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The Qaidam basin in Western China: monitoring Himalayan-Tibetan tectonics and climate evolution

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We studied the formation of the unique intracontinental, intermontane Qaidam basin (Western China) in relation to the formation of surrounding Altyn, Kunlun and Qilian mountain belts at the northeastern edge of the Tibetan plateau. This region accommodates in part India-Asia convergence by eastward lateral extrusion and internal shortening of the Qaidam block. The Qaidam basin covers ca. 120,000 square kilometers, and comprises a maximum 16, in average 6 – 8 kilometers thick basin fill. It was initially formed during Paleocene/Eocene, started to subside mainly during early Oligocene, is active at present comprising up to ca. 3,500 meter thick Quaternary sediments, and displays prominent Pliocene to Recent contractional deformation, which resulted in folds and thrusts. The basin floor shows crustal scale folding with a wave length of ca. 30 - 40 kilometers. This suggests an unusually strong rheology of the deeper crust, likely due to predominance of mafic rocks. These relationships suggest the peculiar feature of the Qaidam basin, which must have a much rheologically stronger crust than adjacent mountain ranges.

The surrounding Altyn, Kunlun/Qimantagh and western Qilian mountain belts were deformed and uplifted during the same Eocene/Oligocene to Recent time interval. They include the sinistral Kunlun and Altyn faults which partly accommodate N-S convergence by eastward lateral extrusion. $^{40}Ar/^{39}Ar$ age dating combined with structural studies give evidence of a major Oligocene ductile shear zones as precursor faults of the present-day Altyn and Kunlun faults, and evidence their significance for the formation of the Qaidam basin.

Because of entirely interior (endorheic) drainage of the Qaidam basin, the volume of denuded mountains largely balances the amount of sediments in the basin. Detailed work on detrital mode of sandstones display exclusively orogenic sources with nearly no variation through time. Only the biotite content increases towards Quaternary monitoring increasing aridity with time. $^{40}Ar/^{39}Ar$ age dating of single, detrital muscovite grains show exclusively late Neoproterozoic, Late Ordovician-Silurian and late Permian/Triassic sources, which can be found in adjacent mountain belts.

The Sr isotopic composition of carbonates does not show any variation through time. Stable oxygen and carbon isotopic compositions of Eocene to Quaternary carbonates monitor regional climate change, mainly increasing aridity and some tectonic events due to the uplift of Tibetan-plateau. Major tectonic steps are during middle Oligocene (ca. 30 Ma), early Miocene (ca. 20-18 Ma), and late Pliocene/early Pliocene. In this later step sharply increasing aridity resulted in deposition of evaporates.

The folded Neogene and Quaternary sediments with its unusual characteristics, e. g. high thickness and tension gashes filled with halite, gypsum or coelestine, allow characterizing the stepwise Pliocene and Quaternary shortening due to transpression and lateral extrusion. Field relationships suggest the following succession of palaeostress orientation tensors, from which D_3 to D_5 are relevant for the final structure of the basin. Normal faults of the D_2 deformation stage are overprinted by N-S and ca. E-W trending strike-slip faults and by NE-trending thrust faults which indicate together NNW-SSW to NW-SE contraction. The overprint of the Qigequan Formation examines the Pleistocene age of deformation. Deformation stage D_4 includes N- and S-dipping thrust faults and WSW-trending sinistral and N- to NNE-trending dextral strike-slip faults suggest ca. N-S to NE-SW contraction. This stage indicates clockwise orientation of the maximum principal stress σ_1 in accordance with results of palaeomagnetic investigations. Deformation stage D_5 is characterized by NE-SW trending dextral and WNW-ESE trending sinistral, in part active strike-slip faults, which argue together ca. E-W contraction. Such faults are common in the western Qaidam basin. A few faults along active E-trending fault traces show Recent stress conditions.

Together, the palaeostress data are characteristic for an extrusional wedge which moves out of the zone of maximum contraction. Clockwise rotation of the principal maximum shortening direction from NW-SE (D_3) over N-S (D_4) to NE-SW to final overall shortening including E-W contraction (D_5) is due increasing inhibition of contraction by resistant forces.