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# Late Silurian–early Devonian adakitic granodiorite, A-type and I-type granites in NW Junggar, NW China: Partial melting of mafic lower crust and implications for slab roll-back

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ABSTRACT

Late Silurian–early Devonian magmatism of the NW Junggar region in the Central Asian Orogenic Belt provides a critical geological record that is important for unraveling regional tectonic history and constraining geodynamic processes. In this study, we report results of Zircon U–Pb ages and systematic geochemical data for late Silurian–early Devonian largely granitic rocks in NW Junggar, aiming to constrain their emplacement ages, origin and geodynamic significance. The magmatism consists of a variety of mafic to felsic intrusions and volcanic rocks, e.g. adakitic granodiorite, K-feldspar granite, syenitic granite, gabbro and rhyrolite. U–Pb zircon ages suggest that the granitoids and gabbros were emplaced in the late Silurian–early Devonian (420–405 Ma). Adakitic granodiorites are calc-alkaline, characterized by high Sr (407–532 ppm), low Y (12.2–14.7 ppm), Yb (1.53–1.77 ppm), Cr (mostly <8.00 ppm), Co (mostly <11.0 ppm) and Ni (mostly <4.10 ppm) and relatively high Sr/Y (31–42) ratios, analogous to those of modern adakites. K-feldspar granites and rhyolites are characterized by alkali- and Fe-enriched, with high Zr, Nb and Ga/Al ratios, geochemically similar to those of A-type granites. Syenitic granites show high alkaline ($Na_2O + K_2O = 8.39$–$9.34$ wt.%) contents, low $Fe^{\#}$ values (0.73–0.80) and are weakly peraluminous (A/CNK = 1.00–1.07). Gabbros are characterized by low MgO (6.86–7.15 wt.%), $Mg^{\#}$ (52–53), Cr (124–133 ppm) and Ni (84.7–86.6 ppm) contents. The geochemical characteristics of the gabbroic samples show affinity to both MORB- and arc-like sources. All granitoids have positive εNd(t) (+3.9 to +6.9) and zircon εHf(t) (+9.8 to +15.2) values and low initial $^{87}Sr/^{86}Sr$ ratios (0.7035–0.7043), with young $T_{DM}$(Nd) (605–791 Ma) and $T_{DM}$(Hf) (425–773 Ma) ages, suggesting significant addition of juvenile material. The adakitic granodiorites probably resulted from partial melting of mafic lower crust, leaving an amphibolite and garnet residue. The K-feldspar granites, rhyolites and syenitic granites probably formed from partial melting of the Xiemisitai mid-lower crust, while the gabbroic intrusion was probably generated by interactions between asthenospheric and metasomatized lithospheric mantle. Voluminous plutons of various types (adakites, A-type granites, I-type granites, and gabbros) formed during 420–405 Ma, and their isotopic data suggest significant additions of juvenile material. We propose that a slab roll-back model can account for the 420–405 Ma magmatic "flare up" in NW Junggar as well as an extensional setting.



## 1. Introduction

The Central Asian Orogenic Belt (CAOB) is the largest Phanerozoic orogenic belt in the world, extending from the Urals in the west to the Pacific in the east and from Siberia in the north to the Tianshan in the south (Fig. 1a; Şengör et al., 1993; Windley et al., 2007; Xiao et al., 2008; Xiao and Santosh, 2014; Xiao et al., 2015). The CAOB is largely characterized by massive granitoids and their volcanic equivalents with positive εHf(t), εNd(t) values and young $T_{DM\text{-}Nd}$ model ages (Şengör et al., 1993; Chen and Jahn, 2004; Yuan et al., 2007; Geng et al., 2009; Tang et al., 2012; Yang et al., 2014a; Li et al., 2015a,b). Although the granitoids reflect crustal growth in West Junggar, the tectonic regimes where crustal growth takes place remain highly controversial. Şengör et al. (1993) proposed that the CAOB was chiefly formed by subduction-accretion processes during the Phanerozoic,

