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Mesozoic reactivated transpressional structures and multi-stage tectonic deformation along the Hong-Che fault zone in the northwestern Junggar Basin, NW China

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ABSTRACT

The recognition of paleo-strike-slip faulting is often difficult, particularly when the associated structures are presently inactive and covered by thick sediments. Fortunately, high-resolution 3D seismic reflection data can provide a powerful tool to solve this problem. In this study, we focus on the structural features and tectonic evolution of Hong-Che fault system, a paleo-strike-slip fault zone recognized in the NW margin of Junggar Basin by using the 2D and 3D seismic data. The results of our analysis demonstrate that: 1) The Middle Triassic to Jurassic dextral transpressional structures were developed along Hong-Che fault zone, which are characterized by the restraining bend on the southern segment, the highly localized shearing deformation on the central segment, and the horsetail splay faulting of a fault tip zone on the northern segment; 2) The Hong-Che fault zone had also experienced the Early Permian rifting and the Late Permian-Early Triassic tectonic inversion, which probably played important roles in controlling the subsequent tectonic deformation; and 3) The demonstrated dextral strike-slip faulting is consistent with the Middle Triassic-Jurassic deformation in the Ke-Bai, Wu-Xia, and Irtysh fault zones, and therefore supports the counterclockwise rotation of Junggar Basin, which might be the far-field effect of the collision between Qiangtang block and Songpan–Ganzi terrane in the Triassic. The results of this study also prove that high-resolution seismic reflection data can serve as a useful tool for investigating the buried paleo-structures.

1. Introduction

Although geomorphic features including the systematic lateral deflection and/or offsets of the mountain ridges, stream channels, alluvial fans, and terrace risers have been successfully used to identify active strike-slip faulting (e.g., Sylvester, 1988; Hubert-Ferrari et al., 2002; Lin et al., 2002; Rao et al., 2011), the recognition of a paleo-strike-slip fault system is still difficult, particularly when the associated structures are currently inactive and covered by thick sediments. Fortunately, benefiting from high-resolution seismic reflection data acquired during the oil and gas explorations, the characteristics of buried paleo-strike-slip structures can also be uncovered (e.g., Hsiao et al., 2004; Benesh et al., 2014; Cheng et al., 2014; Cheng et al., 2015).

The Central Asia Orogenic Belt (CAOB) or the Alatids (e.g., Zhang et al., 1984; Carroll et al., 1990; Sengör et al., 1993) was formed in the Paleozoic resulted from a series of subduction–collision–accretion processes (e.g. Filippova et al., 2001; Xiao et al., 2004, 2008; Xiao et al., 2009). Although the Paleozoic tectonics of the CAOB have been widely reported (e.g., Sengör et al., 1993; Allen et al., 1995; Heubeck, 2001; Xiao et al., 2004, 2008; Xiao et al., 2009; Windley et al., 2007; Tang et al., 2010; Xiao et al., 2010; Charvet et al., 2011; Choulet et al., 2011; Zhang et al., 2011a, 2011b), the deformation history since the Permian remains poorly understood (e.g., Allen and Vincent, 1997; Wang et al., 2007; Choulet et al., 2013; Novikov, 2013). Previous studies have demonstrated that multi-phase tectonic reactivations have occurred in the Tianshan region after the Carboniferous (Molnar and Tapponnier, 1975; Tapponnier and Molnar, 1977; Sengör et al., 1993; Allen et al., 1995; Hendrix et al., 1992; Hendrix, 2000; Dumitru et al., 2001). However, detail studies on the kinematics and timings of tectonic deformations, as well as their control on the subsequent deformation are still lacking.

