Palaeontologia Electronica
http://palaeo-electronica.org

WILL DOWNS' ROLE IN THE GEOLOGICAL RECONNAISSANCE OF RIVER CANYONS IN WESTERN CHINA

Pete Winn

ABSTRACT

Will Downs had three major passions: paleontology, China, and whitewater rafting. In 1994, he was able to combine all three in an expedition on the Yangbi River, a tributary to the Mekong River, in western Yunnan. The Yangbi and Mekong rivers flow through an area of highly deformed Paleozoic rocks overlain by less deformed Mesozoic rocks. The deformation is related to India's ongoing collision with Asia and the resulting displacement of Asian crust. Due to the small number of participants and short time available for the Yangbi expedition, the scope of work was limited to field-checking Chinese geological maps that had been prepared from aerial photos. Subsequent to this expedition and each year until Will died, he provided valuable advice and support for our geological reconnaissance expeditions on major rivers in western China. Considering the scale of the Chinese geological maps, they have been reasonably accurate, except for a few major faults, which were not identified. Before his death in 2002, Will planned to investigate Quaternary sediments in the Yellow River canyon in eastern Qinghai; this sequence suggested recent rapid uplift related to India's collision with Asia. Will's expertise in field geology, his skills as an oarsman, his fluency in Chinese, and his enthusiasm for discovery were critical to the success of all of these expeditions.

Pete Winn. Earth Science Expeditions, 202 North Avenue #102, Grand Junction, Colorado 81501, USA. petewinn@shangri-la-river-expeditions.com

KEY WORDS: William R. Downs, China, Yunnan, Yangbi River, Mekong River, Himalayas, tectonics

PE Article Number: 8.1.1A

Submission: 26 May 2004. Acceptance: 13 April 2005

INTRODUCTION

I first met Will Downs on a Grand Canyon trip in 1974. I was working as a river ranger for Grand Canyon National Park, and Ben Foster and Will came along on one of my patrol trips (Figure 1) to retrieve some late Precambrian fossils they had left on a recent hiking trip. At the time, Will was learning Mandarin Chinese at Northern Arizona University in Flagstaff and was working at the Museum of

Winn, Pete, 2005. Will Downs' Role In The Geological Reconnaissance of River Canyons in Western China, *Palaeontologia Electronica* Vol. 8, Issue 1; 1A:10p, 774KB;
http://palaeo-electronica.org/paleo/2005_1/winn1/issue1_05.htm

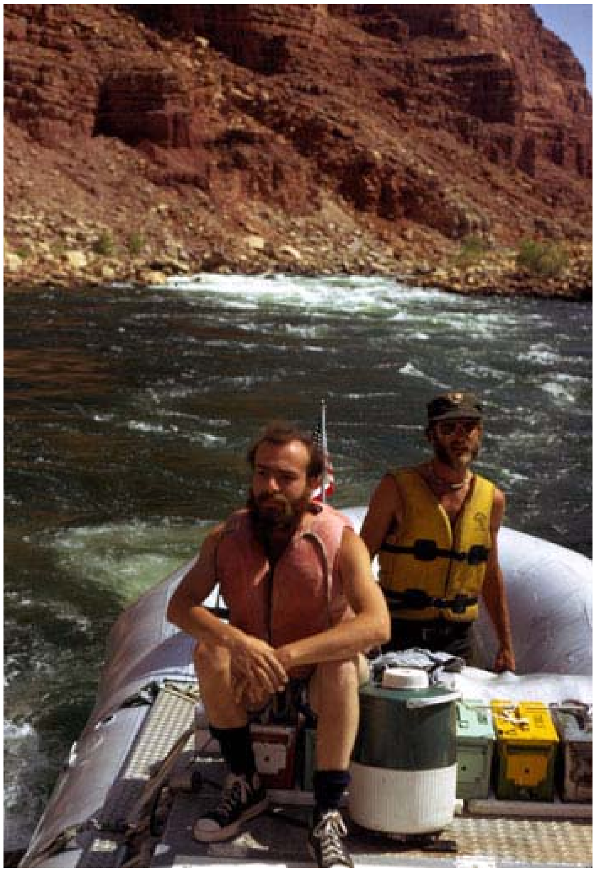

Figure 1. Will at the beginning of his career as a paleontologist.

Northern Arizona as a preparator in the Geology Department.

Will and I became good friends on the patrol trip. He was instrumental in convincing me to go to Northern Arizona University in Flagstaff in 1975 to study geology. Over the next few years, my wife Cindy Appel (a USGS hydrologist) and I taught Will to row a raft on several whitewater rivers in Utah and Arizona. From the late 1970s until he died, Will was one of our favorite oarsmen on numerous trips on the San Juan, Green, and Colorado rivers. He was also an oarsman on a 1988 trip on the Rio Grande River near Taos, New Mexico, with Bruce Babbitt, then Governor of Arizona, who was helping us to raise funds for an expedition on the Mekong River in Yunnan, China. Cindy and I invited Will to row on all four of our Grand Canyon private trips (1982, 1990, 1997, and 2001).

Will became a surrogate uncle to our children, Travis and Carmen, and helped teach them to row. Inspired in part by Will, Travis is currently living in China, studying geology, and learning Mandarin. Carmen is currently a science geek in high school and hopes to travel to China to learn Mandarin when she attends college.

I made a video of Will's runs in major rapids on our Grand Canyon trips. It is available for free in return for contributions to Will's Flip Side website (http://www.shangri-la-river-expeditions.com/willdowns/willdowns.html). This website contains pictures of Will and his friends and stories by and about Will on his paleontological adventures in China, Pakistan, Greenland, Africa, and Arizona and his rafting adventures in China and the USA, plus links to his paleontological publications and his famous "goodbye" missives. The website, the Grand Canyon video, and this article resulted from discussions with Will and many of his friends during our last visit with him in Flagstaff a few weeks before he died.