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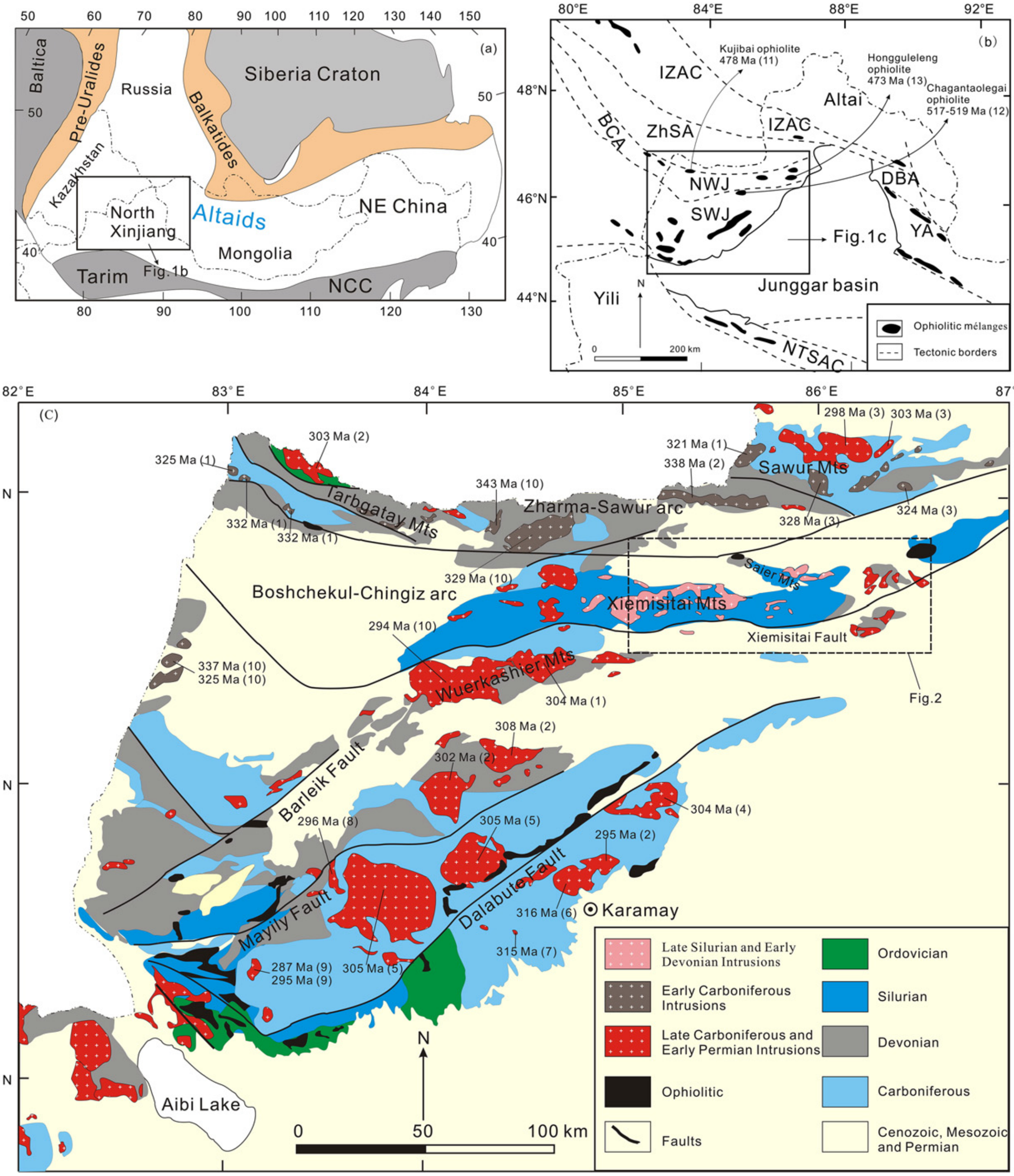


**Fig. 1.** (a) Simplified tectonic divisions of the Central Asian Orogenic Belt (after Jahn et al., 2000). (b) Tectonic map showing the main units separated by major suture zones in the West Junggar and adjacent regions (modified after Xu et al., 2012). IZAC: Irtysh–Zaysan Accretionary Complex; ZhSA: Zharma–Saur arc; BCA: Boshchekule–Chengiz Arc; DBA: Dulate–Baytag arc; YA: Yemaquan arc; NWJ: Northern West Junggar; SWJ: Southern West Junggar; NTSAC: North Tian Shan accretionary complex. (c) Simplified geological map of the West Junggar (modified after Xu et al., 2012). 1, Chen et al. (2010a); 2, Han et al. (2006); 3, Zhou et al. (2008); 4, Feng et al. (2012); 5, Geng et al. (2009); 6, Tang et al. (2012); 7, Tang et al. (2010); 8, Song et al. (2011); 9, Wei (2010); 10, Yin et al. (2013b); 11, Zhu and Xu (2006); 12, Zhao and He (2013); 13, Zhang and Guo, 2010.

while others stressed the role of vertical addition of juvenile material in the Phanerozoic crustal growth (Jahn et al., 2000; Chen and Jahn, 2004; Han et al., 2006). More recent views have suggested that an initial Paleozoic archipelago was formed by multiple, short-lived, subduction zones with different subduction polarities, a scenario similar to that in the present SW Pacific (Windley et al., 2007; Xiao et al., 2008, 2013; Xiao and Santosh, 2014). Granitoids in accretionary orogens can provide not only critical information on crustal growth, but also important constraints on the tectonic evolution of the CAOB. Previous studies, however, mainly concentrated on early Cambrian to early Silurian and Carboniferous to Permian plutons with little attention to plutons emplaced during the transitional period of late Silurian to early Devonian. This imbalance severely restricts a comprehensive understanding of the tectonic evolutionary history during the Paleozoic in West Junggar. Silurian–Devonian granitoids are widely distributed in the CAOB and have been used to discriminate the geological evolution and crustal growth (Filippova et al., 2001; Yuan et al., 2007; Kröner et al., 2008; Sun et al., 2008; Gao et al., 2009; Chen et al., 2010a,b; Cai et al., 2011; Shen et al., 2011). Chen et al. (2010a) reported late Silurian–early Devonian plutons in NW Junggar including A-type granite and associated diorites, K-feldspar granites, and subvolcanic rocks that indicate that middle Paleozoic magmatism was active in West Junggar.