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Middle to Late Ordovician arc system in the Kyrgyz Middle Tianshan: From arc-continent collision to subsequent evolution of a Palaeozoic continental margin

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ABSTRACT

New geological, geochronological and isotopic data reveal a previously unknown arc system that evolved south of the Kyrgyz Middle Tianshan (MTS) microcontinent during the Middle and Late Ordovician, 467–444 Ma ago. The two fragments of this magmatic arc are located within the Bozbutau Mountains and the northern Atbashi Range, and a marginal part of the arc, with mixed volcanic and sedimentary rocks, extends north to the Semizsai metamorphic unit of the southern Chatkal Range. A continental basement of the arc, indicated by predominantly felsic volcanic rocks in Bozbutau and Atbashi, is supported by whole-rock Nd- and Hf-in-zircon isotopic data. $\varepsilon_{Nd(t)}$ of $+0.9$ to -2.6 and $\varepsilon_{Hf(t)}$ of $+1.8$ to -6.0 imply melting of Neo- to Mesoproterozoic continental sources with Nd model ages of ca. 0.9 to 1.2 Ga and Hf crustal model ages of ca. 1.2 to 1.7 Ga. In the north, the arc was separated from the MTS microcontinent by an oceanic back-arc basin, represented by the Karaterek ophiolite belt. Our inference of a long-lived Early Palaeozoic arc in the southwestern MTS suggests an oceanic domain between the MTS microcontinent and the Tarim craton in the Middle Ordovician.

The time of arc-continent collision is constrained as Late Ordovician at ca. 450 Ma, based on cessation of sedimentation on the MTS microcontinent, the age of an angular unconformity within the Karaterek suture zone, and the age of syncollisional metamorphism and magmatism in the Kassan Metamorphic Complex of the southern Chatkal Range. High-grade amphibolite-facies metamorphism and associated crustal melting in the Kassan Metamorphic Complex restricts the main tectonic activity in the collisional belt to ca. 450 Ma. This interpretation is based on the age of a synkinematic amphibolite-facies granite, intruded into paragneiss during peak metamorphism. A second episode of greenschist- to kyanite–staurolite-facies metamorphism is dated between 450 and 420 Ma, based on the ages of granitoid rocks, subsequently affected or not affected by this metamorphism. The latest episode is recorded by greenschist-facies metamorphism in Silurian sandstones and granodiorites and by retrogression of the older, higher-grade rocks. This may have occurred at the Silurian to Devonian transition and reflects reorganization of a Middle Palaeozoic convergent margin.

Late Ordovician collision was followed by initiation of a new continental arc in the southern MTS. This arc was active in the Early Silurian, latest Silurian to Middle Devonian, and Late Carboniferous, whereas during the Givetian through Mississippian (ca. 385–325 Ma) this area was a passive continental margin. These arcs, previously well constrained west of the Talas-Ferghana Fault, continued eastwards into the Naryn and Atbashi areas and probably extended into the Chinese Central Tianshan. The disappearance of a major crustal block with transitional facies on the continental margin and too short a distance between the arc and accretionary complex suggest that plate convergence in the Atbashi sector of the MTS was accompanied by subduction erosion in the Devonian or Early Pennsylvanian. This led to a minimum of 50–70 km of crustal loss and removal of the Ordovician arc as well as the Silurian and Devonian forearcs in the areas east of the Talas-Ferghana Fault.

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1. Introduction

Geodynamic reconstructions of accretionary orogens require, above all, the correct identification of subduction systems that controlled plate convergence. This task is straightforward when an orogen consists of unmetamorphosed or low-grade rocks and was not affected by late deformations. However, it becomes more complicated when regional metamorphism and structural overprints hide primary depositional, magmatic, and/or tectonic features.

The Neoproterozoic to Palaeozoic Central Asian Orogenic Belt (CAOB) is one of the largest accretionary orogens on Earth (Zonenshain et al., 1990; Mossakovsky et al., 1994; Windley et al., 2007; Cawood et al., 2009). Many of the medium-to high-grade metamorphic rock assemblages in this belt were interpreted as Archaean or Proterozoic basement terranes or microcontinents, but recent geochronological and structural studies revealed that many of these formed in accretionary and collisional settings during the Palaeozoic (Shatsky et al., 1999; Sal'nikova et al., 2001; Kozakov et al., 2002; Dobretsov and Shatsky, 2004; Gladkochub et al., 2008; Demoux et al., 2009; Hegner et al., 2010; Alexeiev et al., 2011; Rojas-Agramonte et al., 2011; Konopelko et al., 2012; Kröner et al., 2012; Rojas-Agramonte et al., 2013; Kröner et al., 2014; Rojas-Agramonte et al., 2014). The redefined ages of these metamorphic assemblages often led to major changes in the understanding of the regional tectonic setting and orogenic history and resulted in reassessment of the overall architecture and evolution of the Central Asian accretionary collage.

