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Lithospheric subduction of back-arc basins: analog models and structural processes

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Back-arc basins and their adjacent terranes are commonly characterized by a large variability of their lithologies, and the juxtaposition of magmatic and metamorphic provinces. To gain insight into the structural development of such terrains a series of analog models was carried out using a centrifuge as the only source of structural deformation. The initial setting of the model comprised five units simulating the asthenosphe as well as the ductile and brittle components of the oceanic and the continental lithospheres. The models were arranged in four sectors of continent, back-arc basin, island arc and ocean. In order to avoid setting a preferred site for the subduction, no preferential weakness zones were introduced into the contacts between these sectors. After running the model in the centrifuge for approximately 45 minutes at gravitational acceleration of 800 g, we found out that subduction occurred only along the contact zone between the continent and the back-arc basin, even though evidence for some initial subduction was encountered along the other ocean-continent contacts as well. There is ground to assume that once the continent – basin subduction lithospheric contact was weakened, motion took place mostly along that loose link, while the initial offsets along the other contacts did not develop into subduction zones. Then gravitational collapse affected the continent and it glided seawards until the continental crust and upper mantle collided with the island arc. When we stopped the experiment, we observed folding along the arc-continent contact, where the oceanic lithosphere of the basin was overthrust by the continental upper lithosphere, and extensive outcropping of the intermediate lithosphere took place on the continent.

Based on the experimental results, the following structural sequence is suggested. Landward initial subduction of the back-arc lithosphere uplifted the edge of the continent which, in turn, collapsed gravitationally seawards. The collapse increased the load on the subducting slab, which deepened so that the top of the subduction zone rolled back. The collapse of the overthrust continental sliver, which comprised the crust and the upper mantle, led to the exposure of a core complex on land. Concurrently the convergence of the continent and the arc carried segments of the oceanic lithosphere onto the exposed ductile lithosphere of the island arc. It is suggested here that the structural processes that cause the occurrence of ophiolites over extensive outcropping of metamorphic lithologies along convergent tectonic boundaries occur during the early stages of the collision.