Lithos 256–257 (2016) 243–249

Contents lists available at ScienceDirect

Lithos

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

Letter

A non-plume model for the Permian protracted (266–286 Ma) basaltic magmatism in the Beishan–Tianshan region, Xinjiang, Western China

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ARTICLE INFO

Article history:
Received 20 February 2016
Accepted 13 April 2016
Available online 22 April 2016

Keywords:
Mafic–ultramafic rocks
Geochronology
Geochemistry
Mantle plume
Tectonomagmatic processes

ABSTRACT

The convenient mantle plume model for the Permian protracted mafic–ultramafic intrusions and mafic dykes (266–286 Ma) in the Beishan–Tianshan region, northern Xinjiang, western China can be rejected, because their temporal–spatial distribution does not show a hotspot track predicted by such model. New zircon U–Pb ages reveal that two small mafic dyke clusters (Podong, 280.5 ± 2 Ma; Luodong, 266.2 ± 3.2 Ma) that are separated by only ~20 km in the Pobei area, the southernmost part of the Beishan–Tianshan region, have a large age difference of ~18 Ma. The older mafic dykes are characterized by nearly flat mantle-normalized rare-earth-element patterns, pronounced negative Nb–Ta anomalies and positive $\varepsilon_{Nd}(t)$ values from 5.5 to 7.5, similar to the majority of the Permian mafic–ultramafic intrusions in the region. The younger mafic dykes are characterized by significant light rare-earth-element enrichments as well as pronounced negative Nb–Ta anomalies, plus lower $\varepsilon_{Nd}(t)$ (−1.2 to 2.6) values and higher initial $^{87}Sr/^{86}Sr$ ratios than the older mafic dykes. The observed compositional variations can be explained by source mantle heterogeneity plus different degrees of crustal contamination. Overall, the Permian mafic–ultramafic rocks in the Beishan–Tianshan region are geochemically consistent with the products of basaltic magmatism induced by lithospheric delamination and asthenosphere upwelling in a convergent tectonic zone.

1. Introduction

Beishan is an approximately E–W trending mountain range located in the northeastern margin of the Tarim Craton, northern Xinjiang, western China (Fig. 1A, B). To the north it is bounded by another approximately E–W trending mountain range called Tianshan. The Tianshan mountain range is a southernmost part of the Paleozoic Central Asian Orogenic Belt. It is widely accepted that the accretion of Tianshan to the northern rim of the Tarim Craton took place before Early Permian, as indicated by the late-Carboniferous high-pressure metamorphic rocks in the tectonic sutures that occur between the Tarim Craton and Tianshan (Wang et al., 2010; Yang et al., 2013).

Numerous small mafic–ultramafic intrusions of Permian ages (266–286 Ma) occur as several clusters in Beishan and the eastern part of Tianshan that is commonly referred to as East Tianshan in literatures. The Permian protracted mafic–ultramafic intrusions form a NE-trending, discontinuous magmatic belt that is oblique to the tectonic sutures in the region (Fig. 1B). Some of these mafic–ultramafic intrusions contain important magmatic Fe–Ni–Cu sulfide deposits, such as Huangshandong (Sun et al., 2013) and Huangshanxi (Zhang et al., 2011) in East Tianshan, and Poyi in Beishan (Xia et al., 2013). As a result, the Beishan–Tianshan Permian mafic–ultramafic intrusive belt has received a lot of attention lately by exploration geologists worldwide.

The origin of the Permian protracted mafic–ultramafic intrusions in the Beishan–Tianshan region has been debated for a long time. Some researchers (Zhou et al., 2004) suggested that they are the products of a Permian mantle plume beneath East Tianshan. Other researchers proposed that they belong to the Tarim mantle plume (Pirajno et al., 2008; Qin et al., 2011; Su et al., 2011; Zhang and Zou, 2013). The Tarim mantle plume is inferred from the Permian alkaline basalts that are present in the western part of the Tarim basin and characterized by OIB-like trace element compositions (Tian et al., 2010; Zhou et al., 2009). The presence of xenocrystic zircon crystals in the Tarim alkaline basalts as young as ~282 Ma indicates that these volcanic rocks erupted shortly after ~282 Ma (Li et al., 2014).

