

Part VI

Catastrophic Deposition along the Continental Margin

The debris eroded from the continents during the period of sheet erosion had to be deposited somewhere. Powerful water currents would transport this sediment as a sheet and deposit the sediments as a sheet in areas of waning currents. The ongoing vertical movements of continents rising and ocean basins sinking would cause a large depth difference at the continental margins. It is in this deep water of the continental margin where the current velocity would decrease and deposition occur. The velocity drop would be similar to water moving through a narrow pipe and suddenly encountering a wide pipe. The velocity slows down. Resistant rocks, such as quartzite, of course, were deposited along the Flood path. The softer rocks would have been broken up into small particles because of extreme turbulence and easily transported to the edge of the continent. The sediment load coming off the continents would, therefore, have been deposited along the edge of the continents as a sheet forming the continental shelf, slope, and rise.

Chapter 30

The Sediments of the Continental Margins

In Chapter 7 we considered the evidence that the continents rose as the ocean basins sank. An example of this lies along the East Coast of the United States: the Appalachians rose and the offshore area sank 8.7 miles (14 km).^{1,2} Massive sediments flowed off of the continent and accumulated in deep offshore basins. This chapter will amplify Chapter 7 focusing on the continental margin's sedimentary rocks.

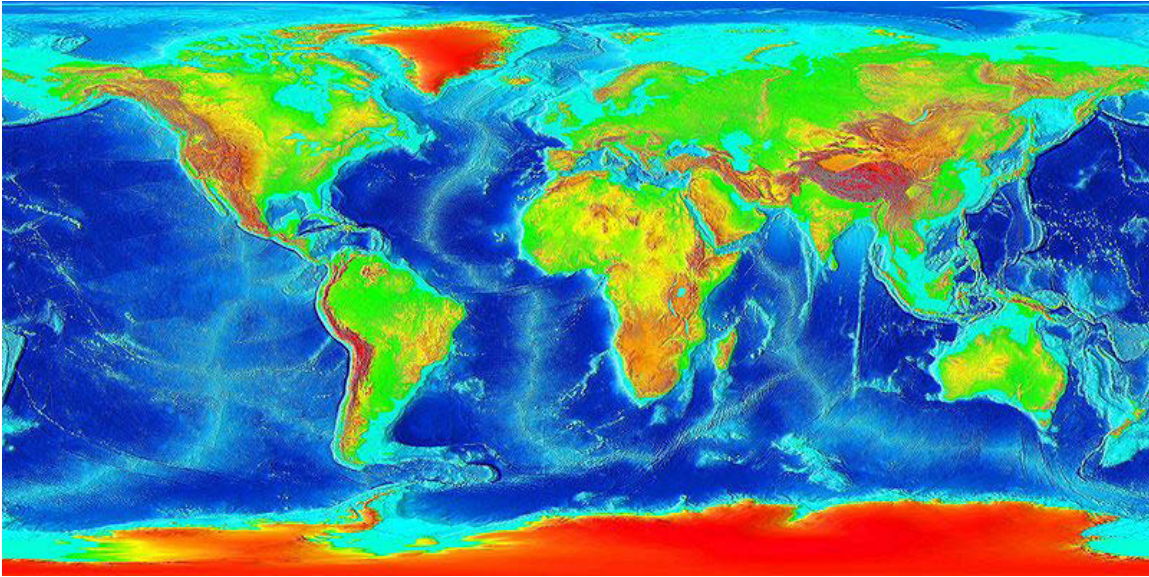


Figure 30.1. The continental margin shown in light blue (from wikipedia).

The Flat Continental Shelf and the Drop Off of the Continental Slope

The ocean floor can be divided into two major areas, the continental margins and the deep ocean basins or abyssal plains. The continental margins make up about 20% of the ocean floor. The margin consists of a continuous band of mainly sedimentary rocks that surrounds all continents and large islands (Figure 30.1). There are two types of continental margins:

- (1) the Atlantic type margin that is generally seismically inactive (Figure 30.2a) and
- (2) the seismically active Pacific type margin (Figure 30.2b).³ The Atlantic margins are also considered passive margins, and the Pacific margins, active.

