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Red River and associated faults, Yunnan Province, China: Quaternary geology, slip rates, and seismic hazard

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Abstract

The 900-km-long right-slip Red River fault of southernmost China and northern Vietnam is a profound structural discontinuity that is mechanically associated with the collision of the Indian and Eurasian plates. Although history records no large earthquakes resulting from slippage along at least the principal segment of the fault in China, youthful landforms and disruptions of young sedimentary rocks indicate that it has generated large earthquakes during the Pleistocene and Holocene epochs. The historic quiescence thus must be regarded as being indicative of a current seismic gap, although the recurrence interval between major earthquakes is evidently much longer than for many other major active fault systems.

That recent displacement has been primarily right lateral is indicated by consistently displaced drainages, ranging in offset from 9 m to 6 km, and the freshness of the smallest and most recent offsets implies repeated Holocene movements. Although physiographic features typical of active faulting such as scarps and drainage diversions are present throughout, the general absence of sag ponds reflects both the high rate of dissection of the fault by the Red River and its tributaries and the lower degree of activity as compared to highly active faults such as the San Andreas fault of California.

In its middle 170 km, the fault zone is made up of two branches. The range-front branch demarcates the northeastern base of the Ailao Mountains and, at least locally, has an appreciable component of dip slip. The mid-valley branch, in large part previously unrecognized, traverses principally deeply dissected Cenozoic valley fill northeast of the range-front fault and has undergone almost pure lateral slip. Lateral postfill offsets along the range-front branch diminish toward the southeast, whereas those along the mid-valley branch diminish northwestward; the net effect is that the total postfill offset across both branches is almost uniform.

The Red River and its major tributaries appear to have experienced about 5.5 km of right slip since the beginning of a major episode of incision that continues to the present day. Restoration of this offset provides a remarkable alignment of most

large tributaries as well as removing a major kink in the course of the Red River itself. Using maximum credible rates of incision, we estimate an average fault-slip rate of 2 to perhaps 5 mm/yr. At this long-term rate of slip, the smallest offsets observed along the fault (9 m) would occur no more frequently than every 1,800 to 4,500 yr on the average. This is consistent with the historical record of fault dormancy for the past 300 yr.

North of the Red River fault, there is a large seismically active region laced with numerous faults of north and northwesterly trends. Several of these faults display clear and even spectacular evidence of youthful normal faulting, and some appear to have left-lateral components as well. These faults, as well as the Red River fault itself, are accommodating regional east-west crustal extension and north-south shortening.

First Page Preview

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INTRODUCTION

The objective of this study was to understand better the current tectonic activity and seismic hazard along a part of the east flank of the great eastern syntaxial bend of the Himalayan mountain chain, as reflected by the Red River and associated faults of Yunnan Province, China (Fig. 1). The Red River fault is one of the great regional faults of China and has long been recognized as a profound geological discontinuity marking the southwest margin of the Yangtze (Yangtze) Platform (Ministry of Geology, 1979). It is particularly striking on satellite images for some 800 km northwest from near Hanoi, Vietnam, to the vicinity of Xiaguan, Yunnan Province (Fig. 2) (Tapponnier and Molnar, 1977; York and others, 1976). Regional geologic maps (Ministry of Geology, 1962) show many other northwest-trending faults in Yunnan, but none seems to have the continuity, linearity, and degree of geologic activity that characterize the Red River fault, and thus field efforts were concentrated on the Red River fault in this study.

A principal quandary regarding the Red River fault has been its degree of current seismic activity and hazard, if any. Although the fault superficially appears very similar to other major active faults, it has produced no significant earthquakes within the long historic record, at least southeastward from Midu.[1] One of the principal efforts of this study thus has been the attempt to determine the fault's degree of late Quaternary activity. Is the fault truly a "dead" fault in the present tectonic environment, or is it simply representative of a temporal "seismic gap"? If the latter, what is its slip rate and degree of hazard, what is its sense of motion, and how does it relate to other nearby structures in the regional plate-tectonics framework? The principal investigative technique used in this study was examination of the late Quaternary history of the Red River fault as expressed in the field, applying methods similar to those used on the San Andreas fault by Sieh (1978a, 1978b).

Note: Chinese surnames are written before given names. All authors' names are given in alphabetical order here, and Chinese names are written in their usual form.

[1]Most place-names used in the text are shown on the accompanying maps, particularly Figure 1, and see Figures 3 and 18 below.

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Index Terms/Descriptors

active faults | Asia | Cenozoic | China | displacements | drainage patterns | earthquakes | engineering geology | environmental geology | Far East | fault scarps | faults | fluvial features | geologic hazards | geomorphology | neotectonics | plate collision | plate tectonics | Quaternary | rates | Red River | Red River Fault | seismic gaps | seismic risk | seismicity | seismology | seismotectonics | stratigraphy | strike-slip faults | structural geology | tectonics | Yunnan China

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