The above various versions of a mantle plume origin for the Permian protracted mafic–ultramafic intrusions in the Beishan–Tianshan have been contested by two alternative tectonomagmatic models: subduction-related basaltic magmatism in an active arc (Ao et al.,

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http://dx.doi.org/10.1016/j.lithos.2016.04.018
0024-4937/

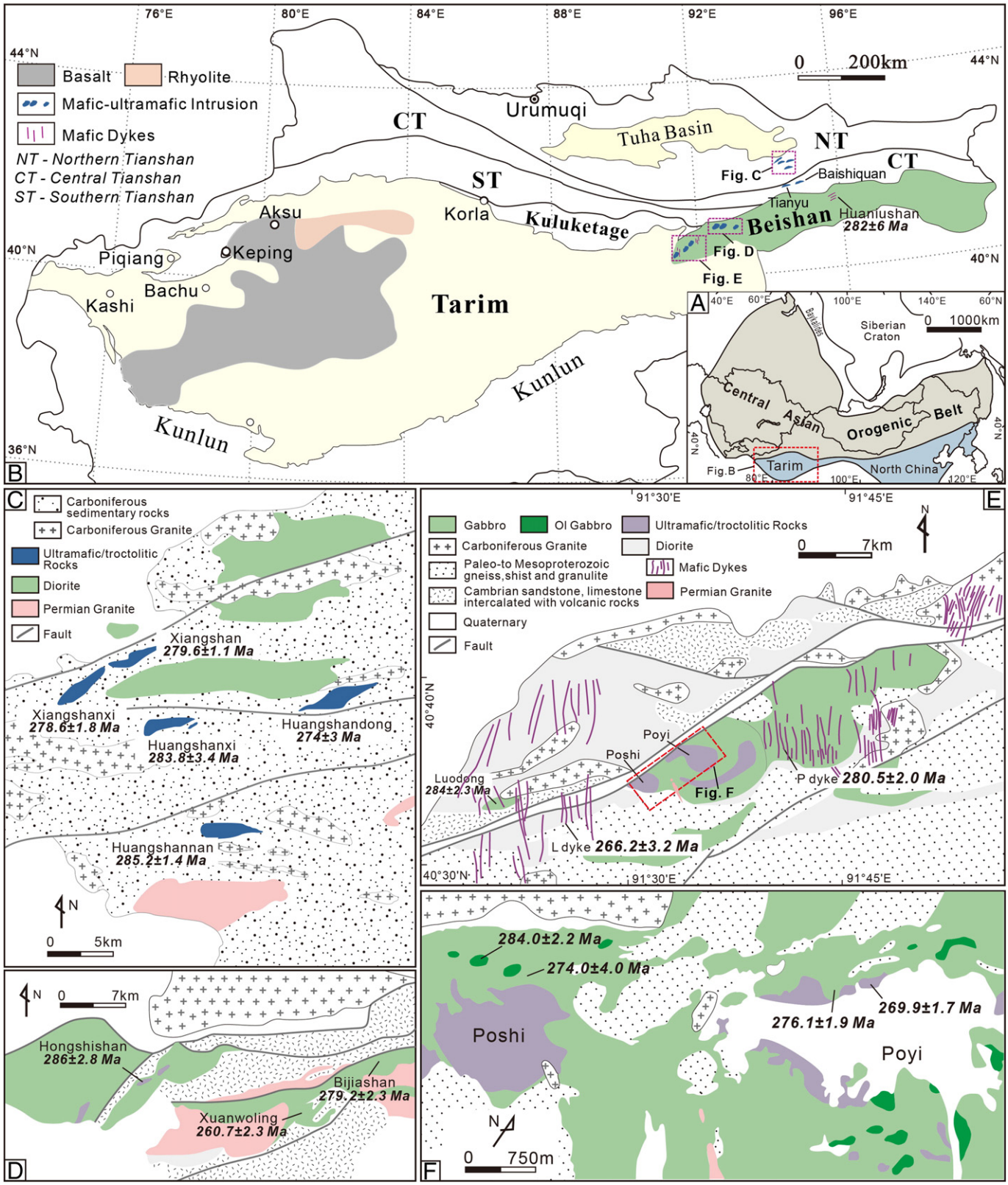

Fig. 1. A: Locations of the Central Asian Orogenic Belt and the Tarim Craton (after Xiao et al., 2004). B: Major tectonic units in northern Xinjiang, showing the distribution of Permian volcanic rocks and mafic–ultramafic intrusions (after Li et al., 2014; Mao et al., 2014). C: Simplified geological map of the Huangshan area, showing a cluster of mafic–ultramafic intrusions with different ages. D: Simplified geological map of the Xuanwoling area, showing several mafic–ultramafic intrusions with different ages (after Mao et al., 2014). E: Simplified geological map of the Pobei area, showing the distribution of mafic–ultramafic intrusions and mafic dykes with different ages (after Xue et al., 2016). F: Simplified geological map of the Poyi-Poshi mafic–ultramafic complex (after Xue et al., 2016). The age data are from Table 1.