By the mid 1980s, I was working on an MS in geology at the University of Utah. Mike Connelly (another University of Utah geology graduate student who had extensive whitewater experience), Will and I decided that we wanted to conduct geological reconnaissance expeditions on rivers in western China. Will had learned Chinese in the mid 1970s, had been translating Chinese paleontological reports into English for several years (translations downloadable as PDF files - http://www.shangri-la-river-expeditions.com/willdowns/willdowns.html), and was embarking on paleontological field work in China in the next few years. His advice was invaluable, especially his frequent reminder that there are three rules for doing business in China: patience, patience, and patience. The Chinese have a vastly different sense of time than we do.

During the 1980s, a team of geologists, writers, and photographers developed plans for raft trips devoted to geological reconnaissance, especially to the tectonics of mountain building. Several of us, including Will and me, recognized that rocks along the upper Mekong drainage were relevant to competing models of Himalayan tectonics (Figure 2). We developed a research proposal to investigate this region.

After failing to get the support of the National Geographic Society and the National Science Foundation, we contacted Bruce Babbitt through mutual friends in Flagstaff, Arizona, to seek his help in getting corporate support. Before he was elected governor of Arizona, Babbitt was a geologist and river runner with an interest in the Mekong drainage. In April 1989, with his help we convinced the Coca-Cola Company to fund a 25-person research expedition. We were planning to conduct the expedition at low flows that November. However, the Tienanmen Square Event occurred in June, so Coca-Cola decided to hold off on funding, plus no one wanted to go to China after that event.

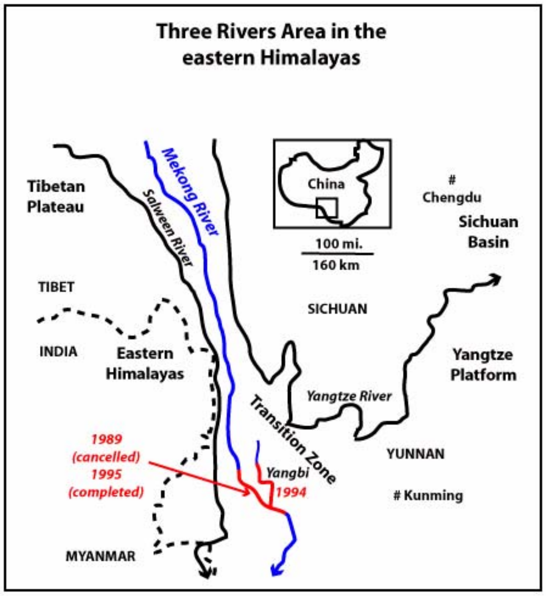

Figure 2. Location of the Mekong and Yangbi rivers in western Yunnan, China.

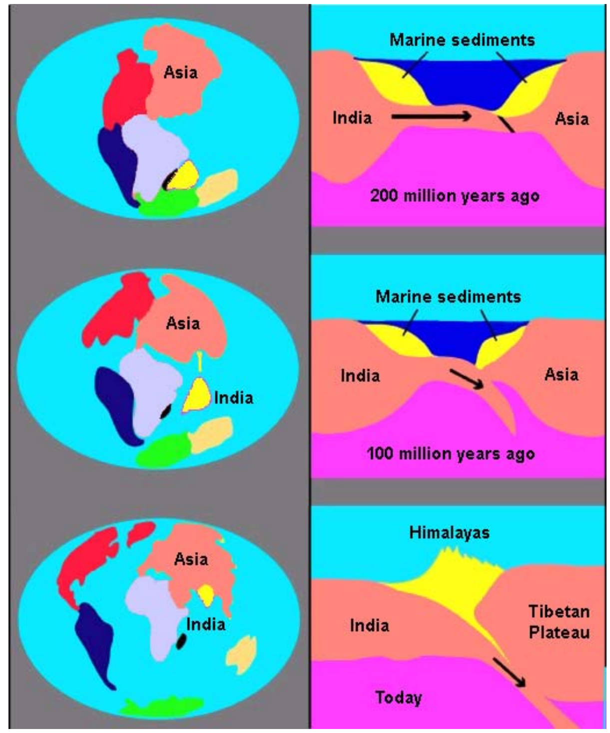

Figure 3. A global view of India's collision with Asia (modified from Molnar 1986).

If you don't recall, the Chinese army drove tanks toward Chinese citizens who were peacefully demonstrating for greater freedom in front of the People's Hall.

GEOLOGICAL SIGNIFICANCE OF THE UPPER MEKONG RIVER AND ITS TRIBUTARIES

By the mid 1970s, the theory that the Himalayas were produced by a collision between India and Asia was becoming widely accepted (Figure 3), but it raised major questions regarding the displaced mass of Asian crust. Since about 50 mya, it appeared that India had penetrated at least 2000 km into Asia, but it was not clear that the mass of the Himalayas and the thickened crust beneath the Tibetan Plateau were sufficient to account for the entire mass of displaced Asian crust. Using satellite images and seismic analysis, Molnar and Tapponnier (1975) recognized major east-trending, left-lateral strike-slip faults emanating from Tibet. These faults sliced the areas east and southeast of Tibet, implying that crustal mass north of the Himalayas was shifting eastward and southeastward as India moved north (Figure 4). Molnar and Tapponnier hypothesized that the Yunnan Plateau and the Shan-Thai Plateau are now much further southeast than they were before the collision (Figure 5).

