Gondwana Research 22 (2012) 325–340

Contents lists available at SciVerse ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

Late Paleozoic calc-alkaline to shoshonitic magmatism and its geodynamic implications, Yuximolegai area, western Tianshan, Xinjiang

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ARTICLE INFO

Article history:
Received 8 June 2011
Received in revised form 15 October 2011
Accepted 15 October 2011
Available online 28 October 2011

Editor: R. Goldfarb

Keywords:
Western Tianshan
Calc-alkaline magmatism
Shoshonitic series
Post-subduction
Geodynamic evolution

ABSTRACT

Continuous Late Paleozoic magmatic activity in the western Tianshan, Xinjiang, China, temporally overlapped the Late Carboniferous collision between the Tarim and the Kazakhstan–Yili plates. Isotopic dating, whole-rock geochemistry, and isotopic characteristics of a suite of calc-alkaline to shoshonitic rocks from Yuximolegai area, in the eastern end of the Awulale Mountains, help define the tectonic evolution of this part of the Tianshan. Zircon U–Pb ages of a quartz diorite and a quartz syenite porphyry are 310.8 ± 2.1 Ma and 284.4 ± 3.6 Ma, respectively. The geochemical and isotopic characteristics of Late Carboniferous igneous rocks, including the quartz diorite, as well as basaltic andesite and K-rich trachyandesite, indicate an evolution from calc-alkaline towards shoshonitic series. This was generated by the partial melting of the hydrated mantle wedge induced by changing subduction angles. The younger quartz syenite porphyry, however, was more likely derived from the partial melting of a thickened crust in a post-collisional setting or the partial melting of hot juvenile basalt in the lower crust during Early Permian delamination of the subcontinental lithospheric mantle. Therefore, the generation of the calc-alkaline to shoshonitic igneous rocks in Yuximolegai area is genetically linked to the geodynamic evolution of the western Tianshan from convergent subduction to collision during the Late Paleozoic.

1. Introduction

Shoshonitic rocks are widely distributed in many orogenic belts (Blatter et al., 2001; Seghedi et al., 2004; Altunkaynak and Dilek, 2006; Chen et al., 2010; Eyuboglu et al., 2011). The formation of these magmatic rocks is controversial. There are various proposed models for their origins, which include asthenospheric upwelling induced by slab break-off (Koprubasi and Aldanmaz, 2004; Boztug et al., 2006; Altunkaynak, 2007; Altunkaynak and Genc, 2008; Negrete-Aranda and Canon-Tapia, 2008), lithospheric mantle delamination (Aldanmaz et al., 2000), and partial convective removal of the subcontinental lithospheric mantle (Altunkaynak and Dilek, 2006; Dilek and Altunkaynak, 2007). It is generally accepted that partial melting of subducted sediments could produce vein networks of clinopyroxene, amphibole, and phlogopite within the sub-continental lithospheric mantle (Foley, 1992; Gao et al., 2009). Interaction between these metasomatic veins and mantle magmas will result in the formation of shoshonites and high-K calc-alkaline rocks (Avanzinelli et al., 2009; Conticelli et al., 2009a,b). This genetic model is accepted for the formation of shoshonitic rocks associated with ultrapotassic, high-K calc-alkaline, or even calc-alkaline magmas (Muller et al., 1992; Blatter et al., 2003; Bonin, 2004; Callegari et al., 2004; Gill et al., 2004; Duggen et al., 2005).

In addition to tectonic implications, shoshonitic rocks have been reported to be the causative bodies for deposition of many important epithermal Au deposits and porphyry Cu–Au deposits, such as the Ladolam, Lihir, and Porgera Au deposits in Papua New Guinea (Muller and Groves, 1993; Muller et al., 2001); Bingham porphyry Cu–Mo–Au deposit in Utah, USA; Cripple Creek Au deposit in Colorado, USA; Cadia and Goonumblla porphyry Cu–Au deposits in New South Wales, Australia (Muller and Groves, 1993); Grasberg porphyry Cu–Au deposit in Indonesia (Muller and Groves, 1997); and Yulong porphyry Cu deposit in southwestern China (Jiang et al., 2006; Liang et al., 2006, 2009a,b; Hou et al., 2007). Therefore, a systematic study on shoshonitic rocks is essential for understanding the generation and distribution of associated epithermal and porphyry deposits.

