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Whole-rock geochemistry and Sr–Nd–Pb isotope systematics of the Late Carboniferous volcanic rocks of the Awulale metallogenic belt in the western Tianshan Mountains (NW China): Petrogenesis and geodynamical implications

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ABSTRACT

The Awulale metallogenic belt (AMB) of the western Tianshan (NW China) includes Late Carboniferous (ca. 320 Ma) ore-bearing volcanic rocks of the Dahalajunshan Formation. The petrogenesis and tectonic setting of these volcanic rocks are important for the understanding of the tectonic evolution and metallogeny of the western Tianshan. This paper presents new major and trace elements and Sr–Nd–Pb isotope data from the Dahalajunshan volcanic rocks, which are mainly calc-alkaline basaltic trachy-andesite and trachy-andesite with subordinate basalt, trachy-basalt and rhyolite. The variations of major and trace elements in the mafic and intermediate volcanic rocks indicate the fractionation of pyroxene and magnetite or hornblende, magnetite, apatite and plagioclase, respectively, during their petrogenesis. The Dahalajunshan volcanic rocks have similar primitive mantle-normalized diagrams and chondrite-normalized rare-earth element (REE) patterns suggesting their similar mantle source(s). They are characterized by enrichment in large ion lithophile elements (LILEs) and light REEs (LREEs), depletion in heavy REEs ($La_N/Yb_N \approx 2.80$ to 9.59) and high field strength elements (HFSEs) and $\varepsilon_{Nd}(t)$ ranging from +1.2 to +6.0 at $^{86}Sr/^{87}Sr_{(t)} = 0.7047–0.7063$ and $^{206}Pb/^{204}Pb_i = 17.49–18.19$. Both the geochemical and isotopic data indicate that the volcanic rocks were probably derived by low-degree melting of sub-arc lithospheric mantle modified by fluids in a continental arc setting. Our obtained results, in conjunction with previous published data, allow us to suggest that the southward subduction of Junggar oceanic crust continued until the Late Carboniferous and was followed by a tectonic shift from continental arc to post-collisional extension environment.

1. Introduction

Volcanic rocks are important constituents of orogenic belts formed in the place of former oceans. They may form in oceanic (mid-oceanic ridges, oceanic islands, seamounts and plateaus) and supra-subduction (intra-oceanic and active margin magmatic arcs) environments and in post-orogenic (intra-continental) settings. Therefore, identification of conditions of petrogenesis and tectonic settings of eruption of volcanic rocks is of crucial importance for the understanding of the geological evolution of orogenic belts. The Central Asian Orogenic Belt (CAOB) is the largest Phanerozoic accretionary orogen in the world (Fig. 1a), whose formation and evolution have been studied by many research teams (Buslov et al., 2001; Jahn et al., 2000; Sengör et al., 1993; Windley et al., 2007; Xiao et al., 2010; Zonenshain et al., 1990). However, the origin of many terranes of the CAOB remains unstudied, in particular, due to limited data on the composition (first of all, trace elements and isotopes), and therefore on the genesis of their hosted volcanic and volcanogenic–sedimentary units. The Chinese Tianshan of NW China (Fig. 1b) is a large Paleozoic orogenic belt in the western CAOB. It represents a collage of terranes of various origins and contains many commercially valuable mineral ore deposits. The mineralization of many ore deposits is linked to the volcanic rocks formed at former convergent margins, whose evolution resulted in the formation of the