We decided that the Mekong River Canyon in western Yunnan was the best region for examining faults to determine whether large blocks of southeast Asian crust were being extruded southward towards Indochina. The river crosses several faults in a canyon two miles deep in the stretch where it changes direction from south to southeast (Figure 6). We hoped to investigate the nature of these faults to determine their relationship to the development of the Himalayas and the uplift of the Tibetan Plateau.

To achieve this objective, our plan was to determine the sense of shear in mylonites, to sample shear zones for radiometric dating, and to sample overlying Triassic red beds to measure paleomagnetic latitude and orientation. Mylonites are fault rocks, which are cohesive, characterized by a well-developed schistosity resulting from tectonic reduction of grain size, and commonly contain rounded porphyroclasts and lithic fragments similar in composition to the matrix minerals. Fine scale layering and an associated mineral or stretching lineation are commonly present. Brittle deformation of some minerals may be present, but deformation is commonly by crystal plasticity (Brodie et al. 2004).

A related objective was to take paleontological samples in hopes of justifying further research on patterns of environmental change as the rising Himalayas modified the climate of this area. Will was one of the oarsmen and the only paleontologist on the team.

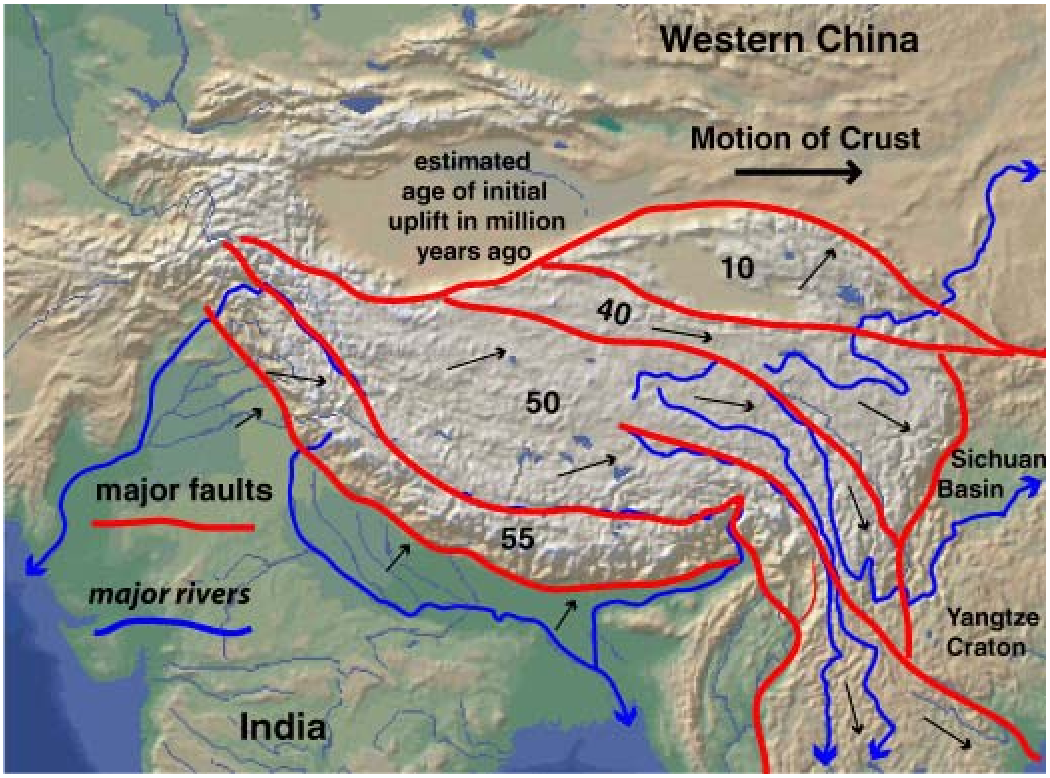

Figure 4. Major crustal blocks, age of uplift and direction of motion in western China (adapted from Tapponier et al. 2001).

In southwestern Yunnan, the Mekong River weaves back and forth across the contact between metamorphic rock units and Mesozoic sedimentary strata (Figure 7). According to Chinese geologists, the metamorphic rocks are of amphibolite grade, and therefore temperatures in them have exceeded 450°C. More importantly, the metamorphic rocks are strongly sheared, with a near vertical northwest-trending foliation and subhorizontal lineation characteristic of rocks that have experienced high shear. Neither the sense of shear nor their age was known. On Chinese maps, the sedimentary rocks were shown as Jurassic and Cretaceous shallow marine deposits in fault contact with the underlying metamorphic rocks. Determining the nature of this contact was an important part of our research proposal.

In summary, we planned to examine in detail the deformation and rotation of rocks exposed along the Mekong River in western Yunnan to characterize the age, style, intensity, distribution, and sense of crustal shearing induced by the collision and penetration of India into Asia. We hoped to constrain the extent and the timing of extrusion of parts of Indochina from an initially more northwesterly position and to place bounds on the amount and distribution of shearing in western Yunnan due to India sliding northward past Yunnan. We believed that a detailed study of one key area was a better approach than a superficial examination of a large area.

The stretch of Mekong that we planned to run appeared to offer a wide range of possible approaches to studying this deformation. Knowledge gained from this area would be fundamental to understanding areas of more complex deformation in northern Yunnan, western Sichuan, Tibet, and Qinghai. We hoped to expand our collabora-

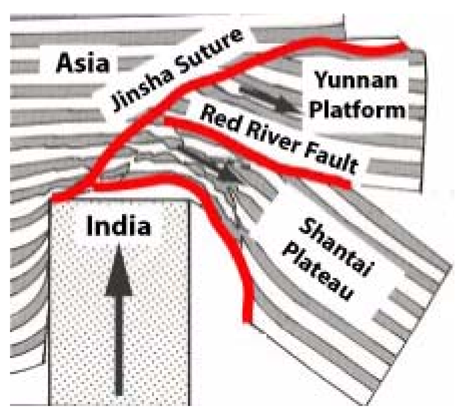

Figure 5. Clay model illustrating the relationship between India's northward motion and east- southeast extrusion of southeast Asia (modified from Tapponnier et al.1982).

