

Long-term fluvial archives in the Fen Wei Graben, central China, and their bearing on the tectonic history of the India–Asia collision system during the Quaternary

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Abstract

Staircases of large-scale river terraces are striking features of the landscape in the Fen Wei Graben, adjacent to the Qinling orogenic belts, central China. Field investigations indicate that all five river terraces are composed of a basal channel gravel and an overlying, thick loess–palaeosol succession. As Chinese loess stratigraphy has been well studied, it favours age determination of these terraces and their correlation with the marine oxygen isotope stages. Our research indicates that the ages of the five terraces are approximately 2.6, 1.2, 0.9, 0.65, and 0.15 Ma, respectively. The formation of these river terraces within the Fen Wei Graben has been attributed to NW–SE crustal extension, associated with left lateral displacement between the North and South China Blocks, in response to the northward movement of India towards Asia since Cenozoic time. Thus, the stepped terraces in the Fen Wei Graben reflects elements of the India–Asia collision systems, in which terraces define episodes of accelerated northward movement of India towards Asia during the Quaternary.

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1. Introduction

The most important tectonic event during the Cenozoic has been the collision of the Indian subcontinent with the Eurasian plate and the uplift of the Tibetan Plateau. Determination of the timing of the Tibetan Plateau uplift provides the basis for evaluating the effects of the high topography on climate and various geological processes. Many views exist concerning the initiation and the amount of uplift of the Tibetan Plateau. One view is that the initial contact of India with Asia (soft collision) occurred in the early Eocene, and the main collision (hard collision) in the Miocene (Gansser, 1964; Copeland et al., 1987; Harrison et al., 1992; Coleman and Hodges, 1995). Another view is that the uplift occurred predominantly within the past 2–5 Ma (e.g., Powell, 1986; Zhao and Morgan, 1987).

Compared with the numerous studies on the timing of the India–Asia collision system during the Tertiary Period, tectonic dynamics during the Pleistocene are not well studied.

Considerable evidence for the collision of India with Asia is preserved in China. Active tectonic collision, for example, is responsible for a number of features including eruption of potassic basalts in the marginal region of Tibet (Liu, 1989; Turner et al., 1993), large-scale strike-slip faults in its northeastern margins, the deposition of thick molasse deposits in the piedmont depression zones of the Kunlun and Tianshan mountains (Liu et al., 1996; Zheng et al., 2000; Sun et al., 2004), and the episodic incision of the Yellow River and its tributaries.

This paper examines the Pleistocene river terraces in the Fen Wei Graben, central China, and their bearing on the tectonic history of the India–Asia collision system during the Quaternary. Our studies are ideal in the following aspects: (1) the formation of the Fen Wei

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Graben is regarded as the result of NW–SE crustal extension, closely linked with the India–Asia collision system (Peltzer et al., 1985), (2) a series of normal faults and the associated five loess-blanketed river terraces are widely distributed within the graben, providing evidence for tectonic-controlled river incision, and (3) the Chinese loess stratigraphy has been well studied, providing the reliable age determination of these loess-blanketed river terraces.

2. Geological setting

The study area is located within the Fen Wei Graben, a NE–SW trending, elongate rift system bounded by a series of NNE–ENE normal faults (Fig. 1). The length of the Fen Wei Graben is about 1000 km and its width ranges from several to approximately 60 km. The Fen Wei Graben is generally divided into two parts: the Fen He Graben which is located in the Fen He River valley, and the Wei He Graben located in the Wei He River drainage basin (Fig. 1). Both the Fen He and Wei He rivers are second tributaries of the Yellow River.

This study is mainly focused on the Wei He Graben, which is constrained by the Chinese Loess Plateau to the north and the W–E trending Qinling Orogen to its south (Fig. 2). This graben formed during the Cenozoic, in response to the relative uplift of the Qinling Mountains. Tectonic activity within the Wei He Graben is still very active. This includes the large-scale strike-slip faults along the Qinling Mountains which actually represent

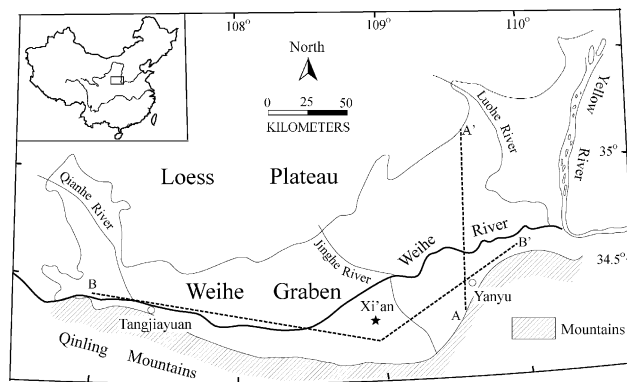


Fig. 2. Study area in the Wei He River drainage basin as well as the location of sites mentioned in the text.



Fig. 3. Prominent triangular facet about 100 m high located at Yanyu (see Fig. 2 for location) indicates Quaternary normal fault in the southern edge of the Wei He Graben. Note the upper part of the scarp is characterized by the closely spaced alternations of reddish (palaeosol) and yellowish (loess) layers, representing typical pedostratigraphic feature of early Pleistocene loess deposits.

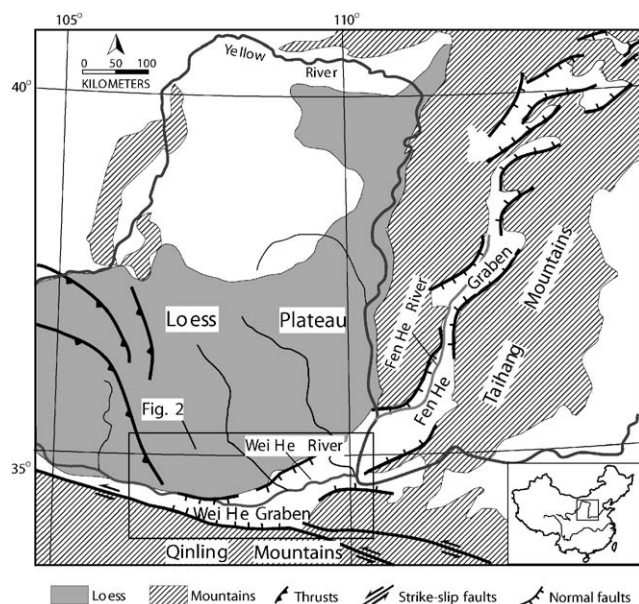


Fig. 1. Map of the Loess Plateau, Qinling Mountains, with major strike-slip faults, and normal faults defining the margins of the Fen Wei Graben (the western part is Wei He Graben and the eastern part is Fen He Graben).

sprays of the eastern end of the famous Altyn Tagh fault system in northeastern marginal Tibet (Peltzer et al., 1985), and a series of normal faults in and along the graben evidenced by the widespread typical triangular facets usually 100–200 m high in the northern front of the Qinling Mountains (Fig. 3). The Cenozoic deposits in the Wei He Graben range mainly from 2000 to ~7000 m in thickness and with a thinning trend towards the north as a result of differential vertical motions within the graben (Fig. 4). The Quaternary deposits reach a thickness of up to 1200 m, and with a sedimentation rate of 0.47 mm/y greatly exceeds the average depositional rate of about 0.08 mm/yr for the Tertiary Period. This indicates accelerated uplift of the Qinling Mountains and the relative subsidence of the Wei He Graben during the Quaternary.

The lithostratigraphy within the graben is also controlled by tectonics. In its southern part, a palaeo-lake (Samen Lake) formed as a result of subsidence of

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