



## The 2005 Tiankeng Investigation Project in China

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### Abstract

A summary report of the Tiankeng Investigation Project, hosted by Prof. Zhu Xuewen in China in 2005. This included an extremely successful field tour to tiankengs (giant collapse dolines) in the karst of Chongqing and Guangxi, and an indoor meeting in the Karst Research Institute in Guilin when the definition of a tiankeng was formalised.

Keywords: tiankeng, karst, doline, China

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### Introduction

Since 1992, a small number of giant collapse dolines have been found in various parts of the limestone karst in southern China. These are very large and truly spectacular landforms (measuring hundreds of metres deep and wide), and they are now recognised in China under the name *tiankeng*.

Tiankengs have only recently been recognised in China because they have only recently been seen by karst geomorphologists. They all occur in remote parts of the highland fengcong karst that were, quite simply, not visited by outsiders in previous years. But China's current explosive development has provided roads that reach close to most of the tiankengs, and their absence from the karst literature is now being remedied. There is also huge local enthusiasm to increase the tourism economy by creating access to any spectacular landscape features, and many of the tiankengs are now star attractions within national, provincial and local parks and geoparks. Consultancy on these new developments has been through Prof. Zhu Xuewen and Chen Weihai, leaders of the speleology team at the Institute of Karst Geology in Guilin, who have therefore visited all the sites in a protracted programme of field research.

Though the Institute team had published various papers and books in Chinese, Prof. Zhu was concerned that tiankengs were still little known outside China. Almost the only foreigners to have

seen the Chinese tiankengs were cavers (largely on the China Caves Project), who had made just passing reference to a few of the sites. Scientists had visited almost none of China's tiankengs, and there was minimal published comparison with the scatter of giant collapse dolines elsewhere in the world, notably those in the Nakanai karst of Papua New Guinea. Prof. Zhu therefore instigated progress in 2005 by creating the Tiankeng Investigation Project, whereby a group of foreign cave scientists could see the finest of the Chinese tiankengs and then discuss their geomorphology in a wider context.

The 2005 event was in two halves. A magnificent field excursion visited China's most important tiankengs and passed through some of the world's finest karst landscapes. This was followed by a conference in Guilin when the geomorphology and hydrogeology of tiankengs were fully discussed in an international context.

The delegates invited to the 2005 Project were - Art and Peggy Palmer from the State University of New York (USA), Will and Beth White from Pennsylvania State University (USA), Andrej and Marija Kranjc from the Karst Research Institute (Slovenia), Alexander Klimchouk from the Institute of Geological Sciences (Ukraine), Julia James from the University of Sydney (Australia), John Gunn from Huddersfield University (UK), Andy and Lilian Eavis from the International Union of

Speleology and the China Caves Project (UK), and Tony and Jan Waltham from Nottingham Trent University (UK). They were joined and hosted in China by Zhu Xuewen, Chen Weihai and Liu Zaihua. It had been hoped that Paul Williams, Derek Ford and Claude Mouret could join the Project to represent their own countries, but personal circumstances precluded their participation.

### The tiankeng tour

The Tiankeng Project in 2005 started with a field tour to visit and investigate some of the largest and finest of the tiankengs in China's limestone karst. Delegates converged on the city of Chongqing on Tuesday 18th October. Unusually inclement weather then set in, with almost continuous low cloud and grey skies, until everyone departed from Guilin twelve days later. The field tour started in the karst within the province of Chongqing (which separated out of Sichuan province in 1997), before moving south into the province of Guangxi (Fig. 1). It was an incredibly spectacular field trip, which visited some of the finest karst landforms and karst landscapes that the world has to offer. Further data on the tiankengs are provided in the following paper, by Zhu & Chen, within this volume.