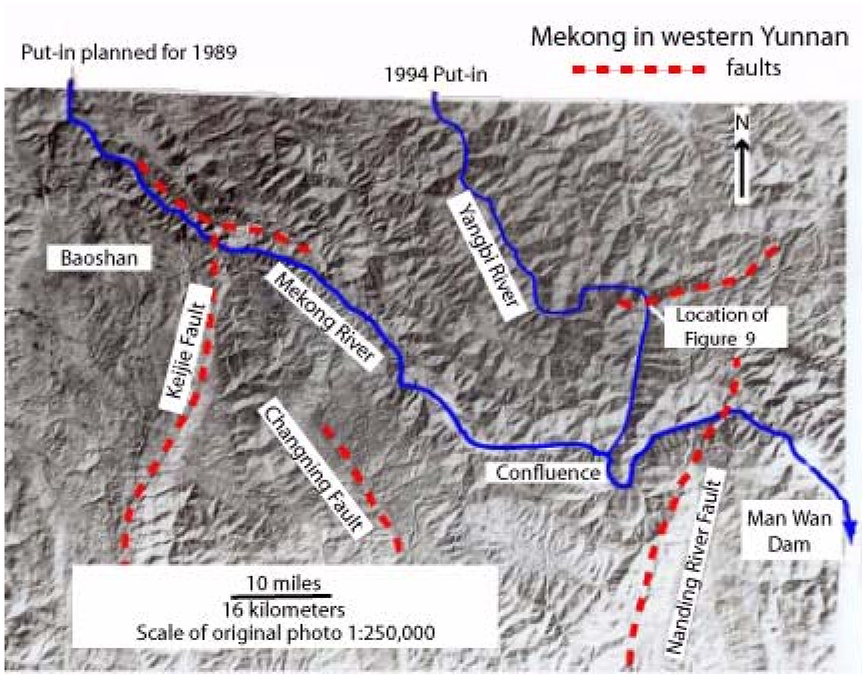

Figure 6. Satellite view of the Mekong and Yangbi drainages in western Yunnan (Landsat photo).

tive research program to these regions, concentrating on areas where our collective expertise could have been used to maximize the results of our research. Although Will's scientific background and interest were generally limited to the paleontological aspects of this expedition, his role as an experienced whitewater river guide who could read, write, and speak Mandarin was critical to the success of the expedition.

THE YANGBI RIVER EXPEDITION, 1994

After the crisis at Tienanmen Square, it took us five years to regain momentum. We were unable to find corporate support, so we weren't able to afford permits for the main stream of the Mekong. The Chinese offered us a discount to run the Yangbi River, a large tributary to the Mekong just east of the stretch we had originally planned to explore (http://www.shangri-la-river-expeditions.com/journals\mekong1994\mekong1994.html). By 1994, there were only seven of us who were still interested in the expedition: Will, Peter Molnar, his wife Sara Neustadtl, Mike Connelly, Ben Foster, Ralf Buckley, and I. By then, Will was traveling so often that he had lots of frequent flyer miles, he had already translated dozens of Chinese paleontological articles into English, and he had published his first article based on field research in China (Tedford et al. 1991). Will graciously gave Sara a free airline ticket so that she could join us, and during the expedition, he developed a lasting relationship with Peter that ultimately led to a coauthored article (Zhang et al. 2001).

With such a small research group and limited time, we decided that it was only feasible to field check a Chinese geological map of the area that Will had obtained for us. It had been compiled from aerial photos with a few field checks where there was road access. Considering the 1:500,000 scale, we found it to be reasonably accurate.

On the way to the river, we stayed in Xiaguan, an industrial town not far from Dali, the ancient capital of the area. From Xiaguan, the road follows the river that drains Er Hai (Ear Lake) west down a

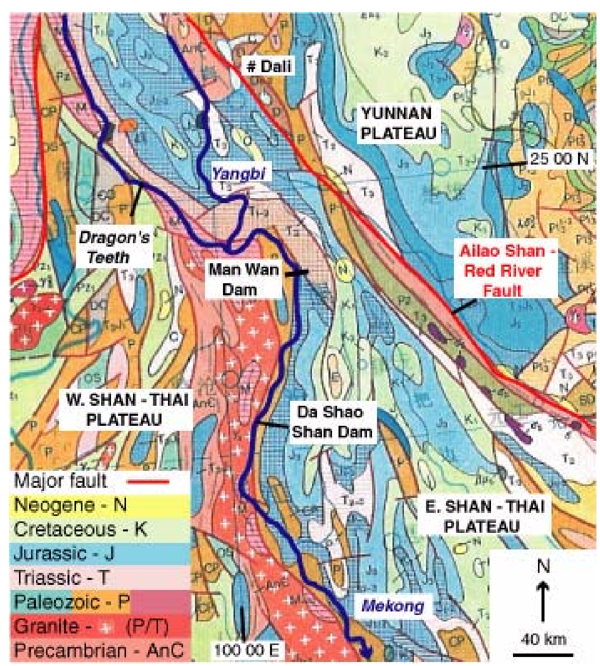

Figure 7. Geologic map of western Yunnan.

