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by John F. Dewey,
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Transtension in Arcs and Orogens

Abstract

Transtension is oblique extension, a combination of coaxial zone-orthogonal extension and non-coaxial zone-parallel shear. It is typical of extensional zones for many reasons, mainly because plate boundary and deformation zones are rarely perfectly orthogonal to plate and block boundaries. The transport direction (TD) is defined as the slip vector between the separating blocks or plates. The instantaneous extension direction (Xi) is not parallel with TD but bisects the angle between TD and the zone boundary orthogonal. The finite extension direction (X) rotates towards TD. Lines, planes, and structures in the obtuse angle between TD and the zone orthogonal rotate, with vorticity, toward TD; those in the acute angle rotate against vorticity toward TD. Where the angle (α) between TD and the zone orthogonal is less than 70.5°, the principle shortening direction (Zi) is vertical and the intermediate (shortening) direction (Yi) is horizontal. This generates sub-horizontal foliation and vertical dikes and fissures and steeply dipping conjugate normal faults intersecting in Yi and folds and constrictional stretching lineations parallel with X. Where α is greater than 70.5°, Zi is horizontal and Yi is vertical, generating vertical foliation and conjugate strike-slip faults (Riedels and anti-Riedels) and folds and lineations parallel with X. Thus, TD can be calculated for any deformation zone where the angle $\alpha/2$ can be determined; this is of enormous potential in determining relative plate motions.

Transtension is of great importance but is, as yet, very poorly understood in convergent plate boundary zones. Intra-oceanic juvenile arcs are dominated by transtension where subduction roll-back occurs with motion of the overriding plate away from the trench line. In Newfoundland, a fine example of a transtensionally distended Cambrian–Ordovician arc with oblique dikes and horizontally stretched pillows and supra-subduction-zone ophiolites is superbly exposed with a complicated polyphase structural and igneous history.

Transtension dominated the late extensional "collapse" of several orogens. Orogenic transtension leads to tectonic denudation by crustal thinning and extensional detachment and the development of high- temperature/and low-pressure metamorphic assemblages with subhorizontal foliations and stretching directions, so typical of the Tasman belt of Australia and the Variscan Belt of Europe. Transtensional Xi and X parallel folds are expressed as periclines and "corrugations" in extensional detachments in the Cenozoic Basin and Range and in the Silurian Caledonides of western Norway.

Biographical Sketch

DR. JOHN F. DEWEY, currently professor at the Department of Geology, UC Davis, Davis, California, holds a PhD from the University of London (1960).

His current focus is in structural geology and tectonics—from the small-scale materials science of deformed rocks to the large-scale origin of topography and structures. His ongoing field-based research is on the rock fabrics and structures of transpression and transtension, especially in California, New Zealand, Norway, Ireland, and Newfoundland. His evolving interests are in the neotectonics of California and Nevada and the relationship among faulting, topography, and sediment provenance, yields and distribution, as well as the geohazards of volcanoes, earthquakes, and landslides.

John is perhaps most widely known for his contributions to plate tectonic theory. He has served in a leadership role in the academic and scientific realm for many years and is the recipient of many awards. Dr. Dewey has also been a consulting geologist for over 20 petroleum companies during the last 15 years and is currently a senior consultant to ExxonMobil and BP. □