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Late Carboniferous - Early Permian intracontinental orogeny in the eastern part of the Altai-Sayan fold zone (South Siberia, Russia): structural data and 40Ar/39Ar geochronology

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The Tunka terrane is situated along the East Sayan Range, in the easternmost area of the Altai-Sayan fold belt, which in its turn is located at the southern border of the Siberian continent. The geology of the Tunka terrane is characterized by a complicated thrust-and-fold structure in Early Palaeozoic metacarbonate, metaterigenous and metavolcanic rocks. This structure originates from the Ordovician collision of the Siberian continent with the Tuva-Mongolia microcontinent. However, klippes of tectonic nappes of post-Devonian age are known in the region: for example in the Carboniferous Sagansair Formation. The age of the Main Sayan Fault, the most prominent large-scale regional structure that delineates the boundary between Siberia and the Tunka terrane, is Late Carboniferous as well.

In the Tunka terrane, the area near Arshan was investigated in this study. In this area several tectonic nappes can be distinguished. Most of them are folded into an antiform structure, with a hinge line striking in E-W direction. The nappes include: (1) metacarbonate rocks of the Cambrian Gorlyk and Tolta Formations, (2) metaterigenous and metavolcanic (greenschist) rocks of the Upper Shumak Formation, (3) gneiss units containing garnet amphibolites. Three tectonic stages could be discriminated based on structural observations and Ar/Ar chronology. For the latter, we used syntectonic muscovite, biotite and amphiboles for dating. The nappe-system was formed in the first tectonic stage, the thrust stage, with an age of 315.2 $\pm$ 3.5 Ma to 316.0 $\pm$ 3.2 Ma (on amphibole mineral lineation). This is confirmed by a biotite age of 310.7 $\pm$ 3.0 Ma of the foliation S1 in the greenschist nappe. The second stage is a fold-thrust stage, involving the entire sequence and responsible for the formation of the antiformal structure, with folds (F2) (sub)parallel to the hinge line strike. Different types of rotation structures (mineral and mineral cluster lineation, syntectonic porphyroblasts with snow-ball structures and asymmetric pressure shadows) in marbles, gneiss and garnet mica-schists originated from flexural-slip folding in this stage. Biotite from a quartz-garnet-biotite schist in the antiformal core yielded an Ar-age of 303.1 $\pm$ 3.0 Ma, constraining this second tectonic stage. The third stage involves folding and strike-slip deformation that resulted in the segmentation of the fold-and-thrust structure into several wedge-shaped tectonic blocks, bounded by steeply dipping strike-slip faults (dextral in the north of the antiform, sinistral in the south). These wedge-shaped blocks in the core of the antiform were wrenched westward by this fault activity. Folds with steeply dipping hinges and steeply dipping foliation, S3, were formed in this third tectonic stage. Amphiboles from the S3 planes were dated to 286.8 $\pm$ 4.8 Ma.

In summary, we can state that the region underwent strong N-S compression in the Late Carboniferous – Early Permian in an intracontinental setting, far away from continental margins. The driving mechanisms are thought to be related to far-field effects of a large regional collision event, reactivating the Ordovician orogen. This is much in analogy to the modern intracontinental Central-Asian and Siberian orogenic systems (e.g. Tien Shan), that are reactivated in an intracontinental setting as a consequence of distant tectonic effects of India-Eurasia convergence.