24. VanDecar, J.C., James, D.E. and Assumpçao, M., Seismic evidence for a fossil mantle plume beneath South America and implications for plate driving forces, *Nature* **378**:25–31, 1995; p. 25.
25. Snelling, A.A., Plate tectonics: have the continents really moved apart? *CEN Tech. J.* **9**(1):12–20, 1995, p. 13.
26. Hast, N., The state of stress in the upper part of the Earth's crust, *Tectonophysics* **8**:169–211, 1969.
27. Anfiloff, V., The tectonic framework of Australia; in: Chatterjee and Hotton III (Eds), Ref. 9, pp. 75–109; p. 90.
28. Snelling, Ref. 25, p. 15.
29. Vardiman, L., Snelling, A.A. and Chaffin, E.F. (Eds), *Radioisotopes and the Age of the Earth: A Young-Earth Creationist Research Initiative*, Institute for Creation Research and Creation Research Society, El Cajon and St Joseph, 2000.
30. Oard, Ref. 10, pp. 29–35.
31. Woodmorappe, Ref. 5, pp. 82–83.
32. Oard, M.J., *Ancient Ice Ages or Gigantic Submarine Landslides*? Creation Research Society Monograph **6**, St. Joseph, pp. 11–13, 1997.
33. Oard, Ref. 10, pp. 35–38.
34. Hill, M.L., Transform faults; in: Kahle, C.F. (Ed.), *Plate Tectonics—Assessments and Reassessments*, American Association of Petroleum Geologists Memoir **23**, Tulsa, pp. 240–243, 1974.
35. Oldenburg, D.W. and Brune, J.N., Ridge transform fault spreading pattern in freezing wax, *Science* **178**:301–304, 1972.
36. Ghosh, S.K., An experimental study of ridge offsets in relation to trends of ridge and transform faults, using wax models; in: Chatterjee and Hotton III (Eds), Ref. 9, pp. 23–32.
37. LeGrand, Ref. 13, p. 56.
38. Oard, Ref. 10, pp. 38–41.
39. McPhee, Ref. 6, p. 127.
40. Oard, Ref. 10, pp. 45–46.
41. Stevenson, A.J., Scholl, D.W. and Vallier, T.L., Tectonic and geologic implications of the Zodiac fan, Aleutian abyssal plain, northeast pacific, *Geological Society of America Bulletin* **94**:259–273, 1983.
42. Froede, Jr., C.R., The expanding African plate: a problem within plate tectonics and catastrophic plate tectonics; in: Reed, Ref. 4, pp. 65–76.
43. Froede, Jr., C.R., Questions regarding the Wilson cycle in plate tectonics and catastrophic plate tectonics; in: Reed, Ref. 4, pp. 147–160.
44. Austin *et al*., Ref. 1, p. 615.
45. Holt, R.D., Evidence for a Late Cainozoic Flood/post-Flood boundary, *CEN Tech. J.* **11**(1):128–167, 1996.
46. Oard, M.J., Where is the Flood/post-Flood boundary in the rock record? *CEN Tech. J.* **10**(2):258–278, 1996.
47. Oard, M.J., Dinosaurs in the Flood: a response, *CEN Tech. J.* **12**(1):69–86, 1998.
48. Morris, H.M., The geological column and the Flood of Genesis, *CRSQ* **33**:49–57, 1996.
49. Woodmorappe, J., Studies in Flood geology: clarifications related to the 'reality' of the geological column, *CEN Tech. J.* **10**(2):279–290, 1996.
50. Froede, Jr., C.R. and Reed, J.K., Assessing creationist stratigraphy with evidence from the Gulf of Mexico, *CRSQ* **36**:51–60, 1999.
51. Walker, T., A Biblical geologic model; in: Walsh, R.E. (Ed.), *Proceedings of the Third International Conference on Creationism, Technical Symposium Sessions,* Creation Science Fellowship, Pittsburgh, pp. 581–592, 1994.


