d12 Oceanic-oceanic, oceanic-continental, and continental-continental boundaries < Marguari, Andean, Himalayan >

There is nothing so practical as a good theory. —Kurt Lewin.[1]

Tectonic plates are fragments of the lithosphere. Most have areas of both continental and oceanic crust as their upper part as is so of the North American plate. However, the Arabian plate has a crust that is almost entirely continental and one with only oceanic crust is the Juan da Fuca plate.

Plate *margins* can be characterized as continental or oceanic if the upper part of the lithosphere at that margin is continental crust or oceanic crust. Accordingly, convergent plate margins can be characterized as: oceanic-oceanic, oceanic-continental (***Figure d12.1***), and continental-continental.[2]

The continental part of a plate, because of its buoyancy, resists subduction. Only the oceanic part of a plate can be completely subducted to vanish at depth within the mantle. In the case of oceanic-oceanic convergence one of the plates subducts (example: Marguari). In the case of oceanic-continental the oceanic plate subducts (example: Andean) and more rarely obducts (example: Oman).[3] In the case of continental-continental convergence one of the plates passes under the other and in so doing doubles the thickness of the continental crust (example: Himalayan) but it does not subduct further into the mantle.[4]

Locally, a plate margin can be:

(1) a **constructive margin** (marked by an oceanic ridge or a continental rift valley, shallow-focus earthquakes, up to ten times the average heat flow, and tholeiitic basalt fissure-eruptions) where newly created lithosphere is being added to the trailing edges of two plates that are moving apart.

(2) a **convergent margin** (marked by an oceanic trench which is sometimes sediment buried, andesitic volcanism, shallow- to deep-focus earthquakes, and young fold mountains), either (a) a ***destructive margin*** where an oceanic plate is being destroyed by subduction into the mantle beneath the bordering plate that is oceanic or continental, or (b) a ***collision zone*** (often broad and diffuse) where two island arcs, or continents, or an arc and a continent, are colliding.

(3) a **conservative margin** (marked by a narrow fault valley or a linear scarp, shallow-focus earthquakes, and no volcanism) where a transform fault separates two plates that are moving in opposite directions along it.

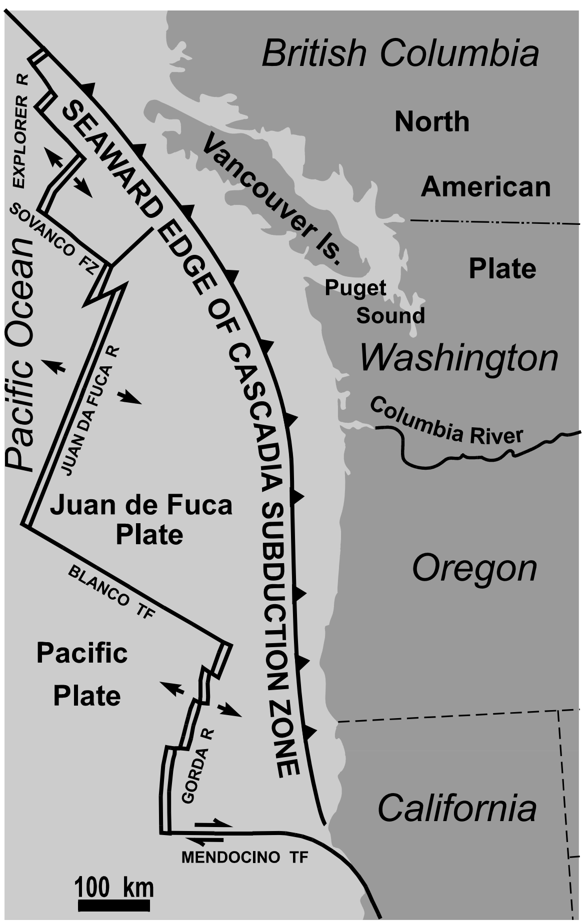

Figure d12.1 [5]
Cascadia arc is an oceanic-continent plate collision with subduction of the Juan de Fuca plate to beneath the North American plate. FZ-fault zone, R-ridge, TF-transform fault.

Tectonics refers to behavior in response to forces that deform the *crust*. The *Moho* (an abrupt change in rock composition) demarks the base of the crust.

Plate tectonics refers to behavior in response to forces that deform the elastic *lithosphere*. The lithosphere, which is comprised of crust and uppermost mantle, overlies a plastic *asthenosphere*.

Oceanic areas are the greater part of Earth's surface but their geology is hidden from direct view. Geophysical techniques are developed for remote-sensing of what is hidden. In oceanic areas, deformation, seismicity, and volcanism, are concentrated in narrow zones that divide the oceanic crust into a mosaic of a few large, and some small, areas within which there is almost no deformation. Tuzo Wilson first noted this and called these rigid areas of seafloor crust "plates" in 1965.[6] In plate tectonics theory, the *plate*s are fragments of the lithosphere. The relatively simplicity of the geology of the oceanic realm has enabled rapid progress in the understanding of the tectonics of oceanic plates. By contrast, the tectonics of continental plates is not so clear. Boundaries between oceanic and continental plates are diffuse and complex, and intracontinent plate boundaries are vague.[7] Seismicity in oceanic plates is to the depth of a sharp thermal transition in the dry mantle from brittle dilatant to ductile viscous rheologies. The standard model of lithosphere and asthenosphere that this provides is suitable for oceanic plates but is not adequate for continental plates (***Figure d12.2***).[8] Initial tensional splitting of continental lithosphere into divergent plates is made possible by basalt diking.[9]

Continental topography is the geohistorical product of geology, climate, tectonism, and feedback interplays between them. Unraveling these spatially varying components and their contributions, with fresh signals overlying fading old, and all episodic in a range from fleeting to eons long, is a challenge that encourages the improvement of old tools and inspires the invention of new ones. For example, geodetic-grade GPS can measure the relative velocity of any two points on Earth's surface. (After a few years of monitoring begun in 1986 it had revealed absolute motions within a fraction of a millimeter per year, *see* Topic *g11*). Geochronology and thermochronology (***Figure d12.3***) combine to provide important constraints on the ages of geological events and the rates of geological processes (such as ages of geomorphic surfaces and rates of crustal exhumation in orogenic belts). ❑

Figure d12.2 [8]
Strength envelopes with depth for continental crust and mantle.

Upper continental crust strength is represented by Byerlee's frictional strength and a thermally activated flow law for wet quartz.

Lower continental crust strengths predicted for dry diabase and wet granulite rheologies.

In a "jelly sandwich" continental lithosphere, a weak zone exists.[10]

Mantle strengths predicted for wet and dry olivine rheologies.