Two Decades of Chinese/US Cooperation in Geology and Environmental Science: Past Success and Future Promise

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我的两个老师 在中国：

徐霞客

我的两个老
师 在中国：

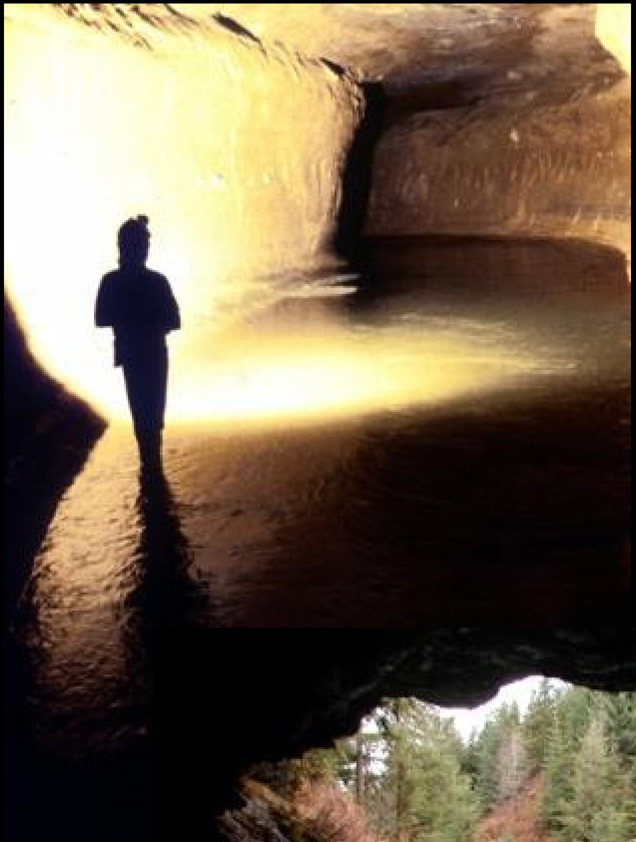
袁道先

Karst: very soluble bedrock dissolves to form a landscape with caves, underground rivers, and large springs

Characteristic features include:

