Cenozoic tectonics of Central Asia: Basement control

Michael M Buslov

United Institute of Geology, Geophysics and Mineralogy, Siberian Branch - Russian Academy of Science, Novosibirsk, RUSSIA, and Hokkaido University, Sapporo, JAPAN

For correspondence, E-mail: misha@uiggm.nsc.ru, mmbuslov@museum.hokudai.ac.jp

The Paleozoic mosaic-block structure of the Central Asia folded area is formed by isometrically outlined Precambrian microcontinents (Tarim, Tadjik, Issyk-Kul, Junggar, Tuva-Mongolian etc.) surrounded by Paleozoic accretion-collision zones and Late Paleozoic-Early Mesozoic transverse strike-slip faults. The complicated structure of the crust in Central Asia has a strong impact on the distribution of strain induced by the India-Eurasia collision. Most implications are based on the study of reactivated ancient faults (Avouac and Tapponnier 1993). The Cenozoic tectonics of Central Asia strongly inherited the fabric acquired from the pre-Cenozoic evolution: the microcontinents comprising Precambrian-Paleozoic metamorphic and magmatic rocks having lens shape and surrounded by thick zones of Late Paleozoic strike-slip deformation. For a long time during the Cenozoic, the deformation was mainly affecting the zone surrounding the microcontinentes. By now the deformation has resulted in a system of compressed mountain ranges around the microcontinent (**Figure 1**). Precambrian microcontinents are overlapped by Meso-Cenozoic sediments and remained homogenous structure. These homogenous structures in Central Asia were uplifted as a far-field effect of orogeny associated with India-Eurasia convergence. The Cenozoic deformation and modern earthquakes (M> 6) are found to be concentrate around microcontinent edges (Buslov et al. 2003).

Northward propagation of deformation front away from the Himalayan collision zone is suggested by systematic northward rejuvenation of mountains and intramontane basins. This model can be outlined in the following manner:

1. The Eocene initial collision phase (52-35 Ma) in which India collided with Asia, the rise of Pamir plateau, anticlockwise rotation of the Tadjik and Tien-Shan blocks (Thomas et al. 2002).

2. The Oligocene Pamir collision phases (35-20 Ma) during which India thrusts under the Himalaya and Tibet, resulting in the rotation of the latter, and thrusting of the Pamir on the Tadjik microcontinent, anticlockwise rotation of the Tadjik and Tien-Shan blocks, first stage of reactivation of the accretion-collision zones and strike-slip faults around the various Precambrian microcontinents.

3. The Neogene-Quaternary Himalayan thrusting phases (last 20 Ma) in which India is thrusting under the Himalaya and Tibet, peak of Main Central Thrust (MCT) activity, subsidence of the Tarim and Tadjik depressions, Tarim and Tadjik microcontinentes started thrusting under the Tien-Shan, the rise of the South Tien Shan (after 20 Ma), reactivation of accretion-collision zones and strike-slip faults around the Issyk-Kul, Junggar and Tuva-Mongolian microcontinents (after 10 Ma), rise of the North Tien-Shan (peak activity at 10 and 3 Ma) and Altai areas (after 6 Ma, peak activity at 3 Ma). Intensive tectonic activity continued in the Late Pleistocene-Holocene resulting in the formation of the present high-mountain relief of Central Asia.