The Awulale Mountains are located in the southwestern Central Asia Orogenic Belt. They include numerous Late Paleozoic volcanic and intrusive rocks and associated Cu (Au) deposits (Hong et al., 2003; Shan et al., 2009; Xiao and Kusky, 2009; Xiao et al., 2009; Luo et al., 2010). The tectonic setting of this region in the Late Paleozoic

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doi:10.1016/j.gr.2011.10.008

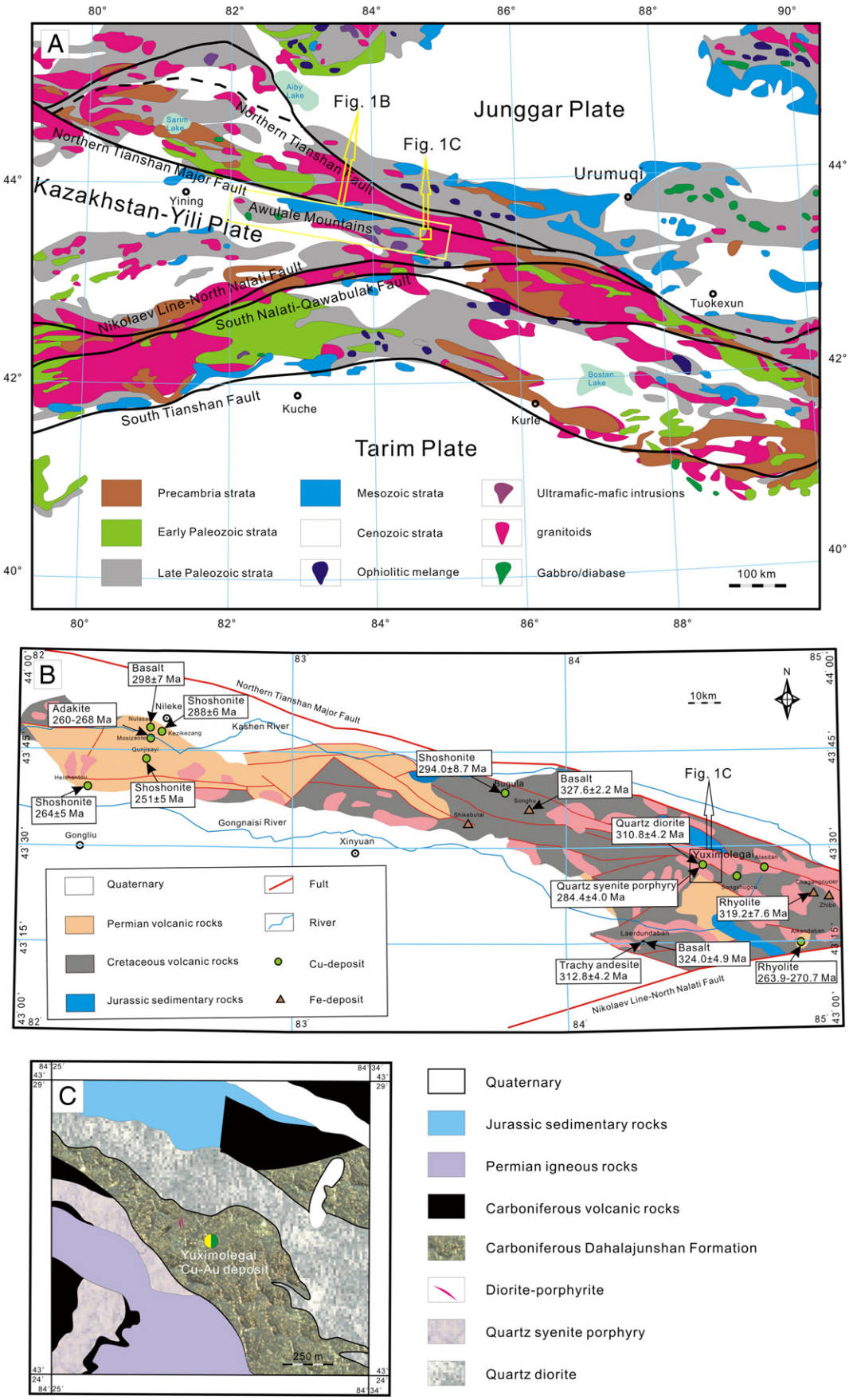

Fig. 1. (A) Tectonic sketch map of the western Tianshan (modified from Gao et al., 2009); (B) tectonic–geological sketch map of the Awulale Mountains (modified from Zhao et al., 2000); and (C) simplified geologic map of the Yuximolegai area. The labeled geochronological data in Fig. 1B are from references (Li et al., 1997; Chen et al., 2004b; Zhao et al., 2009; Zhu et al., 2009), this study and authors' unpublished data. The GPS position of the Yuximolegai porphyry Cu–Au deposit is: 84°23′28″ E, 43°24′30″ N.