Tectono-metamorphic events along a transect of the Altun Shan: timing, conditions and tectonic implications

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The Altun Shan (Altyn Tagh) mountain range of Western China separates the Tibetan plateau from the Tarim basin foreland to north. The Altun Shan is a transpressional feature, which branches off the Kunlun mountain belt and harbors the ca. 1800 km long Altyn fault that shows a cumulative post-Jurassic sinistral offset of ca. 300-400 km. Apart from this young tectonics, little is known about the evolution of this boundary structure of the Tibetan plateau.

We studied the transect across the Dangjinshankou pass, along the main road from Aksay (eastern Gansu province) into the Qaidam basin. Along this section two major shear zones can be discerned, a northern brittle fault with > 100 m thick kakirites, which delimits metamorphic rocks of the Altun Shan to alluvial fan sediments in the north. The southern one follows a prominent valley and is characterized by low-grade, retrograde metamorphic rocks. South of the pass, again medium grade metamorphic rocks crop out.

The northern zone displays a general increase in metamorphic grade from lower greenschist facies to amphibolite facies conditions, from the biotite zone to garnet-in and finally staurolite-in. The stable occurring alumosilicate phase is sillimanite. Average PT calculations (ThermoCalc) gave 6 kbar and temperatures increasing from 550 °C (garnet zone) to 615 °C. The ductile shear zone displays lower greenschist metamorphic conditions, below biotite-in. In extension veins growth of laumontite could be observed. Relics of former higher metamorphic grade are phengite-poor cores of white mica that are overgrown by phengitic rims (3.1 vs. 3.3 Si p.f.u.). The southern unit shows a two-stage metamorphic evolution, both within amphibolite facies conditions. The paragenesis of metapelites comprises mu+bt+gt+stau+plag. The stable alumosilicate of the older paragenesis is kyanite, of the younger one sillimanite. Garnet shows flat major element distributions in the core, then a strong increase in Mg/Fe-ratios. Also staurolite occasionally shows rims with higher Mg/Fe-ratios. Metabasic rocks display the paragenesis amph(act, Al-ts, Mg-hbl)+plag+grt+bt+mu. Garnets show increasing Mg/Fe-ratios and Ca-rich rim overgrowths, plagioclase An-poor rims and replacement of plagioclase by muscovite. Average PT conditions are ca. 620 °C and 7 kbar for the first event, ca. 550 °C and 6 kbar for the overprint.

Along this transect, four $^{39}Ar/^{40}Ar$ age groups are evident: (1) ages of ca. 450 Ma (mu: 445.1 ± 1.9 Ma, 453.8 ± 1.9 Ma, 449.3 ± 1.9 Ma, 448.9 ± 1.9 Ma; bt: 455.4 ± 1.9 Ma, 461.0 ± 1.9 Ma, 447.8 ± 1.9 Ma, 450.7 ± 1.9 Ma, 409.8 ± 1.8 Ma) between the two shear zones; (2) ages of ca. 165 Ma in rocks straddling the southern shear zones (mu: 167.6 ± 0.8 Ma; bt: 162.9 ± 0.8 Ma); (3) ages down to ca. 30 Ma within the latter shear zone; and (4) ages of ca. 350 Ma (mu: 352.0 ± 1.5 Ma; bt: 342.7 ± 1.5 Ma, 354.7 ± 1.5 Ma, 370.1 ± 1.6 Ma) in metamorphic rocks of the southern zone. A muscovite concentrate from the southern shear zone gave a somewhat disturbed age spectrum with a total gas age of 32.4 ± 0.4 Ma, one other of 251.9 ± 0.4 Ma with ages increasing in steps from ca. 120 to 300 Ma. A K-feldspar from the northern boundary of the shear zone shows a stair-case pattern with ages from ca. 32 Ma to a plateau at 137.5 ± 0.6 Ma. Hornblende from the southern unit yielded a total gas age of 426.4 ± 1.7 Ma.

These data allow to discern four distinct tectono-metamorphic events in the area. A major Ordovician (about 450 Ma) metamorphism and cooling, which is a major event in a regional context. A second, late Devonian-early Carboniferous (about 350 Ma) event south of Dangjinshankou, that overprinted a paragenesis belonging to the first phase probably. Within the Altun Shan, a mid-Jurassic event (ca. 165 Ma) is observable, and finally a strong retrograde metamorphism and shearing at about 30 Ma, which represents a ductile precursor fault to the active Altyn Tagh fault.