Figure 1 demonstrates the tectonic scheme of Central Asia with triangle-like peaks of compressed mountain ranges divided by sedimentary depressions including the Tarim ramp basin, Junggar and Inner-Altai semi-ramp basins. Triangle or rhomb-shaped depressions and horsts tend to the NW front of the Tien Shan-Junggar system: (1) the Zaysan, Junggar, Alakol, Chu, Issyk-Kul, Fergana basins, (2) the Saur, western Kyrgyz and Kuramin horsts. The largest oil-bearing basins in the Turan, Tarim, Turfan, Junggar, and Zaysan depressions evolved as intermountain depressions since the Permian-Triassic, mainly in the Late Jurassic-Early Cretaceous. After the Late Cretaceous-Paleogene stage of regional tectonic stabilization, the Neogene-Quaternary stage of active tectonics and sedimentation began. In the Eocene an epicontinental sea existed and was located in the Fergana, Afghan-Tadjik and western Tarim depression. Sea-beach sediments accumulated in the Issyk-Kul depression. Uplifting took place in the territory of the present axial zones of the Himalayas, Karakoram, Hindukush, South Tien Shan, and Pamirs resulting in denudation. Locally, the depressions were filled with molasse. Orogenesis in the Pamirs and South Tien Shan was accompanied by the accumulation of Late Oligocene coarse-clastic continental red sediments. In the Miocene the landscape of the Pamirs and South Tien Shan was dominated by uplifts of up to 3 km elevation and interlying troughs. In the Pliocene climatic cooling was responsible for the change of red molasse to gray molasse as the elevation of uplifts reached 4-5 km. In the Quaternary the further uplifting of the Pamirs caused the development of a typical glacial landscape. Miocene uplifting of the Pamirs and Southern Tien Shan was accompanied by molasse depositing in the Fergana, Afghan-Tadjik, Issyk-Kul and other depressions. In the Late Pliocene-Middle Pleistocene a thick series (over 1.5 km) of alluvial pebble-stone deposits formed. At that time, the faults were reactivated mainly as strike-slip faults or reverse faults.

Deformation of SW Altai (Zaysan basin) began in the late Eocene, after a widespread Late Cretaceous-Pleistocene period of erosion and peneplanation. The paleogeographic environment in the Zaysan basin changed from a marginal sea during the Late Cretaceous-Pleistocene, to an intracontinental lake in the Late Eocene-Early Oligocene. Movement of the Junggar microcontinent and rotation of the Tuva-Mongolian microcontinent induced regional uplift of the Altai Mountains. The structure of the Altai Mountains is interpreted as a result of the reactivation of Paleozoic accretion-collision zones and faults between the Junggar and Tuva-Mongolian microcontinents (Dobretsov et al. 1996, Buslov et al. 1999). The faults were reactivated mainly as strike-slip faults or reverse faults. The Junggar microcontinent subsided beneath the Altai together with the Zaysan basin. This induced several tectonic phases recorded along the margin of the Zaysan depression: Middle Eocene (40-35 Ma), Middle Oligocene (30-25 Ma), and Late Miocene-Pliocene (6-3 Ma). In the Chuya depression (at the NE-margin of the Altai and Tuva-Mongolian microcontinent) tectonic pulses occurred in the Late Oligocene (28-23 Ma) and Late Pliocene - Early Pleistocene (3-2 Ma). Periods of relaxation between the tectonic phases are recorded by lacustrine carbonaceous clay sedimentation in extensional setting during the Lower-Middle Miocene in the Zaysan basin and the Upper Miocene in the Chuya basin. In the Middle Eocene, the SW-area of the Altai uplift formed in the frontal part of the Junggar microcontinent. In the Late Pliocene, deformation reached the NE-margin of Altai.

The Altai range has a modern block structure, with flat plateaus separated by thrusts and oblique-reverse faults. The most contrasting deformation took place around Altai and resulted in the formation of conjugated grabens, ramps and horsts. In the Middle Miocene, the northern part of the Junggar basin subsided northward, turning the Zaysan depression into a half-graben. In the Upper Miocene, the graben of the Chuya depression formed. The Altai area was fragmented into alternating mountains ranges and intramontane depressions starting in the Late Pliocene - Early Pleistocene.

