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When did the subduction first initiate in the southern Paleo-Asian Ocean: New constraints from a Cambrian intra-oceanic arc system in West Junggar, NW China

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ABSTRACT

We report here a Cambrian southward-subducting intra-oceanic arc system in the southern West Junggar, NW China, where an immature arc occurred initially on SSZ-type ophiolites and finally evolved into a more mature one. The immature arc is dominantly represented by Early–Middle Cambrian (~510 Ma) low-K tholeiitic felsic rocks, whereas the mature arc is characterized by Late Cambrian (~495 Ma) medium- and high-K calc-alkaline felsic and mafic rocks. The SSZ-type ophiolites show remarkable depletion of Nb and Ta and contain high-Cr spinel (Cr# > 0.6), resembling these formed in the forearc. Altogether, they record the initiation of subduction and transformation of crust during early subduction of the Paleo-Asian Ocean in the southern part of the Central Asian Orogenic Belt (CAOB). The subduction initiation might occur in the Early Cambrian (>515 Ma), as constrained by both the SSZ-type ophiolites (516 Ma) and the oldest arc plutons (515–509 Ma) that crosscut the ophiolites. The immature felsic plutons have high SiO_2 (>72 wt%) contents and variable MgO (0.42–1.49 wt%) and Mg# values (22–62). Crustal anatexis may be responsible for the genesis of those plutons and thus the transformation from oceanic to continental crust. These results, combined with regional data, convincingly indicate that it is one of the oldest intra-oceanic arc systems in the southern CAOB, which may mark the initial subduction of the Paleo-Asian Ocean in its southern part, much later than those reported in the north. An archipelago-type model is proposed for the evolution of the southern West Junggar and has implications for the development of the southern part of the CAOB.

1. Introduction

The Central Asian Orogenic Belt (abbreviated as CAOB) or Central Asian Orogenic System (CAOS, Briggs et al., 2007), one of the largest accretionary orogens on Earth, is predominately formed by accretion of microcontinents, intra-oceanic island arcs, oceanic plateaus, seamounts, accretionary complexes, and post-collisional magmatic rocks during Late Mesoproterozoic to Mesozoic (Fig. 1a; ca. 1000–250 Ma, Sengör et al., 1993; Han et al. 1997, 2006, 2010a, 2010b, 2011; Chen and Arakawa, 2005; Windley et al., 2007). The accretionary processes may have resulted from either the progressive duplication of a single and long-evolving island arc system (Sengör et al., 1993; Sengör and Natal'in, 1996) or the collision of several and more island arcs and microcontinents that are similar to the complex archipelago systems in the modern southwestern Pacific (Zonenshain et al., 1990; Filippova et al., 2001; Yakubchuk et al., 2001, 2005; Khain et al., 2003; Windley et al., 2007). Although there are different models for evolution of the CAOB (e.g., Sengör et al., 1993; Yakubchuk et al., 2001, 2005; Windley et al., 2007), the consensus is that the subduction–accretion processes in the southern CAOB are apparently younger than those in the north (Zonenshain et al., 1990; Sengör et al., 1993; Windley et al., 2007). In Kazakhstan and contiguous China of the southern CAOB, the subduction–accretion process may result from a collage of Precambrian microcontinental blocks and Cambrian to Early Silurian island arcs during Late Mesoproterozoic to Early Paleozoic (Windley et al., 2007 and references therein), and the initial subduction of Paleo-Asian Ocean is supposed to start in Early Cambrian (Sengör et al., 1993; Windley et al., 2007), but such a speculation needs to be tested.

