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Rock magnetic properties and paleoenvironmental implications of an 8-Ma Late Cenozoic terrigenous succession from the northern Tian Shan foreland basin, northwestern China

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ABSTRACT

In the northern Tian Shan foreland basin, northwestern China, the thick Cenozoic terrigenous succession is crucial for paleoclimate–environmental reconstruction of the Asian interior. Here we present a detailed rock magnetic investigation on 245 samples from the ~1200-m-thick Neogene Taxi He section with a magnetostratigraphic age span of ca. 8.0 to 2.0 Ma in the northern Tian Shan foreland basin. Our rock magnetic results indicate that the significant variations in composition, concentration and grain size of magnetic minerals occurred at ca. 6.0, 3.7 and 2.7 Ma. The comparable compositions of rare earth elements (REEs) throughout the Neogene Taxi He section suggest no significant modification of the source materials during the interval between ca. 8.0 and 2.0 Ma, and thus sediment provenance is not regarded as responsible for these observed variations in rock magnetic properties. Our further analyses show that the variations in magnetic properties of the Taxi He section are casually linked mainly with lithofacies transition due to range encroachment into foreland basin as well as climate aridification. Identified enhancement of aridification was chronologically constrained at ca. 6.0 and 2.7 Ma. Such climate events are important archives for reconstructing the Late Cenozoic paleoclimatic history of the Asian interior. Further comparison between different paleoclimate records clearly indicates that magnetic parameters such as S_{-100mT} are potentially effective proxy indices for paleoclimate–environmental reconstruction in the Tian Shan foreland basins and the nearby areas.

1. Introduction

The Asian inland is characterized by exceptional topographic relief and widespread deserts and semi-deserts (Fig. 1a). Its environmental evolution during the late Cenozoic is featured by two processes: (1) growth and uplift of the Tibetan Plateau (including the hinterland to the north) and (2) stepwise development of dry climate. Many investigations have attempted to reconstruct the process of plateau uplift (e.g., Li and Fang, 1998; Zheng et al., 2000; Kirby et al., 2002; Fang et al., 2005; Clark et al., 2005; Charreau et al., 2005, 2006; Lu et al., in press) or constrain the aridification history (e.g., Sun and Zhang, 2008; Huang et al., 2010; Sun et al., 2010, 2011; Chang et al., 2012; Miao et al., 2013; Zhang et al., 2013). The relative role of the Tibetan Plateau uplift and Cenozoic global cooling in the aridification process of the Asian interior, however, remains an issue of debate (e.g., Dupont-Nivet et al., 2007; Miao et al., 2012). This is in part due to the fact that paleoenvironmental records from this region are still quite limited, considering such a broad area of the Asian inland including arid and semi-arid northwestern China (Fig. 1a). Furthermore, different paleoenvironmental proxy data (e.g., palynology, geochemistry, rock magnetism, sediment-accumulation rate, etc.) from different areas might lead to contradictory results due to imprints of local settings and different recording mechanisms. Therefore, more detailed paleoclimatic/tectonic investigations over a broad area should be beneficial to paleoenvironmental reconstruction of the Asian interior.

The east–west trending Tian Shan range, separating the Junggar Basin to the north from the Tarim Basin to the south (Fig. 1a), lies about 2000 km north of the initial India–Asia collision front. In response to the India–Asia collision during the early Cenozoic (Najman et al., 2001), the Tian Shan range has been tectonically reactivated and uplifted and intensely extended into its both northern and southern foreland basins (e.g., Molnar and Tapponnier, 1975; Avouac et al., 1993). The uplifted topography and changed geomorphic patterns