# Dealing carefully with the data

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**Michael Oard's first contribution in this forum lays out a valid criticism of uniformitarian plate tectonics—namely the quantity and character of the sediments in the deep ocean trenches. His paper is to be considered a valuable contribution to the discussion for that reason alone. This single difficulty for uniformitarian plate tectonics, however, is not sufficient justification for ignoring other key issues or not treating them carefully. It seems to me Oard's conviction that the data from trenches falsifies the entire concept of plate tectonics, somehow in his mind, gives him authority to be careless with other issues. On several points his approach is to construct a straw man, one hardly anyone in the Earth-science community would consider representative of the observational facts, and then criticise it. This gives the impression to people not familiar with these facts that the case for plate tectonics is not to be trusted. He does this for the evidential basis for plate tectonics as a whole, as well as for specific issues such as Wadati-Benioff zones, the fit of continents across the Atlantic, transform faults, spreading ridges surrounding Africa and Antarctica, among others. On the other hand, I believe Oard's arguments concerning the quantity and character of the sediments in the deep ocean trenches to be valid. He is correct in pointing out that these observations are contrary to what uniformitarian plate tectonics predicts. However, in assuming these same inconsistencies also apply to catastrophic plate tectonics, he fails to appreciate that most of the plate motion takes place during the most intense, transgressive phase of the Flood, before the runoff producing the trench sediments occurs. Sediments now filling the trenches are almost entirely a product of that runoff from the continents during the regressive stage of the catastrophe itself and the centuries since when plate speeds were minuscule by comparison. Finally, his claim to have a genuine alternative mechanism involving vertical tectonics is hollow if, as for the case of catastrophic plate tectonics, the term 'mechanism' is taken to include a clearly defined source of energy and a clearly defined means that harnesses this energy to perform the geological work demanded by the observational data.**

## A more complete picture of the evidential basis for plate tectonics

As I emphasized in my first contribution to this forum, the issue on which the ultimate validity of the plate tectonics paradigm rests is the age of the ocean floor, specifically of its igneous crust and overlying sediments, relative to the sediment record of the continents. To begin this contribution I would like in summary fashion to focus on this topic.

The igneous ocean crust and sediments overlying it today postdate the entire continental Paleozoic sedimentary record. This fundamental claim is based on multiple interlocking lines of evidence. First of all, there is the physical character of the ocean floor itself. In regard to its sediment cover, apart from deltaic fans of a few large rivers such as the Ganges, Indus, Amazon, and Mississippi, the overall sediment thickness on the ocean bottom, relative to that typically observed on the continents, is surprisingly small. The mid-ocean ridge system, that runs like a baseball seam for some 60,000 km about the planet, has hardly any sediment within 1,000 km of the ridge axis. And with few exceptions, the thickness of the sediment cover increases in a smooth and regular fashion as one moves away from the ridge axis. The distribution of ocean sediment therefore appears to be profoundly connected in a geometrical sense with this mid-ocean ridge system. Especially when combined with other lines of evidence, this evidence at least suggests a vast amount of seafloor spreading has occurred along the mid-ocean ridge system.

Further, we have clear evidence for new seafloor being generated in today's world along the axis of the mid-ocean ridge system. Heat flow measured along the axis is many times the average oceanic value. 'Black smokers' expelling jets of hot water represent an obvious physical manifestation of this high heat flow near the ridge axis. Submarine magmatic eruptions along the ridge system have even been photographed. The very topography across the ridge system is precisely what is expected for rifting plates, namely, a central graben with uplifted flanks superimposed on a broader band of elevated topography.

Moreover, seismic investigations of the ocean floor have revealed a ubiquitous crustal layer about 6 km thick, consistent with rock of basaltic composition. Based on its chemical composition and the contexts in which it erupts at the Earth's surface, basalt is known to be the product of partial melting of the denser mantle rock below. The inference that the ocean crust is indeed comprised of basalt and gabbro (its intruded counterpart) is supported by rock samples dredged from the ocean bottom as well as by detailed studies of ophiolites that represent pieces of former ocean floor, which through tectonic processes have been incorporated into continental environments. The basaltic composition of this layer has also been confirmed by the Deep Sea Drilling Program (DSDP) and Ocean Drilling Project (ODP) from some 2,000 holes, most of which were drilled to basaltic basement.

This evidence therefore strongly suggests that the partial melting/intrusion/extrusion processes observed to generate this basaltic crust at mid-ocean ridges today are responsible for the production of the 6-km-thick layer generic to ocean floor everywhere on the planet. Is it possible to determine if this is actually the case, and if so, when it may have occurred?

