Forearc Deformation During Subduction and Collision – SW Japan to Taiwan

Compilation of geologic and geophysical studies of the forearc regions in SW Japan and Taiwan, including paleomagnetic data from the Muroto gabbro and magnetic anomaly data from Taiwan, suggest substantial along-strike deformation in the forearc, although plate convergence obliquity is relatively small (≤ 20°) in both areas.

In SW Japan integrated field-based structural studies and recent paleomagnetic data from the Muroto Peninsula are consistent with previously published studies of the structural history of the region just offshore that suggest the interference of two horizontal shortening directions – plate-motion parallel (NNW-SSE) and plate-margin parallel (WSW-ENE). Structural studies of the Miocene Nabae Group on Muroto reveal three structural domains: (1) a landward domain characterized by NNW-dipping structural fabrics (bedding, mélange and penetrative cleavage) and a relatively sharp deflection to NE-dipping structural fabrics in northeastern exposures (i.e., the "Muroto Flexure"); (2) a seaward domain characterized by SE-dipping (i.e., seaward-dipping) fabrics; and (3) a domain that overlaps the eastern exposures of both domains and is characterized by N-trending subvertical fabrics that represent either a second penetrative fabric or re-oriented fabrics of domains 2 or 3. Paleomagnetic data from igneous dikes at two localities indicate that the fabrics domain 2 have been tilted landward 60 degrees (rot axis 061, 16) since about 14 Ma whereas the fabrics in domains 1 and 3 were not rotated during this time. Taken together these observations suggest the following progression: seaward verging accretion in domains 1 and 2, landward tilting of domain 2 followed by along-strike shortening of both domains and formation of the Muroto flexure (domain 3). This interpretation is consistent with results by Okamura (1990) who proposed NNW-shortening followed by WSW-shortening just offshore of the Muroto Peninsula, and with interpretations of Sugiyama (1989) and Kimura (2003) who proposed along-strike shortening along the shelf in SW Japan.

Integrative studies of the forearc region of Taiwan also reveal distinct structural domains and along-strike flow. In this area, however, the domains are defined primarily by current kinematics (e.g., GPS and earthquake distributions and focal mechanisms) and are superposed on a classic suite of accreted continental margin sediments. The colliding arc and the foreland fold and thrust are generally characterized by horizontal compression, as expected for a collisional orogen. In contrast, structural domains in the hinterland where topographic and metamorphic grades are relatively high are generally characterized by horizontal extension with only local areas of shortening. Domain boundaries vary from being diffuse zones of rotational strains to well-defined clusters of earthquakes with internally consistent kinematics. In southern Taiwan where strain rates are relatively high, GPS data show lateral flow and extrusion of accreted materials to the SSW, towards the South China Sea. Magnetic anomaly data (integrated sea and land data around Taiwan) show a prominent magnetic high that correlates with the continental margin. The margin, however, appears to be offset left-laterally, forming an irregular, or saw tooth-shaped margin that acts as an indenter in central Taiwan. The indenter has affected the deformation front as well as the fold-and-thrust belt, and it correlates with a domain of horizontal compression and a drop in maximum elevation in the hinterland.

The indenter also separates areas of horizontal extension and lateral flow to the NE and SW. Forearc deformation in Taiwan therefore appears to be related to impingement of a continental margin indenter with the accretionary prism.

The origin of lateral forearc flow in Japan, in contrast, is less clear as the down-going plate is oceanic rather than continental. Irregularities in the down-going plate topography, however, may have played a similar role as the continental margin indenter in Taiwan. For example, collision of the Izu-Bonin Arc and the Zenizu Ridge in Central Japan or the recent collision and partial subduction of a relatively large sea mount SE of the Muroto Peninsula may have reoriented stresses, allowing lateral flow.