Chapter 54

The Mystery of Tower Karst

Karst is terrain with distinctive landforms caused by a combination of high rock solubility and well-developed secondary porosity (the void space in rocks).[1] It is almost always formed in limestone, dolomite, gypsum, and salt rocks and is characterized by sinkholes, caves, and underground drainage. The geomorphological expression of karst is intimately tied to the ground water cycle in these rocks.

Unusually High Tower Karst

In karst settings, there are sometimes unusually high rock pinnacles of limestone called *tower karst* (Young reports tower karst in sandstone,[2] but these should technically be called inselbergs.) There are four types of tower karst that include a variety of forms from tall vertical-sided towers to cones or even hemispheres.[3] Those of most interest for us are the ones that *protrude above a gravel-capped planation surface*. In this setting, tower karst consists of highly eroded residuals that rise above a generally flat terrain.[4] Some towers are isolated while others are in groups rising from a common base.

Tower karst generally rises from 130 to 1,000 feet (40 to 300 m) above the terrain.[5,6] For example, in Malaysia towers nearly 1,000 feet (300 m) high rise above the surrounding plains[7] and can be in rows. Some towers up to 1,180 feet (360 m) high have been reported.[8]

Tower Karst Mostly Found in the Tropics

The best examples of tower karst are found in the tropics; the most famous are those in southwest China (Figure 54.1).[9,10] Tower karst are also found in Vietnam, Malaysia, Sarawak, other parts of Southeast Asia, in northwest Australia, Central America, Cuba, Puerto Rico, Jamaica, and other Caribbean islands.[4] But, they are by no means restricted to the tropics.[11] An

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[1] Ford, D.C. and P.W. Williams, 1989. *Karst Geomorphology and Hydrology*, Unwin Hyman, London, U.K., p.1.
[2] Young, R.W., 1986. Tower karst in sandstone: Bungle Bungle massif, northwestern Australia. *Zeitschrift für Geomorpholgie N. F.* 30:189-202.
[3] Ford and Williams, Ref 1, pp. 440-444.
[4] Trenhaile, A.S., 1998. *Geomorphology: A Canadian Perspective*, Oxford University Press, Toronto, Canada, p. 278.
[5] Thomas, M.F., 1994. *Geomorphology in the Tropics: A Study of Weathering and Denudation in Low Latitudes*, John Wiley & Sons, New York, NY, p. 347..
[6] McDonald, R.C., 1979. Tower karst geomorphology in Belize. *Zeitschrift für Geomorpholgie N. F., Suppl.-Bd* 32:35-45.
[7] Jennings, J.N., 1976. A test of the importance of cliff-foot caves in tower karst development. *Zeitschrift für Geomorpholgie N. F. Suppl.-Bd* 26:92-97.
[8] Jennings, J.N., 1972. The character of tropical humid karst. *Zeitschrift für Geomorpholgie N. F.* 16(3):336-341.
[9] Daoxian, Y., 1987. New observations on tower karst. In, Gardiner, V. (editor), *International Geomorphology 1986*, Proceedings of the 1st International Conference on Geomorphology, Part II, pp. 1,109-1,123.
[10] Tang, T. and M.J. Day, 2000. Field survey and analysis of hillslopes on tower karst in Guilin, southern China. *Earth Surface Processes and Landforms* 25:1,221-1,235.
[11] Twidale, C.R., 2003. Canons revisited and reviewed: Lester King's views of landscape evolution considered 50 years later. *GSA Bulletin* 115:1,155-1,172.

isolated tower karst has been found in the Mackenzie Mountains, northern Canada.[12] So, tower karst is not necessarily related to climate, although it is predominantly found in the tropics.[7,13]

Origin of Tower Karst a Mystery

As with many surface geomorphological features, the origin of tower karst is an enigma. Like inselbergs, tower karst could be related to areas with less jointing.[14,15] Although the karst may appear solid, it is commonly riddled with caves.[7] Daoxian, refers to the famous tower karst in southwest China (Figure 54.1) and describes why these towers should not remain for many millions of years:

> Recent limestone denudation measurement gives a rather high corrosion rate, so how and why Tertiary karst features could remain for millions or even *tens of millions* of years is another question needing explanation (emphasis mine).[16]

Figure 54.1. Tower karst around a bend in the Lijiang River, Guilin, China (wikipedia).

The most popular explanation is that the soluble rock around the towers was dissolved by rainfall over time, while the towers themselves dissolved very slowly. This is called the

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[12] Ford, D.C. and P.W. Williams, 1989. *Karst Geomorphology and Hydrology*, Unwin Hyman, London, U.K.
[13] Ahnert, F., 1998. *Introduction to Geomorphology*, Arnold, London, U.K., p. 257.
[14] McDonald, R.C., 1985. Tower karst geomorphology in northern Borneo. *Zeitschrift für Geomorpholgie N. F.*29:483-495.
[15] Drogue, C. and P. Bidaux, 1992. Structural and hydrogeological origin of tower karst in southern China (Lijiang plain in the Guilin region). *Zeitschrift für Geomorpholgie N.F* 36:25-36.
[16] Daoxian, Ref. 9, p. 1,118.

weathering hypothesis and will be discussed in Chapter 56. It is not known whether cone karst and tower karst are different phases of geomorphic development, or whether both develop at the same rate.[17] All that is really known is the rock between the towers eroded faster than the tower rock, resulting in topographical relief.[3]

A major shortcoming of this hypothesis is that it does not take into account the regional geological setting. Water, both flowing above ground as rivers and underground as ground water, is an important solution agent.[18] The most difficult tower karst to explain are those on slopes,[19] probably because water action on a sloped surface is more limited than that on flat areas.

Some believe tower foot notches and some abandoned caves that contain *rounded* rocks were cut by lateral river planation from the surrounding plains.[14,20,21] The association between rivers and tower karst is witnessed today. In Belize, McDonald noticed rivers sometimes undercut tower karst causing them to collapse.[6] However, rivers do not seem to form tower karst, which formed in the past by some currently unobserved process.

Many tower karsts would be described as inselbergs, if they did not develop in limestone.[22] Some researchers even refer to the towers as "monadnock-like."[23] Similar to inselbergs, tower karst also possesses flared slopes and tafoni with caves that are common at the foot of the tower.[7,24,25] Some towers only have tafoni and caves at their base, which is rather perplexing, since it is expected that caves form by slow erosion of the area. However, similar caves should be seen throughout the vertical walls of the tower, if the tower became exposed slowly over time.[7] It is likely the origin of tower karst is the *same* mechanism as formed the inselbergs (see part XII).

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[17] Tang and Day, Ref. 10, p. 1,224.
[18] McDonald, Ref. 6, p. 36.
[19] Jennings, Ref. 7, p. 97.
[20] McDonald, R.C., 1975. Observations on hillslope erosion in tower karst topography of Belize. *GSA Bulletin* 86:255-256.
[21] Thomas, Ref. 5, p. 350.
[22] Thomas Ref. 5, pp. 346-352.
[23] Tan Ming, N., 1992. Mathematical modelling of catchment morphology in the karst of Guizhou, China. *Zeitschrift für Geomorpholgie N. F.* 36:37-51.
[24] McDonald, R.C., 1976. Limestone morphology in South Sulawesi, Indonesia. *Zeitschrift für Geomorpholgie N. F., Suppl.-Bd* 26:79-91.
[25] Thomas, Ref. 5, p. 349.