Lack of Evidence for Subduction Renders Plate Tectonics Unlikely Part II — Extension Dominant at "Convergent Subduction Zones"

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Abstract

Instead of areas of massive convergence, extension predominates at subduction zones. The lack of geological and geophysical evidence for subduction calls into question the plate tectonics paradigm. The paradigm of vertical tectonics provides an alternative to plate tectonics.

Introduction

In Part I, I discussed the anomalous features of trenches: 1) the absence of sediments in some trenches; 2) the horizontal, undeformed sediments in other trenches; and 3) the lack of pelagic and hemipelagic oceanic sediments in trenches, which are predominantly filled with sediments from off the land. A brief analysis of accretionary prisms on the landward or arcward slope of trenches resulted in the following anomalous features: 1) the lack of accretionary sediments on 44% of the length of trenches, 2) not nearly enough sediments in the accretionary prism of the remaining 56% of the length of trenches, 3) the lack of oceanic sediments in the prism, 4) some prisms subsided instead of uplifted, 5) sediments dated too old and ascribed to a hypothetical process called subduction erosion, and 6) the ad hoc rationalization to account for missing sediment called sediment subduction.

In Part II, I will examine structural features of subduction zones to analyze how well new data line up with expected plate convergence processes advocated by plate tectonics. I will propose an alternative explanation for subduction zones at the end.

Extensional Features Common in Subduction Zones

Plate convergence has been assumed at subduction zones. One would think that copious evidence for such convergence over many millions of years would be obvious. But what if the evidence for convergence is weak? Or worse, what if there is abundant evidence *against* convergence in the form of its opposite tendency—*extension*? The paradigm of plate tectonics would be greatly weakened.

A subduction zone represents the convergence of two plates over millions of years. It has five main components: 1) the oceanward trench slope; 2) the trench itself; 3) the forearc, which includes basins, ridges, and terraces; 4) the island arc in oceanic systems; and 5) the backarc basin (Figure 1). Evidence for convergence should be widespread and obvious in and surrounding the trench. This process was assumed to occur and was considered a logical prediction of plate tectonics before the extensive exploration of the ocean bottoms by the deep-sea drilling project and geophysical methods. Hatherton (1974, p. 95) notes that:

> The development of plate tectonics reversed this process, with 'a priori' acceptance of compression at the active margins to force down the new lithosphere created at the ocean ridges.

I shall examine the five components of the subduction zone for evidence of the predicted convergence.

Backarc Basins

Backarc or marginal basins are mainly associated with western Pacific trenches. Some of these marginal basins are considered active and are related to a particular trench. Others are believed inactive. High crustal heat flow occurs in most of these backarc basins (Karig, 1971). A flood of information on backarc basins has overwhelmingly shown that they are *extensional* features, often associated with magnetic anomalies that are similar to mid-ocean spreading ridges but often of lower amplitude and usually not basinwide (Karig, 1971). For instance, the Lau Basin, a backarc basin associated with the Tonga-Kermadec Trench, is believed to be rapidly extending with irregular and discontinuous magnetic lineations that are difficult to interpret (Bevis et al., 1995, also see Karig, 1970; Hawkins,

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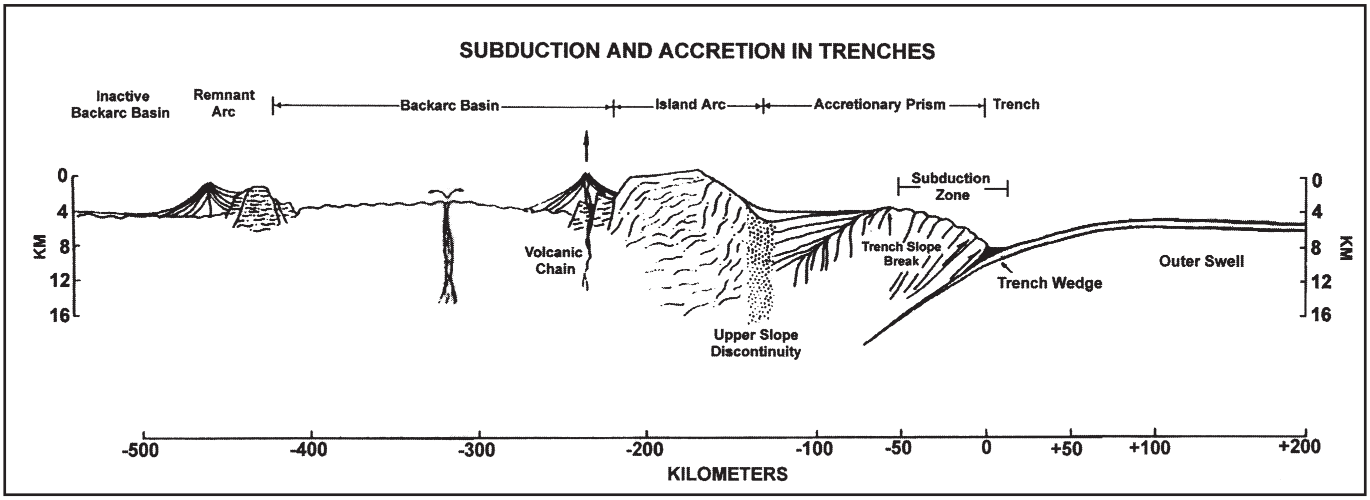

