# Classic localities explained 3

## The karst lands of southern China

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A sequence of limestone, thousands of metres thick and almost unbroken from the Devonian to the Triassic, forms the world's largest and most spectacular karst terrain largely within the southern Chinese provinces of Guangxi and Guizhou. This terrain is perhaps best known for its dramatic limestone towers, which rise almost vertically from plains covered with rice paddies. The city of Guilin is surrounded by some of the finest of the karst; it was beloved by the traditional artist's community (whose paintings of vertical crags actually have significant elements of reality), and is now a major tourist destination for seekers of great landscapes. But the karst lands reach far beyond Guilin, and they constitute a real classic of geoscience.

### Fengcong and fenglin

In the warm and wet environments of their southern homeland, Chinese geomorphologists distinguish the karst types not by the shape of their hills but by the presence or not of a karst plain between the hills. This gives rise to the two main types of karst: fengcong and fenglin.

Fengcong karst (pronounced *fungtsung* and translating as 'peak cluster') has roughly conical hills separated by deep, closed depressions, all standing on a common bedrock base so that it forms a continuous terrain of steep slopes and significant relief (Fig. 1). Slope angles and individual profiles of the hills do vary, though entirely vertical sides cannot exist on hills that are clustered together. Western geomorphologists have traditionally described tropical karst by hill shapes, and their main type is 'cone karst'. Though Westerners' best-known cone karsts are probably those in Java and Jamaica, the karst in Guizhou, in the northern part of China's great karst belt (Fig. 2), was actually the first one to be described this way, by visiting Austrians. While local exceptions and variations do exist, fengcong and cone karst can be regarded as essentially the same.

Fenglin karst (pronounced *funglin* and translating as 'peak forest') has isolated hills rising from a plain, which is normally formed of limestone with a thin cover of alluvium. Slope angles and individual profiles of the hills are again irrelevant. The best-known fenglin is that with vertical-sided towers rising from the alluvial plains, so the Western term for it is 'tower karst', and the type example is without question the splendid karst in Guangxi, especially that just south of Guilin (Fig. 3). In these areas, fenglin and tower karst are clearly the same. But Westerners have over-used tower karst as a landscape term at sites outside China (which cannot be described as fenglin), and there are also areas of isolated conical hills on karst plains that are still described as fenglin within China.

The terminology may be a little confusing. Cones and towers are good descriptive terms, but fengcong

**Fig. 1.** Hill profiles that are very steep-sided cones within the fengcong karst east between Guilin and Yangshuo, Guangxi.

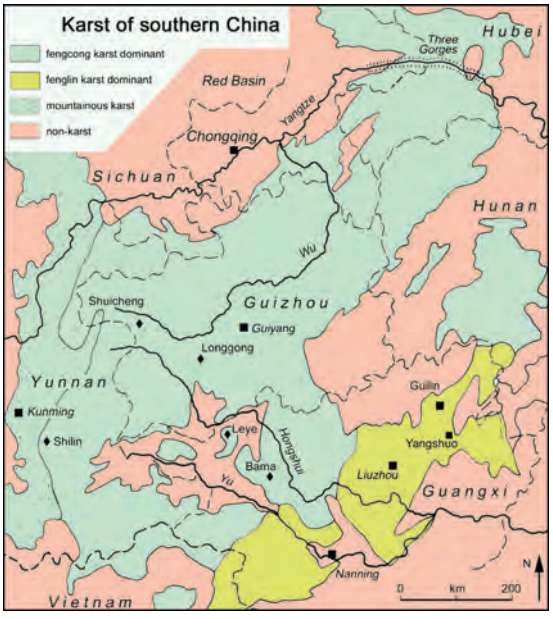


**Fig. 2.** The broad extent of the limestone karst in southern China, showing the adjacent areas that are dominated by fengcong and fenglin.


 

and fenglin are perhaps the more significant terms, as they have genetic significance and also originate from the world's greatest karst.

## The fengcong karst of Guizhou

The finest of the fengcong karst is spread across the huge Guizhou Plateau, though it overlaps into other provinces including northwestern Guangxi. It forms the greatest share of China's karst, but the diagnostic conical hills are not so well developed in some of the higher mountain areas of Yunnan and Sichuan. The classic fengcong terrain consists of roughly equally-spaced conical hills and deep dolines, with local relief that is anything from 30 m to over 300 m high (Fig. 4). This has often been labelled as egg-box topography, a conveniently descriptive term for the chaotic terrain of crowded hills that are devoid of integrated valley systems, but such a degree of perfection is rarely attained. Across great tracts of Guizhou, endless conical hills have slope angles of 45–55°, though plenty of variation in slope angles and cone profiles is created by contrasts within the limestone lithology (Fig. 5). Fengcong karst is drained almost entirely underground, by long and deep cave systems that contain some very large passages and chambers. As might be expected, the alignments of the caves bear no relation to the surface topography, although they do coincide in some large collapse features; there is also some debate about the relative importance of rock collapse and sub-soil dissolution in forming the numerous dolines between the fengcong hills.