rivers sink underground

then flow underground

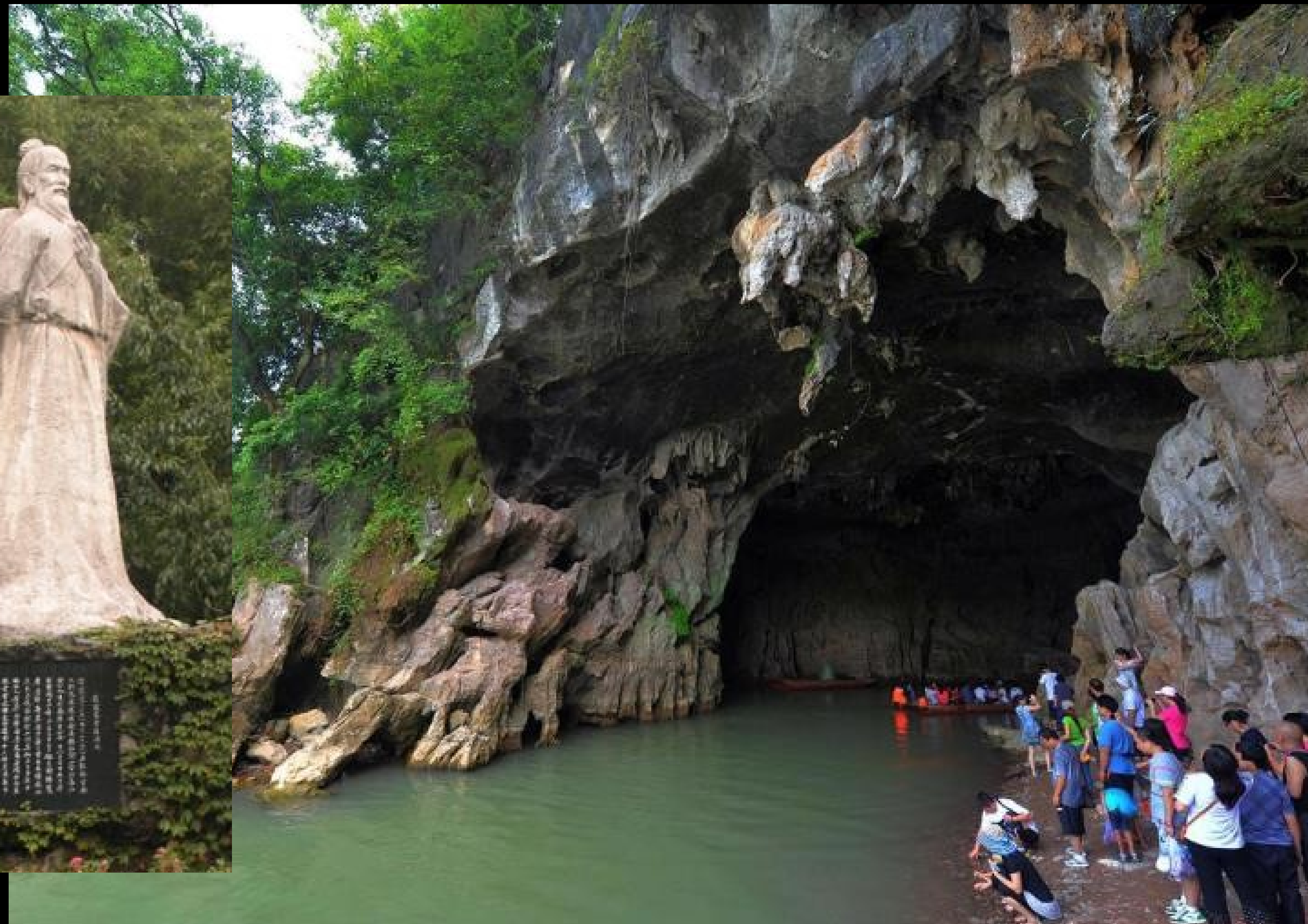


eventually to emerge

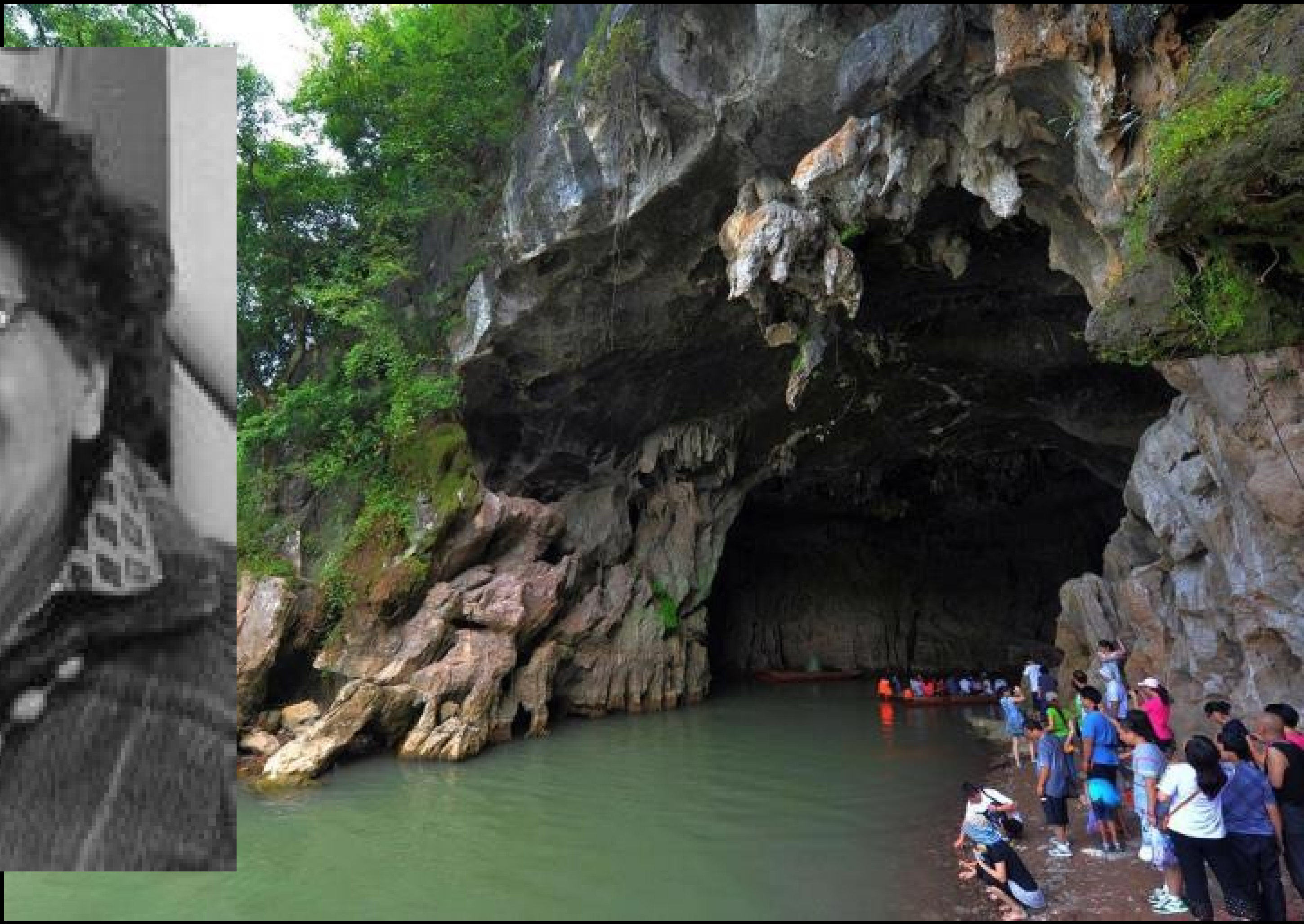
Southwest China has one
Of the world’s greatest karst
landscapes