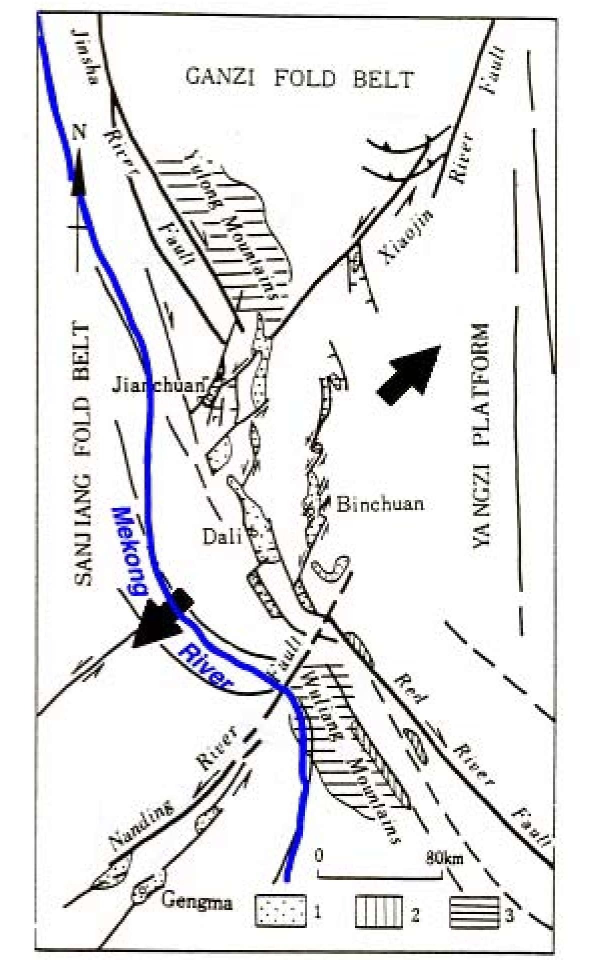

Figure 8. Neogene regional extension in western Yunnan and southwestern Sichuan (adapted from Deng et al. 1986).

steep canyon through amphibolite-grade Paleozoic rocks with a northwest near vertical foliation and a near horizontal lineament – probably the northwest extension of the Ailiao Shan shear zone (Figure 7). Tapponier et al. (1990) hypothesized that about 500 km of left-lateral strike-slip displacement occurred along this shear zone. Further southeast, the younger and more clearly defined right lateral Red River Fault follows this lineament (Allen et al. 1984; Figure 8). Both faults appear to be related to India's collision with Asia. As the "horn" of the Indian subcontinent (the east Himalayan syntax) passed the extruded Indochina block, displacement changed from left lateral to right lateral (Huchon et. al. 1994).

We rafted and kayaked about 120 km of the Yangbi in eight days, then took another two days to cross the recently created 100 km Man Wan Reservoir. For the first two days, the river flowed in a narrow, challenging canyon composed of Mesozoic slates that were being mined for roof shingles. For the next four days, we floated through a wide, deep valley in Mesozoic red sandstones, with no rapids and few rock exposures. Halfway through this stretch, the river turned sharply to the east. Will was fascinated by frequent exposures of what appeared to be poorly consolidated Quaternary sandstone in large "patches," often extending one or two hundred meters up steep valleys, suggestive of a much drier, windier climate subsequent to development of the river canyon. He had studied late Quaternary deposits that had been useful in placing constraints on the age of the Grand Canyon as a topographic feature and thought that these sandstones might provide some constraints on the age of the Yangbi drainage.

On the seventh day, the river turned due south, and we immediately began to encounter challenging rapids. We camped that night across from an unmapped 30 m wide fault zone in Mesozoic redbeds (Figure 9). A huge mudslide beginning at the head of a side canyon following the fault had occurred two weeks earlier, destroying houses and crops and forcing the river into a narrow rock-filled channel with numerous rapids (Figure 10). Like most Himalayan rivers, the Yangbi can move a lot of sediment in flood (Figure 11).

Above river level, the canyon slopes were often so heavily vegetated that faults were poorly exposed, and we had little opportunity to search for mylonites. Contacts between the high grade Paleozoic metamorphic and intrusive rocks and the overlying Mesozoic low grade metasediments obviously were not fault contacts as suggested by the Chinese map; rather, the transition from high grade to low grade suggested two metamorphic events. (1) High grade metamorphism in the Paleozoic rocks that most likely predated deposition of the Mesozoic rocks (above a nonconformable contact), and (2) low grade metamorphism in the Mesozoic rocks, such as the slates we had encountered on the first two days, that could have been produced by deformation resulting from India's Cenozoic collision with Asia.

Two nights later, we camped at the confluence of the Yangbi and Mekong. Overnight, the Mekong rose yet its velocity decreased, a sure sign that we were on a reservoir. The Man Wan Dam, located about 100 km downstream, had been completed in 1993. The Man Wan Dam is the first of seven that the Chinese plan to complete on the Mekong in Yunnan by 2018. The cumulative hydropower will be equivalent to all of the major dams managed by the US Bureau of Reclamation in the western United States – about 15 gigawatts. The river-scoured exposures of the Nanding Fault that we

Figure 9. A large unmapped fault zone is exposed on the opposite river bank (location on Figure 6). Will is facing the camera, Peter Molnar is facing away from it.

had planned to examine on the 1989 expedition were inundated by the new reservoir.

Although it was evident from the Yangbi expedition that further research on the structural relationships among unmetamorphosed Cenozoic, low grade metamorphic Mesozoic and high grade metamorphic pre-Mesozoic rocks was warranted, we were never able to motivate a group of geoscientists to pursue research in this area. The Chinese government was rapidly opening Tibet to research by foreigners, and it has received most of the emphasis of tectonic research over the past decade.