Figure 1. A classic subduction zone-island arc system as envisioned in the 1970s (from Karig and Sharman, 1975; redrawn by Nathan Oard). Vertical exaggeration is 5:1.

1974; Bloomer and Fisher, 1987; Clift et al., 1998). The Mariana Trough, the backarc basin associated with the Mariana Trench, is an extensional, not a compressive, feature (Mrozowski and Hayes, 1980; Hussong and Uyeda, 1981).

Backarc basins are anomalous within plate tectonics. Uyeda (1982) states that extensional backarc basins with high heat flow are difficult to explain within the plate tectonics paradigm. Karig (1991, p. 477) corroborates and probably best summarizes the extensional nature of backarc basins and their significance to plate tectonics:

> The large basins with oceanic characteristics that lie behind many convergent plate margins and separate them from continents have long been a tectonic puzzle, but they became even more controversial with the advent of plate tectonics...Such extension, close to and associated with the focus of plate convergence was seemingly inconsistent with plate mechanics in these early days of plate tectonics and initiated a lively discussion as to why this extension occurs that has not yet been resolved.

Oceanward Trench Slope

Evidence for extension is ubiquitous on the subducting ocean plate close to the trench axis in the form of horsts and grabens with normal faults (see Figure 4 of Part I) (Fisher, 1974; Uyeda, 1974, p. 480; von Huene and Scholl, 1991, p. 291). Rather infrequent earthquakes indicate an extensional mechanism. Grabens as deep as 600–800 m with intervening horsts have been observed by Seabeam profiling oceanward of the Tonga Trench (Lonsdale, 1986, p. 304). Normal faults produce horsts and grabens on the ocean plate that are supposedly converging at the Middle America Trench (Moore, Shipley, and Lonsdale, 1986). The same pattern is seen oceanward of the Peru-Chile Trench (Thornburg and Kulm, 1987). The profile of the oceanic lithosphere descending into the Aleutian Trench shows a rough, sawtooth pattern caused by seaward-dipping normal faults (McCarthy and Scholl, 1985). Grabens lie eastward of the Japan Trench (Ludwig et al., 1966). The Kuril-Kamchatka Trench seems to be the only trench where extensional features are absent oceanward (McCarthy and Scholl, 1985, p. 699).

The conventional explanation of these extensional features on the downgoing plate is that the ocean plate bends due to tension while descending into the subduction zone (Caldwell et al., 1976; Aubouin and von Huene, 1985). There is often a bowing upward of the ocean plate just before reaching the trench (Hatherton, 1974, p. 483). Extensional faulting due to bending is a reasonable interpretation within the plate tectonic paradigm.

There is also evidence that some of the extensional features originated, at least in incipient form, far from the "bending" area. It is believed that horsts and grabens associated with the Middle America Trench were inherited from the East Pacific Rise spreading axis and were enhanced close to the trench (Aubouin, Bourgois, and Azéma, 1984; Aubouin and von Huene, 1985). Furthermore, it is observed that the horst and graben structure west of the Middle America Trench strikes *obliquely* to the trench axis. A similar situation occurs west of the Peru-Chile Trench (Hussong, Reed, and Bartlett, 1988, p. 125). If these horsts and grabens were caused by faulting as the ocean plate approached the trench, the strike of the normal faults, horsts and grabens should be parallel to the trench axis. Therefore, the occurrence of horsts and grabens may not have been caused, or at least not totally caused, by bending of a plate down into a subduction zone.