Li River,
Guangxi

Xu Xiake explored Crown Cave near Guilin in 1637



Western/Chinese cooperation in karst studis began by 1980



Major joint Chinese/UK expedition at Crown Cave in 1986

I first came to China in 1995

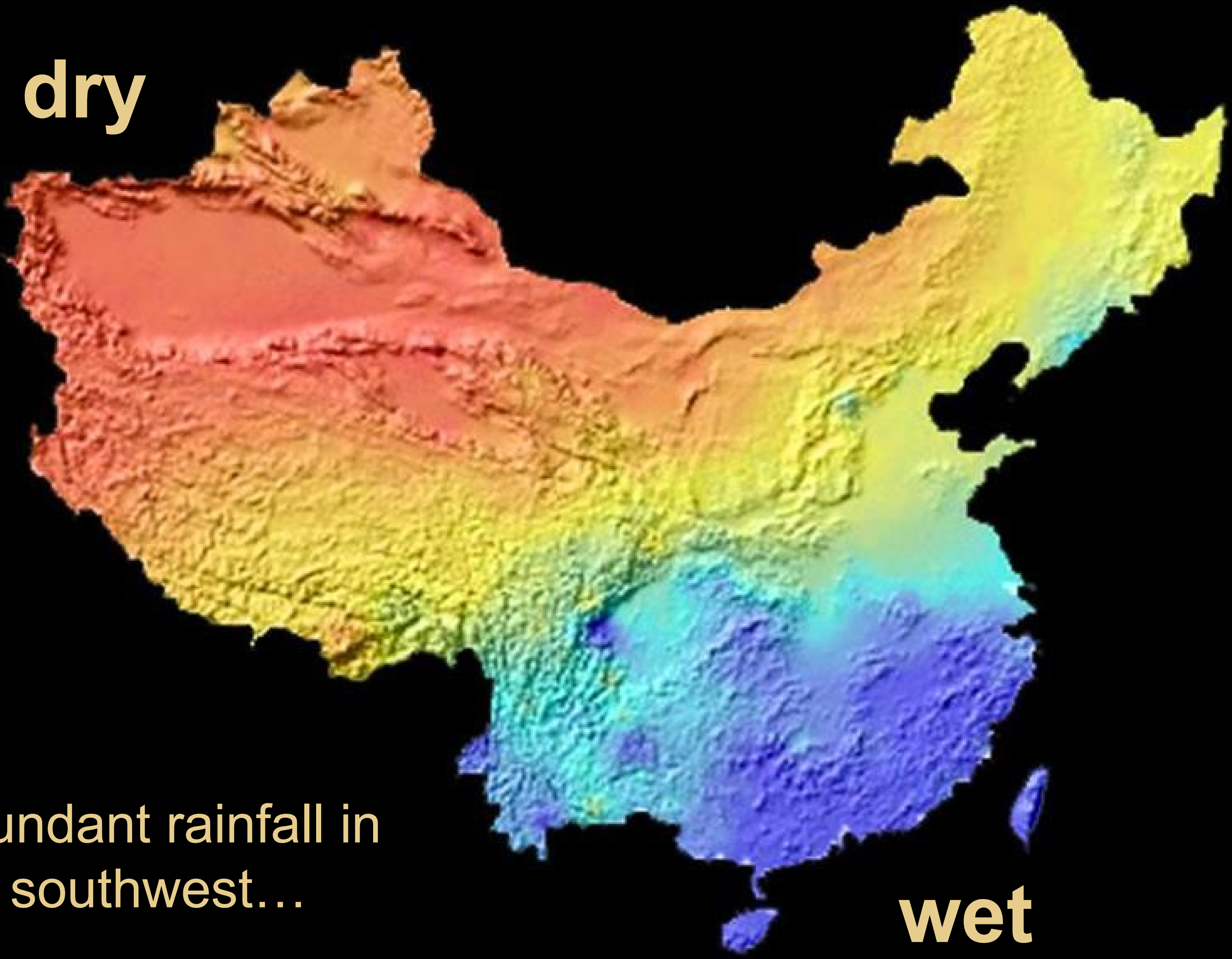
I have now come to China 38 times and have many close colleagues (and friends!)

I especially thank Yuan Daoxian, Cao Jianhua, Jiang Zhongcheng, Zhang Cheng, and Liu Zaihua

