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Mio-Pliocene morphotectonic evolution of the Iranian Plateau: from outward expansion to incision and excavation

Paolo Ballato (1), Ghasem Heidarzadeh (1), Gerold Zeilinger (1), Mohammad Ghassemi (2), Francesca Cifelli (3), Massimo Mattei (3), Jamshid Hassanzadeh (4), Philipp Balling (1), István Dunkl (5), Masafumi Sudo (1), Andreas Mulch (6), and Manfred Strecker (1)

(1) Institut für Erd- und Umweltwissenschaften, Universität Potsdam, Potsdam, Germany (ballato@geo.uni-potsdam.de; heidarzadeh.gh@gmail.com; zeilinger@geo.uni-potsdam.de; msudo@geo.uni-potsdam.de; philipp. balling@gmail.com; strecker@geo.uni-potsdam.de), (2) Research Institute for Earth Sciences, Geological Survey of Iran (GSI), Tehran, Iran (m.r.ghassemi@gsi.ir), (3) Dipartimento di Scienze, Università Roma TRE, Roma, Italy (francesca.cifelli@uniroma3.it; massimo.mattei@uniroma3.it), (4) Division of Geological & Planetary Sciences, California Institute of Technology, Pasadena, USA (jamshid@caltech.edu), , (5) Geoscience Center, University of Göttingen, Göttingen, Germany (istvan.dunkl@geo.uni-goettingen.de), (6) Biodiversity and Climate Research Centre (BiK-F), Frankfurt am Main, Germany (Andreas.Mulch@senckenberg.de)

Located along plate convergence zones, high orogenic plateaus form extensive and elevated morphotectonic provinces that are flanked by high mountain ranges at their margins. The Iranian Plateau (IP) is a prominent NW-SE striking (ca. 1500 km in length for a width of 140 to 260 km), elevated (> 50% lies between 1.5 and 2 km of elevation), mostly internally drained (at present ca. 55% has internal drainage), arid (mean annual precipitation ranging from 0.1 to < 0.5 m/yr), virtually aseismic and thick (crustal thickness up to 70 km) morphotectonic feature of the Arabia-Eurasia collision zone. The major backbones of the plateau are the Sanandaj Sirjan Zone, the Urumieh Dokhtar Magmatic Arc, and locally the High Zagros Mountains. Although the plateau must be younger than 18-17 Ma (based on uplifted marine deposits of the Qom Formation) very little is known about the mechanisms and timing of plateau vertical growth and lateral expansion.

The northern IP is constituted by a series of mountain ranges and sedimentary basins, which have been excavated by the Qezel-Owzan a major river flowing into the Caspian Sea. This provides easy access to synorogenic sediments and hence makes this region an ideal location to decipher the tectono-stratigraphic and possibly topographic history of the IP. To address these goals we have designed a multidisciplinary strategy including characterization of synorogenic deposits (sedimentology and provenance) and establishment of a detailed chronostratigraphic framework (magnetostratigraphy and geochronology).

Our data show that a wedging (to the NE) sedimentary body started developing from ∼17 Ma during the deposition of the Upper Red Formation. Sediment provenance and magnetic lineations show that detritus was sourced from the interior of the plateau, suggesting that sedimentation was associated with the development of large regional drainage systems. At the same time, growth strata document intrabasinal contractional deformation between ∼14.5 and 12.5 Ma. At ∼10.5 Ma an increase in sediment flux into the basin occurred as documented by an extensive progradation (> 50 km of distance) of conglomerates in the distal sectors of the basin. This event was followed by basin uplift and erosion with a shift of the basin depocenter toward the outer margin of the plateau (to the N and NE; Zanjan and Mianeh basins). There, sedimentation lasted until fluvial incision and basin excavation of sub-horizontal sediments started sometime during the last 4 Ma.

Overall, our data suggest that sedimentation took place in a contiguous foreland-basin system, most likely triggered by thrust stacking and topographic loading in the interior of the plateau from ∼17 Ma. The outward N to NE-directed propagation of the deformation fronts (< 10.5 Ma) excised parts of the foreland, incorporating new basin sectors into the orogenic plateau and compartmentalizing the foreland into a contractional basin and range topography. This implies that the IP developed during crustal shortening and thickening processes and that sometime after 10.5 Ma the northern IP had reached a lateral size similar to the modern one.