Island Arcs

Island arcs were once considered mysterious features in that they are curved chains of volcanoes and volcaniclastic sedimentary rocks with a trench lying on the convex side. Since they are depositional features, island arcs are not expected to be either convergent or extensional. However, at least two active island arcs possess evidence of extensional tectonics. The Izu-Bonin Arc lies mostly underwater and is extensively rifted (Taylor, 1992). Some have suggested that several basins on top of the Aleutian Arc are caused by extensional faulting (Geist, Childs, and Scholl, 1988).

Trenches Appear to be Grabens

A number of workers have commented that trenches have the physical characteristics of a downfaulted graben, which is an extensional feature. For instance, Aubouin and von Huene (1985, p. 955) state that along a perpendicular transect across the Middle America Trench off Guatemala, "...the Trench is essentially a graben despite the anticipated dominantly compressional forces from subduction." Scholl et al. (1970, p. 142) commented that the Peru-Chile Trench is generally considered to be a graben-like structure. Hatherton (1974, p. 95) stated that benches along the sides of trenches favor a graben interpretation and "...an extensional mechanism of formation that supersedes the earlier compressional hypothesis." Yoshii (1979) reported normal faults near the axis of the Japan Trench off northeastern Honshu. Although generally undeformed, trench sediments themselves often display normal faults, indicating extension, such as in the Peru-Chili Trench (Malahoff, 1970; Thornburg and Kulm, 1987).

Landward or Arcward Trench Slope

Anyone who has some knowledge of plate tectonics has been taught that the landward or arcward trench slope is the part of the trench where ocean sediments have converged, forming an accretionary wedge. Extension is ubiquitous on the oceanward trench slope and in backarc basins. The trench has the cross-sectional appearance of a graben, and extension is even found where not expected, on the island arc. Therefore, the evidence for plate convergence should be found on the landward or arcward slope, if it is to be found at all.

Paradoxically, much recent evidence indicates that extension is common even on the landward or arcward trench slope! Normal faults dipping seaward were discovered on the landward side of the Middle America Trench off Guatemala (Aubouin, Bourgois, and Azéma, 1984). Furthermore, fault-bounded steps and local downslope failure on the lower trench slope suggest normal faulting and extension on the landward slope of the Middle America Trench (Aubouin and von Huene, 1985, pp. 942, 955). These authors (pp. 954,955) summarize:

> *Despite plate convergence, little compressional structure is detected in the rocks cored and in the seismic reflection records along the Guatemalan active margin transect* [italics theirs].

The Peru-Chili Trench appears to be similar to the Middle America Trench with landward slope extensional features. Bourgois et al. (1988, p. 111) state:

> The Andean margin off Peru is an "extensional active margin" or a "collapsing active margin" developing a subordinated accretionary complex induced by massive collapse of the middle slope area.

A large 20 by 33 km slump block or a detachment fault at mid slope and a large debris flow that has spread down the lower slope and into the trench have been detected landward of the Peru Trench near 5°S (Bourgois et al., 1988; von Huene et al., 1989; Bourgois et al., 1993). (Debris flows and other types of submarine mass flow are discussed in Oard, 1997, pp. 33–39.) Even the Andes Mountains, once thought to be caused by compressional uplift, are now considered by many geologists to be dominated by extensional features (Katz, 1971; Carey, 1988, pp. 176, 177). The toe of the landward slope of the Peru Trench is the only area where compressional features are still claimed to be present.

Extensional normal faults are pervasive on the arcward side of the Mariana Trench. Hussong and Uyeda (1981, p. 921) exclaim: "No compressional deformation (which would be expected from the formation of an accretionary prism) has been found anywhere on the fore-arc." They say elsewhere:

> Thus, as noted by Hussong and Fryer (this volume), except for the megashear zone at the contact between the Pacific and Philippine plates, the top of the crust throughout this region of plate convergence is, paradoxically, in tension.

The Japan Trench also has evidence of extensional tectonics. Many normal faults were discovered on the landward slope of the Japan Trench during Legs 56 and 57 of the Deep Sea Drilling Project (Nasu et al., 1980). Cadet et al. (1987, p. 314) state: "The landward slope of the Japan Trench is cut by numerous normal faults trending sub-parallel to the trench axis..." Large slump scars were also seen by submersibles in both the Japan and Kuril Trenches.

