Stable Isotopic Constraints on Paleoelevation and Paleoclimate along the Northern Margin of the Tibetan Plateau

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In this study we present oxygen isotope data from thirteen terrestrial records that span the northern margin of the Tibetan Plateau, including Tarim and Qaidam Basins, Hexi Corridor, and the Altun Shan. Oxygen isotope values from the analysis of 1475 samples of paleosol, lacustrine, fluvial, and alluvial carbonate, yield $\delta^{18}O$ values that range from 13.1 to 38.9‰ (SMOW). In these data we identify a Paleogene decrease in oxygen isotope values and a Neogene increase in oxygen isotope values (Fig. 1).

We interpret the Paleogene trend, in which oxygen-isotope values become less variable and decrease 1-3‰, to result from a change from disorganized, low-gradient depositional environments with diverse water sources, to more integrated and mountainous source areas. In most sections, this isotopic shift occurs in conjunction with a lithologic transition from mostly finer-grained mudstone, siltstone, and sandstone to coarser-grained sandstone and conglomerate. The finer-grained sediments were deposited in playa, lacustrine, and meandering fluvial depositional environments, where oxygen-isotope compositions of waters may reflect a variety of water sources in absence of a single major integrated drainage system. Waters in these types of environments are likely to further evolve with evaporative effects, evidenced in the study areas by the formation of evaporite minerals. As grain sizes increase upsection to sandstone and conglomerate deposited in braided fluvial and alluvial fan environments, oxygen-isotope average values and variability decrease. Because the isotopic change is associated with a sedimentological change to higher energy deposits, we believe that the isotopic change most likely occurs with the transition to a more regionally integrated drainage system with less-variable source waters, that may record an isotopic signal of uplift south of the study area itself, probably in the region of the northern Qiangtang terrane and Fenghuoshan (Wang and others, 2008). Furthermore, with the transition to fluvial depositional environments, we expect there to be less extreme evaporation than in the playa and lacustrine facies downsection. This decrease in oxygen isotope variability causes mean oxygen isotope values to decrease.

We interpret the Neogene isotopic trend, in which both oxygen and carbon isotopic values increase through time, to result from the uplift of basin-bounding ranges in the study region itself, with ranges blocking moisture sources to the region and increasing aridity and evaporative effects. The uplift of basin bounding ranges in this region is supported by a change to depositional environments that include high-energy braided fluvial and alluvial fan deposits, with paleocurrents showing the establishment of strong unimodal drainage systems from adjacent ranges, similar to the modern drainage systems. Uplift at this time is also shown by an increase in elevation in some Tarim study areas from sea level to their current elevations (~1400 m), beginning as late as the early middle Miocene in the Miran River section (Ritts and others, 2008). The contribution of evaporative effects to the isotopic record is indicated by the presence of aeolian and evaporite deposits, extreme oxygen and carbon isotope values ($\delta^{18}O$ up to 39‰ in Lenghu), and covariation between oxygen and carbon isotope values (Kent-Corson and others, 2009)

The isotopic data presented in this study provides additional evidence for a transition in tectonic style along the northern margin of the Tibetan Plateau in the early to middle Miocene from accommodation of convergence through plate-like escape along the Altyn Tagh Fault to accommodation of convergence through distributed shortening and crustal thickening (Yue and others, 2003; Ritts and others, 2008). The early to middle Miocene initiation of mountain building in this region also significantly postdates isotopic predictions for the attainment of high elevations on the central Tibetan Plateau (e.g. Rowley and Currie, 2006; DeCelles and others, 2007), and predates isotopic evidence for the contribution of high elevation waters to study areas along the Tian Shan to the north (Graham and others, 2005; Charreau and others, in review), consistent with differential uplift of the Tibetan Plateau.

