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Analog models of convergence and divergence: perspectives of the tectonics of the Middle East

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Three series of analog models of convergence and divergence of tectonic plates illuminate the possible tectonic processes that shaped the lithology of the Middle East since the early Miocene. The Mid-East geographic province extends from the Ionian Sea to the Arabian Sea, and comprises the Hellenic subduction zone, the Aegean back-arc basin, the motion of Anatolia southwestwards, the oblique collision of Arabia and Iran along the Zagros suture, and the continental break-up of the Gulf of Aden and the Red Sea. The tectonic evolution of all these diverse domains started in the Miocene nearly contemporaneously, and modeling suggests that the convergence and divergence, though derived from unrelated processes, their tectonics is intertwined.

Centrifuge models of the initiation of subduction show the correlation between early subduction and the opening of its back-arc basin (Mart et al., 2005). The models emphasize the significance of extensive seawards roll-back of the deformation front when friction between the thrust slabs is reduced, and consequently, the pull within the overthrust slab that leads to its structural extension. That extension produced the Aegean domain with its volcanism and the exposure of its core complex, as well as the westwards displacement of Anatolia along the North and East Anatolian Faults.

Sand-box models of oblique subduction, namely the gradual shift from subduction to collision along the convergence front, showed orthogonal patterns of extension in distal parts of the underthrust slab (Bellahsen et al., 2002). It is suggested that the extensional domains deflected the propagation of Carlsberg Ridge to swing 1200 and penetrate the Gulf of Aden in the early Miocene. The structural differences between the Gulf of Aden and the Red Sea can be accounted for by the results of sand-box experiments in oblique rifting (Mart and Dauteuil, 2000). The models suggest that oblique rifting, where the deviation from the normal extension was ca. 50, would propagate continuously like wedge. However, where the deviation exceeds 150, the rifting takes place in two stages. At first a series of structural basins develops along an axial zone with no continuous boundary fault. Then the basins expand in their axial direction and, in time, interconect to form a rift with boundary faults that determine the down-thrown rift from its elevated margins.

When these structures were welded into a mountain chain, it would be very complicated to determine the low friction from the high friction subduction, the temporal transition from subduction to collision, and the penetration of a spreading ridge into a tectonic convergence zone. The Middle East offers a unique view into the structural development of the continental lithosphere as it takes place.

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