2016 China International Science and Technology Cooperation Award

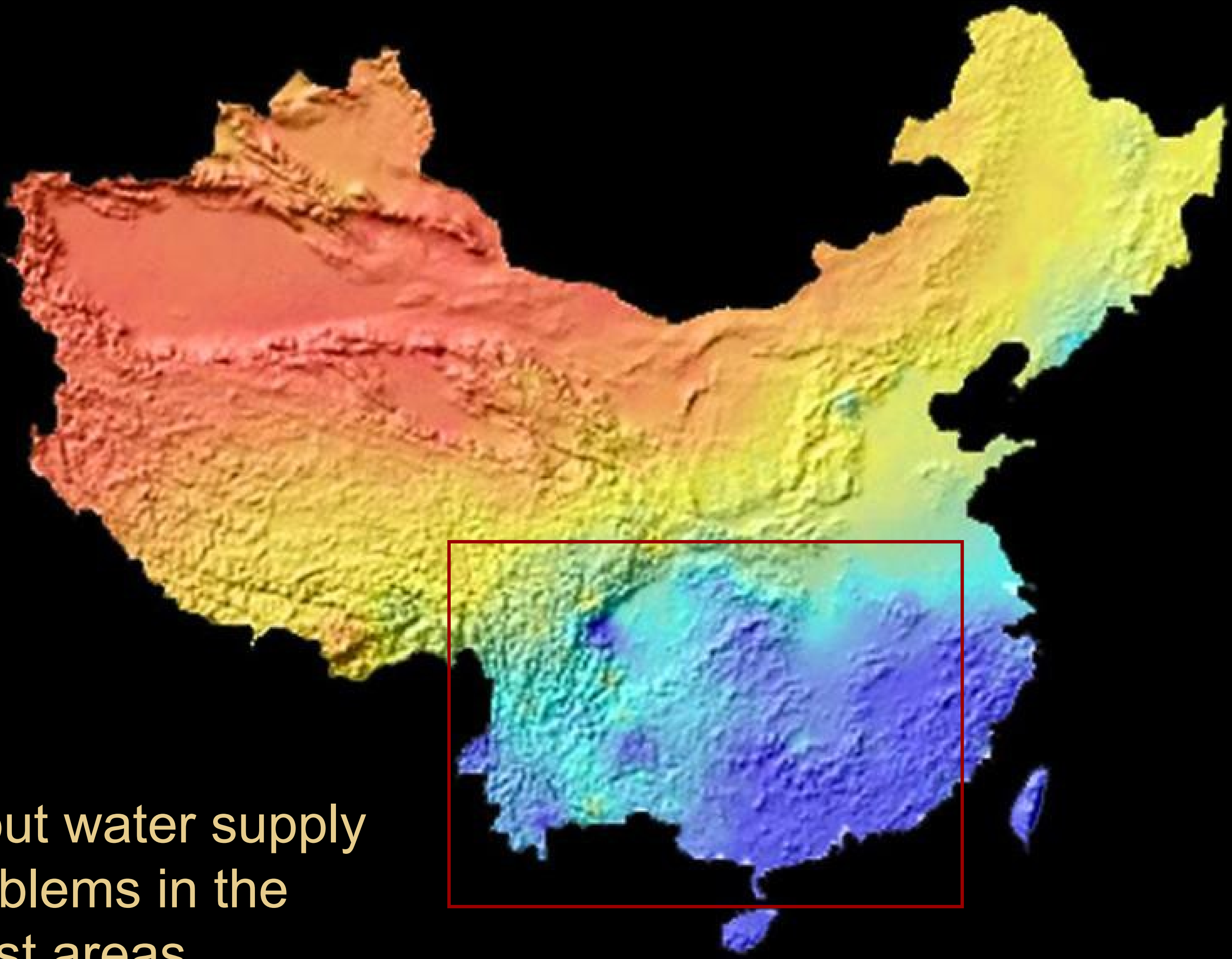
我是中国人, 因为我的女儿来自中国

dry



Abundant rainfall in the southwest…

wet



…but water supply problems in the karst areas

disappearing streams
that sink underground

so, much water is
underground

instead of at the surface

August

February

deforestation and soil loss has led to *karst rocky desertification*

water quality challenges also

2000: First Geographic Information Systems (GIS) training course: brought first ESRI software to IKG

2000: Joint fieldwork to attempt cave level dating Using cosmogenic isotopes at Ti Xing Dong, Guangxi

2002: Cooperative hydrogeologic research at the Yaji Experimental Site, Guangxi

HYDROLOGICAL PROCESSES
Hydrol. Process. 18, 2423–2437 (2004)
Published online 30 June 2004 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hyp.1472

Hydrochemical variations during flood pulses in the south-west China peak cluster karst: impacts of $CaCO_3-H_2O-CO_2$ interactions

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Abstract:

High-resolution measurements of rainfall, water level, pH, conductivity, temperature and carbonate chemistry parameters of groundwater at two adjacent locations within the peak cluster karst of the Guilin Karst Experimental Site in Guangxi Province, China, were made with different types of multiparameter sonde. The data were stored using data loggers recording with 2 min or 15 min resolution. Waters from a large, perennial spring represent the exit for the aquifer's conduit flow, and a nearby well measures water in the conduit-adjacent, fractured media. During flood pulses, the pH of the conduit flow water rises as the conductivity falls. In contrast, and at the same time, the pH of groundwater in the fractures drops, as conductivity rises. As Ca^{2+} and HCO_3^- were the dominant (>90%) ions, we developed linear relationships (both $r^2 > 0.91$) between conductivity and those ions, respectively, and in turn calculated variations in the calcite saturation index (SI_C) and CO_2 partial pressure (P_{CO_2}) of water during flood pulses. Results indicate that the P_{CO_2} of