The key question with both fengcong and fenglin is how they evolve, and indeed how they are, or are not, related to each other in their geomorphological development. It is widely accepted that fengcong karst is a natural evolutionary progression from doline karst, created when the dolines enlarge towards coalescence, leaving residual hills that ultimately tend towards conical in both plan view and profile. An ancestral stage of valley development is recognizable in parts of the Guizhou karst where chains of dolines

**Fig. 3.** The city of Guilin, in Guangxi, stands on areas of alluvial plain between the limestone towers of its well-known fenglin karst.

**Fig. 4.** Sharply pointed conical hills rise above the western margin of the Shuicheng basin within the classic fengcong of western Guizhou.

**Fig. 5.** Both conical and domed hill profiles occur within the fengcong that rises above a small alluviated karst plain near Longgong in Guizhou.

**Fig. 6.** Steep conical hills in the mature fengcong karst of Bama, in northwestern Guangxi, rise between linear dolines that may be remnants of earlier valleys.

appear to be the remnants of valleys perhaps superimposed from a cover rock, but this is not ubiquitous (Fig. 6). Once efficient underground drainage was established, the dolines became deeper and deeper, and traces of any early valleys are totally lost.

Fengcong karst continues to evolve towards higher local relief as long as the surface lowering of the ever-deeper dolines does not reach either the floor of the limestone or the regional base level. Mature fengcong with the greatest local relief therefore requires rapid or intermittent tectonic uplift to keep it rejuvenated while its dolines get deeper. If tectonic uplift is slower, the doline floors may reach base level; there is then a switch from surface lowering towards lateral planation, so that the fengcong may evolve into fenglin karst.

## The fenglin karst of Guangxi

The famously spectacular fenglin karst of the Guilin-Yangshuo region in eastern Guangxi is recognized as the definitive example of fenglin or of tower karst. It also extends across much of the lowlands of southern Guangxi and into Vietnam. However, except for a few isolated patches across the rest of Vietnam, Thailand and Burma, this is just about the full extent of the world's true fenglin tower karst.

Classic fenglin is the dramatic landscape of isolated, steep-sided towers rising from a flat plain that is covered by alluvium and rice paddies (Fig. 7). The fenglin around Yangshuo, at the southern end of the Guilin karst, represents a geomorphological extreme with numerous individual towers well over 100 m tall. Many of the towers do have vertical sides (Fig. 8) and are the more dramatic when they lack any talus aprons around their bases. Others are more truly conical, but most fenglin towers have sides far steeper than those on fengcong cones. Limestone lithology again influences profiles, creating asymmetrical or even conical towers in steeply dipping limestones and lower profiles in weaker rocks, while the vertical-sided towers can only survive in strong and almost horizontally bedded limestone.

The fenglin landscapes have major systems of surface rivers flowing on the alluvial plains between the towers. There is also likely to be significant groundwater flow through the limestone beneath the plains, but few large springs are known, and no long flooded caves have yet been found. Remnants of old caves survive at high levels within some towers, and there are also numerous foot caves formed by dissolution at the water table. Some of the latter carry rivers through individual towers, but the fenglin has no great caves to match those in the fengcong.

A key process in fenglin karst is the enhanced rock dissolution that takes place due to chemically aggressive water occurring at the water table, which fluctuates only very slightly around the level of the alluvial plain. The effect of this is to undercut the bedrock limestone of any rising slopes marginal to the alluvial plain by the creation of dissolution notches and foot caves (Fig. 9). In the long term, collapse over these undercuts is widespread, so cliff retreat is accelerated at lower elevations and the whole process effectively turns a cone into a tower. A splendid variant of fenglin is created where karst plains have been invaded by the sea, so that the tall residual tow-


 

**Fig. 7.** The dramatic landscape between Yangshuo and Fuli, in Guangxi, is among the finest of the fenglin, with tall limestone towers surrounded by rice paddies on the alluvial plain.

**Fig. 8.** A splendid tall tower with nearly vertical sides rises above the Jingbao River within the fenglin near Yangshuo, Guangxi.

ers are further undercut by wave action and marine dissolution, notably at Ha Long Bay, Vietnam, in an extension of the Guangxi karst.

