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Deformation of forearcs caused by subduction of aseismic ridges: The role of ridge orientation and convergence direction investigated with 3D finite-element models

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Subduction of aseismic oceanic ridges causes considerable deformation of the forearc region. To investigate the role of ridge orientation relative to the margin and convergence direction on the style of forearc deformation, we developed a series of 3D finite-elemente models, in which a rigid oceanic plate carrying the model ridge subducts beneath a deformable forearc wedge. Experiments were carried out for angles of 30°, 60° and 90° between the ridge axis and the trench and for different convergence directions. In the experiments, in which the ridge axis is parallel to the convergence direction, the ridge is stationary; in all other experiments, the ridge migrates along the margin and thus affects different regions of the forearc. Our results show that the ridge indents and uplifts the forearc in all models. For obliquely subducting ridges the displacement and strain fields become highly asymmetric regardless if the ridge is stationary or migrates along the forearc. Only if the ridge is stationary and oriented perpendicular to the margin, the deformation is symmetric relative to the ridge axis. Stationary ridges show uplift only above the ridge tip, whereas a migrating ridge causes a wave of uplift above the leading flank of the ridge followed by subsidence above the trailing flank. Horizontal strain components show domains of both extension and shortening, with extension occurring above the ridge tip and shortening above the ridge flanks. To compare our results with natural case studies, we computed additional models reflecting the setting of the stationary Cocos Ridge subducting beneath southern Costa Rica and of the Nazca Ridge, which migrates along the Peruvian margin. The results of these adjusted models are in good agreement with field observations. For the model of the Cocos Ridge the highest degree of shortening occurs normal to the margin, which coincides with the location of a thrust belt in the forearc of Costa Rica with its maximum shortening inboard of the Cocos Ridge. The modeled maximum uplift rate for the Nazca Ridge model is ∼1 mm/a, which is consistent to estimations of ∼0.7 mm/a derived from the elevation of marine terraces in southern Peru.