THE YEARS FOLLOWING THE YANGBI EXPEDITION

Immediately following the Yangbi expedition, Will traveled north to the Gongga Shan (Minya Konka) area southwest of Chengdu, Sichuan, with Ben Foster, the other oarsman on the Yangbi expedition. At 7,590 m, Gongga Shan is the highest mountain outside of the Himalaya proper. With Will

Figure 10. Will is rowing, with Peter Molnar and Sara Neustadtl as passengers.

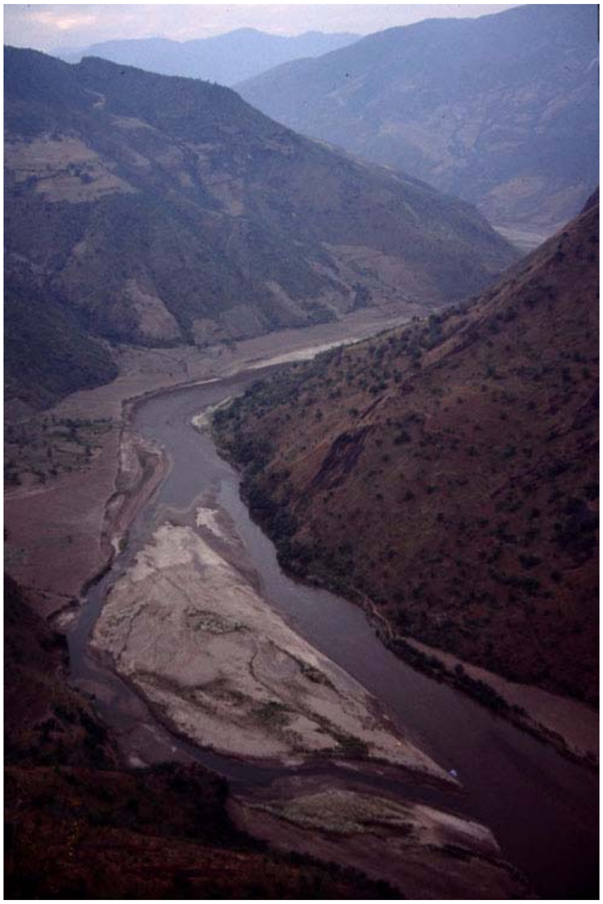

Figure 11. View of the Yangbi River Canyon from about 500 m above the river. For scale, the small blue dot at end of the island (lower right) is two 5 m rafts parked side by side.

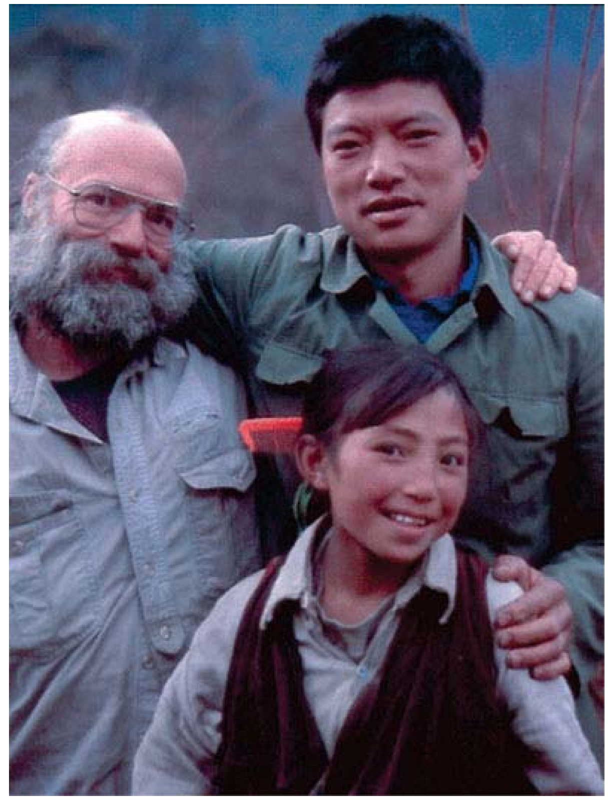

Figure 12. Will and Chinese friends on the Gongga Shan trek.

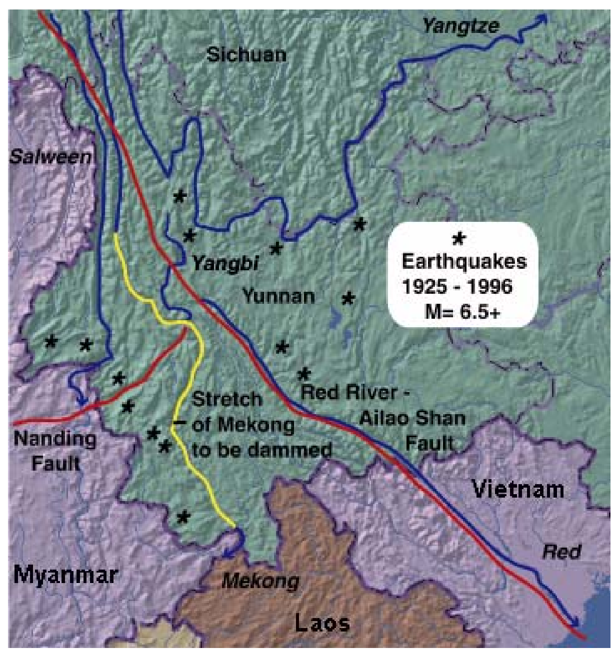

Figure 13. Major earthquakes in western Yunnan from 1925 to 1996 (data from the National Geophysical Data Center http://www.ngdc.noaa.gov/, map modified from Rand McNalley's *New Millennium Atlas*)."

as translator, they managed to reach the base camp at 5,500 m on the south side of the peak (Figure 12), then continued around to the west and north sides before returning home three weeks later.

