Gondwana Research 23 (2013) 998–1020

Contents lists available at SciVerse ScienceDirect

Gondwana Research

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

Thermo-tectonic history of the Issyk-Kul basement (Kyrgyz Northern Tien Shan, Central Asia)

Johan De Grave [a,*], Stijn Glorie [a], Mikhail M. Buslov [b], Daniel F. Stockli [c,d], Michael O. McWilliams [e,f], Vladislav Yu. Batalev [g], Peter Van den haute [a]

[a] Department of Mineralogy & Petrology, Ghent University, Ghent, Belgium
[b] Institute of Geology & Mineralogy, Siberian Branch, Russian Academy of Sciences, Novosibirsk, Russia
[c] Department of Geology, Kansas State University, Lawrence, KS, USA
[d] Jackson School of Geosciences, University of Texas, Austin, TX, USA
[e] Department of Geological & Environmental Sciences, Stanford University, Stanford, CA, USA
[f] CSIRO Earth Science and Resource Engineering Division, Perth, Australia
[g] International Research Station, Russian Academy of Sciences, Bishkek, Kyrgyzstan

ARTICLE INFO

Article history:
Received 20 December 2011
Received in revised form 13 June 2012
Accepted 13 June 2012
Available online 11 July 2012

Handling Editor: W.J. Xiao

Keywords:
Kyrgyz Tien Shan
Issyk-Kul Basin
Thermochronology
Zircon U/Pb
Tectonics

ABSTRACT

Lake Issyk-Kul occupies a large Late Mesozoic–Cenozoic intramontane basin between the mountain ranges of the Northern Kyrgyz Tien Shan. These ranges are often composed of granitoid basement that forms part of a complex mosaic assemblage of microcontinents and volcanic arcs. Several granites from the Terskey, Kungey, Trans-Ili and Zhetyzhol Ranges were dated with the zircon U/Pb method (SHRIMP, LA-ICP-MS) and yield concordant Late Ordovician–Silurian (~456–420 Ma) emplacement ages. These constrain the "Caledonian" accretion history of the Northern Kyrgyz Tien Shan in the amalgamated Palaeo-Kazakhstan continent. The ancestral Tien Shan orogen assembled in the Early Permian when final closure of the Turkestan Ocean ensued collision of Palaeo-Kazakhstan and Tarim. A Late Palaeozoic structural basement fabric formed and Middle–Late Permian post-collisional magmatism added to crustal growth of the Tien Shan. Permo-Triassic cooling (~300–220 Ma) of the ancestral Tien Shan was unraveled using $^{40}Ar/^{39}Ar$ K-feldspar and titanite fission-track (FT) thermochronology on the Issyk-Kul granitoids. Apatite thermochronology (FT and U–Th–Sm/He) applied to the broader Issyk-Kul region elucidates the Meso-Cenozoic thermo-tectonic evolution and constrains several tectonic reactivation episodes in the Jurassic, Cretaceous and Cenozoic. Exhumation of the studied units occurred during a protracted period of intracontinental orogenesis, linked to far-field effects of Late Jurassic–Cretaceous accretion of peri-Gondwanan blocks from the Tethyan realm to Eurasian. Following a subsequent period of stability and peneplanation, incipient building of the modern Tien Shan orogen in Northern Kyrgyzstan started in the Oligocene according to our data. Intense basement cooling in distinct reactivated and fault-controlled sections of the Trans-Ili and Terskey Ranges finally pinpoint important Miocene–Pliocene (~22–5 Ma) exhumation of the Issyk-Kul basement. Late Cenozoic formation of the Tien Shan is associated with ongoing indentation of India into Eurasia and is a quintessential driving force for the reactivation of the entire Central Asian Orogenic Belt.

1. Introduction

The Tien Shan currently is a more than 2000 km long mountain belt in Central Asia, running from Xinjiang, China in the east to their western counterparts in Kyrgyzstan, Kazakhstan, Uzbekistan, and Tajikistan. The mountain belt is roughly 200 to 300 km wide in north–south direction. Most of the western ranges of the Tien Shan are situated in the Republic of Kyrgyzstan (Fig. 1). This paper deals with the evolution of the Kyrgyz Tien Shan, with a minor amount of samples taken from the most northern ranges in Kazakhstan (Fig. 2). All samples were collected from "basement" rocks (including the crystalline basement sensu stricto, such as metamorphic basement and granitoids). No detrital minerals are used in this study and hence we use the term "basement" in a flexible manner, often implying "non-detrital".

