Tectonophysics 629 (2014) 14–26

Contents lists available at ScienceDirect

Tectonophysics

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

Cenozoic magnetostratigraphy and magnetic properties of the southern Issyk-Kul basin, Kyrgyzstan

Michael R. Wack [a,*], Stuart A. Gilder [a], Euan A. Macaulay [b], Edward R. Sobel [b], Julien Charreau [c], Alexander Mikolaichuk [d]

[a] Department of Earth and Environmental Sciences, Ludwig Maximilians University, Theresienstr. 41, Munich D-80333, Germany
[b] Institut für Erd- und Umweltwissenschaften, Universität Potsdam, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam-Golm, Germany
[c] Centre de Recherches Pétrographiques et Géochimiques, Ecole Nationale Supérieure de Géologie de Nancy 15, rue Notre Dame des Pauvres, 54500 Vandoeuvre les Nancy, France
[d] Central Asian Geological-Geophysical Association, Bishkek, Kyrgyzstan

ARTICLE INFO

Article history:
Received 25 May 2013
Received in revised form 10 January 2014
Accepted 30 March 2014
Available online 12 April 2014

Keywords:
Cenozoic
Magnetostratigraphy
Rock magnetism
Issyk-Kul
Anisotropy of magnetic remanence

ABSTRACT

We present paleomagnetic data from the northern flank of the Tianshan range, southeast of Lake Issyk-Kul (Kyrgyzstan). 613 cores were collected in two parallel sections with a total thickness of 960 m (Chon Kyzylsuu, CK) and 990 m (Jeti Oguz, JO), as well as 48 cores at six sites in a nearby anticline. Rock magnetic analyses identify both magnetite and hematite in the fluvial–lacustrine sediments. The concentration of both minerals, the magnetite:hematite ratio, and the average magnetite grain size increase upward in both sections. Anisotropy of anhysteretic remanent magnetization defines a tectonic fabric with sub-horizontal maximum axes that parallel the strike direction together with intermediate and minimum axes that streak out about a great circle orthogonal to the maximum axes suggestive of a tectonic fabric emplaced during folding. Stepwise thermal demagnetization isolates interpretable magnetization components in 284 samples that define 26 polarity chrons in CK and 19 in JO. A positive fold test, dual polarities and systematic changes in rock-magnetic parameters with depth suggest that the high temperature magnetization component was acquired coevally with deposition. An age model based on a visual magnetostratigraphic correlation of both sections with the geomagnetic polarity time scale defines absolute ages from 26.0 to 13.3 Ma, with a fairly constant sedimentation rate of 9–10 cm/ka. A correlation based on a numerical algorithm arrives at a slightly different conclusion, with deposition ages from 25.2 to 11.0 Ma and sedimentation rates from 5 to 8 cm/ka. In comparison with sedimentation rates found at other magnetostratigraphic sections in the Tianshan realm, we infer that the sedimentary record in this part of the Issyk-Kul Basin precedes the more rapid phase of uplift of the Kyrgyz Tianshan. The onset of deposition and concomitant erosion of the adjacent Terskey Range is in good agreement with independent assessments of the exhumation history of this mountain range, with erosion increasing at 25–20 Ma and accelerating after 11–13 Ma.

1. Introduction

The 2500 km long Tianshan mountain range in central Asia is a product of deformation driven by the India–Asia continental collision superimposed on older episodes of Paleozoic orogenesis (Molnar and Tapponnier, 1975; Tapponnier and Molnar, 1979; Cobbold et al., 1993; Mikolaichuk et al., 1997; Burtman, 2006). Its imposing topography, with peaks up to 7000 m, and a plethora of exposures in a fairly arid environment provide exceptional conditions to study tectonic deformation and mountain building processes. Late Quaternary slip rates and GPS data suggest that deformation is rather continuously distributed across the central Tianshan (Thompson et al., 2002; Zubovich et al., 2010). While the overall compressional deformation regime is evident, the timing and mode of local deformation are much less well understood.

One way to study the uplift and erosion history of a mountain range is to examine the sediments shed from it. Deriving two-dimensional accumulation rates from the sediments and extrapolating them into a three-dimensional volume quantifies the amount and timing of mass removal from the system. For this reason, magnetostratigraphic studies can be extremely useful to develop a precise chronology of otherwise fossil-poor sediments, and ultimately to derive deposition rates. Complimented with ancillary rock magnetic analyses, clues on sediment source and the hydrodynamic regime acting during sedimentation can also be ascertained (Gilder et al., 2001). Such studies are becoming commonplace in the Tianshan range (Bullen et al., 2001; Charreau et al., 2005, 2006, 2009a,b, 2011; Heermance et al., 2008; Huang et al., 2006; Sun et al., 2004, 2009; Sun and Zhang, 2009). Together with fission track cooling ages, these studies converge on the interpretation that the modern phase of Tianshan growth began at around 25 Ma and accelerated around 11 Ma (Abdrakhmatov et al., 2001; Bullen et al., 2001; Charreau et al., 2006; Sobel et al., 2006a,b; Heermance et al., 2008;

* Corresponding author at: Department of Earth and Environmental Sciences, Ludwig Maximilians University, Theresienstr. 41, Munich D-80333, Germany.

http://dx.doi.org/10.1016/j.tecto.2014.03.030
0040-1951/

Li et al., 2011; Macaulay et al., 2014; Macaulay, 2014). Exceptions naturally exist and most of the work has taken place within the Chinese portion of the Tianshan.

