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New structural data on Late Paleozoic tectonics in the Kyrgyz Tien Shan (Central Asian Orogenic Belt)

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ABSTRACT

The tectonic evolution of the Central Asian Orogenic Belt (CAOB) is characterized by the successive accretion of lithospheric blocks, leading to different interpretations about the polarity of subductions during the Paleozoic, the number of microplates and oceanic basins and the timing of tectonic events. This is especially the case in the Tien Shan area.
In this paper, we propose new structural maps and cross-sections of Middle and South Kyrgyz Tien Shan (MTS and STS respectively). These cross-sections highlight an overall dextral strike-slip shear zone in the MTS at the crustal scale and a North verging structure in the STS. These structures are Carboniferous in age and sealed by a late Carboniferous conglomerate, later overlain by Mesozoic and Cenozoic deposits. The STS exhibits two deformation phases: (1) a top-to-the-South normal shearing that can be related to subduction or exhumation dynamics and (2) a top to the North nappe stacking that we link to the late Paleozoic collisional events between the MTS and the Tarim block.
We propose a new interpretation of the tectonic evolution of the Kyrgyz Tien Shan during the Late Paleozoic collision. This model involves a partitioned collisional deformation in Late Carboniferous times, with an orthogonal collision to the south, between the Tarim and MTS, and a strike-slip regime to the north along a dextral E-W zone located between the MTS and the North Tien-Shan/Kazakh platform, the so-called Nikolaev Line. The docking of the large Tarim Craton against the CAOB corresponds to a collision phase, which ended the long-lived Paleozoic subduction history in the CAOB and was followed in the TS region by intense strike-slip deformation during the Permian.

1. Introduction

Orogens are classically divided into collisional orogens and accretionary orogens (e.g., Cawood et al., 2009; Kusky, 2011). The Alpine-Himalayan and Andean orogens are considered as typical examples of these two end-members, respectively (Demets et al., 1990; Guillot et al., 2003; Isaks, 1988; Le Fort, 1975). Collisional orogens commonly involve large cumulated strains both on the plate interface and within the colliding plates (e.g., Vanderhaeghe, 2012). They are the result of continental subduction and/or continental underthrusting and shortening, following the closure of an oceanic domain (Chen et al., 1999; Faccenda et al., 2008). In contrast, accretionary orogens develop on long-lasting oceanic subduction zones. As a result, they are composed of an amalgamation of material from the upper and lower plates associated with magmatic and metamorphic rocks (e.g., (Cawood et al., 2009), and references therein). Accretion itself corresponds to a short-lived collisional phase (10–20 Ma) followed by a subduction jump, which favors the transfer of the plate interface to the opposite block boundary (e.g., Rolland et al., 2012). In such long-lived subduction systems, the subduction of oceanic ridges and transforms might induce large strike-slip motions in the upper plate with the detachment and oblique accretion of continental slices like in the NW American coast (Atwater, 1970; Furlong et al., 1989). Accretion can therefore be characterized by different kinematics from frontal collision to strike-slip motion.

The Central Asian Orogenic Belt (CAOB, e.g., (Windley et al., 2007; Xiao et al., 2014), also named “Altaids” (Şengör et al., 1993), results of the docking of numerous continental blocks and volcanic arcs against the Archean Siberian craton since the late Proterozoic and until the late Paleozoic (e.g., De Boisgrollier et al., 2009; Windley et al., 2007; Yarmolyuk et al., 2014). Although it has long been recognized as a typical example of an accretionary orogen, the collisional or accretionary nature of the CAOB is still a matter of debate. Indeed, it involves several large-scale collisions between important cratonic blocks, like the

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cratonized Kazakh platform and the Tarim craton (e.g., Xiao et al., 2013, 2014).The Paleozoic CAOB accretion history ended in Late Carboniferous with the collision of the large and rigid Tarim block with the Kazakh continent (e.g. Charvet et al., 2011; Windley et al., 2007)).

The Tien Shan (TS) belt (Fig. 1) is a part of the CAOB and runs in a ~SW-NE direction over more than 2000 km from Uzbekistan to western China; it is located between the Kazakh and Junggar blocks to the North, and the Tarim craton to the South. Since about 30 Ma (Macaulay et al., 2014; Sobel et al., 2006), this area has been a typical intracontinental collision zone undergoing a ~North-South shortening rate of ~1.3 cm/yr in response to the India-Asia convergence (Abdrakhmatov et al., 1996; Avouac et al., 1993). The present-day morphology and structural pattern of the TS belt largely result from this still on-going compression. Although it is widely admitted that most Cenozoic structures reactivate ancient thrusts and suture zones inherited from previous deformation stages (e.g., Buslov et al., 2007; Glorie et al., 2011), the amount of Paleozoic shortening is still largely unconstrained. In the following sections, we will only consider the part of the Paleozoic TS belt located east of the major dextral Talas Fergana Fault (TFF).

Lateral correlation of the different units constitutive of the TS belt remains difficult because of its complex geometry because it spreads over different countries. Another point of debate is the vergence of subduction zones that led to the final Paleozoic collage. There have been some attempts to synthesize the tectonic history of the TS belt based on unit correlation and available geochronological constraints (e.g., Loury et al., 2015a, 2015b; Wilhem et al., 2012; Windley et al., 2007; Xiao et al., 2013), but their interpretations differ in terms of timing and vergence of subduction zones.

In this paper, we present new field data in the Kyrgyz TS combined with published structural and geochronological results, which allow us to shed light on the style of deformation and unravel the Late Paleozoic tectonic history of the TS.