fracture water during flood periods is higher than that at lower flows, and its SI_C is lower. Simultaneously, P_{CO_2} of conduit water during the flood period is lower than that at lower flows, and its SI_C also is lower. From these results we conclude that at least two key processes are controlling hydrochemical variations during flood periods: (i) dilution by precipitation and (ii) water–rock–gas interactions. To explain hydrochemical variations in the fracture water, the water–rock–gas interactions may be more important. For example, during flood periods, soil gas with high CO_2 concentrations dissolves in water and enters the fracture system, the water, which in turn has become more highly undersaturated, dissolves more limestone, and the conductivity increases. Dilution of rainfall is more important in controlling hydrochemical variations of conduit water, because rainfall with higher pH (in this area apparently owing to interaction with limestone dust in the lower atmosphere) and low conductivity travels through the conduit system rapidly. These results illustrate that to understand the hydrochemical variations in karst systems, considering only water–rock interactions is not sufficient, and the variable effects of CO_2 on the system should be evaluated. Consideration of water–rock–gas interactions is thus a must in understanding variations in karst hydrochemistry. Copyright © 2004 John Wiley & Sons, Ltd.

KEY WORDS hydrochemical variation; rainfall; water level; water–rock–gas interaction; dilution; the Guilin Karst Experimental Site; China

INTRODUCTION

The Guilin Karst Experimental Site was established in 1986 as a Sino-French cooperative project between the Institute of Karst Geology, Chinese Academy of Geological Sciences (CAGS), China, and the Laboratoire d'Hydrogeologie, USTL, France (Yuan and Drogue, 1990). The site is located within an area of well-developed

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Received 7 January 2003
Accepted 1 September 2003

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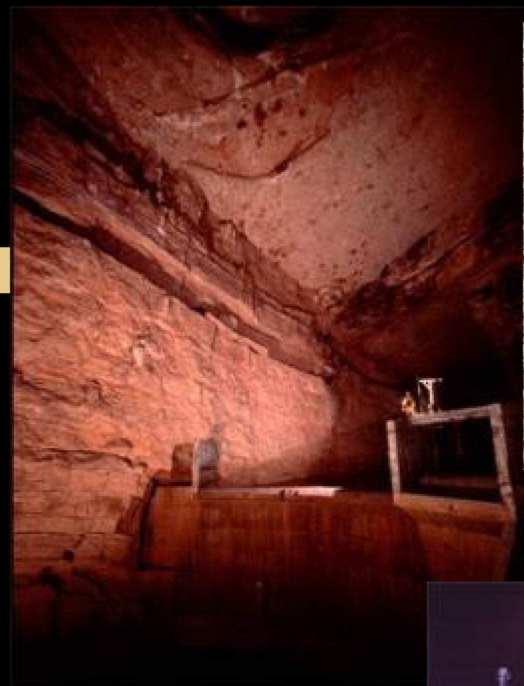
2004: first of 10 China/US peer-reviewed publications from this work