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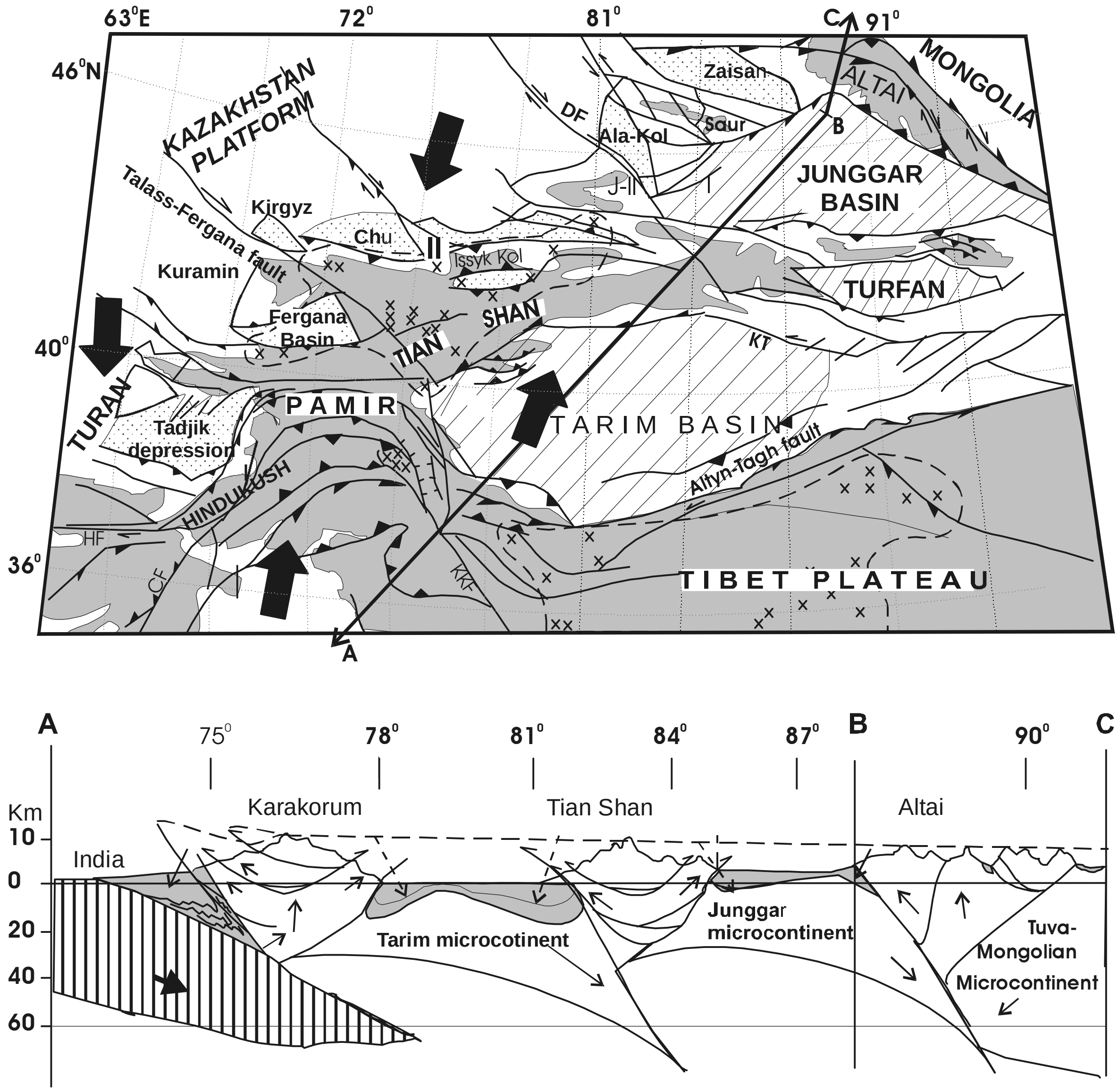

FIGURE 1. Tectonic scheme and cross-section of the Central Asia. Diagonal crosses show the localities of mantle plume basalts. Thick arrows show the main direction of compression. Schematic cross-section from the India continent to the Altai mountain range (line ABC). Vertical stretching shows the Indian plate crust, dots-sediments. Grey tone show the mountain range (more 2000 m) on tectonic scheme and the sediment basin on the cross-section