¹ Poag, C.W., 1992. U.S. middle Atlantic continental rise: provenance, dispersal, and deposition of Jurassic to Quaternary sediments. In, Poag, C.W. and P.C. de Graciansky (editors), *Geological Evolution of Atlantic Continental Rises*, Van Nostrand Reinhold, New York, NY, pp. 100–156.

² Poag, C.W. and W.D. Sevon, 1989. A record of Appalachian denudation in postrift Mesozoic and Cenozoic sedimentary deposits of the U.S. middle Atlantic continental margin. *Geomorphology* 2:119–157.

³ Kennett, J., 1982. *Marine Geology*, Prentice-Hall, Englewood Cliffs, NJ, pp. 23–30.

Although there is considerable variety, continental margins consist mainly of a shelf and a slope. Atlantic margins include the added feature of a continental rise. Pacific margins usually do not possess a continental rise and the slope usually continues down into a deep-sea trench. Figure 30.2 shows the features of typical Atlantic- and Pacific-type margins.

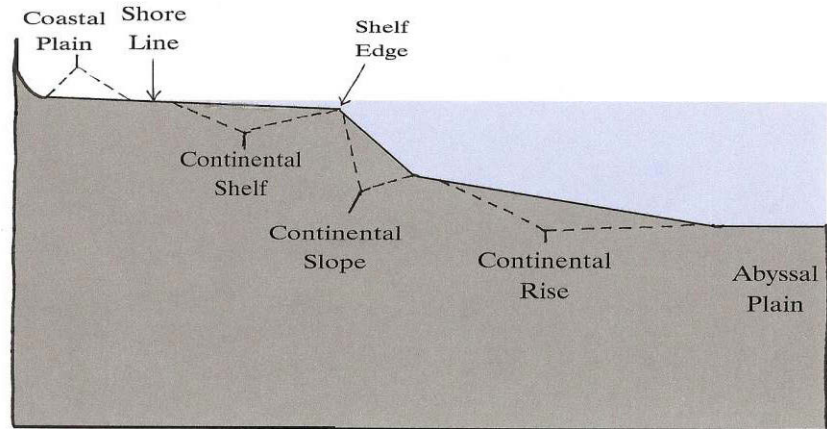


Figure 30.2a. Schematic of an Atlantic type margin (drawn by Mrs. Melanie Richard).

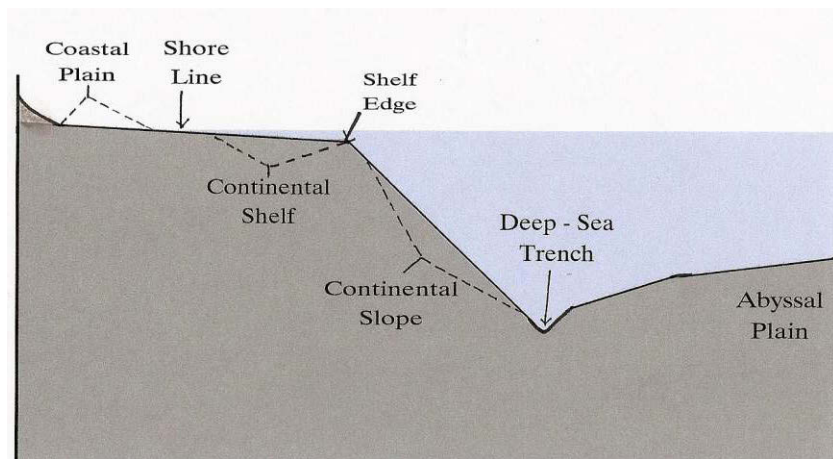


Figure 30.2b. Schematic of a Pacific type margin (drawn by Mrs. Melanie Richard).