In the central part of the CAOB, the Northwestern Junggar Basin is developed adjacent to the West Junggar Unit (Fig.1a). The

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kinematics and evolution history of the NW Junggar margin fault system that consists of three fault domains (I–III), are particularly vital to investigate the coupling mechanism related between mountain and basin (Fig. 1). In contrast to the thrust-fold belts along the southern margin of the Junggar Basin characterized by conspicuous active deformation (Fig. 1b; Tapponnier and Molnar, 1979), in this study area, several kilometers of thick Cretaceous–Cenozoic sediments without distinctive tectonic deformation hinder the further investigations of surface geology. Although a few investigators inferred it as a thrust fault system (e.g., Guan et al., 2008; Ma et al., 2008), significant strike-slip motions have also been emphasized (Sengör et al., 1993; Allen and Vincent, 1997; He et al., 2004; Yang et al., 2009; Choulet et al., 2011; Wang, 2011; Shao et al., 2012). However, most of previous studies have focused on the Wu-Xia (Wuerhe-Xiazijie) and Ke-Bai (Kelamy-Baikouquan) fault domains in the northern part. In Contrast, the deformation mechanism of the Hong-Che (Hongshanzhui-Chepaizi) fault domain in the south is still unclear (Fig. 1).

In this study, we used the 2-D and 3-D seismic survey and well-log data to investigate the structural features and tectonic evolution of the Hong-Che fault in the southern part of the NW margin fault system (Fig. 1). Comparing the results of previous studies, we demonstrated the Hong-Che fault zone had served as a significant strike-slip fault during the Mid-Triassic to Late Jurassic, and probably had experienced multi-phase tectonic deformations. As a result, we present a more reliable evolutionary history of the Hong-Che fault zone since the Late Paleozoic.

2. Geological setting

The triangular shaped Junggar Basin is located in the central part of the CAOB, which is bounded by the West Junggar to the northwest, the Altay Orogen to the northeast, and the TianShan Mountain to the south (Fig. 1b). The basement of the Junggar Basin was constructed during the collision and amalgamation of the CAOB in the Late Paleozoic (e.g. Carroll et al., 1990; Allen et al., 1991; Allen and Vincent, 1997). In the Mesozoic, colliding with the Paleo-Asia, the north hinterland of Kunlun orogenic belt including northwestern margin of the Junggar Basin was subjected to the north–south compression (Sengör, 1990), resulting in the widespread tectonic reactivation (e.g., Zhang et al., 1984; Allen and Vincent, 1997). The deposition of Mesozoic conglomeratic strata in the Tarim, Junggar, and Turfan Basins suggests the pulsed deformation associated with the successive collisions in the Late Triassic (230–200 Ma), the Late Jurassic — Early Cretaceous (140–125 Ma), and the Late Cretaceous (80–70 Ma) (Hendrix et al., 1992; Hendrix, 2000; Li et al., 2004a, 2004b). Recent paleomagnetic studies reveal a significant counter-clock rotation of the Junggar Basin with respect to the Siberia and Tarim Blocks in the Permian (Wang, 2011), and during the Mesozoic (Choulet et al., 2013). The rotation might be accompanied by the strike-slip faulting along the boundary of the Junggar Basin.

Due to the Indo-Eurasia collision, the Cenozoic reactivation took place in Central Asia, which is particularly evident in the Tianshan area (Molnar and Tapponnier, 1975; Tapponnier and Molnar, 1977). The paleo-structures in the West Junggar, such as the Dalabute strike-slip fault, were reactivated in the Cenozoic (Allen and Vincent, 1997;

