Journal of Asian Earth Sciences 113 (2015) 310–324

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Continuous denudation and pediplanation of the Chinese Western Tianshan orogen during Triassic to Middle Jurassic: Integrated evidence from detrital zircon age and heavy mineral chemical data

Meng Wang, Jinjiang Zhang *, Kai Liu

Key Laboratory of Orogenic Belts and Crustal Evolution, Ministry of Education, School of Earth and Space Sciences, Peking University, Beijing 100871, China

ARTICLE INFO

Article history:
Received 14 March 2014
Received in revised form 9 May 2014
Accepted 14 May 2014
Available online 27 May 2014

Keywords:
Detrital zircons
U–Pb geochronology
Provenance
Mesozoic
Chinese West Tianshan

ABSTRACT

The Mesozoic tectonic framework of the Chinese Tianshan orogen is ambiguous. However, thick Mesozoic sediments both inside and in front of the orogen can provide clues to solve this problem. LA-ICPMS U–Pb dating on detrital zircons and electron microprobe analysis on detrital heavy minerals are carried out on the Triassic to Middle Jurassic sediments along the Kuqa River section in the northern Tarim basin and in two intermountain basins (Bayanbulak basin and Gongnaisi valley), to reveal the change in provenance through time and space. Zircons from the Kuqa River section are mainly of magmatic origin and their ages have a wide range from 2800 to 234 Ma, 70.5% of which are Palaeozoic. This age signature indicates a main provenance from the Tianshan orogen. Detrital heavy minerals (garnet and tourmaline) from the Kuqa River section suggest a complex provenance from granitic and metamorphic rocks of the South Tianshan belt, the South Tianshan suture and the Yili-Central Tianshan block. Detrital zircon U–Pb ages of the Early-Middle Jurassic sandstones from the Gongnaisi valley and Bayanbulak basin are predominantly Palaeozoic, without Precambrian, indicating a simple source from the Yili-Central Tianshan block. The different features of detrital zircon ages and heavy mineral chemical compositions in individual sample reflect provenance changes due to continuous denudation and pediplanation of the Chinese West Tianshan orogen in an extensional setting during Triassic to Middle Jurassic: (1) during Early to Middle Triassic, the South Tianshan belt towered to the north of Tarim basin, acting as a watershed and being the main source area for northern Tarim basin; (2) since Late Triassic to Early Jurassic, material from southern Yili-Central Tianshan block was largely transported to Tarim basin because of the continuous denudation of the South Tianshan belt; (3) in Middle Jurassic, the Chinese Western Tianshan orogen reached a peneplain state, resulting in the direct deposition in intermountain basins and the decrease of sediment supplying from Yili-Central Tianshan block to Tarim.

1. Introduction

The Tianshan orogen, situated in the southernmost of the Central Asian Orogenic Belt (CAOB), underwent a very complex tectonic evolution since Palaeozoic and thus is a hotspot for geodynamic studies. Until now, most of previous studies focus on either the Paleozoic assemblage (Coleman, 1989; Windely et al., 1990; Allen et al., 1992; Carroll et al., 1995; Zhou et al., 2001; Gao et al., 1998, 2009, 2011; Xiao et al., 2004, 2008; Charvet et al., 2007, 2011; Han et al., 2010, 2011) or the Cenozoic uplift of the Tianshan orogen (Yin et al., 1998; Bullen et al., 2001, 2003; Huang et al., 2006; Charreau et al., 2005, 2006). However, the Mesozoic tectonics of the Chinese Tianshan orogen is controversial due to the absence of geological records in the orogen. Fortunately, Mesozoic and Cenozoic sediments in the basins in front of and inside the Tianshan orogen can provide constrains on the geological evolution. Previous studies suggest that the basins on both sides of the Chinese Tianshan orogen have been foreland basins since the Mesozoic (Dumitru et al., 2001; Hendrix et al., 1992; Hendrix, 2000; Carroll et al., 2013). However, the Kuqa depression on the southern side of the orogen is believed to have experienced a more complicated evolution: a late Permian–Triassic foreland basin, a Jurassic-Paleogene faulted basin, and a Neogene rejuvenated foreland basin (Lu et al., 1994; Jia et al., 2003).

Provenance studies of clastic sediments in sedimentary basins adjacent to the mountains are important in paleogeographic and tectonic reconstructions (Tsikouras et al., 2011). High mechanical

* Corresponding author. Tel.: +86 13520122757; fax: +86 10 62751150.
E-mail address: zhjj@pku.edu.cn (J. Zhang).

http://dx.doi.org/10.1016/j.jseaes.2014.05.013
1367-9120/

and chemical resistance to weathering of zircon makes detrital zircon U–Pb dating a powerful tool for determining the provenance of clastic sediments, assessing the paleogeography and providing constraints on the basin-range patterns in geological time (Veevers et al., 2005; Brain and George, 2006; Li and Peng, 2010; Yang et al., 2013; Liu et al., 2013). Besides, mineral chemical analysis of a single mineral group is readily applied in many provenance studies, amongst which garnet and tourmaline are most frequently used as provenance indicators because of their stability during transportation and sedimentation (Henry and Guidotti, 1985; Morton, 1985; Morton et al., 2004, 2005; Zack et al., 2004; Mange and Morton, 2007; Meinhold et al., 2010).

On the south margin of the Chinese West Tianshan orogen, a successive section of strata from Triassic to Middle Jurassic outcrops along the Kuqa River. Five sandstone samples from this section were collected to be performed U–Pb dating on detrital zircons and another five samples for EMP (Electron microprobe) analysis on detrital garnets and tourmalines. Another two sandstone samples from the intermountain basins, i.e., Gongnaisi valley and Bayanbulak basin, were collected for detrital zircon dating. Based on these data and integrating previous works, we discuss the provenance of the sandstones, paleotopographic evolution of the Tianshan range through geological time, and then we give an explanation for the basin-range patterns and the tectonic evolution of the Chinese West Tianshan orogen from Triassic to Middle Jurassic.

