicated to enhancing agricultural productivity, agrologist Zucong Cai studies the carbon and nitrogen cycle of soils, the microbes that live within the soil, and how these cycles interface with air and water. His team has focused on 'reductive soil disinfestation', a technique to remove soil-borne pathogens, which has been used widely on farms across China.

Atmospheric scientist Jian Liu also studies the paleoclimate. Her research looks at human and natural influences on global monsoons over the past 2,000 years, and how the Earth's orbit has changed intensity of monsoons over the past 300,000 years. Her team is also predicting monsoon variability over the coming century, under the influence of climate change.

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