Continental Shelf

The continental shelf is a seaward extension of the continent, or coastal plain, from the shoreline to the shelf break or shelf edge, which is the seaward terminus of the continental shelf and the beginning of the continental slope. The continental shelf dips very gently seaward at less than 0.1° , with a subdued relief of less than 65 feet (20 m). Relief is the altitude difference between the highest and lowest points of the terrain (see Figure 2.5). In other words, the continental shelf is almost flat with a very slight seaward inclination.

The Antarctica continental shelf is anomalous. The shelf edge is much *deeper*, at 655 to 1,310 feet (200 to 400 m) below the sea surface. And most unusual, the continental shelf actually becomes deeper moving from the shelf edge toward the shoreline.⁴ The Antarctica continental margin pattern reflects subsidence of the continent due to the great weight of the Antarctica Ice Sheet, which formed after the formation of the continental shelf. As expected it has greater subsidence closer to shore than farther out because it is closer to the thick ice. If it weren't for the ice sheet, Antarctic would be consistent with other continental margins.

A seaward width of a continental shelf varies considerably from a few miles (several km) to more than 250 miles (400 km); the average is 50 miles (80 km). At least one shelf is over 600 miles (1,000 km) wide.⁵ The widest shelves are found along the Arctic Ocean. The Bering Sea, and Grand Banks, Newfoundland, shelves are also very wide.

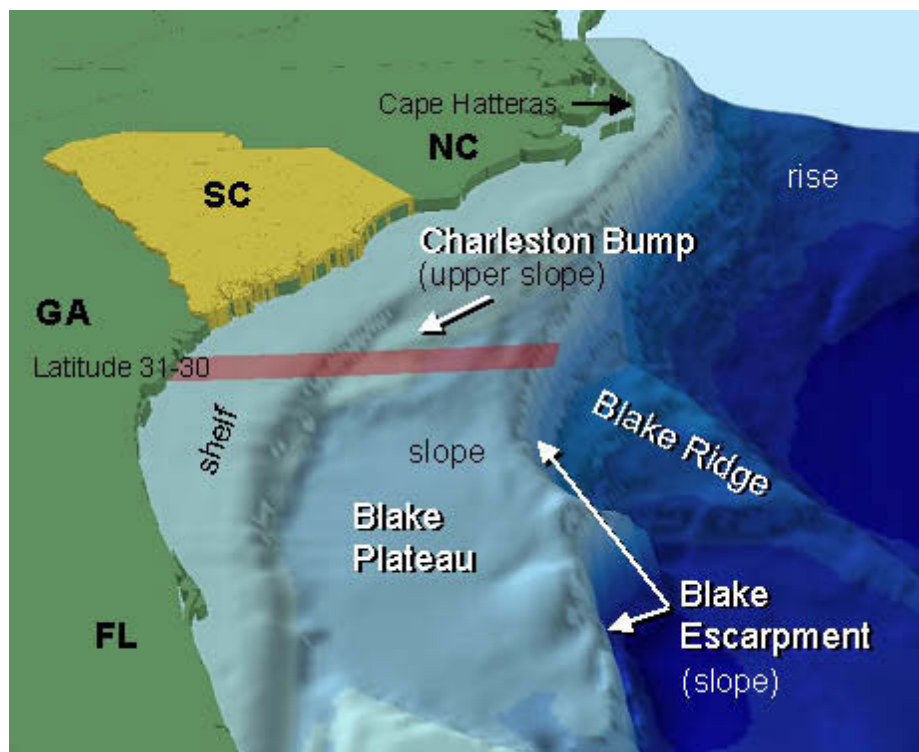


Figure 30.3. The nearly flat continental shelf and the drop off of the continental slope off the southeastern United States (from Wikipedia). The drop off is especially steep in the north where it descends down to the continental rise.