This lateral planation effectively extends the base level plain, at the expense of the reducing hill profiles, and so can steadily transform fengcong into fenglin. The whole process requires a base level and water table that are stable, or are declining very slowly. Critical to development of the mature fenglin are the relative rates of base level decline, of dissolutional lowering at the rock surface beneath the alluvial plain, of surface denudation on the karst hills, and of clastic sediment input (from adjacent hills that are not limestone) to maintain the evolving alluvial plain.

## Evolution of the fenglin

It appears that the fenglin, so beautifully developed in Guangxi, can only exist where a number of independent factors have combined to create the perfect environment. These factors may be listed (in no particular order):

1. Limestone that is pure, compact and strong;
2. A huge thickness of limestone, sufficient to allow massive surface lowering, without reaching the base of the limestone, which gives time and space for the karst landscapes to evolve to maturity;
3. A veneer of alluvium overlying the bedrock limestone of a karst plain;
4. A karst water table that is stable and is maintained at the level of the karst plain;
5. Major inflows of allogenic water and clastic sediment that can recharge and maintain the alluvial plain as it evolves through surface and bedrock denudation;
6. Slow tectonic uplift that matches surface denudation and thereby maintains the karst plain

**Fig. 9.** In the fenglin karst of Guilin, Guangxi, a deep dissolutional notch round the base of a limestone tower is a key feature in steepening the hill profile by undercutting and collapse.

