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No sedimentary records indicating southerly flow of the paleo-Upper Yangtze River from the First Bend in southeastern Tibet

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ABSTRACT

It is a long-debated issue whether the Upper Yangtze River once flowed southward from its First Bend as a major tributary of the Red River. The Yangbi valley was assumed as a trough carved by the paleo-Upper Yangtze River. This argument, however, has not been substantiated because of the uncertainty of what is beneath the Quaternary sediments of the valley. We conducted a drilling project in an attempt of resolving this outstanding puzzle. We also studied the Upper Eocene–Lower Oligocene Baoxiangsi and Jinsichang Formations distributed widely to the west of the Yangbi valley because sandstone of the Baoxiangsi Formation were previously regarded as remnants of the south-flowing paleo-Upper Yangtze River. Two drilled holes reveal that the Yangbi valley is entirely filled with Quaternary alluvial-fan and bog deposits and contains no typical fluvial sandstone. The base of the valley is the well-consolidated breccia of the Baoxiangsi Formation. The sedimentary analysis shows that the Baoxiangsi and Jinsichang successions are composed mostly of alluvial-fan, lacustrine, fan-delta and braided-stream facies, and interpreted to have formed in an intermontane rift basin. Facies analysis in conjunction with paleocurrent restoration further shows that the bulk of the Baoxiangsi and Jinsichang sediments were shed from local highlands and debouched to the basin mainly from the south and west. Collectively, our sedimentary investigations of both boreholes and outcrops lend no support of the long-held view that the paleo-Upper Yangtze River flowed to the south through the region south of the First Bend. It, however, remains an unresolved problem how the ancestral Upper Yangtze River evolved during the Tertiary.

1. Introduction

Streams are sensitive to crustal deformations (Schumm et al., 2000), and thus temporal–spatial variations of drainage patterns can reflect evolution of actively deforming regions, such as the Tibetan plateau. Most rivers developed synchronously with the growth of the Tibetan plateau, flowing eastward in plateau interior and then turning to the south at the eastern edge of the Tibetan plateau, such as the Nu (Salween), the Lancang (Mekong) and the Upper Yangtze (Jinsha) rivers (cf. Brookfield, 1998). The three rivers consistently curve to the south as they pass through the eastern Himalayan syntaxis (Fig. 1). However, the south-flowing Upper Yangtze River makes an anomalous ca. 150° loop at Shigu, known as the First Bend of the Yangtze River (Figs. 1 and 2). A narrow trough, termed as the Yangbi valley (Clark et al., 2004) or known as the Hongwen-Diannan valley in the Chinese literature (cf. Xu and Li, 1982), exists just south of the First Bend, extending north-northeast to south-southwest for about 53 km. The valley is ca. 200 m above the Yangtze River, with the Yangbi River flowing through it (Fig. 2). Controversies have remained for decades about the origin of the First Bend. It was speculated that the Upper Yangtze River originally flowed southward through the Yangbi valley as a tributary of the Red River (Gregory and Gregory, 1925; Lee, 1933). It was then captured at Shigu by another river, and flowed to the northeast. The capture created a sharp bend of the Yangtze River's course, and left a paleo-channel south of Shigu, as represented by the Yangbi valley (Lee, 1933; Ren et al., 1959). It was also proposed that the Yangbi valley was a structural valley (Shen and Yang, 1963; He et al., 1991), and possibly formed as a result of left-slip movement of the Jianchuan fault in the Late Pliocene (Fig. 2B) (E. Wang et al., 1998). Clark et al. (2004) also hold that the Yangbi valley was not an abandoned stream course, but insisted that the paleo-Yangtze Rive did flow southward, as recorded by fluvial sandstone in the Eocene Baoxiangsi Formation exposed west of the Yangbi valley (Fig. 3). The Yangbi valley is covered with Quaternary sediments, and no one knows for sure if the "Upper Yangtze River" deposits existed beneath the Quaternary cover. Identification of sedimentary facies beneath the Yangbi valley's cover is therefore crucial to determine whether this valley was once a channel carved by the paleo-Upper Yangtze River. To solve this outstanding puzzle, we conducted a drilling project on the Yangbi valley, and also carried out a field investigation of the Upper Eocene Baoxiangsi and Lower Oligocene Jinsichang formations exposed to the west of the Yangbi valley, which