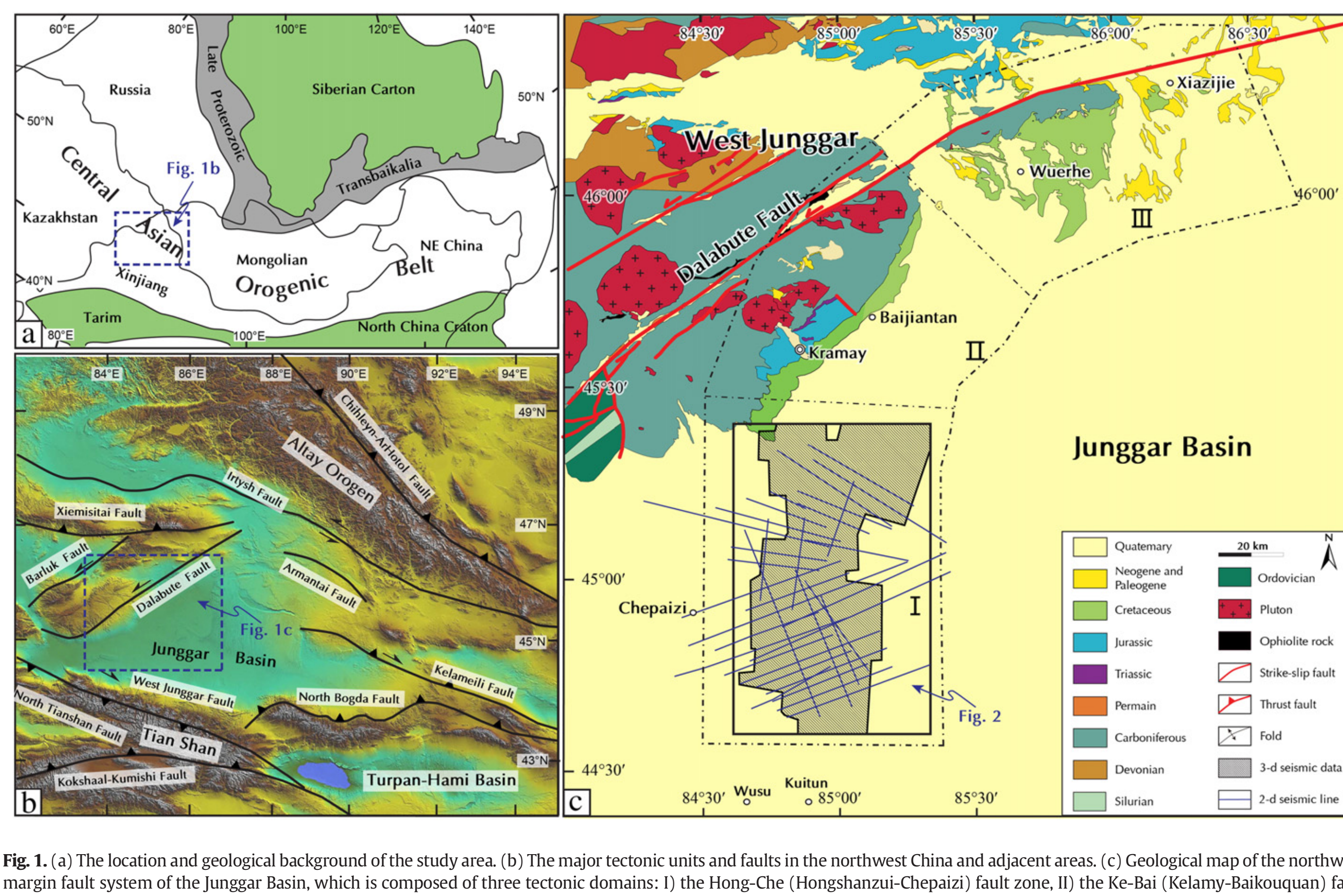

Fig. 1. (a) The location and geological background of the study area. (b) The major tectonic units and faults in the northwest China and adjacent areas. (c) Geological map of the northwest margin fault system of the Junggar Basin, which is composed of three tectonic domains: I) the Hong-Che (Hongshanzui-Chepaizi) fault zone, II) the Ke-Bai (Kelamy-Baikouquan) fault zone, and III) the Wu-Xia (Wuerhe-Xiazaijie) fault zone. The shaded area reveals the coverage of 3-D seismic survey, and blue lines show the distribution of 2-D seismic lines.