### Tiankengs in Chongqing

On the Wednesday morning, the tour started by bus along a motorway from Chongqing to Fuling, and then south up the gorge of the Wu Jiang (Wu River) to Wulong. The first visit was to Furong Dong, an excellent tourist cave, distinguished by massive stalagmites, incredible helictites and beautiful aragonite crystals in a large, abandoned phreatic tunnel that loops up and down in the dipping limestone. The afternoon visit was to the Wulong Sanqiao (Three Bridges) National Park and Geopark. The fragmented remains of a major trunk cave system now forms a karst gorge with an underfit stream. Three natural bridges survive across the gorge and separate the two tiankengs of Qinlong and Shenyang, each over 200 m across and ringed by vertical cliffs 200 m high. Between a descent into the gorge via a lift and steps, and a cable car ascent, the tourist path across the tiankeng floors and beneath the high rock bridges provides a truly spectacular walk (Fig. 2). The clean and vertical cliffs exhibit traces of the gently dipping bedding planes that were the likely sites of the initial cave development, indicating various degrees of roof collapse to leave the remnant bridges and the open tiankengs. The night was spent at the splendid Fairy Mountain Resort.

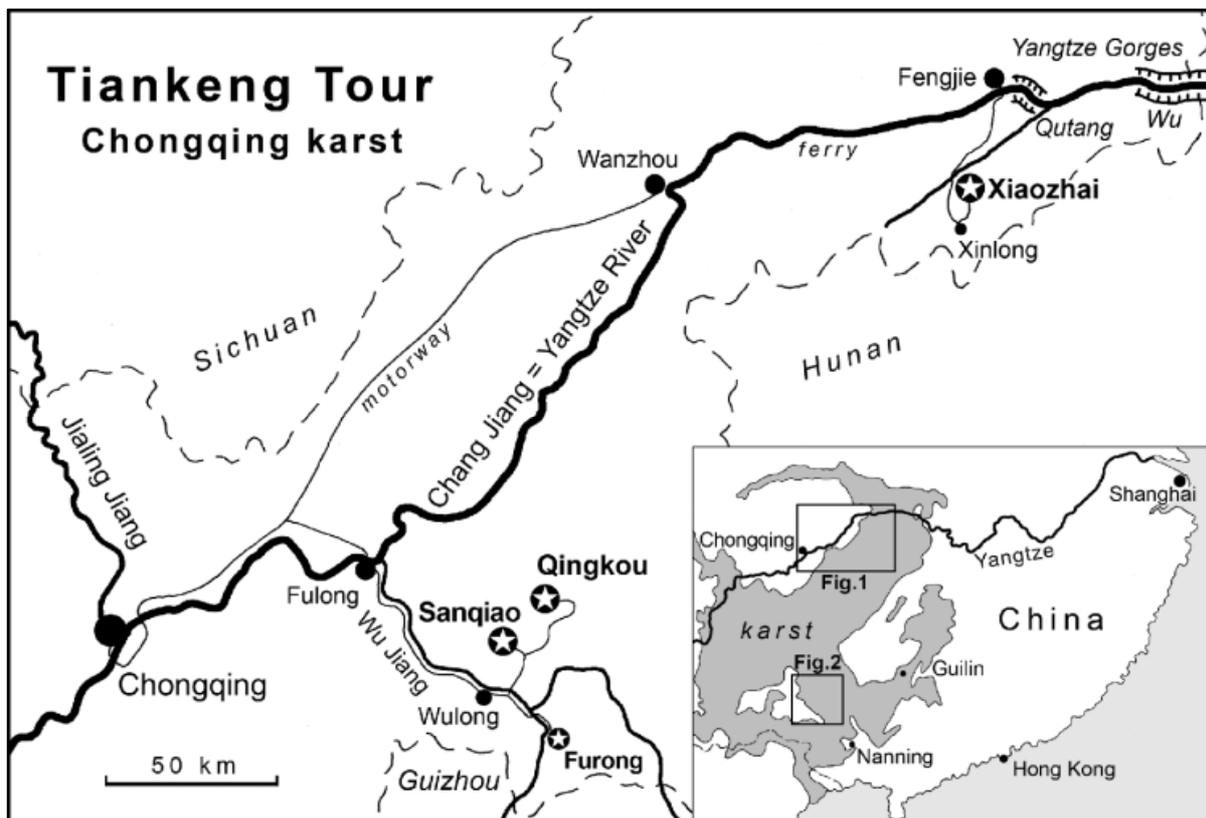


Fig. 1. Route of the tiankeng tour through Chongqing.



**Fig. 2.** View along the floor of the Qinlong Tiankeng, towards the natural bridge at its western end, in the Wulong Sanqiao Park.



