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Mesozoic cooling history of the "Bachu Uplift" in the Tarim Basin, China: Constraints from zircon fission-track thermochronology

Jian Chang [a,b], Roderick W. Brown [c], Wanming Yuan [d], Wenzheng Li [a,b], Yongquan Que [a,b], Nansheng Qiu [a,b,*]

[a] State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing 102249, China
[b] Basin and Reservoir Research Centre, China University of Petroleum, Beijing 102249, China
[c] School of Geographical and Earth Sciences, University of Glasgow, Glasgow G12 8QQ, UK
[d] Institute of Earth Sciences, China University of Geosciences, Beijing 100083, China

HIGHLIGHTS

- ZFT were firstly used to study Mesozoic cooling events of the Tarim Basin, China.
- ZFT data revealed cooling events of 192 Ma, 151 Ma and 126 Ma.
- Cooling events were related to the collisions in the Eurasia southern margin.

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ABSTRACT

We applied zircon fission-track analysis to outcrop and borehole samples to study the Mesozoic cooling history of the Bachu Uplift, the Central Uplift of the Tarim Basin. Zircon fission-track (ZFT) ages of 182 Ma – 249 Ma are younger than the sample depositional ages indicating substantial post burial thermal annealing and can effectively reveal cooling events in the Bachu Uplift. The strong correlation between single grain ZFT age and U content indicates that most of the zircon grains represent ages that have been partially annealed and so the age is not directly indicative of the time of cooling. The youngest ZFT age populations with modal peak ages of 151 ± 8 Ma (Well HT1 samples), 126 ± 6 Ma (Well T1 samples) and 192 ± 10 Ma (Xiaohaizi Reservoir profile samples) from the decomposition of the ZFT single-grain ages represent the onset of cooling events in the Bachu Uplift, which were related to the collisions of the Qiangtang Terrane and Lhasa Block with the southern margin of the Eurasia continent, respectively. This study provides new insights into the tectonic and sedimentary evolution of the Tarim Basin and even Central Asia by constraining the higher temperature (c. 250–180 °C) part of the basin thermal history.

1. Introduction

The Bachu Uplift in the Tarim Basin has experienced multiple phases of tectonic movement since the Proterozoic crystalline basement first formed (Fig. 1a; Kang and Kang, 1996; Jia, 1997). Although many studies have discussed the tectonic evolution of the Bachu Uplift based on regional stratigraphic unconformities, tectonic burial histories, seismic inversion and sequence analysis (Xie et al., 1998; Zhang et al., 2002; He et al., 2005; Ding et al., 2008; Qiu et al., 2011), the timing and magnitude of Mesozoic cooling history in the Bachu Uplift remains uncertain due to the absence of Mesozoic strata. Vitrinite reflectance R_0% values of 1.5%~2.0% reported by Cai et al. (2002) and Qiu et al. (2011) indicated that the Paleozoic strata in the Bachu Uplift experienced higher palaeo-temperature than ~120 °C, the apatite fission-track (AFT) closure temperature. The thermal modelling results constrained only by the AFT data revealed multiple phases of uplift (Qiu et al., 2011), but the maximum temperatures the samples experienced wasn't constrained very well because of the temperature limitation of AFT dating. Compared to the apatite fission-track method, the zircon fission-track analysis (ZFT) can reveal the thermal history of rocks at higher temperatures which correspond to 190 °C–310 °C with a cooling rate of 10 °C/Myr

* Corresponding author. Basin and Reservoir Research Centre, China University of Petroleum, Beijing 102249, China. Tel.: +86 10 89733340; fax: +86 10 89733423.
E-mail addresses: qiunsh@cup.edu.cn, Jian.Chang@glasgow.ac.uk (N. Qiu).