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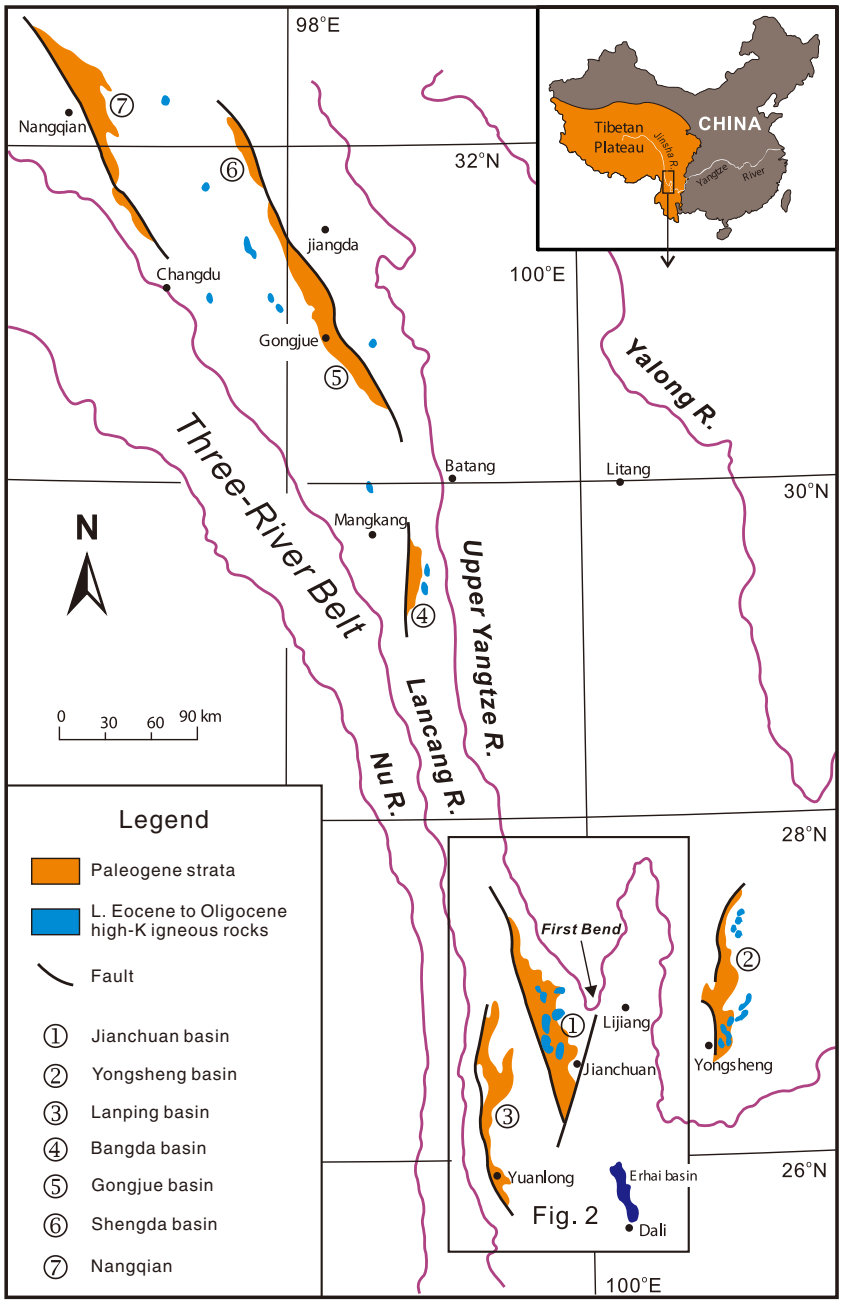

Fig. 1. Diagram showing distribution of Paleogene strata and high-potassium intrusions in southeastern Tibet. Note that Paleogene strata are spatially and temporally associated with igneous rocks.

were once interpreted as products of the south-flowing paleo-Upper Yangtze River (Clark et al., 2004). In this contribution, we report the results of our sedimentary analysis of both the borehole cores and the Baoxiangsi — Jinsichang sequences, and argue that there are no sedimentary records indicating that the Upper Yangtze River once flowed southward from the First Bend.

2. Regional tectonics and stratigraphy

The First Bend of the Yangtze River is located in the southeastern margin of the Tibetan plateau where Cenozoic deformations was quite active, as manifested by the development of the Ailao Shan–Red River shear zone and the Three-River belt (cf. Burchfiel and Chen, 2012). The Ailao Shan–Red River shear zone commenced large-magnitude ductile left-slip movement around ~27 Ma and continued until ~17 Ma (Wang et al., 2000; Gilley et al., 2003; Searle et al., 2010). Brittle right-slip faulting modified the shear zone in the Quaternary (Allen et al., 1984). Several NE-trending left-slip faults developed to the north of the Ailao Shan–Red River shear zone, such as the Heqing, Lijiang, and the Jianchuan faults (Fig. 2). Left-lateral shearing along these faults might have resulted from clockwise rotation of crustal blocks owing to right slip of the Ailao Shan–Red River shear zone (Tapponnier et al., 1986) or northerly advance of the northeastern Indian plate (Wang and Burchfiel, 1997, 2000). Alkaline magmatism took place in the interval from the Late Eocene to Oligocene, as evidenced by a number of potassic intrusions dated at 40–30 Ma in western Yunnan (Chung et al., 1997; Deng et al., 1998). The alkaline magmatism was regarded to be indicative of lithospheric stretching

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