Will's description of this epic journey (http://www.shangri-la-river-expeditions.com/willdowns/china/gonggashan.html) provides an enlightening insight into Will's attitude toward life. On this trek, they encountered bamboo forests (home to the giant panda bear) at elevations near 2,500 m. Will had often used plant fossil assemblages as an indicator of elevation in his research on the timing and effect of the rise of the Himalayas during the Cenozoic and was disturbed to find bamboo at such high elevations because he believed that bamboo fossils in other areas indicated a much milder climate at this latitude.

Tapponnier et al. (2001) and other researchers still believe that extremely large brittle displacements and block rotations of Tibetan and southeast Asian crust have occurred as a result of India's

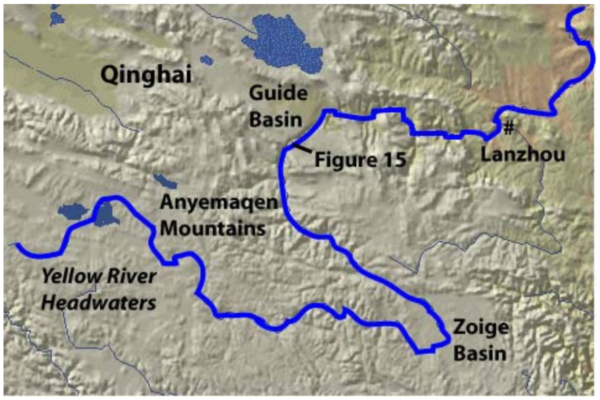

Figure 14. Relief map of the Yellow River headwaters (modified from Rand McNally's New Millennium Atlas).

penetration into Asia. However, recent GPS measurements of surface motions over distances of about 100 km in western China suggest highly distributed crustal motions that are not compatible with rotations of rigid blocks bounded by large strike-slip faults (Zhang et al. 2004). Research over the past decade or so shows that crustal motion appears to be distributed over the entire region and not concentrated in major fault zones. The controversy continues.

Based on the safe completion of the 1994 Yangbi expedition, I've run a geological reconnaissance river expedition in China nearly every year since. Unfortunately, all of them conflicted with Will's commitments to field paleontology expeditions. Of course, those with whom he worked benefited from this perennial conflict. We really missed him on the 1995 and 1996 expeditions on the stretch of the Mekong that we had originally planned to run in 1989. The geology was dramatic,and there were abundant Grand Canyon size rapids. Will was amazed by the video footage of rafts flipping in the huge waves in Dragon's Teeth Rapid, formed by a landslide caused by two large earthquakes that occurred within 10 minutes of each other in 1988. We also ran expeditions on the Mekong in southwest China (1997, south of the Man Wan Dam), the Mekong in Qinghai (1999, its source area), the Salween in eastern Tibet (2000), the Tsangpo in western Tibet (2002), and the Mekong in Tibet (2004). On this last expedition, we had to hike out after 137 km, because it was not safe for rafts. My son Travis and I spread some of Will's ashes at Tibetan Terminator, the rapid that forced us to abandon our effort on that part of the river.

Each year, Will would send me Chinese geological maps for the river segment we planned to run, plus an English translation of the map key. After the expedition, he would review my reports before I sent them to our host agency, the Chinese Academy of Sciences. Will's support was invaluable–I'm not sure we would have been successful without it.

I've made a DVD on the history of exploration of the rivers of western China based on these and other expeditions (available on request). In addition to documenting the whitewater challenges, it summarizes the geology and geography, and addresses the Chinese domination of Tibetan culture and the rapid pace of dam building on rivers draining the Himalayas and the Tibetan Plateau. There's a high density of young, active faults and a large earthquake about every 10 years in western Yunnan alone (Figure 13), probably related to India's continued northward push into Asia. Building dams in this area creates hazards that only a

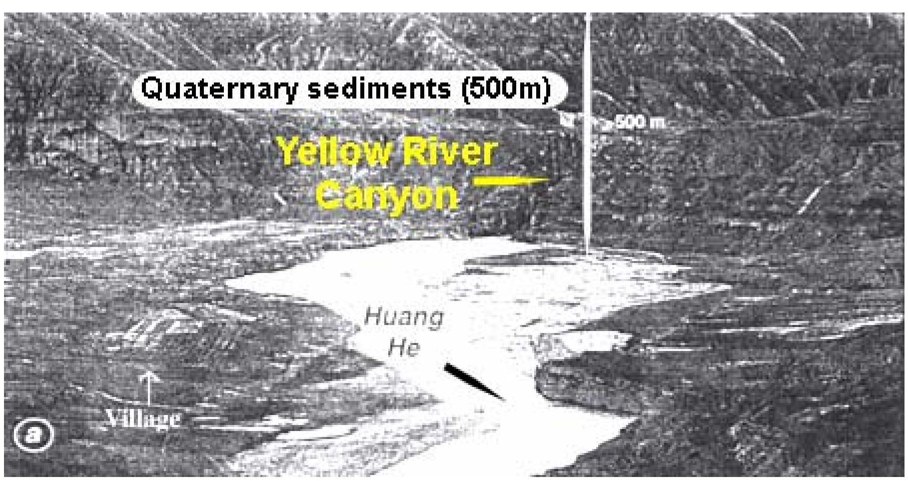

Figure 15. The Yellow River (Huang He) exiting the northern flank of the Anyemaqen Mountains, Qinghai where 500 m of Quaternary sediments are exposed. Photo supplied by Will Downs, photographer unknown.