Extensional features are also observed in the Tonga forearc (Clift et al., 1998), the Aleutian forearc (Fisher, 1979), the Nankai subduction zone (Leggett, Aoki, and Toba, 1985), and the Izu-Bonin forearc (Renard et al., 1987). The upper landward slope of the Cascadia subduction zone off Washington and Oregon shows ubiquitous normal faulting (McNeill et al., 1997; Parsons et al., 1998). In fact, these are listric normal faults that curve oceanward, indicating large-scale slumping of the conti-

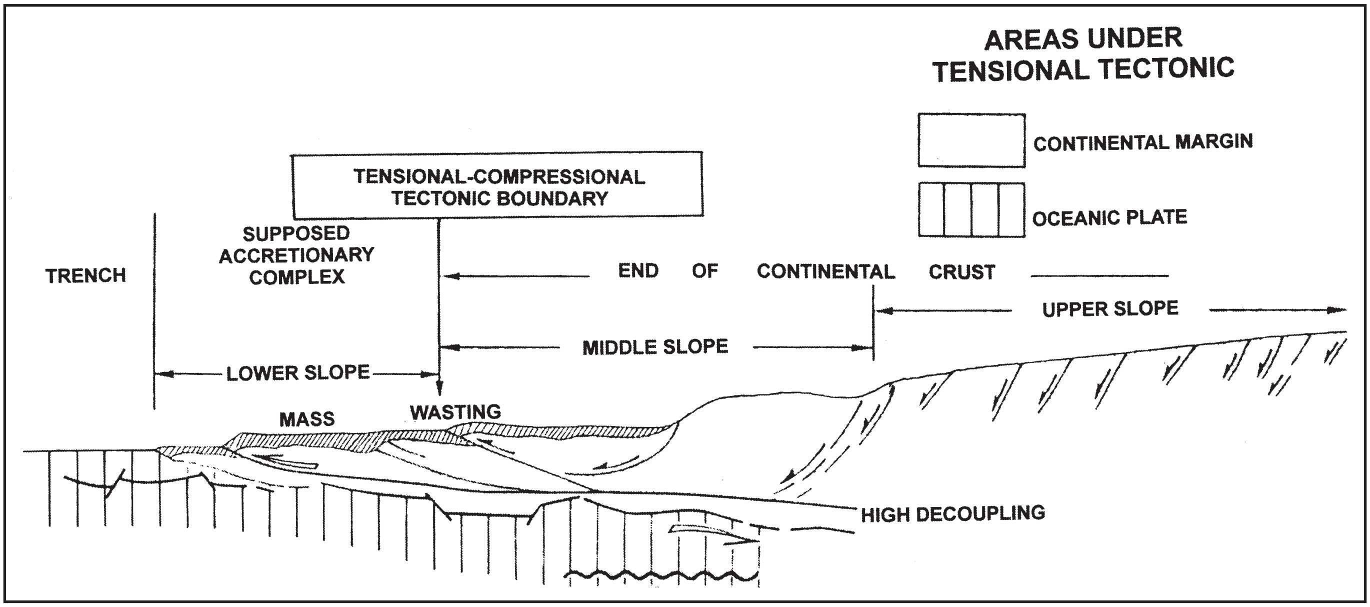

Figure 2. Schematic of the Andean margin of Peru in the Paita area (from Bourgois et al., 1988; redrawn by Nathan Oard).

nental shelf and upper slope sedimentary rocks (McNeill et al., 1997). These authors (pp. 12,123) state that normal faulting and margin subsidence are *common on passive margins and forearcs of convergent margins*:

> Listric normal faulting is a common feature of passive margins, where fault movement contributes to crustal thinning and margin subsidence. Extension and normal faulting are also *a fairly common phenomenon on convergent 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].

A surficial slump containing 32 km^3 of debris has also been discovered at the toe of the Cascadia subduction zone (Goldfinger et al., 1992). Von Huene and Scholl (1991, p. 293) corroborate that extensional faults are common on convergent margins. Ryan and Scholl (1989, p. 499) reinforce the new idea that folds and faults cannot simply be interpreted as accretion against a backstop.