Palaeozoic fold-and-thrust belt of the Tianshan in south CAOB (Fig. 1) has been studied for decades, but many questions of its evolution still remain far from clear. Extensive geochronological studies carried out by several teams from Bishkek, Ghent, London, Mainz, Moscow, Munich, Novosibirsk, Tashkent and St-Petersburg in western (former USSR) Tianshan during last years significantly promoted understanding of the Precambrian and Palaeozoic history of this region (Apayarov, 2009; Konopelko et al., 2009; Glorie et al., 2010; De Grave et al., 2011; Glorie et al., 2011; Kröner et al., 2011; Seltmann et al., 2011; Kröner et al., 2012; Mirkamalov et al., 2012; De Grave et al., 2013; Degtyarev et al., 2013; Kröner et al., 2013; Konopelko et al., 2014; Kröner et al., 2014; Rojas-Agramonte et al., 2014) and also allowed to distinguish several Palaeozoic high-grade metamorphic terranes, that were previously related to Precambrian (Tagiri et al., 1995; Simonov et al., 2008; Hegner et al., 2010; Alexeiev et al., 2011; Konopelko et al., 2012; Kröner et al., 2012; Rojas-Agramonte et al.,

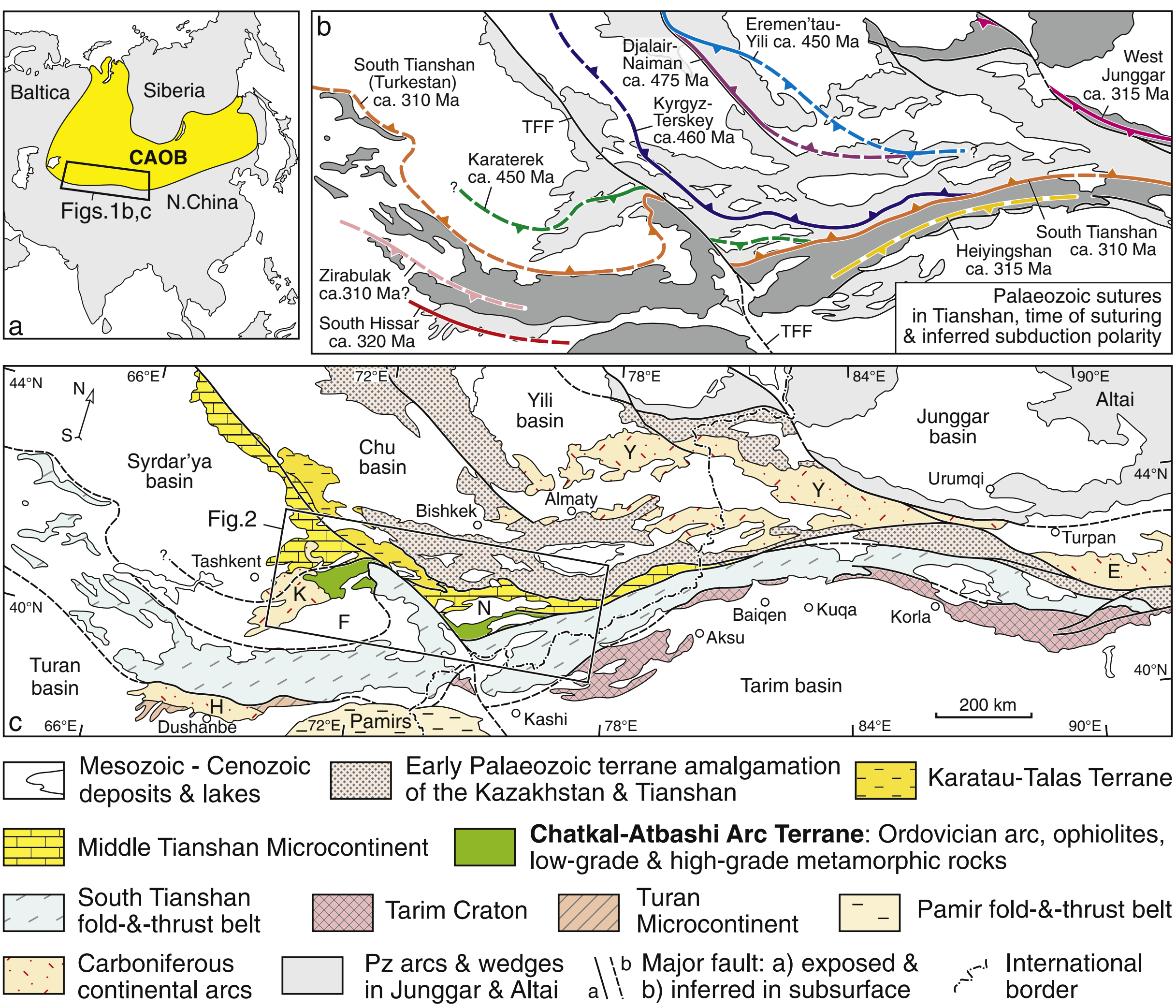

Fig. 1. (a) Central Asian Orogenic Belt (CAOB) and study area. (b) Palaeozoic sutures in the Tianshan, their ages (time of suturing) and inferred subduction polarity. Triangles show inferred direction of subduction. Compiled from Biske (1995, 1996); Brookfield (2000); Bakirov and Maksumova (2001); Degtyarev (2003); Windley et al. (2007); Biske and Seltmann (2010); Han et al. (2010); Kröner et al. (2012); Degtyarev et al. (2013); Alexeiev et al. (2015) and this study. (c) Tectonic elements and Palaeozoic basement terranes of the Tianshan fold belt (modified after Alexeiev et al., 2015). Abbreviations: Carboniferous continental arcs — Chatkal-Kurama (K), Hissar (H), Yili (Y), and East Tianshan (E). Cenozoic basins — Ferghana (F), and Naryn (N). TFF — Talas-Ferghana Fault.