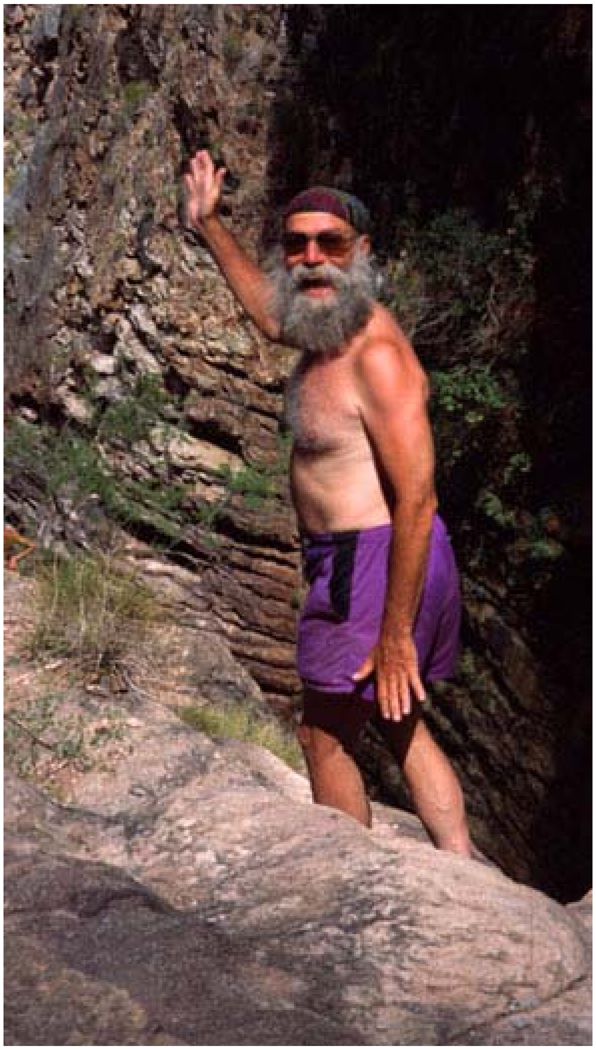

Figure 16. “See you on the Flip Side!”

culture desperate for energy would accept. Over the years of our relationship, I valued Will’s opinions about these complicated issues and they are reflected in this DVD.

In 2002, Will asked me to help him plan an expedition on the Yellow River in Qinghai with Josep Pares at the University of Michigan. In Qinghai, the Yellow River flows southeast into the Zoige Basin, then makes a huge U- turn to the northwest and crosses the Anyemaqen Mountains before entering the Guide Basin and resuming its eastward trend. Large sections of young sediments in the Guide Basin suggest that this change in drainage pattern is late Cenozoic, perhaps even Quaternary. Will, Josep, and I hoped to examine these sediments from the river (Figures 14, 15).

Will died before we could conduct the expedition. Maybe someday Josep and I will complete the expedition in Will’s memory (Figure 16). I’m sure he would appreciate it.

REFERENCES

Allen, C., Gillespie, A, Han, Y., Sieh, K., Zhang, B, and Zhu, C. 1984. Red River and associated faults, Yunnan Province, China: Quaternary geology, slip rates, and seismic hazard. *GSA Bulletin,* 95:686-700.

Brodie, K., Fettes, D., Harte, B., and Schmid, R. 2004. Towards a unified nomenclature in metamorphic petrology: 3. Structural terms including fault rocks. Recommendations by the IUGS Subcommission on the Systematics of Metamorphic Rocks. Version 30.11.2004:1-9.

Deng, Q., Daning, W., Zhang, P., and Chen, S. 1986. Structure and deformational character of strike-slip fault zones. *Pageoph (Birkauser Verlag, Basel),* 124, No. 1/2:203-223.

Huchon, P., Le Pichon, X., and Rangin, C. 1994. Indochina Peninsula and the collision of India and Eurasia. *Geology*, 22:27-30.

Molnar, P. 1986. The geologic history and structure of the Himalaya. *American Scientist,* 74:144-154.

Molnar, P. and Tapponnier, P. 1975. Cenozoic tectonics of Asia: Effects of a continental collision. *Science*, 189: 419-426.

New Millennium World Atlas Deluxe CD. 1992. Rand McNally & Company, Chicago, IL.

Tapponier, P., Lacassin, R., Leloup, P.H., Scharer, U., Zhong, D., Wu, H., Liu, X., Ji, S., Zhang, L., and Zhong, J. 1990. The Ailao Shan/Red River metamorphic belt: Tertiary left-lateral shear between Indochina and South China. *Nature*, 343:431-437.

Tapponnier, P., Peltzer, G., Le Dain, A.Y., Armijo, R., and Cobbold, P. 1982. Propagating extrusion tectonics in Asia: New insights from simple experiments with plasticine. *Geology*, 10:611-616.

Tapponnier, P., Xu, Z., Roger, F., Meyer, B., Arnaud, N., Wittlinger, G., and Yang, J. 2001. Oblique stepwise rise and growth of the Tibet Plateau. *Science*, 294:1671-1677.

Tedford, R.H., Flynn, L.J., Qiu, Z., Opdyke, N.D., and Downs, W.R. 1991. Yushe Basin, China; paleomagnetically calibrated mammalian biostratigraphic standard from the late Neogene of eastern Asia. *Journal of Vertebrate Paleontology*, 11(4):519-526.

Zhang, H., Molnar, P., and Downs, W.R. 2001. Increased sedimentation rates and grain sizes 2-4 Myr ago due to the influence of climate change on erosion rates. *Nature,* 410:891-897.

Zhang, Z., Shen, Z., Wang, M., Gan, W., Bürgmann, R., Molnar, P., Wang, Q., Niu, Z., Sun, J., Wu, J., Hanrong, S., and Xinzhao, Y. 2004. Continuous deformation of the Tibetan Plateau from global positioning system data. *Geology*, 32:809-812.