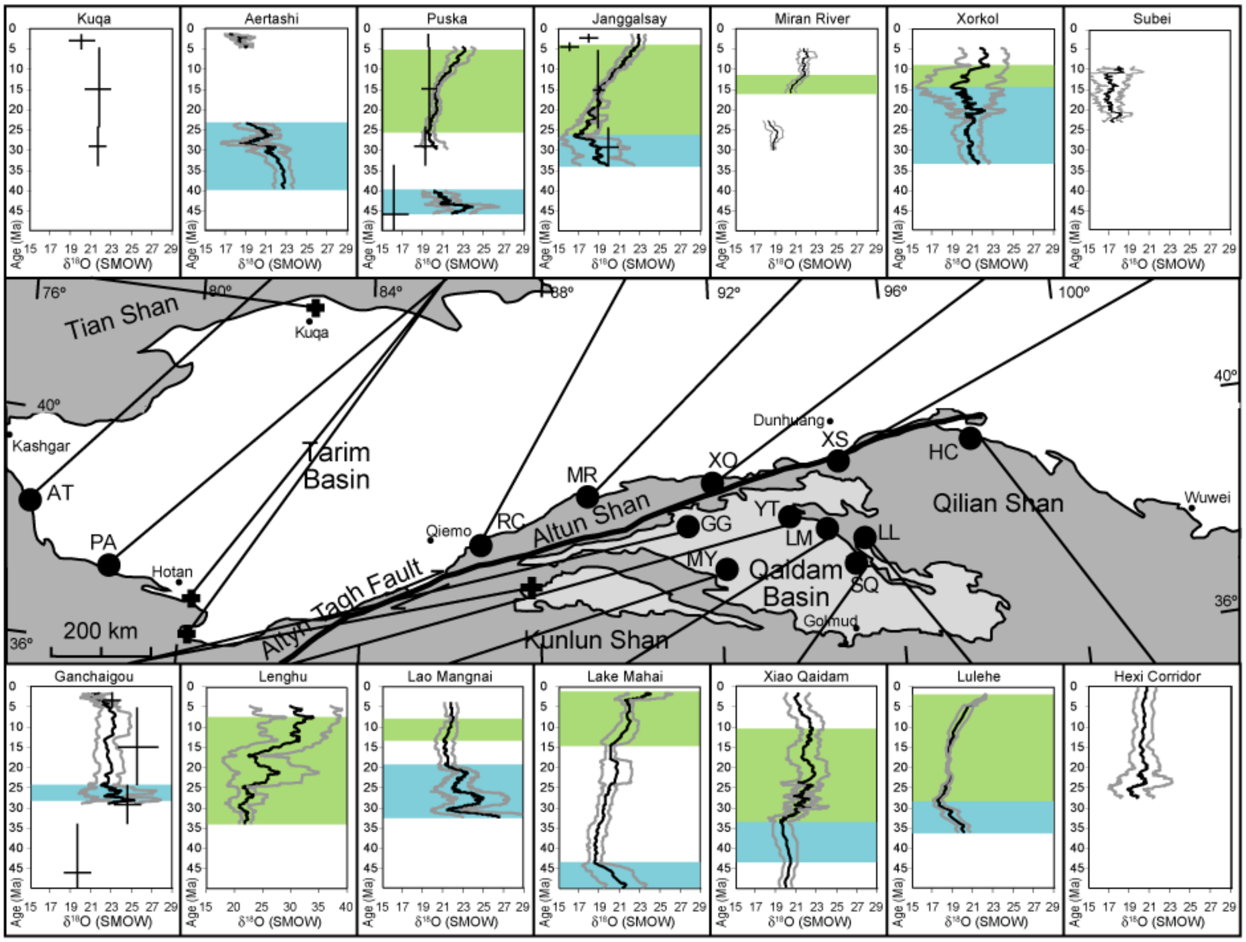

Figure 1. Oxygen isotope data plotted with age. Nine-point running average is shown by black line, and running standard deviation is shown by gray lines. The two trends are shaded, with the "Paleogene" trend shown in blue, and the "Neogene" trend shown in green. Data from Graham and others (2005) are shown with crosses.

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