2. Geological setting of the Tien Shan Belt

2.1. General structure of the Kyrgyz Tien Shan

In Kyrgyzstan, the TS is characterized by three tectonic domains: the North, Middle and South TS (NTS, MTS and STS, respectively), squeezed between the more rigid lithospheres of the Kazakh platform and Tarim craton (Fig. 1). Suture zones of different ages and kinematics separate all these domains. The NTS and MTS are located on both sides of a ~E-W suture zone of middle Ordovician age, which worked as a broad strike-slip crustal zone during Permian times (e.g., Choulet et al., 2011). This broad wrench zone as well as the succession of individual strike-slip fault segments (when observed) are given the name "Nikolaev line" (e.g., Mikolaichuk et al., 1997; Windley et al., 2007). Further south, the MTS and STS are separated by a suture zone and an accretionary complex known as the At-Bashi-Kokshaal suture zone, running E-W from Kyrgyzstan to NW China (e.g., Burtman, 2008; Glorie et al., 2011; Simonov et al., 2008).

The MTS progressively narrows eastward and disappears near the Kyrgyzstan/China border. Likewise, other blocks are only present in China and consequently, the tectonic units of the Chinese Tien Shan have a different nomenclature. There, the TS belt encompasses from North to South the Junggar, Yili-NTS, Central TS and South TS blocks (e.g., Gao et al., 1998).

From China to Kyrgyzstan, the At-Bashi-Kokshaal suture zone therefore marks there the junction between the Yili-NTS, and the CTS and STS blocks (Fig. 1). Most of the sutures are reworked by Permian strike-slip faults (e.g., Laurent-Charvet et al., 2002, 2003; Wang et al., 2007a). In particular, the prolongation of the strike-slip Nikolaev line in China runs along the NTS-CTS suture (Narat Fault, Fig. 1).

2.1.1. North Tien Shan

The NTS is essentially composed of deformed Proterozoic to Cambrian sediments and volcanics highly intruded by magmatic bodies with calc-alkaline affinities, suggesting the presence of an active margin which lasted from the Ordovician in Kyrgyzstan (Bakirov and Maksumova, 2001; Bazhenov et al., 2003; Glorie et al., 2010; Konopelko et al., 2008; Kröner et al., 2012, 2014) to the Carboniferous in China (Wang et al., 2007b; Zhu et al., 2005).

In Kyrgyzstan, the active margin setting of the NTS is interpreted as the result of the northward subduction and closure of the Terskey Ocean during the Ordovician, eventually leading to the accretion of the MTS against the NTS in the Middle-Late Ordovician (Bakirov and Maksumova, 2001; Glorie et al., 2010; Lomize et al., 1997).

In China, observations on this margin two magmatic events are observed and correspond to the closure of two different oceanic domains: (i) the northward subduction of an oceanic domain located between the Tarim craton and the Yili-NTS block during the Ordovician (Allen et al., 1993; Chen et al., 1999; Gao et al., 1998, 2009; Qian et al., 2009; Windley et al., 1990; Xiao et al., 2004, 2014); (ii) the southward subduction of an oceanic domain located between the NTS and the Junggar block during the Carboniferous (Allen et al., 1993; Charvet et al., 2011; Wang et al., 2008, 2009; Windley et al., 1990).

The rest of the Paleozoic sedimentary cover of the NTS consists of Ordovician flyschs composed of volcanic tuffs, siltstones and sandstones sometimes overlain by Devonian volcanics (Bazhenov et al., 2003). Carboniferous (Late Tournaisian to Bashkirian) deposits in the NTS are clastic sediments composed of sandstones and siltstones with gypsum

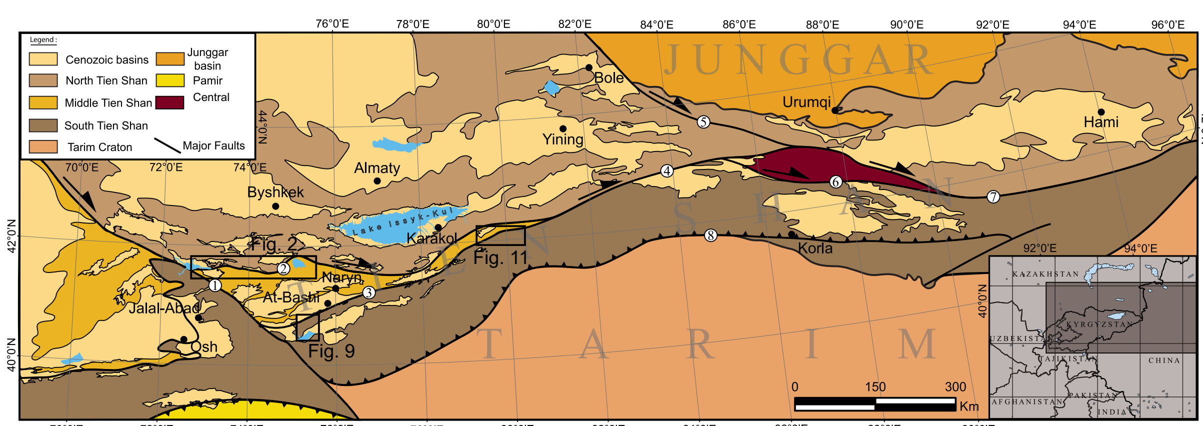

Fig. 1. Synthetic structural map of the CAOB and surrounding areas from Kyrgyzstan to North China. (Modified after (Charvet et al., 2011; Xiao et al., 2013) and official 1:500,000 geological map of Kyrgyz Republic). 1. Talas Fergana Fault; 2. Nikolaev Line (reworking the Terskey suture); 3. At-Bashi-Inylshek Fault (reworking the Turkestan Ocean suture); 4.Narat Fault; 5. North Tien Shan Fault; 6. Baluntai Fault; 7. Main Tien Shan Shear Zone; 8. North Tarim Fault. Insets show the location of Figs. 2, 9 and 11.