2004: Technical Assistance and Training: Water Resources Development in W Hunan



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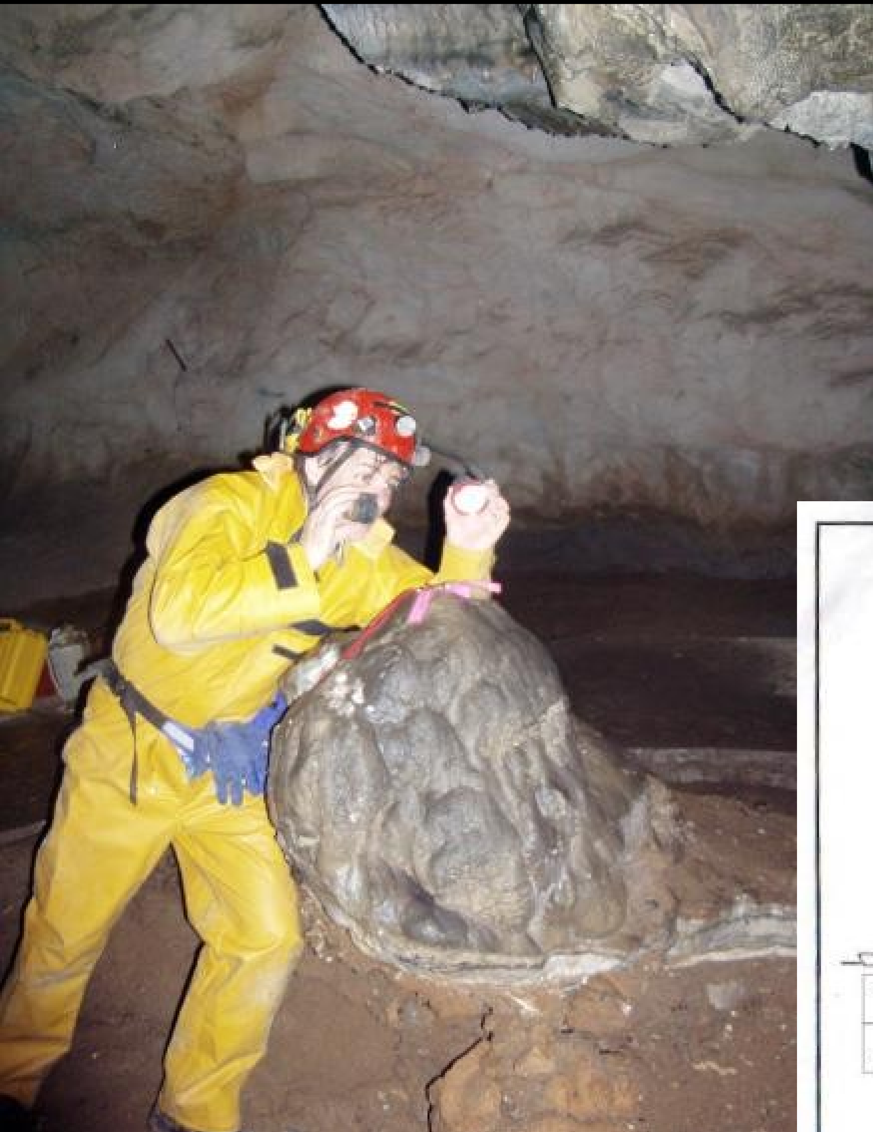
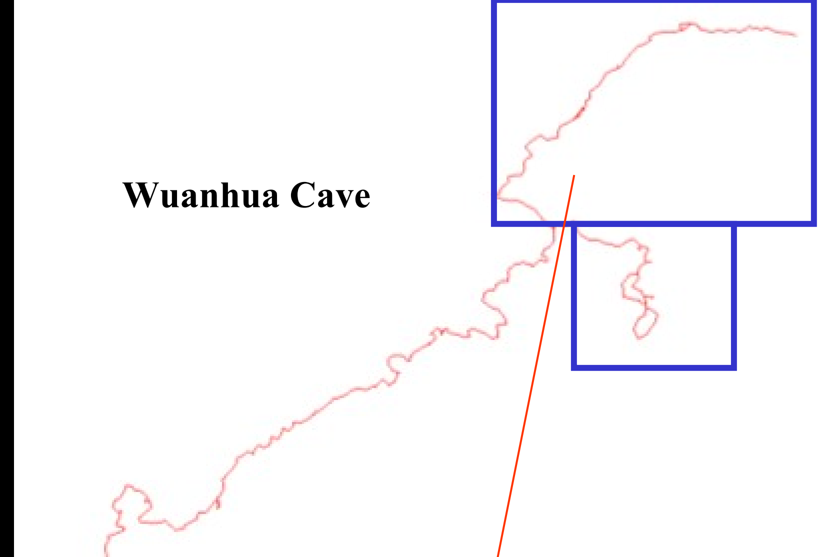
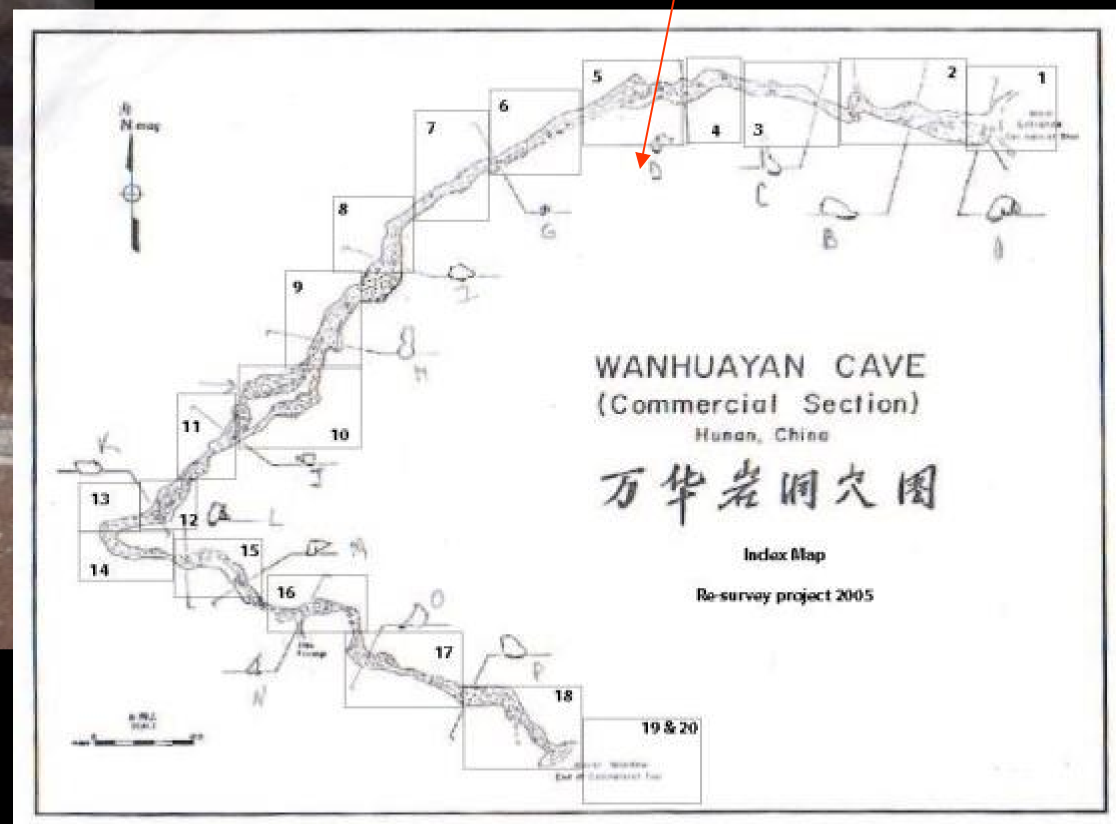
people
water