The current, modern Tien Shan orogen developed in the Late Cenozoic, from the Oligocene–Miocene to the present. It currently forms an active intracontinental mountain belt characterized by both fold-and-trust and strike-slip tectonics (Buslov et al., 2003a), developing in between the Kazakhstan (north) and the Tarim (south) microcontinents (Fig. 1). The Late Cenozoic deformation in the Tien Shan can be linked to far-field effects of the continued indentation of

* Corresponding author at: Department of Mineralogy & Petrology, Ghent University, Krijgslaan 281/S8, WE13, B-9000 Ghent, Belgium. Tel.: +32 9264 4564.
E-mail address: Johan.DeGrave@UGent.be (J. De Grave).

1342-937X/$ – see front matter
doi:10.1016/j.gr.2012.06.014

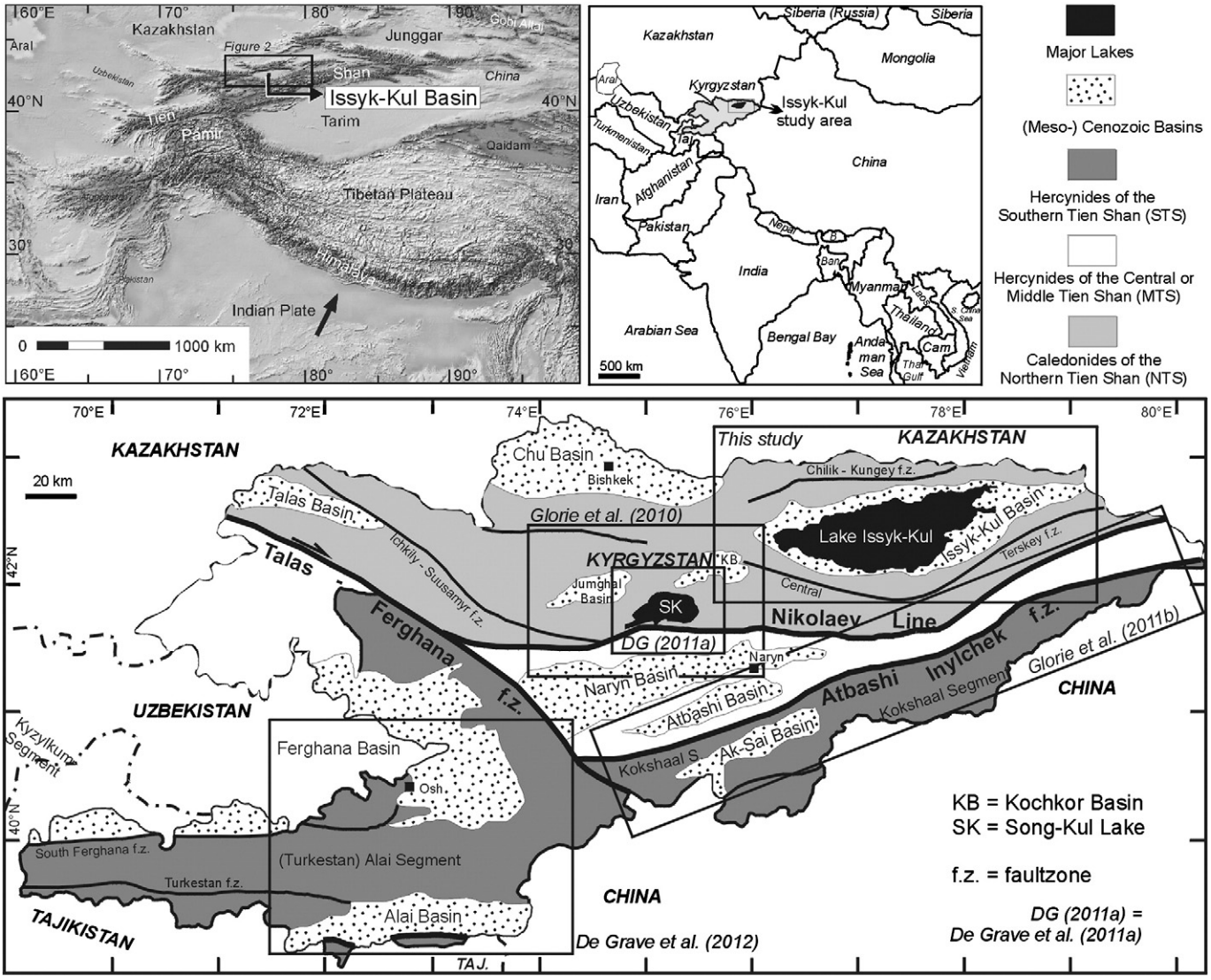

Fig. 1. General location of the Kyrgyz Tien Shan orogen in Central Asia with indication of the Issyk-Kul Basin study area. In Kyrgyzstan the Palaeozoic Tien Shan basement is traditionally subdivided in the Northern, Middle and Southern Tien Shan (NTS, MTS and STS, respectively). The Issyk-Kul Basin and its basement are situated in the NTS; this current study forms part of a broader effort in characterizing the thermo-tectonic history of the Kyrgyz Tien Shan (see outlined boxes).

the Indian continent into Eurasia (Molnar and Tapponnier, 1975). This large-scale collision reactivated the Tien Shan basement structures, eventually building the current intracontinental orogenic edifice. In this broader framework, the Tien Shan forms part of the southern swaths of the vast Central Asian Orogenic Belt (CAOB). More to the north, the CAOB includes other active intracontinental mountain belts such as Gobi-Altai and Altai-Sayan for example. During the Mesozoic, the Tien Shan orogen was subjected to reactivation as distant response to accretion–collision events occurring at the Eurasian margins as well (e.g. Allen and Vincent, 1997; Otto, 1997). These events are cumulatively grouped as the Cimmerian Orogeny, and entail the progressive closure of the Palaeo-Tethyan Ocean and the associated docking of several blocks with Eurasia in a punctuated fashion (Golonka, 2004). Especially the accretion–collision of the Pamir–Tibetan blocks (such as Qiangtang, Lhasa and others) are of crucial importance in relation to the construction of the Mesozoic Tien Shan.

