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Cenozoic tectonics and climate of Central Asia

M. Buslov (1), J. De Grave (2), V. Zykin (1)

(1) Institute of Geology, Siberian Branch of the Russian Academy of Science, Novosibirsk, Russia, (misha@uiggm.nsc.ru / Fax: +7 3832 333584) (2) Mineralogy & Petrology dept., Ghent University, Ghent, Belgium (johan.degrave@ugent.be / Fax: +32 9 2644984)

Recent Cenozoic tectonics data of the Central Asian mountains infers three deformation phases. The driving forces for this tectonic deformation were transmitted over great distances from the India-Eurasian collision zone. The impact of the collision and ongoing convergence resulted in reactivation of the inherited structural fabric. The Central Asian crust comprises rigid fragments or microcontinents (Tarim, Issyk-Kul, Junggar, Tuva-Mongolia) overlain by thick Cenozoic deposits. The rigid fragments are sutured by mobile belts or by fault zones in ancient accretion-collision belts. The pre-existing sutures form the prime reactivation sites during the Cenozoic deformation phases that were each accompanied by growth of mountain ranges and climatic changes. Proxies for these events are found in many Central Asian lacustrine basins. North Eurasian orography and climate changes in turn, are well correlated with the Central Asian deformation phases and are also recognized in lake sediments.

The first phase (55-35Ma) started soon after Indian collision with incipient building of the Himalayas, Tibet and (possibly) the South Tien Shan. Modest deformation is detected further north. The Central Asian climate started cooling $\sim$35Ma ago as seen in the floral/pollen fossil record and the associated vegetation zoning. An abrupt temperature-drop of $\sim 10^{\circ}$C occurred with respect to warm Mesozoic conditions.

The second phase (35-5Ma) was manifested after continued India-Eurasia convergence resulted in the formation of high mountain ranges in Tibet, the entire Tien Shan, Junggar, and Altai-Sayan. Coarse sediments fill the Central Asian lake basins during this phase. The deformation zone hence propagated north over thousands of kilometers from India over Tien Shan, to Altai-Sayan, even to the Baikal rift zone. During this phase, further climatic cooling in the Oligocene (34-25Ma) has been inferred from paleoclimatic data from the Russian platform and West-Siberian Basin. Sub-aerial

reddish carbonate-rich clay and loam and aeolian sediments typical of arid climate are widespread in the low-hilly Early Oligocene environment of Central Asia. This increasing aridity and cooling coincides with the extinction of many (sub)tropical lacustrine mollusk species in the Zaysan depression for example. In the Late Oligocene further aridization led to the formation of modern-type deserts in the Zaysan depression with desert-pavement-surfaces, carbonate weathering crusts, wind-shaped sedimentologic structures and features. Tectonic deformation and relief-increase continued in the Miocene (25-5Ma) and resulted in a mountainous landscape in a cool, often arid climate and an associated characteristic biocoenosis spread over Eurasia.

The third phase (5-0 Ma) is shown in an EW-striking belt up to 600 km wide, extending from the Pamir indenter to the southern margin of the rigid Siberian craton. The latter acts as a giant backstop to deformation. This phase resulted in simultaneous growth of high mountains between the Pamirs and southern Siberia. A continuous climate change record in Central Asia for the past 5 Ma was obtained by coring and drilling of Lake Baikal sediments. Two cooling peaks (2.8-2.4 and 1.8-1.5 Ma) were recorded in the sediments as witnessed by diatomic algae, clay/sand ratios, sediment density and water content, magnetic characteristics, organic/non-organic chemistry, granulometry, and palynological features.

The Cenozoic building of the vast Central Asian intracontinental mountain system changed regional and even global atmospheric circulation, positioned a huge area above the snow-line, increasing solar reflection, and ultimately resulting in climatic cooling. In particular since the Late Pliocene the high mountains became an effective barrier between cold northern Eurasian and warm southern airflows primarily from the Indian Ocean. Warm air could not longer reach northern Central Asia and Siberia, resulting in strong temperature fluctuations typical of the modern continental climate and in steep, semi-desert landscapes typical of an arid climate.