Vein structures from deep sea drilling cores are now recognized as caused by extension and are predominantly found on the upper trench slope (Moore, 1986). The lack of compression, especially on the middle and upper slopes, has given rise to the ad hoc model of "convergent-extensional margins," supposedly a *new* type of active margin (Aubouin, Bourgois, and Azéma, 1984). A "convergent-extensional margin" seems like an oxymoron. Regardless, the prediction of plate tectonics for ubiquitous compressive structures on the forearc has not been successful.

The evidence for convergence and imbricate thrusting has been relegated to the lower trench slope where a series of ridges and sediment-filled troughs strike parallel to the trench axis. McNeill et al. (1997) suggested that these folds may not be related to convergence, but instead may be due to large scale subsidence of the continental margin in view of the ubiquitous normal faulting of the upper slope. If the middle and upper slope are areas of normal faulting and slumps, why should the lower slope compressional area not be the lower portion of a slump?

Thrust faults are supposed to be common on the lower trench slope due to convergence, but there is accumulating evidence for normal faulting. For instance, normal faulting has occurred in the Middle America Trench (von Huene, 1986; Moore, Shipley, and Lonsdale, 1986, p. 514) and the so-called Makran accretionary prism off southwest Pakistan (Platt and Leggett, 1986). All this normal faulting on the Middle America forearc has led some to suggest that there is no evidence of compression off Guatemala (von Huene et al, 1980; Aubouin and von Huene, 1985).

Several researchers have even suggested that the middle and lower slopes of at least a few trench segments are caused by slumping and mass wasting. Figure 2 is a schematic of the Andean margin off the Paita area of Peru showing many oceanward-dipping normal faults on the upper slope with a huge slump with mass wasting on the middle and lower slope. Similar features as shown in Figure 2 can also be seen in seismic images from other trenches. Thus, the lower forearc slopes can just as well, if not better, be interpreted as slump and mass wasting features instead of plate convergence.

Summary

In view of the quick acceptance of the plate tectonics paradigm, and the practice of fitting almost any observation into it, I have critically analyzed geological observations of subduction zones. Trenches were envisioned as linear belts of thick sediment accumulated during millions of years of convergence. However, many trench segments are either empty or nearly empty of sediments! The remainder have moderately thick trench fills of *horizontally layered* sediments indicating a lack of convergence during the time of filling. The trenches were presumed to have been filled with oceanic pelagic and hemipelagic sediments from the ocean plate, but instead are predominantly turbidites from the land. These strongly anomalous features of trenches are explained by several ad hoc mechanisms that seem far fetched.

During the initial enthusiastic days of plate tectonics, oceanic and trench sediments were simply assumed to accrete against a continent or island arc—a backstop as it is called. McCarthy and Scholl (1985, p. 691) remind us:

> Prior to the investigations of the Deep Sea Drilling Project and to the acquisition of multi-channel seismic reflection profiles, many geologists envisioned that one general mechanism of subduction accretion operated along underthrust continental margins.

This makes theoretical sense, but later observations have shown that this is not the case. Many unexpected complexities and anomalies have been discovered over the years. These include the following: 1) 44% of trenches have no accretionary prism, 2) all accretionary prisms are too small, 3) the sediments in these "accretionary prisms" are predominantly terrigenous, 4) some "accretionary prisms" have subsided instead of uplifted, and 5) large areas of the continental margin have supposedly been subducted. Despite the secondary hypothesis of sediment subduction, one can legitimately ask whether landward and arcward slopes show compelling evidence for plate tectonics at all.

Compressive features associated with trenches should be common and obvious, considering that plates supposedly have been converging in the trench area for millions of years, but they are rare. The landward slope, if anywhere, should show massive evidence for compressive strain, but except for the lower landward slope, extension is ubiquitous. von Huene (1986, p. 3) writes: "At first glance it may seem paradoxical that in a dynamic system dominated by plate convergence, this convergence does not control structural style." Of course, von Huene argues against the obvious. Early hypotheses on subduction zones predicted abundant and obvious compressional features, and the fact that there is little evidence for compression should be enough to discredit the hypothesis of plate subduction and hence plate tectonics.