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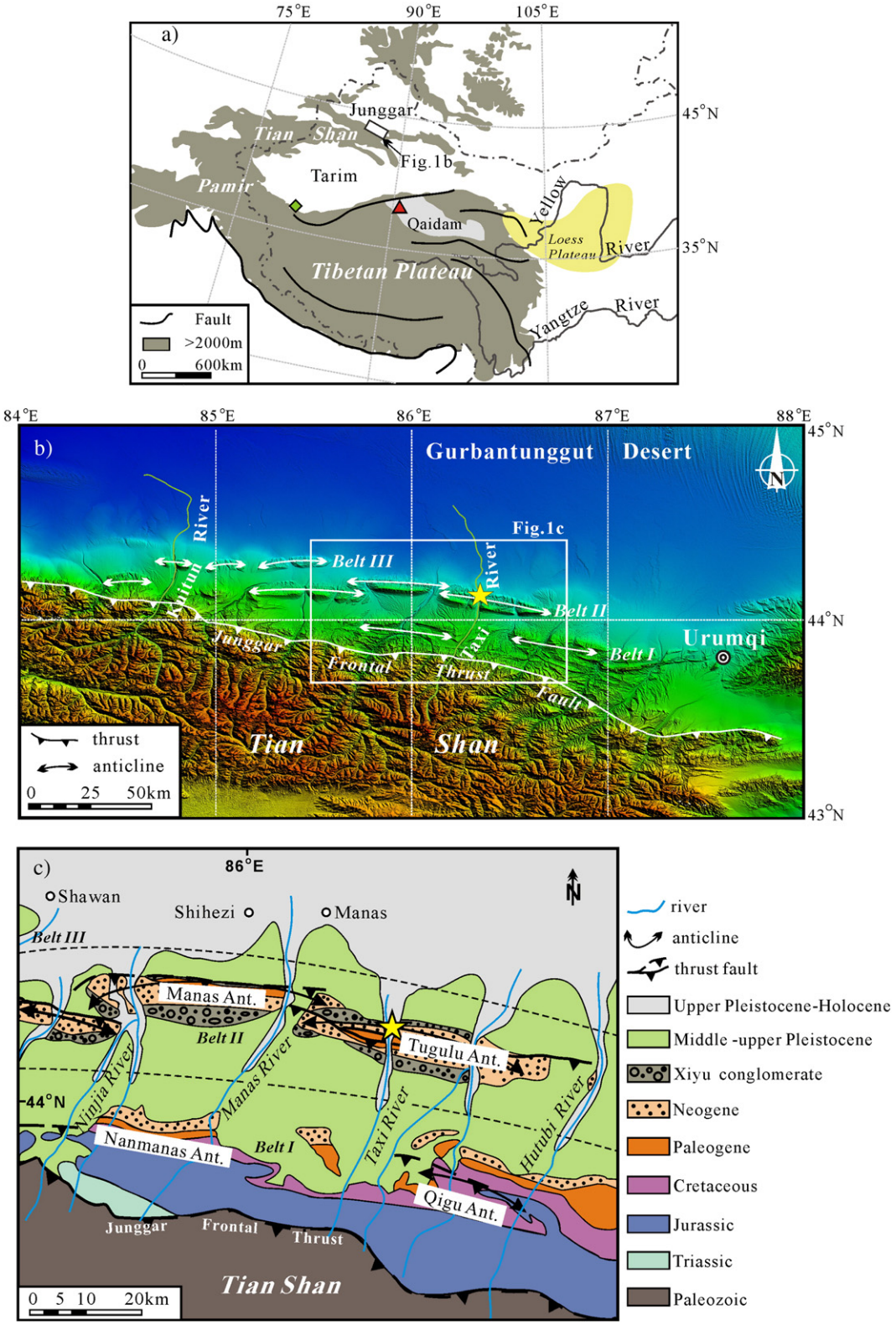

Fig. 1. (a) Map shows overall topographical pattern and tectonic setting of the interior of Asia. Prismatic and triangle show location of Sun et al.'s (2008) and Miao et al.'s (2013) sections, respectively, which are compared in Fig. 11. (b) Digital elevation model (DEM) map of the northern Tian Shan foreland showing tectonic setting. (c) Mesozoic and Cenozoic depositional strata exposed in structural belts. Stars in (b) and (c) indicate the location of the studied Taxi He section.

have caused Cenozoic environmental change within the Tian Shan range and its surrounding area (e.g., Cui et al., 1998), which is documented in the terrestrial sediments shed from the range and deposited in its intramontane and foreland basins. Studying this Cenozoic terrigenous succession is thus of great importance for better understanding regional environmental change and its possible relationship with uplift