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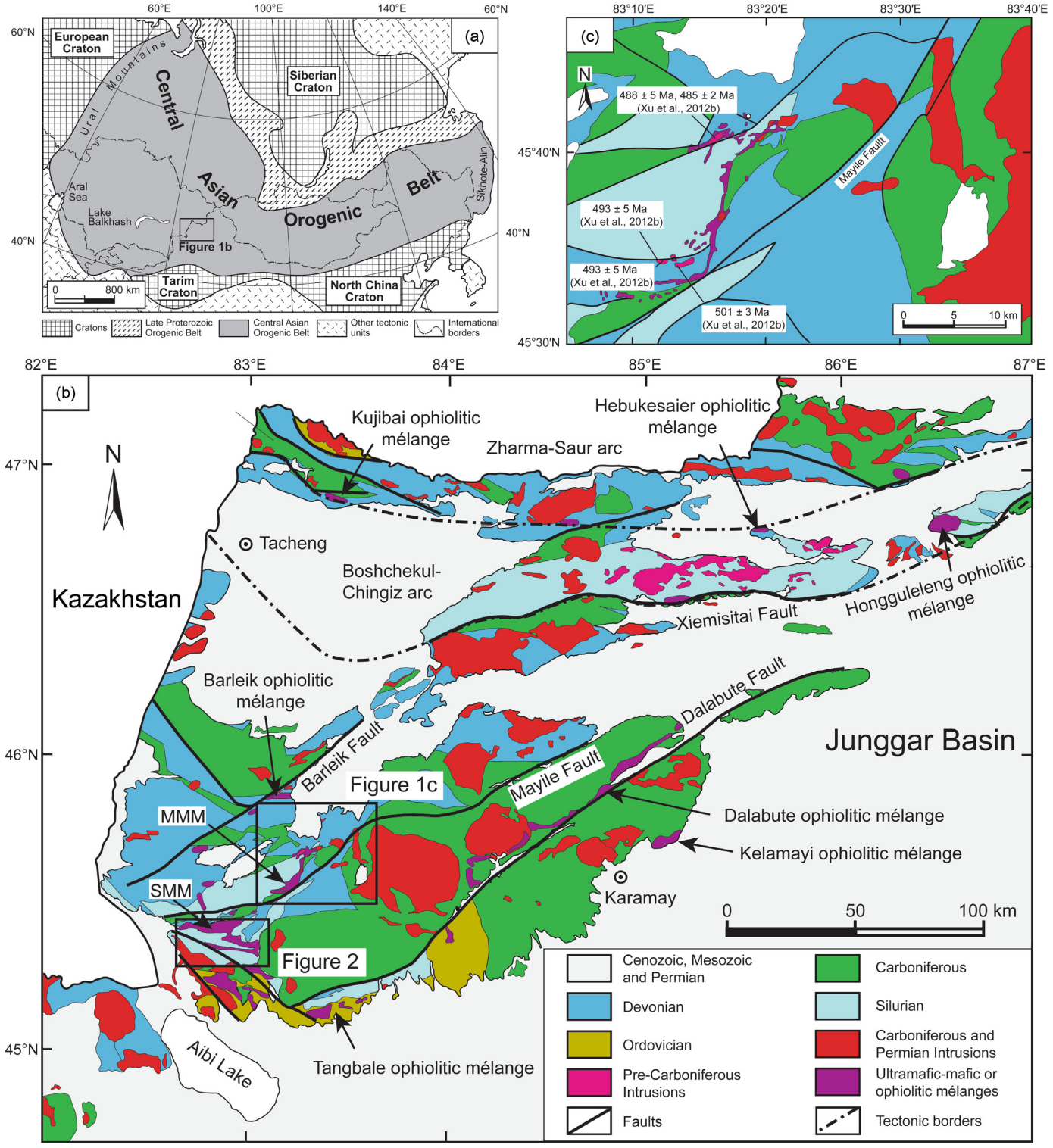

Fig. 1. (a) Simplified tectonic map of the Central Asian Orogenic Belt (modified from Han et al., 2010b) with the approximate location of Fig. 1b shown with a box, (b) sketch tectonic map of the West Junggar region (modified from BGMRXUAR, 1993 and Xu et al., 2012b) with the approximate location of Figs. 1c and 2, and (c) geologic map of the Mayile Mountain area (modified from BGMRXUAR, 1993 and Xu et al., 2012b).

Recent researches have revealed that the West Junggar, in the western segment of the southern CAOB, is characterized by a Paleozoic intra-oceanic subduction–accretion system (Fig. 1b; Wang et al., 2003; Buckman and Aitchison, 2004; Xiao et al., 2008; Xu et al., 2012a, 2012b), and the oldest mature arc occurred in the Late Cambrian (501–493 Ma), which developed upon the supra-subduction zone (SSZ)-type Mayile Mountain ophiolitic mélange (Fig. 1c; Supplementary Table 1), possibly implying that the initial subduction is supposed to occur during the Early–Middle Cambrian (Xu et al., 2012b), although there are no identifications of Early–Middle Cambrian magmatism in outcrop and even in detrital zircons from Paleozoic sedimentary rocks of the West Junggar accretionary complexes (Choulet et al., 2012). Obviously, the Early–Middle Cambrian island arc magmatism in the West Junggar is a critical argument for the timing of the initial subduction of the southern Paleo-Asian Ocean.