The ocean floor sediment cover contains powerful clues with which to address these questions. In contrast to continental environments that generally have experienced a complex history of sedimentation, erosion, and tectonic deformation, the sedimentary history of most of the ocean basins appears to have been dramatically simpler. Apart from those areas near a continental margin, the history, as reconstructed via cores from more than 2,000 holes drilled in DSDP/ODP cruises over the past 30 years, displays amazing vertical and horizontal continuity. In particular, these sediment cores contain an amazingly consistent and coherent record of a succession of distinguishingly different marine microfossils as well as of a pattern of oriented magnetic mineral grains that record periods of normal and reversed magnetic field polarity. These cores therefore contain well-defined markers from which global scale correlations can be made.

With respect to the magnetic record, one can simply count magnetic reversals from the top of the core to the bottom and connect these reversals with those recorded in successive lava flows on the flanks of continental volcanoes, beginning at the top and going downward, and with the reversals recorded in the shallow basaltic rocks as one moves away from a mid-ocean ridge. These correlations are strong and exist independent of radioisotope methods and dates. Of course, because these reversals are captured in Flood rocks, they must have occurred rapidly as part of the cataclysm itself. In a similar manner the microfossils in the deep ocean cores can be compared and correlated with identical microfossils from the continental shelves. Again, the correlations in fossil types and vertical succession are strong and also exist independent of radioisotope methods, dates, and any assumptions of 'deep time'.

What these correlations reveal, with an extremely high level of confidence, is that the age of the basaltic basement rocks increases from near zero at the mid-ocean ridges to a maximum age corresponding to rocks classified as early Mesozoic in continental environments. In terms of the Flood cataclysm, the very oldest basement rocks in today's oceans formed when dinosaurs were first being buried in significant numbers as the floodwaters began encompassing their continental habitats. The extremely important implication is that all of today's ocean plates have formed via seafloor spreading processes at mid-ocean ridges since sometime in the middle of the Flood cataclysm. It also implies all of the pre-Flood ocean plate has disappeared from the face of the Earth, almost certainly by being subducted into the Earth's interior. The logical implication, of course, is that something like catastrophic plate tectonics must be true.

In terms of this forum, it is crucial to understand that thus far Michael Oard has failed to address this category of evidence that deals, first of all, with the nature of the ocean igneous basement rocks and the ocean sediments with their microfossils and record of magnetic reversals, and then with the correlations with the continental geological record and the implication concerning the relative age of the ocean plates. Until he addresses these central issues upon which the wide acceptance of the plate tectonics paradigm is really based and demonstrates these conclusions to be defective, his overall critique of the paradigm will remain in the straw man category.

### Comments on criticisms of specific aspects of plate tectonics theory

I will now attempt to respond briefly to several specific issues Oard raised in his first contribution. In regard to Wadati-Benioff zones, Oard's basic claim is that since these zones can be complex in their geometry, with variations in dip angle and in earthquake density and intensity, this somehow implies the basic interpretation of these zones as plate boundaries, where one plate is sliding beneath another, is faulty. But the Earth is complex, and continental boundaries are complex. By implying plate tectonics demands that these zones be simple, when this is not the case at all, Oard is criticizing a difficulty he himself has created.

In regard to mountain building, Oard's claim that the Andes are mostly volcanic in origin simply is not true. The case is strong that a large portion of the mass of the Andes is the result of mechanical thickening of the continental crust along South America's west coast. This is certainly consistent with seismic evidence for vast amounts of subduction having occurred beneath these mountains that caused significant east-west shortening of the South American continental crust. Mechanical thickening of continental crust by plate subduction is also clearly associated with the formation of the Himalayas, Alps, and Rockies. Oard's further claim that magma generation above a subducting plate via melting and the subsequent migration of this magma to the surface suffers from a 'space' problem is simply not correct. Buoyancy of this lower density magma is potent, even at depths of 100 km or more. It generates large stresses that create new fractures and open old ones to allow the molten rock to reach the surface, usually quite rapidly. This is just basic rock mechanics.

A truly astonishing claim on Michael Oard's part is that geophysicists have not provided a mechanism for plate tectonics. Yet a paper of mine from more than seven years ago[1] describing a 3-D model for the Flood shows that solving the conservation equations for mass, energy and momentum with a simple deformation law to relate stress to deformation rate plus a simple plate formulation yields amazingly realistic plate motions and behaviour. The relative contributions of slab pull and ridge push naturally come out of the numerical calculations. In those calculations it is primarily the negative buoyancy of the cold, dense upper boundary layer that drives the overall mantle/plate motions. I am thus surprised by Oard's statement 'Hence the driving mechanism for plate tectonics is still unsolved.' There are published examples to the contrary, even in the creationist literature.

