Linking basin fill with mountains by isotopical and compositional constraints: a case study from the Cenozoic Qaidam Basin, China

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The Qaidam Basin is a ca. 120,000 km^2 large intracontinental sedimentary basin at the northeastern margin of the Tibetan Plateau. It contains a thick Mesozoic to Cenozoic sedimentary sequence. The entirely terrigenous Cenozoic sequence was the subject-matter of a PhD-study, of which this abstract gives a summarizing overview.

Paleogeographic relationships can be monitored by $^{40}Ar/^{39}Ar$ dating of detrital white mica and classic provenance analysis. Detrital material in the internally drained Qaidam Basin monitors changes induced by either tectonic or climatic events. The sediments can be of a northern (Altyn Mountains), southern (Qimantagh/Kunlun Mountains) and/or eastern (Qilian Mountains) provenance. $^{40}Ar/^{39}Ar$ dating of detrital white mica single grains yielded several ages groups. These include: (1) ca. 350–450 Ma, (2) 220–280 Ma, subordinate clusters with (3) 122–140 Ma and (4) a minor group around 500 Ma. Ages between 350 and 450 Ma are most frequent in the western part, while an eastern section revealed solely Permian ages (220–280 Ma). The dominating age group of 350–450 Ma in the northwestern part of the Qaidam Basin is well known from intrusions in the Altyn Mountains while the young ages (120–126 Ma) have been found within shear zones along the Central Kunlun and the Altyn Tagh fault. However, hinterland sectors beyond the Altyn Tagh and Central Kunlun faults have to be considered as potential source areas as well. Early Paleozoic ages (~500 Ma) have so far only been documented in the Hongliugou suture zone north of the Altyn Tagh fault. This suggests late or slow continuous uplift of the southern Altyn range. Because of sinistral strike-slip along the Altyn Tagh fault, further units of the same age now exposed farther westwards may also be taken into account. The dominance of the uniform ages of 220–280 Ma along the eastern basin margin indicates that Permian tectonic units are likely more widespread at the north-eastern margin of the Tibetan Plateau as known at present. This is inconsistent with the present hinterland, which is composed of early Paleozoic metamorphic units with subordinate early Paleozoic and few Permian granites. The preferred explanation is that the Qaidam block represents a rigid indenter, which indented into early Paleozoic orogenic units along the future Qilian Mountains during late Tertiary times. This explanation is consistent with a finding of a

NW-trending sinistral Permian ductile shear zone and a dextral, NW-trending Tertiary fault system close to the north-eastern margin of the Qaidam Basin.

Together with the age-distribution of detrital mica classical point-count analysis helps to identify probable provenance areas for the sediments. Based on the moderate sorting of the sandstones and the subangular grains, one can conclude on relatively short transport distances. This is further supported by the immaturity of the sandstones, indicated by a high proportion of feldspars and lithic fragments. They have quartz contents between 29–65 %, averaging between 40 and 45 %. Given the high amount of 25–40% of matrix material the sandstones are classified as wackes. Despite variable climatic conditions during the Cenozoic no significant changes can be observed in framework constituents within the sandstones. Alone mica contents are increasing with time and proven higher aridity during the Neogene.

Carbon and oxygen stable isotopic composition of Eocene to Pleistocene lacustrine carbonates yield cycles of variable length and show several distinct events related to tectonics and climate changes. From Eocene to Oligocene, the general all-over trend in the $d^{13}C$ data shows a shift towards positive values, possibly related to higher proportions of the dissolved inorganic carbon transported to the lake, which existed in the Miocene. During the same period, the $d^{18}O$ values are decreasing in accordance with the global cooling trend. During the Miocene, large and distinct events can be recognized, although their interpretation and linkage to a certain tectonic event remains difficult. Isotopic patterns, such as positive and negative excursions are concomitant with uplift of the Himalayas at 24 Ma, the strongest phase of uplift in the Altyn Mountains at 19–18 Ma and the pronounced subsidence of the Qaidam Basin at ca. 12 Ma. The positive $d^{13}C$ excursion from 7–5 Ma may be related to the apparition of C4 plants on land. Generally cold, highly evaporative environmental conditions are starting in Pliocene and Quaternary times, as can be deduced from $d^{18}O$ data.

This case study shows that a combination of different methods can lead to an enhanced understanding of basin formation processes.