2. Geologic setting

The Chinese Tianshan orogen is divided into West and East Tianshan orogen by the Longitude of ~E 88°, and two major suture zones divide the West Tianshan orogen into three major tectonic units: North Tianshan, Yili-Central Tianshan and South Tianshan (Fig. 1; Xiao et al., 2013). After the Paleozoic accretionary orogeny, Mesozoic and Cenozoic non-marine sediments of over 10 km were deposited in the basins in front of the Tianshan orogen, and in several intermountain basins e.g., the Yili basin, Turpan basin, Bayanbulak basin and Yanqi basin (Fig 1; XBGMR (Xinjiang Bureau of Geology and Mineral Resources), 1993). The study areas of this paper are located in Chinese West Tianshan orogen and cover both the two kinds of basin.

The study area for basin in front of the orogen is on the southern side of the Tianshan orogen and covers a part of the Kuqa depression. This depression is a secondary structure along the northern boundary of the Tarim basin with an NEE trend for ~550 km and a width of 30–80 km (Fig. 1). It is a present rejuvenated foreland basin of the South Tianshan belt caused by the remote effect of the India-Asia convergence (Molnar and Tapponnier, 1975; Yin et al., 1998; Bullen et al., 2001, 2003). Kuqa River flows southwards across the Kuqa depression and cut through the Mesozoic-Cenozoic strata (Fig. 2).

The study area inside the Tianshan orogen covers several intermountain basins, where the Mesozoic strata are exposed in the Gongnaisi valley and on the northern margin of the Bayanbulak basin (Figs. 1 and 3). The Gongnaisi valley is on the southern margin of the Yili block next to the Central Tianshan belt. The Bayanbulak basin is a wide intermountain basin on the northern slope of the South Tianshan belt (Fig. 3), and its northern margin is bounded by a south-directed thrust system which is part of the South Tianshan Fault in Fig. 1 (Dumitru et al., 2001; Jolivet et al., 2010).

3. Mesozoic stratigraphic and sedimentary characteristics of the study areas

Clastic sediments with a thickness of 6–8 km were deposited in the Kuqa depression during the Mesozoic and Cenozoic (Fig. 4; XBGMR, 1993). Five evolutionary phases are distinguished by four depositional unconformities (Li et al., 2004). The four hiatuses are observed at the boundaries between Lower and Middle Triassic, Upper Jurassic and Lower Cretaceous, Lower Cretaceous and Paleogene, and Miocene and Pliocene (Li et al., 2004).

The Triassic sequence exposed on the northern margin of the Kuqa depression is divided into four formations: the Lower Triassic Ehuobulake Fm., the Middle Triassic Kelamayi Fm., and the Upper Triassic Huangshanjie and Taliqike Fm.s (Fig. 4). The Lower Triassic sediments resulted from a gravel-containing braided river-alluvial plain deposition, whilst the other Triassic series were produced in a fluvial delta-lacustrine environment (Li et al., 2004).

The Jurassic sequence in the Kuqa depression is divided into the Ahe and Yangxia Fm.s of Lower Jurassic, Kezilenuer and Qiakemake Fm.s of Middle Jurassic, Qigu and Kazhala Fm.s of Upper Jurassic (Fig. 4). Abundant coal in the Lower and Middle Jurassic strata indicates a meandering river system with a locally lacustrine deltaic depositional environment (Hendrix et al., 1992). Red fine-grained sand- and silt-stone of the uppermost Jurassic sequence (Kazhala Fm.) suggests a relatively dry and hot environment (Li et al., 2004).

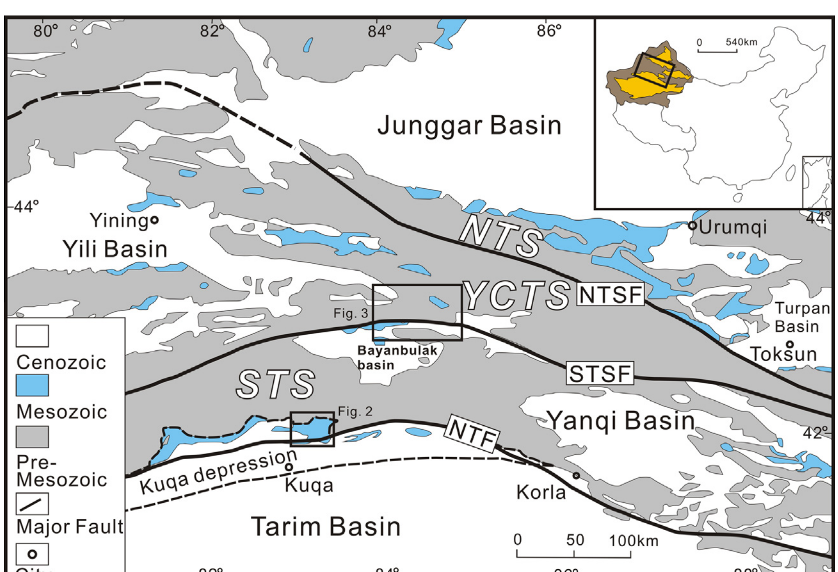

Fig. 1. Geological map of the Chinese West Tianshan orogen and adjacent regions (Modified from Institute of Geology of Chinese Academy of Geological Sciences, 2006). NTSF–North Tianshan Fault; STSF – South Tianshan Fault; NTF – North Tarim Fault; NTS – North Tianshan; YCTS – Yili-Central Tianshan; STS – South Tianshan.