**Fig. 3.** Xiaozhai Tiankeng seen from the southern rim; the path down the stone steps is obscured by trees and shrubs - it curves round to the right and descends the steep debris fan inside the lower pit.

On Thursday morning, a string of 4WD cars took the group up to Houping, where the mountains were shrouded in cloud but were largely of sandstone that caps the limestone. At the end of a very muddy road, a short walk across the fields led to a cliff edge where a bamboo viewing platform had been specially built for the group's visit. It overlooked the huge Qingkou Tiankeng - which was unfortunately lost in thick cloud. A further drive on muddy tracks then took the group to a fire-cracker welcome at the tiny village in front of the entrance of Erwan Dong, part of the large cave system being mapped by the Hong Meigui Cave Exploration Society. The guides in the cave were Erin Lynch (who had taken time off from her current Hong

Meigui project to join the tour for the day) and a horde of villagers (mostly without lights). Villagers and international delegates alike traversed 3 km of old, high-level, phreatic tunnels (mostly around 10 m high and wide) to reach the foot of the Qingkou tiankeng. Waterfalls drop small streams nearly 200 m down the tiankeng walls, but their tops were lost in clouds on the day. Though Qingkou is described as an erosional tiankeng, it appears to have origins in the large trunk cave at its foot, which predates the collapse and surface breach.

The night's hotel was back in Wulong. On Friday the route doubled back to Fuling, and onto a new and empty motorway east to Wanzhou. There the group boarded an express ferry (shuifeuchuan =

water-fly-boat = a Ukraine-built hydrofoil) down the Chang Jiang (Yangtze River) to Fengjie. A bus ride south into the mountains and darkness took everyone to a hotel in Xinlong.

On Saturday, the group took the new tourist road to Xiaozhai (= Little Village), which stands just above the world's finest tiankeng. Xiaozhai Tiankeng is 662 m deep from the top of the cliff faces broken into the two conical hills that have collapsed into it, and is 511 m deep from the lowest point on its rim (Fig. 3). Its upper section is 600 m in diameter. The lower section is 300 m across, with vertical cliffs over 300 m high round its entire perimeter, except where a steep fan of collapse debris is banked against its northern wall; they are scored by at least three sub-vertical faults. In the wet weather of the visit, a small river swirled from the tall canyon of the upstream cave, crossed the tiankeng floor, and cascaded into the downstream cave (explored and mapped by the China Caves Project in 1994 for 4 km to the cliff resurgence). The tiankeng now has a stone path that winds down to a viewpoint and restaurant that overlooks the lower shaft, and stone steps also zigzag down the debris fan to the floor; there are 2800 steps from rim to floor. The visit to Xiaozhai was memorable - it offers one of the most impressive karst sights in the world. The afternoon was spent in the accessible parts of the Tianjingxia (Tianjing Gorge, sometimes known as the Great Crack), around the sinks that feed drainage into Difeng Dong and thence into the base of the Xiaozhai tiankeng. It was a late return to Fengjie.

Sunday and Monday were largely spent travelling (between more splendid hotels and sociable banquet dinners). The express ferry back to Wanxian was followed by the long bus ride to Chongqing for the night. A morning flight of 750 km south to Nanning was followed by a long bus-ride north to Baise and then to Lingyun (offering distant views of fenglin then fengcong karst), before reaching Leye after dark (Fig. 4).

#### *Tiankengs in Guangxi*

On a warm and slightly brighter Tuesday morning, the group first visited the excellent Tiankeng Geopark Museum in Leye, with display material (in both Chinese and English) that largely originated from the Institute of Karst Geology. Almost behind it lies Luomei Lianhua Dong (Lotus Cave), a fine tourist cave in a passage just above the level of the Leye polje floor, normally dry though it does carry floodwater. It is notable for its many fine, circular shelfstone deposits up to 2 m across that were formed in pools (now drained)

around stalagmite stumps (often known as lotus deposits in China or as lily pads in the West). From the back exit of the cave, the tour bus took the group to Chuan Dong, a truncated fragment of ancient trunk passage that was walked through from the valley side to a ledge 100 m up in one wall of the Chuandong Tiankeng. Steps to the floor revealed a breakdown-choked cave below and a large side chamber with a skylight that heralds further collapse in the future.