Continental Slope

Continental shelves continue until the shelf breaks at a consistent average depth of about 425 feet (130 m). Beyond the shelf break, the surface slope suddenly changes seaward from nearly flat to about 4° and drops from 425 feet (130 m) to depths of 4,900 to 11,480 feet (1,500 to 3,500 m). This steep slope is appropriately named the continental slope. If all the water were removed from the oceans, the continental slope would be the *most conspicuous geomorphological boundary on earth* (Figure 30.3).

⁴ Ten Brink, U.S. and C. Schneider, 1995. Glacial morphology and depositional sequences of the Antarctic continental shelf. *Geology* 23:580–584.

⁵ Hedberg, H.D., 1970. Continental margins from viewpoint of the petroleum geologist. *AAPG Bulletin* 54(1):6.

Continental slopes vary considerably in slope. Some can be much steeper than average with slopes of 35° to 90° . The width of these steep slopes is rather narrow compared to the width of the continental shelf. It is important to note, the wider the continental shelf, the steeper the continental slope, reflecting that when deposition is farther out to sea, the water depth deepens.

The relief of the continental slope varies considerably due to faulting, submarine slides, and numerous submarine canyons (see Volume III on submarine canyons).

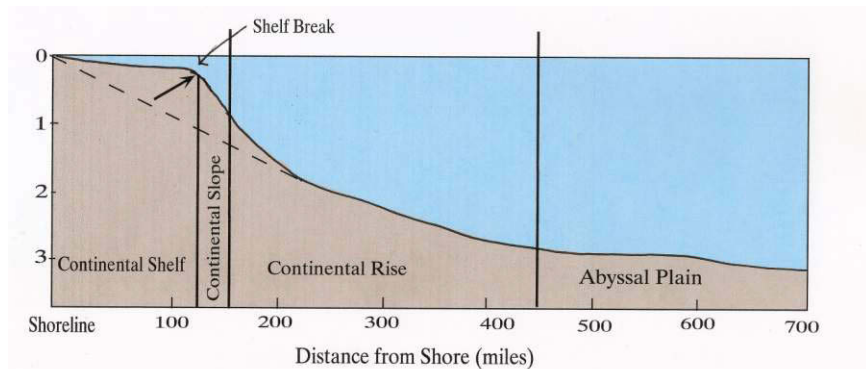


Figure 30.4. Principal features of an Atlantic-type margin with a vertical exaggeration of about 1/50 (drawn by Mrs. Melanie Richard). Note the dashed line, which represents the slope that should occur by normal wind driven currents in the ocean today.

Continental Rise

The continental rise exists only along Atlantic-type, passive margins (Figure 30.2a). It is expressed as a gradual decline in slope seaward of the continental slope. The continental rise blends into the deep abyssal plains, which are mainly composed of abyssal hills at an average depth of 2.5 miles (4 km) and covered with sediments. The rise can vary from 60 to 600 miles (100 to 1,000 km) wide and have a much lower relief than the slope. Figure 30.4 shows the profile of an Atlantic type margin, including the continental rise and the abyssal plain, with a vertical exaggeration of 50/1. Huge amounts of sediment make up the continental rise, especially in the form of submarine fans that spread out from the submarine canyons (see Part XV).

Subsurface Sedimentary Rocks

The sedimentary rocks along the continental margin can be extremely thick (Figure 30.5), over 12 miles (20 km) deep in places. Near and along the continental margin there are many buried rifts or basins that were caused by extension and subsidence. The extension was caused by stretching the continental crust as the continents rose and the ocean margins subsided. Examples of sediment-filled rifts are in the subsurface along the East Coast of the United States east of the Fall Line and along the continental margin. The Fall Line is the boundary between the gently rolling Piedmont Province east of the Blue Ridge Mountains and the Coastal Plain Province. The long axes of these buried basins are usually parallel to the coast indicating the rift basins opened up while the continents were

