$^{40}Ar/^{39}Ar$ mineral ages from basement rocks in the Eastern Kunlun Mountains and their tectonic implications

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$^{40}Ar/^{39}Ar$ dating was carried out on basement rocks of the Eastern Kunlun Mountains, China. Samples from the Jinshuikou, Xiaomiao, Kuhai, Wanbaogou, and Nachitai Groups revealed distinct metamorphic events and four age groups. The age group of 363–439 Ma is interpreted to represent cooling after Silurian-Late Devonian granulite (?) and amphibolite facies metamorphism, which is dominated by low-middle pressure/high temperature conditions. This tectono-thermal event is related to the closure of an oceanic basin or marginal sea. An age group of 212–242 Ma represents cooling after Indosinian (Late Permian to Triassic) metamorphic overprint, which was probably associated with magmatic intrusions, too. This thermal event, together with the Permo-Triassic ophiolite zone along the South Kunlun fault, points to the closure of a major ocean (between India and Eurasia) and the eventual N-ward accretion of the Qiangtang block to Eurasia in Permo-Triassic times. The significance of the age group of 104–172 Ma is interpreted to be related to ductile deformation along the Xidatan fault due to the northward-directed accretion of the Lhasa block. Biotites from Nachitai record a partial isotopic resetting at ca. 32 Ma that is interpreted to represent a late-stage exhumation caused by further crustal shortening.

The P-T conditions were calculated with version 2.75 of the program THERMOCALC and dataset 12/97. Metamorphism of the Jinshuikou Group is dominated by amphibolite facies conditions with local granulite facies relics as observed in this study. Widely distributed granitic gneisses record amphibolite facies metamorphism with P-T conditions of 4.8-6.3 kbar and 638-687 °C. Within these granitic gneiss there are scattered relics of granulite, a sample gave P-T conditions of 4.5 kbar and 826°C. Samples from Tiantaishan record two metamorphic stages. The two assemblages gave P-T conditions of 11.5 kbar and 900 °C for the mineral core paragenesis and 9.0 kbar, 683 °C for the rims. The former P-T condition is interpreted to represent the early granulite facies metamorphism; the latter to represent either a protracted stage on the uplift path or an entirely different metamorphic cycle. The calculated temperatures of a granulite sample strongly depend on the assumed H_2O activities, from ca. 1020 °C for unit activity to ca. 725 °C for a water activity of 0.1. The calculated pressures are about 7 kbar, though not precise, and do not depend on the assumed H_2O activity. In summary, the calculated P-T conditions indicate that the Jinshuikou Group suffered two metamorphic stages, an early stage granulite facies metamorphism followed by amphibolite facies metamorphism, both indicating a rather high geothermal gradient.

The calculated P-T conditions of samples from the Xiaomiao Group suggest that the metamorphic peak in the Xiaomiao Group falls into the upper amphibolite facies field at different pressure conditions. The metamorphic overprint of the Kuhai Group is within lower amphibolite facies conditions but most rocks of the Kuhai Group have suffered retrogression under greenschist facies metamorphic conditions. The minerals separated for $^{40}Ar/^{39}Ar$ dating (biotite, muscovite and hornblende) are first generation minerals from samples that show only minor retrogression. The metamorphism of rocks exposed within the Wanbaogou and Nachitai Groups is within low-grade, greenschist facies conditions with P-T conditions of 535 °C at medium, poorly constrained pressures. There is no indication for the occurrence of an earlier higher grade metamorphism.

In conclusion, the metamorphic grade decreases from north to south in the study area. Granulite facies metamorphic relics occur only to the north of the Central Kunlun Fault. Amphibolite facies conditions are widely distributed north of the Central Kunlun Fault, south of the Central Kunlun Fault only the Kuhai Group suffered amphibolite facies metamorphism. To the south of the Central Kunlun Fault only greenschist facies metamorphism has been observed (Wanbaogou and Nachitai Groups) and also the Kuhai Group is strongly overprinted at greenschist facies metamorphic conditions.

Our geochronological studies, combined with regional metamorphic P-T conditions studies, give more constraints on the tectonic history of the Eastern Kunlun Mountains and have important tectonic implications for the formation of the Kunlun Mountains. In particular, they emphasize the overall importance of Silurian-Late Devonian tectonic events for the formation of this segment of Inner Asia.