2005: Cooperation in Cave Management and Study at Wanhua Cave, Hunan

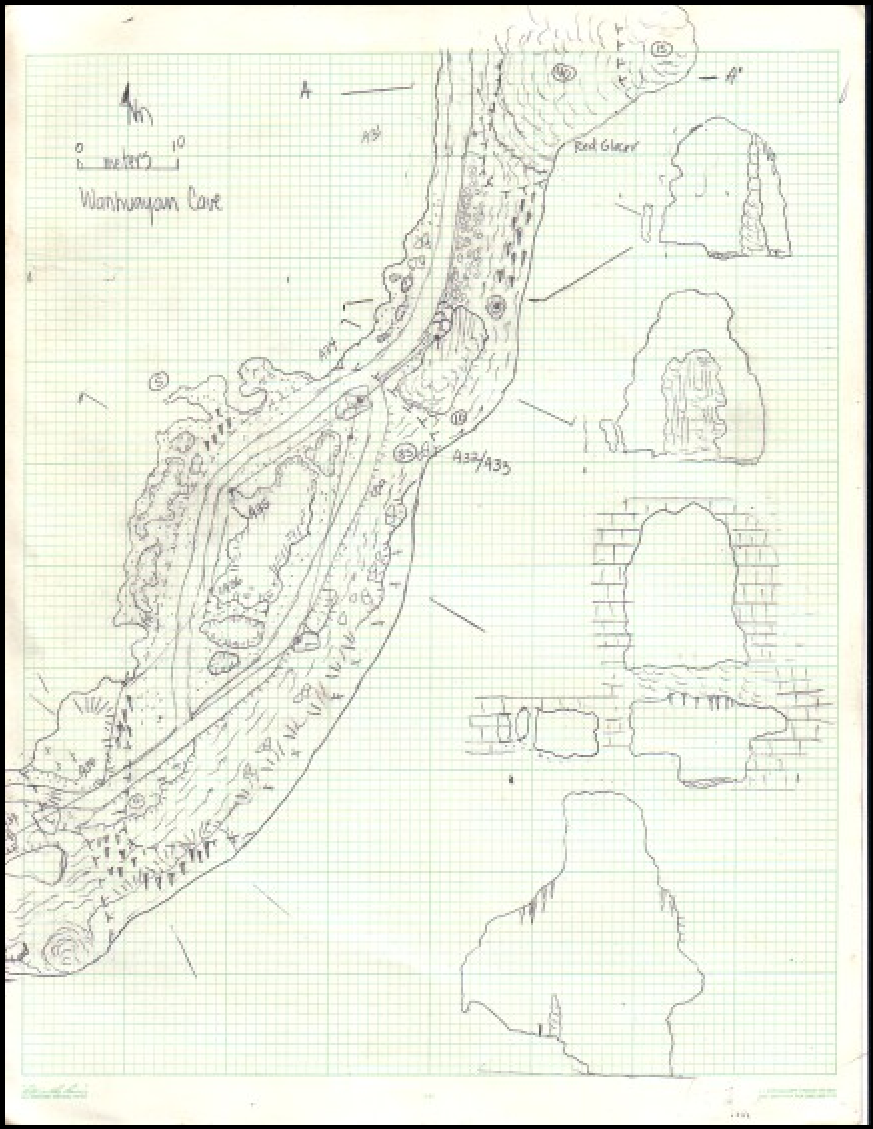






Detailed survey of developed section of cave

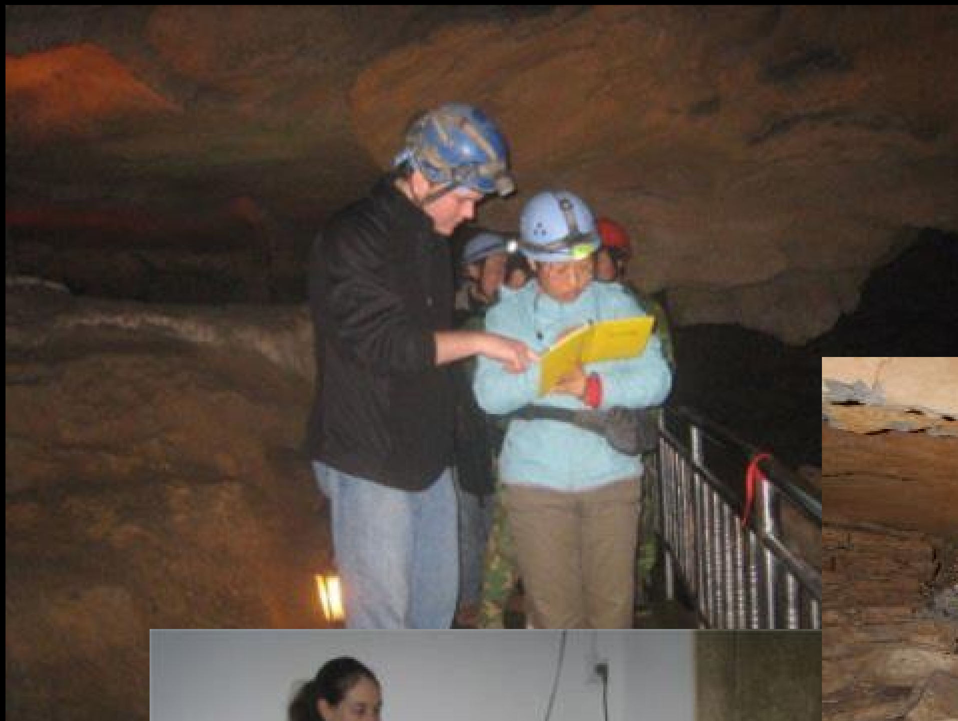
Teaching our colleagues to map caves



Resource inventory of of Wanhua Cave

2006: China Environmental Health Project training in karst resource development and protection

groundwater tracing



cave survey
and resource inventory

Safe cave climbing techniques

GIS Computer mapping technology

training the trainers

2008: Clean water for 14,200 kids

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a child's right
每个孩子有权利喝干净的水
every child has a right to clean water

2010 onwards: cooperative works to measurement of the carbon sink from carbonate mineral weathering

2011: Article about IKG Carbon work in *Science*

Limestone cowboy. As a proxy for CO_2 absorption, Cao Jianhua measures dissolved ions in a karst formation in southwest China.

An Unsung Carbon Sink

GUILIN, CHINA—Cao Jianhua bounds up the craggy karst, leaving his panting colleagues far behind. Halfway up the 250-meter-high limestone outcrop, he meticulously arranges vials and water droppers the way a surgeon lays out scalpels. At this site near Old Dragon Spring, water is gradually dissolving calcite, a reaction that consumes carbon dioxide (CO_2) and spits out what Cao, a soil scientist here at the International Research Center on Karst, intends to measure: calcium and bicarbonate ions. "We're working backwards to figure out how much CO_2 has been taken out of the air," he says.

The answer could have global implications. Carbonate karst formations cover roughly 15% of Earth's land surface, including broad swaths of southwestern China. Limestone degradation could be a substantial inorganic carbon sink, says George Veni, executive director of the National Cave and Karst Research Institute in Carlsbad, New Mexico. The Guilin team, adds Nico Goldscheider, a hydrogeologist at the Karlsruhe Institute of Geology in Germany, "is doing pioneering work to understand and quantify the role of karst processes as a global carbon sink."

As China embarks on a campaign to trace the flow of carbon on land, sea, and air (see main text), inorganic sinks are now increasingly understood as a critical part of the equation. A few years ago, for instance, scientists discovered that alkaline soils in China's Gubantonggut Desert and the U.S.'s Mojave Desert absorb CO_2 (*Science*, 13 June 2008, p. 1409). Because almost a third of Earth's land surface is desert or semiarid, "the total carbon absorption in deserts should be significant in the global sense," says Li Yan, a plant ecophysiologist at Xinjiang Institute of Ecology and Geography in Urumqi.