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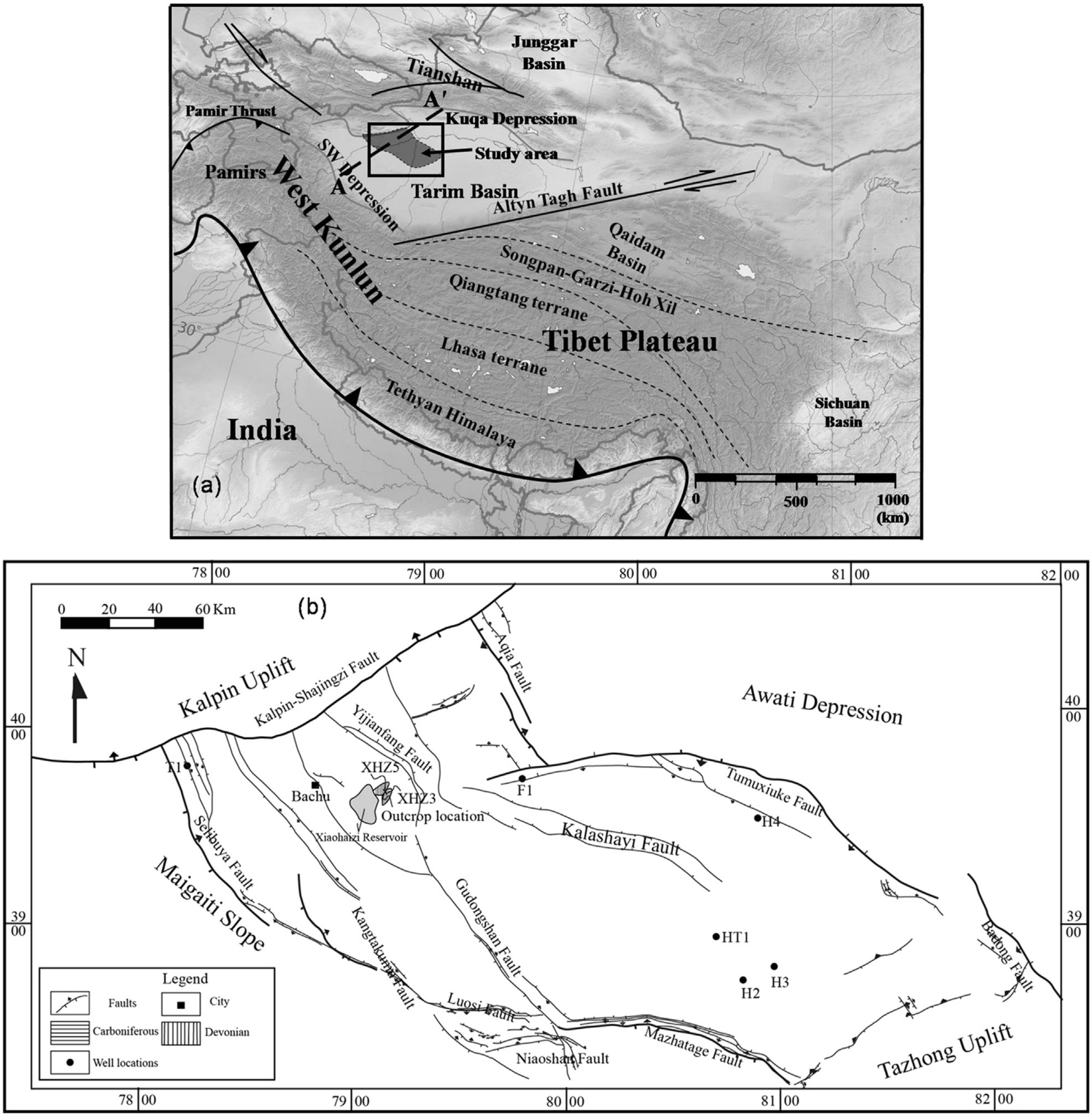

Fig. 1. (a) Map of Central Asia illustrating the locations of major tectonic boundaries and faults (Clark, 2011; Robinson et al., 2012). SW Depression means Southwest Depression. (b) Simplified geologic map of the Bachu Uplift showing the important well locations and the Xiaohaizi Reservoir outcrop location.

(Yamada et al., 1995, 2007; Tagami et al., 1996; Garver et al., 1999, 2002; 2005; Garver and Bartholomew, 2001; Garver and Kamp, 2002; Hasebe et al., 2003; Rahn et al., 2004; Murakami et al., 2006; Tagami and Murakami, 2007; Bernet, 2009; Guedes et al., 2013) and is an effective tool for investigating the cooling history in the Bachu Uplift. The annealing behavior of spontaneous fission tracks in zircon is controlled by the temperature and the time the temperature has lasted (Tagami et al., 1996; Yamada et al., 2003; Ewing et al., 2003; Garver et al., 2005; Murakami et al., 2006; Yamada et al., 2007). In addition, the degree of amorphization is controlling the final annealing temperature (Li et al., 2011a). Therefore, the range of temperature between 190 °C and 310 °C is a function of degree of amorphization, absolute temperature and time the temperature has lasted. Amorphization in zircon is caused by the alpha decay process of uranium and thorium (Li et al., 2011a). the alpha decay process creates an alpha particle and the alpha recoil nucleous. Both particles receive kinetic energy during the decay process. Both particles deposit their kinetic energy while they move through the crystal lattice. The deposition of the kinetic energy created the amorphization in the crystal lattice of zircon. Beside the content of REE in zircon the amount of amorphization creates a change in color of the zircon (Garver and Kamp, 2002; Garver, 2003; Marsellos and Garver, 2010). Zircons with high degree of amorphization are red in color whereas zircon with low degree of amorphization are white in color. In this paper, the ZFT data was