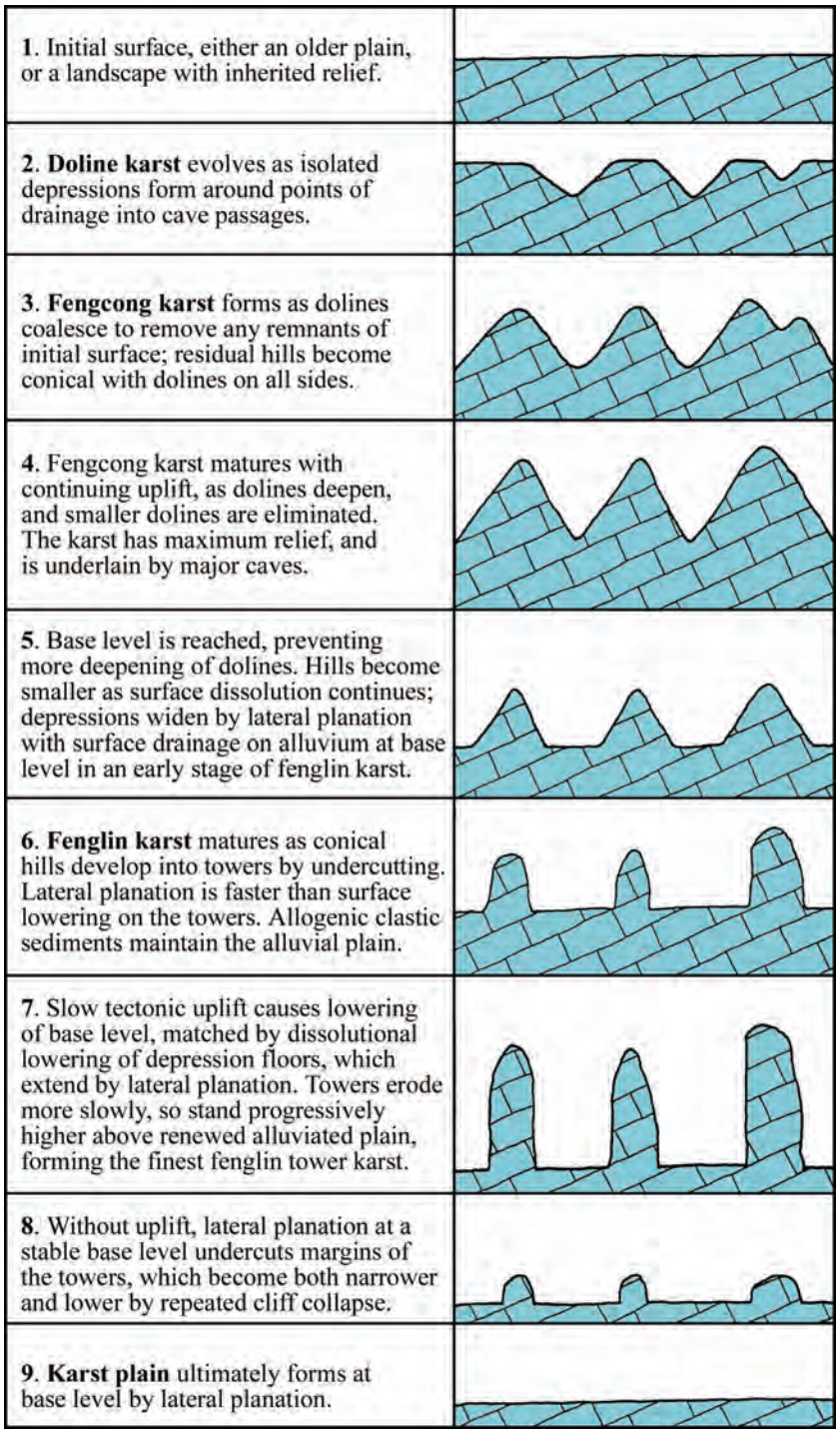


**Fig. 10.** A diagrammatic sequence that, if completely developed, shows stages in landscape evolution from an initial plain, to doline karst to fengcong to fenglin, and then back to a karst plain.

as it is lowered through the limestone profile;

7. A hot and wet climate with significant rates of carbonate dissolution in a regime of abundant biogenic carbon dioxide; and
8. Equilibrium between rates of surface lowering and lateral planation that allows maintenance of the residual towers while the karst plain is lowered around them.

In simple terms, fenglin is a very mature form of karst terrain that can only evolve during surface lowering through a great thickness of limestone; furthermore it requires long-term lowering of an alluviated karst plain, which is only possible where slow tectonic uplift is matched both by its own bedrock denudation and by the supply of sediment that can maintain its alluvial cover.

It is possible to identify a sequence of tropical karst evolution that originates from a plain surface, evolves into a doline karst, then into fengcong, and matures into fenglin, before degrading in old age back to a karst plain (Fig. 10). Clearly, this is a simplified progression, which is much more complicated in nature where both regional and local factors impose. But it incorporates all the factors essential to fenglin development, and its first seven stages do provide a genesis for the tall limestone towers of the classic fenglin karst around Yangshuo.

## The karst system

Though fengcong may evolve through to fenglin, there is plenty of evidence that much of China's fengcong evolves down a parallel track that does not lead to fenglin. On the large scale the contrast is down to tectonics, with fengcong dominating in the uplifted karst of the Guizhou plateau, while fenglin is largely restricted to the more stable lowlands of Guangxi. Related to the sequence in Fig. 10, Guizhou's fengcong has evolved through the first four stages and then continued to increase its local relief under conditions of rapid tectonic uplift and repeated rejuvenation. Furthermore, multiple levels of sets of concordant summits indicate that some areas of fengcong have complex multi-phase histories that reach far beyond a single evolutionary sequence (Fig. 11). In contrast, a lower rate of tectonic rise in Guangxi has allowed fenglin to develop, either by passing from stage 2 direct to stage 5 or by evolving through the whole sequence.

But, especially within the limited extent of the Guilin-Yangshuo karst (Fig. 12), small areas of fenglin and fengcong are so intertwined that there must have been parallel evolution of the two systems in the one tectonic environment. Tectonic contrast cannot account for different landforms within units only a few kilometres across; in these cases, the critical factor on such a local scale generally appears to be the sediment input. Many of the fenglin areas are associated with sediment fans of rivers derived from the adjacent non-carbonate hills. At the same time, the lower gradient of the trunk Li River precludes its ability to transport sediment so that it has entrenched a gorge through the finest of the fengcong karst (Fig. 13).

It is clear that the mature forms of fengcong and fenglin in Guizhou and Guangxi have both evolved over very long periods of time, and there is an im-


 

**Fig. 11.** In the best of the fengcong just west of Caoping, within the Guilin-Yangshuo karst of Guangxi, conical hills with very steep sides show multiple summit levels indicative of a long history; hills along the margin of the floodplain of the Li River (in the foreground) have some undercutting that is steepening their profiles towards those of towers.