An Alternative Explanation

New geological and geophysical information as outlined above makes subduction unlikely. The significance of this is far reaching and means that other data attributed to subduction would be caused by other mechanisms. For instance, evidence for subduction from geochemistry, tomography, magmatism, and seismology (Wadati-Benioff zones) can be interpreted by another process.

Without subduction, plate tectonics also is not likely, unless the earth expands. There are plenty of anomalies and complexities with other aspects of plate tectonics that makes one question the veracity of the paradigm. Many uniformitarian critics still question plate tectonics (Kahle, 1974; Beloussov et al., 1990a,b; Chatterjee and Hotton, 1992). Because of accumulating anomalies and complexities, even believers in plate tectonics are questioning the paradigm. For example, Anita Harris (formerly Anita Epstein) once published much-cited evidence of a match of Ordovician conodonts between the northern Appalachian Mountains and northwest Europe. This was considered strong support for plate tectonics—until she found the *same* conodonts in Nevada (McPhee, 1983, pp. 127–130). Although apparently still a believer in plate tectonics, she has become skeptical of the paradigm:

> The geology has refuted plate-tectonic interpretations time and again in the Appalachians. Geology often refutes plate tectonics. So the plate-tectonics boys tend to ignore data. The horror is the ignoring of basic facts, not bothering to be constrained by data (McPhee, 1983, p. 209).

Cliff Ollier, a well-known Australian geomorphologist, has gone on record a number of times criticizing plate tectonics. In 1991, he stated:

> The very weakness of plate tectonics [sic] is that the power of explanation is too great. Subduction, for example, may be called upon to create an island arc, a deep sea trench, or a mountain range; it may lead to sediments being scraped off a down-going slab, or subduction of the sediments under the continent...
>
> Most of the input into plate tectonic speculation appears to come from geophysicists, who have models which may be elegant mathematically but do not take landforms into account at all (Ollier, 1991, pp. 208,209).

If subduction and plate tectonics are not true, then catastrophic plate tectonics is unlikely as well as unnecessary. Catastrophic plate tectonics is postulated during the Flood (Wise et al., 1994) and after the Flood during the time of

Peleg (Molén, 1994). Rapid subduction is a necessary component of these models. While catastrophic plate tectonics solves some of the problems of plate tectonics, it creates others, such as a heat problem due to rapid horizontal sliding of plates and the addition of a new basaltic ocean floor (Wise et al., 1994). The resurfacing of the ocean floor with hot basalt that must cool for hundreds of years after the Flood logically leads to the conclusion of copious post-Flood catastrophism. This catastrophism is caused by the sinking of the ocean basins and the tectonic elevation of the continents—all post-Flood! There is copious evidence against such post-Flood catastrophism (Holt, 1996; Oard, 1996,1998,1999; Morris, 1996; Woodmorappe, 1996; Froede and Reed, 1999).

Walter Brown's hydroplate model (1995) posits plates rapidly spreading away from the mid-Atlantic ridge and has a number of features that are an improvement over plate tectonics and catastrophic plate tectonics. For instance, subduction zones in his model are not areas where one plate dives below another. They are areas of downbuckling that agrees with the thesis of this paper. However, his model lacks detail that would aid evaluation of his model. I especially question the adequacy of the driving force to propel such huge plates a few thousand kilometers over a spherical earth, even with pockets of water below a 16 kilometer thick granitic crust.

I believe evidence used in support of plate tectonics can support another model, which I call *vertical tectonics*. With proper understanding, I believe mid-ocean ridges, ocean floor magnetic anomalies, and the so-called fit of the continents across the Atlantic, etc. can be explained within the paradigm of *vertical tectonics* during the Flood. I interpret the forearc areas of trenches as caused by rapid sedimentation and *vertical tectonics* during the later stages of the Genesis Flood. This was a time when Flood water was draining off the continents, first as sheet flow and second by more channelized flow, according to the Biblical Flood model of Tas Walker (1994). The continents were uplifted while the ocean basins subsided. At the margins of continents, massive slumping and mass movement of newly deposited, consolidated to semi-consolidated sediments would be expected at many scales. The normal faults on the continental shelves and upper slopes are evidence for this slumping. Thus, the middle and lower slopes would simply be the toe of large slumps or mass movement debris. Forearc ridges and basins would be the topographic expression of these processes.

The evidence against subduction presented here will be expanded elsewhere (Reed, in preparation). Other arguments against plate tectonics will also be developed in that publication.

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