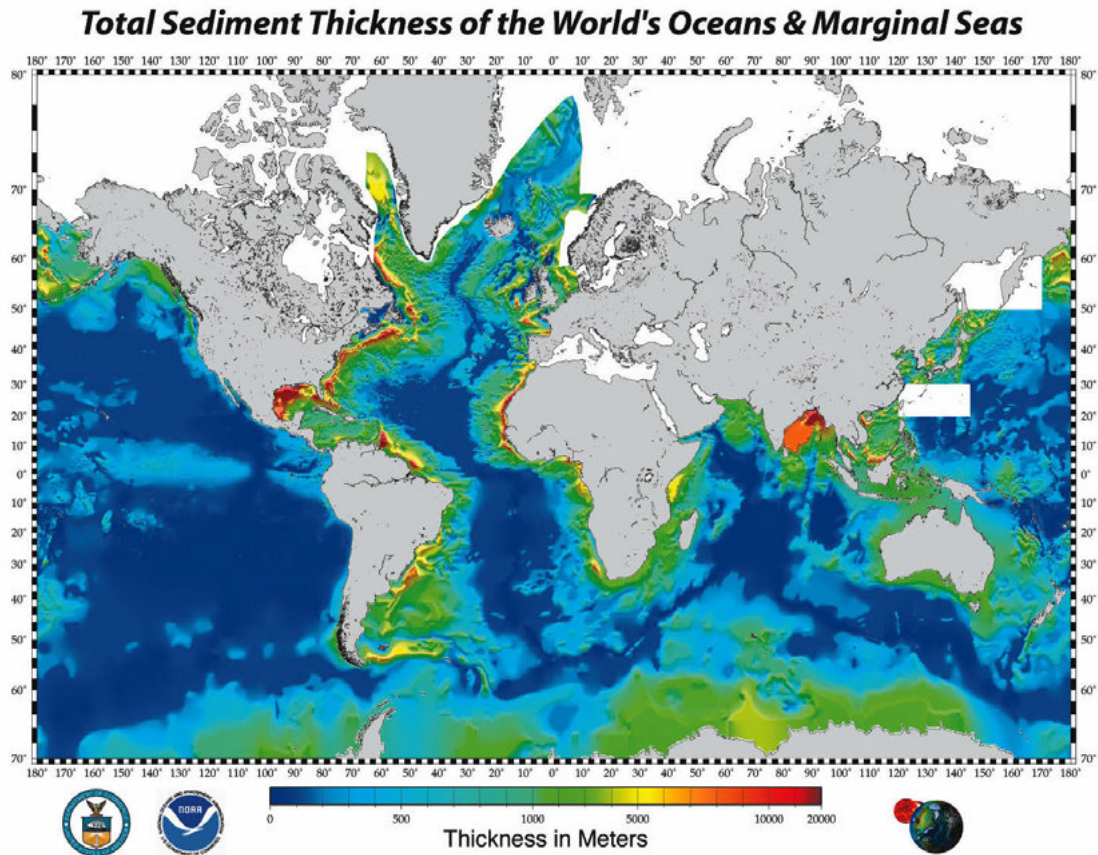


Figure 30.5. Depth of sedimentary rocks along the continental margin (courtesy of NOAA). The deepest sediments are in the northern Gulf of Mexico, off the east coast of North America, and in the Bay of Bengal. There is no data from the Arctic Ocean, but the sedimentary rocks are very thick along that margin.

rising and the ocean basins sinking. Horsts and grabens generally occur in the continental crust rocks below the sedimentary fill of the continental margin, especially in rift basins. Horsts are uplifted blocks, and grabens are downfaulted blocks of the crust.

Disturbed sedimentary rocks fill the bottom of the grabens, but above the disturbed sediment and seaward the sedimentary rocks become more horizontal, sheet like, and thicker. Concerning these margin sedimentary rocks, Pitman wrote:

The sedimentary strata consist of seaward-thickening wedges separated, at least in the shallower sections, by remarkably undisturbed planar horizons.