To better understand the Cenozoic uplift history of the central part of the Tianshan range, we studied fluvial–lacustrine sediments deposited within the Issyk-Kul basin, Kyrgyzstan. Our intention was to date the fossil-poor strata via magnetostratigraphy and use the magnetostratigraphy to establish sedimentation rates. A suite of rock magnetic experiments on the same rocks was carried out to constrain the magnetic remanence carriers and identify potential changes in sediment composition and depositional environment, and to establish the extent that deformation or compaction may have affected the sediments and paleomagnetic directions.

2. Geology, sampling and methodology

We sampled two parallel sections in the Tianshan Mountains, southeast of Lake Issyk-Kul in Kyrgyzstan (Fig. 1). The sections are located in NNW-trending river valleys, separated by ~13 km. The western section lies close to Chon Kyzylsuu village and the eastern section near the

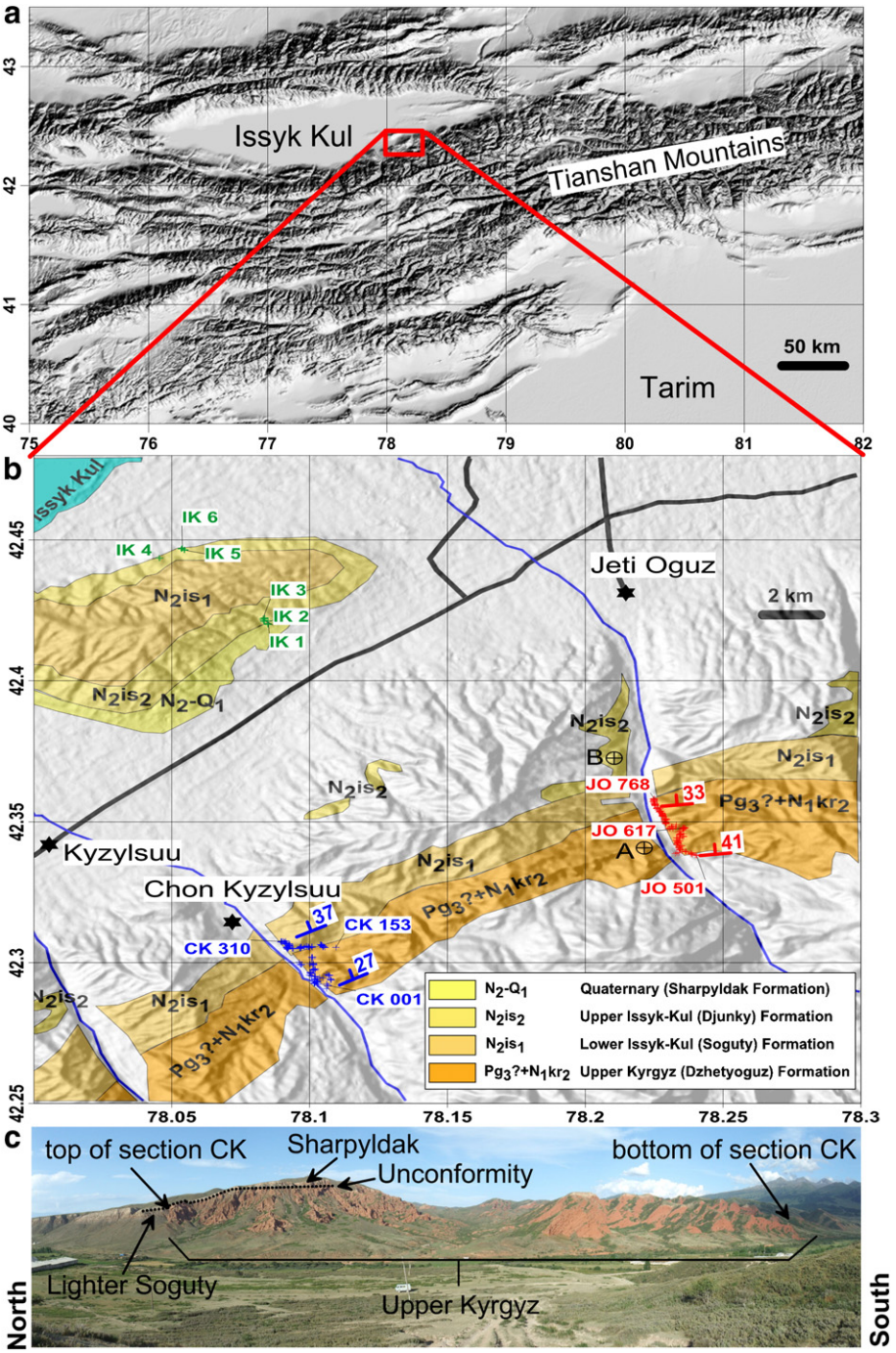

Fig. 1. (a) Topographic map of the Tianshan based on the ASTER GDEM model from METI and NASA. (b) Cenozoic geologic map of the sampling area indicated in (a). The location of every second core from the Chon Kyzylsuu (CK) and Jeti Oguz (JO) magnetostratigraphic sections are shown in blue and red, respectively. Locations of six sampling sites in the anticline north of Chon Kyzylsuu are labeled IK. Formation boundaries follow the regional geological map of Knauf (1965). Pg = Paleogene, N = Neogene, Q = Quaternary, 2 and 3 = Late, 1 = Early. A more detailed stratigraphic column is given in Fig. 2. A and B indicate sampling localities of tortoise fossils that constrain the age of sediments (Ryabinin, 1927; Kuznetsov et al., 1964). (c) Panoramic photo of the Chon Kyzylsuu section (view towards the east). The section is unconformably overlain by Quaternary deposits (Sharpyldak Formation).