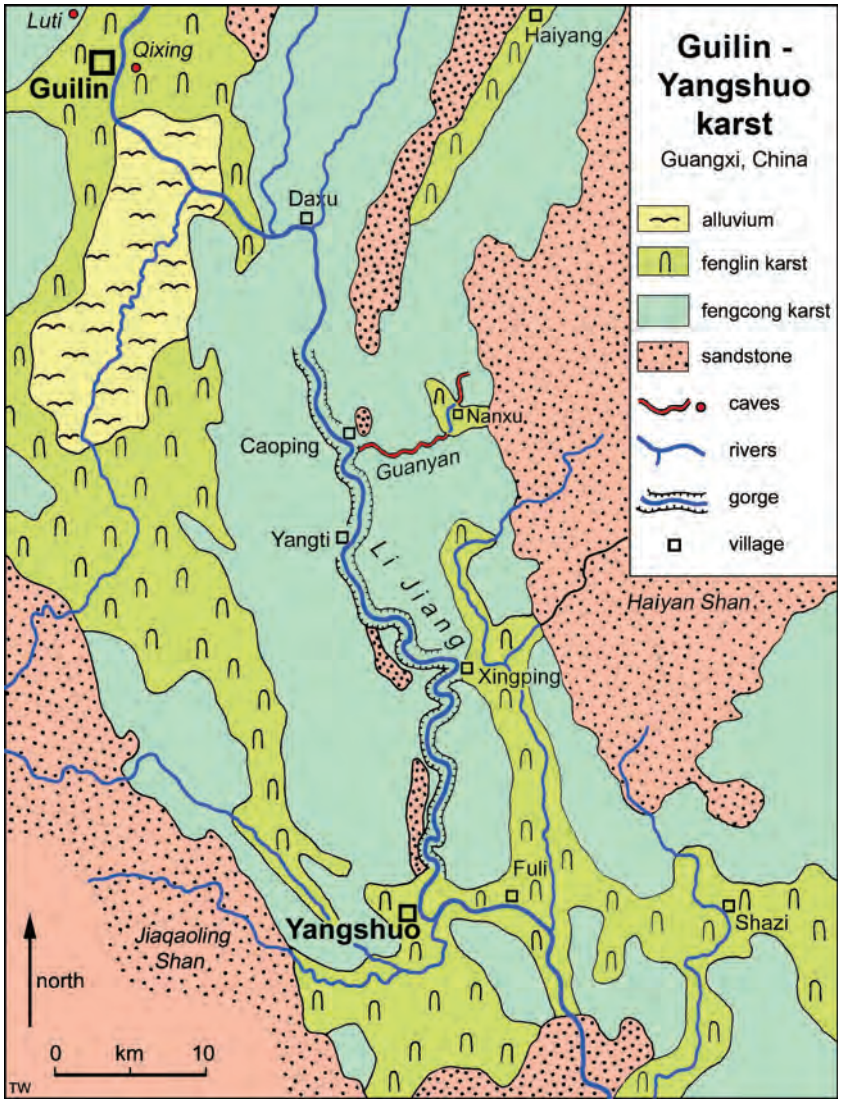


**Fig. 12.** Outline distribution of fengcong and fenglin in the karst between Guilin and Yangshuo, Guangxi.

plication that the fenglin has the longer timescale of the two. Some evidence for the lengths of these timescales comes from cave sediments that have been dated within the fenglin karst around Guilin. From a variety of dating programmes, a very rough figure of 50–100 mm/kyr appears to be reasonable for the long-term rate of surface lowering in the Guilin karst. The geology indicates that denudation has worked down through about 1000 m of limestone, and this therefore extends the timescale of the karst evolution to around 10–20 Ma. This very approximate figure places the origins of the karst well back into the Tertiary (Fig. 14).

While Europe and most of the Western world have their limestone terrains dominated by the bare crags of glaciokarst or the endless pockmarks of doline karst, southern China has the right geological and environmental conditions for karst to have developed to a new level of maturity. The fengcong of Guizhou is vast and magnificent, but the fenglin of Guangxi is the extreme form that makes it a truly spectacular classic of landscape evolution (Fig. 15).

**Fig. 13.** Empty tourist boats returning up the Li River in Guangxi past the conical hills of the fengcong near Xingping.

## Visiting China's karst

China is one of the great travel destinations, for geologists and everyone else. Guilin is easily reached, and is included on many China tours. The boat trip down the Li River is a well-organized and essential geological delight (now taken by many millions of tourists each year), while the independent traveller will do well to stay on for a few days in Yangshuo to tour the fenglin on foot and by bicycle. Going further afield requires some effort by the experienced traveller, and

**Fig. 15.** Near Yangshuo, Guangxi, tall towers rise from the alluvial plain in an area of fenglin that is almost surrounded by fengcong with its steep conical hills.

many areas are very difficult to reach without local contacts. But China's countryside is rapidly opening up, with some of the great karst landforms becoming tourist sites that will be more accessible.

## Suggestions for further reading


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**Fig. 14.** Guangxi's finest fenglin stretches away from Yangshuo, with a concordance of summit heights that suggests a phase of planation long ago in its evolutionary history.


 