The deepest strata are often disturbed by basement horsts and grabens, reefal structures, and diapirs.⁶

Reefal structures are actually rare. Diapirs are intrusions of salt, mud, or sand from the lower sedimentary rocks that were squeezed upward by the weight of the sediments. Salt layers seem to be common at the bottom of these rifts.

⁶ Pitman III, W.C., 1978. Relationship between eustacy and stratigraphic sequences of passive margins. *GSA Bulletin* 89:1,393.

The sedimentary rocks making up the continental margin possess a generally sheet-like geometry, separated by minor unconformities and sedimentary rocks that dip more steeply seaward (see Figure 7.3). The more steeply dipping strata are believed to have formed by either sea level changes, changes in sediment supply, or subsidence.^{7,8} The shallowest strata on seismic profiles are generally parallel with the surface of the continental shelf, slope, and rise.⁹ The dip of the sedimentary rocks is steeper where they are buried deeper.¹⁰ Geomorphologist Lester King commented:

We note that all the formations drilled [along the continental margin] dip offshore. The oldest and deepest formations dip at several degrees, the youngest and upper most dip at less than one degree.¹¹

Nonetheless, the seaward slope of the continental margin sedimentary rocks is still slight, even deep within the sedimentary wedge.

This profile of the subsurface sedimentary rocks of the continental margin reinforces the evidence for a broad scale uplift of the adjacent continental area and sinking of the continental margin.^{9,12} The hinge line that separates inland uplift from offshore subsidence is near the coast. King stated:

The formations and unconformities have been tilted seaward (monoclinally) at intervals during the later Cenozoic. There have been repeated tectonic episodes: *always in the same sense—the lands go up and the sea floor down...* (emphasis mine, parentheses his).¹³

The last phrase is a paraphrased statement of Psalm 104:8. It is most fascinating that it is made by a uniformitarian geomorphologist. King believed that stepwise tectonic movements caused the unconformities or breaks in sedimentation, but others think these unconformities could be caused by other processes, such as a change in the amount of sedimentation.¹⁰ King also believed vertical tectonics took place quite late in geological time, which would fit in nicely with the differential vertical tectonics late Flood.¹⁴

⁷ Poulsen, C.J., P.B. Flemings, R.A.J. Robinson, and J.M. Metzger, 1998. Three-dimensional stratigraphic evolution of the Miocene Baltimore Canyon region: implications for eustatic interpretations and the systems tract model. *GSA Bulletin* 110:1,105–1,122..

⁸ Pellaton, C. and G.E. Gorin, 2005. The Miocene New Jersey passive margin as a model for the distribution of sedimentary organic matter in siliciclastics deposits. *Journal of Sedimentary Research* 75:1,011–1,027.

⁹ Uchupi, E. and K.O. Emery, 1967. Structure of continental margin off Atlantic coast of United States. *AAPG Bulletin* 51 (2):223–234.

¹⁰ Steckler, M.S., G.S. Mountain, K.G. Miller, and N. Christie-Blick, 1999. Reconstruction of Tertiary progradation and clinoform development on the New Jersey passive margin by 2-D backstripping. *Marine Geology* 154:399–420.

¹¹ King, L.C., 1982. *The Natal Monocline*, second revised edition. University of Natal Press, Pietermaritzburg, South Africa, p. 45.

¹² Pazzaglia, F.J. and Gardner, T.W., 1994. Late Cenozoic flexural deformation of the middle U. S. Atlantic passive margin. *Journal of Geophysical Research* 99 (B6):12,143–12,157.

¹³ King, L.C., 1983. *Wandering Continents and Spreading Sea Floors on an Expanding Earth*, John Wiley and Sons, New York, NY, p. 200.

¹⁴ Walker, T., 1994. A Biblical geological model. In, Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism*, technical symposium sessions, Creation Science Fellowship, Pittsburgh, PA, pp. 581–592.