Fig. 4. Route of the tiankeng tour through Guangxi.

The tour then continued further into the spectacular Leye karst - distinguished by high fengcong cone karst, a suite of large tiankengs and major cave systems that are only partly explored. Leye must rank among the most extreme karst terrains in the world (*i.e.*, extremely mature without degrading into old age), yet it has only been known to the outside world since Prof Zhu was shown it in 1998. There were glimpses of rims and walls of various tiankengs, with roadside stops above the degraded Datuo Tiankeng and another at the lip of Maoqi Dong. The bus then dropped off delegates to walk around the rim of Dashiwei Tiankeng. Along with Xiaozhai this is the giant of tiankengs, 400-600 m across with unbroken, vertical perimeter walls that cut through three conical hills (and the three intervening dolines) with a maximum height of 613 m (Fig. 5). It is a fantastic sight, but perhaps not as awesome as Xiaozhai. A long section of downstream river cave lies below the edge of the breakdown pile on the tiankeng floor. The group returned to Leye after a fabulous day in fabulous karst.



**Fig. 5.** Dashiwei Tiankeng, in the Leye karst, with some scale given by the road on the right.



**Fig. 6.** Huangjing Tiankeng, with its perimeter cliffs all over 120 m high.

Wednesday was another grey morning, for a visit to Huangjing Tiankeng. Though only 160 m deep, this is a beautiful sight, with a flat floor inside a circle of vertical perimeter cliffs over 200 m across (Fig. 6). The cliffs are all limestone but the tiankeng has breached the feather edge of a sandstone caprock that supports stream channels

and modest allogenic inflow from the north and west. An adjacent, large, old, decorated cave passage descends steeply, and a short mined tunnel from its foot gives access to the tiankeng floor. In the past, villagers lowered pigs and deer down the cliff to graze the perfectly enclosed field on the tiankeng floor. This was the last tiankeng that was

visited, and a return to Baise was made in the afternoon.

On Thursday the tour bus took the scenic route back to Guilin, via backroads linked by new sections of tourist highway that wound through the magnificent fengcong karst of Bama and Fengshan, sadly all in rather grey weather. There was a stop at Sanmenhai Dong, for a show cave boat ride through the lake chambers on the resurgence below the large abandoned passages of Mawang Dong. A second stop was for a visit to the very impressive new show cave of Yuanyang Dong, which has two large chambers adorned with numerous stalagmites 20 and 30 m tall. Impressive fengcong karst was then crossed to Donglan, before heading through darkness to Guilin. Friday was a relaxation day, with a tour of the equally magnificent fenglin karst around Yangshuo.

### **The tiankeng conference**

The Saturday was spent in indoor meetings at the Institute of Karst Geology in Guilin. In the morning, the foreign delegates each made short presentations on concepts of tiankeng development and their knowledge of tiankengs and very large dolines in other parts of the world. These are published in the following pages of this volume, each in a form abridged in the light of our new observations of the tiankengs of China. Prof Zhu's contribution on tiankengs in China was taken as read from his initial presentation in Chongqing prior to the field tour. An overview of tiankengs in foreign lands was an additional project contribution, but was prepared subsequently, and only for publication. The tiankeng session closed in the late afternoon with an open discussion on the status, definition, geomorphology and evolution of tiankengs; the conclusions of this meeting are also published in this volume.

In the early afternoon, Prof Liang Yongning (from Kunming University) made a presentation on the forthcoming application for World Heritage inscription for the South China Karst. The group

currently preparing the nomination were meeting at the Institute at the same time as the tiankeng group, so some joint discussion was welcomed. The South China Karst is a serial-site WH nomination with nine elements - that include selected tiankengs at Wulong, Fengjie and Leye. The work of the WH group was applauded and supported by the delegates from the tiankeng project. Without going into details on the various sites, the delegates unanimously agreed in principle that the South China Karst was an essential element of the WH portfolio.

The intended outcome of the Tiankeng Investigation Project was to recognise, establish and define the tiankeng as a significant karst landform in an international context. It was the consensus of opinion among the foreign delegates that this had been satisfactorily achieved. The work on tiankengs by Prof Zhu and his colleagues at the Karst Research Institute should be both recognised and applauded by karst geo-scientists around the world.

### **Acknowledgements**

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