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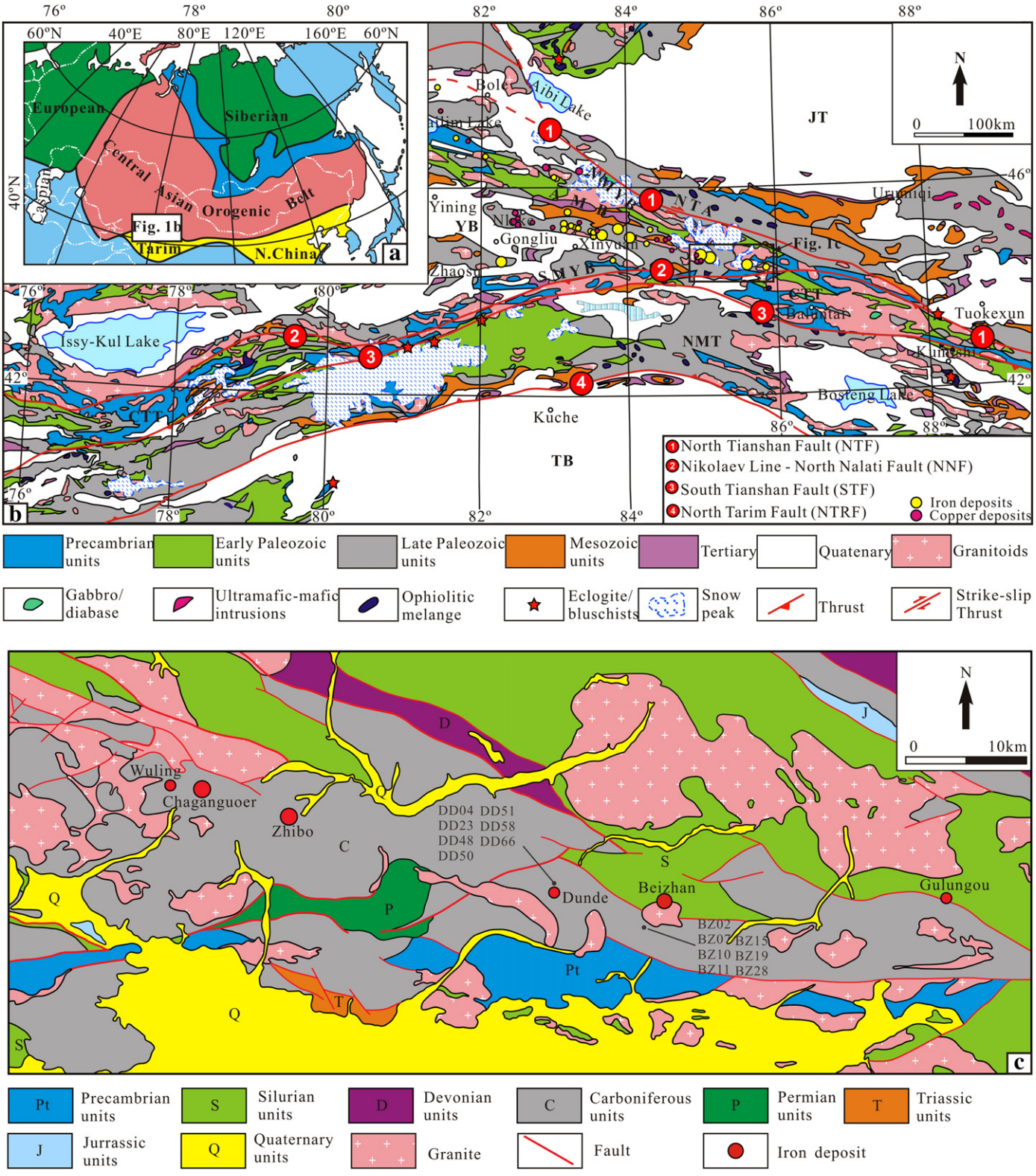

Fig. 1. (a) Tectonic sketch map of the Central Asian Orogenic Belt and adjacent structures; (b) simplified geological map of the western Tianshan and adjacent regions. (c) Simplified geological map of the eastern Awulale metallogenic belt showing the location of Dunde and Beizhan iron deposits. JT, Junggar Terrane; NTA, North Tianshan Arc Accretionary Wedge; NMYB, Northern Active Continental Margin of the Yili Block; YB, Yili Block; AMB, Awulale metallogenic belt; SMYB, Southern Active Continental Margin of the Yili Block; CTT, Central Tianshan Composite Arc Terrane; NMT, Northern Margin of the Tarim Block; TB, Tarim Block.
(a) Modified from Jahn et al. (2000), Sengör et al. (1993), and Xiao et al. (2010). (b) Modified from Gao et al. (2009b). (c) Modified from Zhang et al. (2012a).

Tianshan orogen. Therefore studying the origin of those volcanic units and/or terranes hosting valuable mineral deposits is necessary to develop metallogenic models and to understand prospects of this or that mineral deposit.

The Awulale metallogenic belt (AMB) is located in the western Chinese Tianshan (Fig. 1b; Zhang et al., 2014). It includes numerous volcanogenic ore deposits hosted by Carboniferous volcanic and volcaniclastic rocks (Gao et al., 1998; Zhang et al., 2012a; Zhu et al.,