Margin Basalt Flows

Seismic reflection imaging has revealed there are thick layers of basalt lavas in the subsurface of some continental margins.^{15,16} Off the East Coast of the United States, the lava flows are estimated to be 12 to 16 miles (20 to 25 km) thick!¹⁶ The seismic reflections dip oceanward, again supporting the hypothesis the ocean floor sank while the adjacent continent rose, assuming that the basalt lava flows were laid down in a general horizontal position or on a gentle slope. It is thought that the East Coast positive magnetic anomaly, paralleling the coast, emanates from these lava flows.¹⁶

Seaward Dipping Faults Common—Even on Pacific Type Margins

Seismic profiles also show numerous faults along the continental margins. Normal, predominantly seaward-dipping faults, called listric faults, are common, with blocks of sedimentary rock dropped down and seaward. These faults are pervasive along Atlantic-type margins.^{15,17,18} However, more recently scientists are finding a greater number of large normal faults along Pacific-type margins, as well as along island arcs.^{19,20,21,22,23} Faulting causes a terraced profile along many active margins. Sometimes, the profile shows an outer ridge with a basin filled with sedimentary rocks inward toward shore. McNeill *et al* summarized:

Listric normal faulting is a common feature of passive [Atlantic-type] margins, where fault movement contributes to crustal thinning and margin subsidence. Extension and normal faulting are also *a fairly common phenomenon on convergent [Pacific type] margins throughout the world*. . . . Discovery of these extensional structures requires a reevaluation of structures previously interpreted as folds and faults related to plate convergence (emphasis mine).²⁴

So, normal faulting, in which a continental block breaks off and sinks toward the deep sea, is now commonly seen in the seismic profiles of both the Atlantic-type and Pacific-type of continental margins. They are the result of the continents rising and the ocean basins sinking.

¹⁵ Mutter, J.C., 1993. Margins declassified. *Nature* 364:393–394.

¹⁶ Holbrook, W.S. and P.B. Kelemen, 1993. Large igneous province on the US Atlantic margin and implications for magmatism during continental breakup. *Nature* 364:433–436.

¹⁷ Lister, G.S., M.A. Etheridge, and P.A. Symonds, 1986. Detachment faulting and the evolution of passive continental margins. *Geology* 14:246–250.

¹⁸ Lister, G.S., M.A. Etheridge, and P.A. Symonds, 1991. Detachment models for the formation of passive continental margins. *Tectonics* 10 (5):1,038–1,064.

¹⁹ Aubouin, J., J. Bourgois, and J. Azéma, 1984. A new type of active margin: the convergent-extensional margin, as exemplified by the Middle America Trench off Guatemala. *Earth and Planetary Science Letters* 67:211–218.

²⁰ Cadet, J.P., *et al.*, 1987. Deep seismic dives in the Japan and Kuril Trenches. *Earth and Planetary Science Letters* 83:313–328.

²¹ Bourgois, J., *et al.*, 1988. Seabeam and seismic reflection imaging of the tectonic regime of the Andean continental margin off Peru (40° to 100°S). *Earth and Planetary Science Letters* 87:111–126.

²² Fryer, P., C.G. Wheat, and M.J. Motti, 1999. Mariana blueschist mud volcanism: implications for conditions within the subduction zone. *Geology* 27:103–107.

²³ Oard, M.J., 2000. Subduction unlikely—Plate tectonics improbable. In, Reed, J.K. (editor), *Plate Tectonics: A Different View*, Creation Research Society Monograph No. 10, Creation Research Society, Chino Valley, AZ, pp. 115–118.

²⁴ McNeill, L.C., K.A. Piper, C. Goldfinger, L.D. Kulm, and R.S. Yeats, 1997. Listric normal faulting on the Cascadia continental margin. *Journal of Geophysical Research* 102(B6):12,123.