"If you think of the global carbon cycle like a bank account, we're trying to keep track of all the deposits and withdrawals impacting the level of CO_2 in the atmosphere," says geologist Chris

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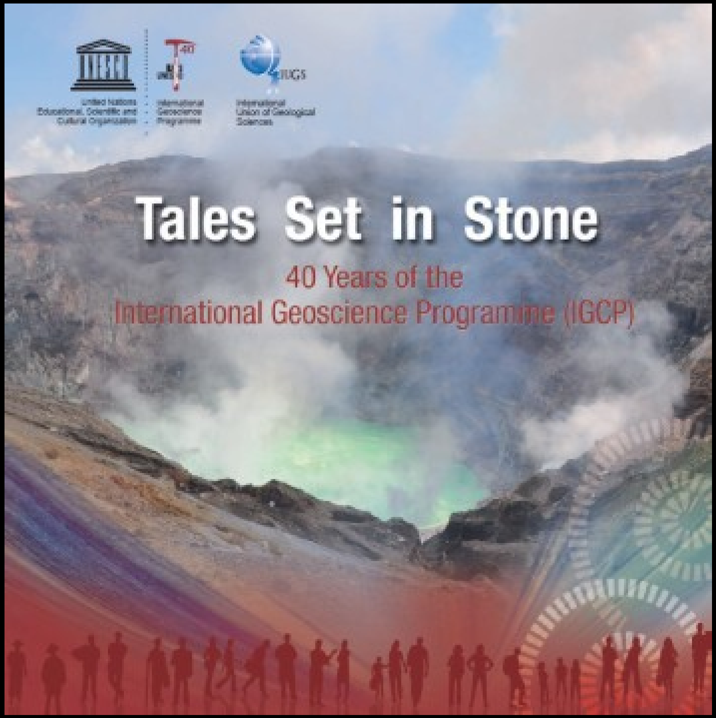
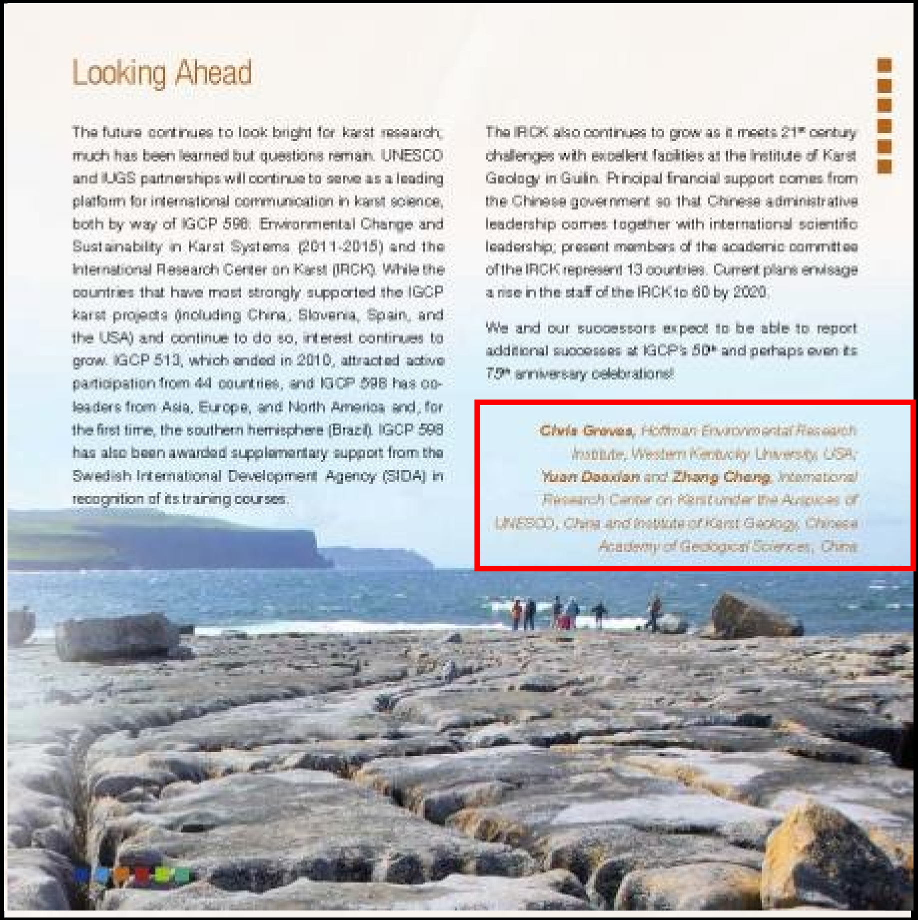
Published by AAAS

2011: Global Efforts to Understand the Nature of Karst Systems: over two Decades with the IGCP

Groves, C. D. Yuan and Z. Cheng





Looking Ahead

The future continues to look bright for karst research; much has been learned but questions remain. UNESCO and IUGS partnerships will continue to serve as a leading platform for international communication in karst science, both by way of IGCP 598: Environmental Change and Sustainability in Karst Systems (2011-2015) and the International Research Center on Karst (IRCK). While the countries that have most strongly supported the IGCP karst projects (including China, Slovenia, Spain, and the USA) and continue to do so, interest continues to grow. IGCP 513, which ended in 2010, attracted active participation from 44 countries, and IGCP 598 has co-leaders from Asia, Europe, and North America and, for the first time, the southern hemisphere (Brazil). IGCP 598 has also been awarded supplementary support from the Swedish International Development Agency (SIDA) in recognition of its training courses.

The IRCK also continues to grow as it meets 21st century challenges with excellent facilities at the Institute of Karst Geology in Guilin. Principal financial support comes from the Chinese government so that Chinese administrative leadership comes together with international scientific leadership; present members of the academic committee of the IRCK represent 13 countries. Current plans envisage a rise in the staff of the IRCK to 60 by 2020.

We and our successors expect to be able to report additional successes at IGCP's 50th and perhaps even its 75th anniversary celebrations!

Chris Groves, *Hoffman Environmental Research Institute, Western Kentucky University, USA;*
Yuan Daoxian and **Zhang Cheng**, *International Research Center on Karst under the Auspices of UNESCO, China and Institute of Karst Geology, Chinese Academy of Geological Sciences, China*

Into the future?