Both the Cenozoic and the Mesozoic tectonics of the Tien Shan mainly transpired through reactivation of more ancient, inherited structures (e.g. Allen and Vincent, 1997; Glorie et al., 2011b). These constitute zones of crustal and lithosperic weakness compared to the more rigid composing basement blocks in the intricate Tien Shan collage. The ancestral Tien Shan basement is predominantly composed of Palaeozoic units that amalgamated throughout the evolution of the so-called Palaeo-Asian Ocean and its sub-basins such as the Terskey and Turkestan Oceans for example (e.g. Windley et al., 2007; Burtman, 2010; Xiao et al., 2010). In this context, the Kyrgyz Tien Shan basement is traditionally subdivided into three units: the Northern (NTS), Middle (MTS) and Southern Tien Shan (STS) (Fig. 1; e.g. Biske and Seltmann, 2010). The NTS contains Precambrian micro-continental units (Kröner et al., 2012), delineated by Cambrian–Ordovician ophiolites, on which Palaeozoic continental magmatic arcs and Meso-Cenozoic basins developed. The NTS is further characterized by large amounts of Early Palaeozoic ("Caledonian"; i.e. Cambrian–Silurian) granitoids which in fact make up a large area of the NTS basement (Fig. 2). Smaller, more isolated Late Palaeozoic ("Hercynian") plutons (Konopelko et al., 2008; Glorie et al., 2010; Seltmann et al., 2011) occur as well. The NTS is separated from the MTS by the Nikolaev Line, a complex Late Palaeozoic sinistral strike-slip fault (Mikolaichuk et al., 1997; Biske and Seltmann, 2010). The MTS basement is mainly composed of Precambrian crust with Neoproterozoic volcanic rocks, covered by Early Palaeozoic sediments and Middle Palaeozoic passive margin sequences. In contrast to the NTS, Early Palaeozoic granitoids are hitherto only described at the southern MTS margin, while Neoproterozoic and Late Palaeozoic plutons are more widely prevalent (e.g. Seltmann et