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Stratigraphic architecture of the Miocene foreland basin deposits of the Southern Alborz mountains (N Iran): tectonic versus climatic external forcing

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The Alborz mountains of N Iran constitute an intracontinental, double-verging orogen related to the Arabia-Eurasia continental collision. The range is located between the aseismic South Caspian Basin and Central Iran. The steep flanks with peak elevations in excess of 4.5 km comprise an efficient orographic barrier to moisture sourced in the Caspian Basin, with northern slopes receiving up to ca. 2 m/yr of precipitation and southern slopes receiving less than 0.3 m/yr. Here, we summarize our work on sedimentary facies analysis, magnetostratigraphy, structural observations, thermochronology, and stable isotope analysis of soil carbonates to decipher the paleo-environmental evolution of the Alborz foreland in relation to tectonic and climatic forcing associated with orogen evolution.

The southern foreland basin of the Alborz is composed of three coarsening upward units (Unit 1, 2 and 3), including lacustrine and fluvial/alluvial deposits of the Upper Red (17.5 to 7.6 Ma) and the Hezardarreh (7.6 to 6.2? Ma) formations. To a first-order approximation long-term sediment-accumulation rates (105-106 yr) show a systematic correlation with sedimentary facies pattern, with fine-grained facies corresponding to higher accumulation rates (0.8 to 2 mm/yr; base of Unit 1, 2 and 3), and coarser facies to lower rates (ca. 0.3 mm/yr; top of Unit 1 and part of Unit 2). Within this trend, however, moderate to relatively high sediment-accumulation rates are associated with coarse-grained facies deposition (ca. 0.6 mm/yr top of Unit 2 and 3), suggesting a more complex setting. This progradation of sedimentary facies apparently coincides with wetter climatic phases and climate variability (105-106 yr), which occurred within an overall arid climate regime as suggested by stable oxygen isotope values obtained from pedogenic carbonates ($-3‰$ and $-2‰$ isotopic shift on pedogenic carbonates for the top of Unit 2 and 3, respectively). With respect to the orogen, low-temperature thermochronology data (apatite and zircon (U-Th)/He) from the southern flank of the range indicate pulses in exhumation during the entire Miocene, including the late Miocene, when the deposition of the third coarsening upward unit is observed and when the orogenic deformation front migrated to its present-day position between ca. 9 and possibly 6 Ma.

We interpret each bottom cycle to result from a high accommodation space/sediment supply (A/S) ratio where increased tectonic subsidence induced by orogenic shortening and thickening, together with protracted aridity with reduced efficiency of surface processes caused sediment-facies retrogradation. Conversely, a low A/S ratio is interpreted to have triggered sediment-facies progradation during decreased tectonic subsidence and prevailing arid conditions (Unit 1 and part of Unit 2). Finally, sedimentary facies progradation seems to have occurred during conditions with a moderate A/S ratio. At this time tectonic subsidence was moderate to high, but sediment supply was greater because it was forced by wetter climatic conditions (top of Unit 2 and 3) and was associated with the southward migration of the deformation front to its present-day position (top of Unit 3).

In summary, the combination of our data highlights the rich interactions and a strong feedback between tectonic and climate in dictating the evolution of the Alborz orogen and the nature of regional moisture transport as well as the characteristics of the spatiotemporal trends in the distribution of sedimentary facies in the foreland basin.