Oard suggests that the fit of the continents across the Atlantic Ocean is the product of 'integrated subsidence and uplift' or 'a common horizontal stress field'. If that were so, one should expect the ocean floor to consist of the same material as the continents. It does not. His argument ignores the basic difference between the structure of the continents and that of the ocean floor. The continents have a layer of continental crust typically about 35 km in thickness that the oceans do not have. The relative buoyancy of continental crust, that is some 15% less dense than the rock beneath, is why the continents' surfaces stand approximately 4 km above the oceans' abyssal plains. A mechanical principle known as isostasy yields this difference in height. Oard here seems to be proposing an incredible scenario to avoid the obvious evidence for seafloor spreading in the Atlantic Ocean, namely, that a landmass corresponding to today's Atlantic Ocean floor, with matching shape on either side, simply sank. As to what mechanism could cause it to sink, or why this landmass without a layer of continental crust would be elevated in the first place, or how isostasy fits into the picture, he gives no clue.

Concerning the fracture zones that offset segments of the mid-ocean ridge system, Oard again erects a straw man picture of the seafloor spreading process involving massive large-scale mantle upwelling beneath the zones of spreading. Numerical modelling as well as seismic studies since the early to mid-1980s have shown that the upwelling associated with seafloor spreading is almost completely a local and passive process associated with the spreading itself. The experiments involving the pulling apart of freezing wax he mentions truly capture many of the physical aspects of the process and support the standard understanding of seafloor spreading. The conflict here is with Oard's incorrect representation of the process.

In regard to Oard's claim that the Zodiac fan of terrigenous sediment in the Gulf of Alaska represents a difficulty for the standard reconstructions of plate motion has an obvious answer. This fan was formed almost certainly during the early runoff stage of the Flood when the plate was located further to the east, adjacent to the Alaskan coast, and east of the eastern end of the Alaska trench. An extinct but still visible spreading ridge, causing east-west extension on the east side of this fan, almost certainly has displaced the fan to the west relative to the Pacific plate to the south. Oard is using the complexity of the seafloor spreading and subduction in the region again to erect yet another straw man difficulty.

Still another imaginary difficulty for plate tectonics raised by Oard concerns the fact that spreading ridges, with no internal compensating subduction zones, mostly surround the Africa and Antarctica plates. The basic scenario of how this can occur is contained in my paper describing a 3-D global model for the Flood.[1] In the case of Africa, the compensating subduction occurred on the west coast of South America and to the north beneath the southern parts of Europe and Asia. As South America was pulled westward by subduction on its western margin, the Mid-Atlantic ridge migrated westward relative to Africa. In addition, India moved to the northeast, Antarctica moved to the south, and Africa itself moved to the north-northeast, in all cases toward zones of subduction. Simultaneously, the Carlsberg ridge, the Mid-Indian ridge, and the Southwest Indian ridge all spread apart to leave ridges on all sides of the African plate except on the north. In the case of Antarctica, it moved mostly southward, away from Africa and Australia, and overrode a zone of subduction that was previously on its south coast (just as North America has overridden a zone of subduction that was previously along its west coast). So in the case of Antarctica, there actually is a compensating subduction zone. It is simply hidden from view today and no longer active.

### The deep ocean trenches and their sediments

A major thrust of Michael Oard's critique of plate tectonics concerns sediments in the deep ocean trenches. He correctly emphasizes that the almost complete lack of sediments in a significant fraction of the total length of trenches in the world is a serious problem for the uniformitarian framework. He also correctly emphasizes the generally horizontal layering, as opposed to a highly deformed character for trench sediments, argues for very little plate convergence across the trenches since these sediments entered. Moreover, he is correct that evidence for an extensional, as opposed to compressional, stress regime in most trenches is also sharply inconsistent with the uniformitarian expectation. I commend him for his labours to research and document these issues so thoroughly.

But Oard seems to have invested hardly any effort to analyze what one should expect in regard to the character of trench sediments in the framework of catastrophic plate tectonics. In this framework, the vast majority of subduction and plate motion must occur during the runaway episode, when the strength of rock throughout most of the mantle, including most of the lithosphere, is reduced by as much as a staggering 8–10 orders of magnitude.[2] However, as the gravitationally unstable material in the mantle's top and bottom boundary layers reach and spread over the opposite boundary, the instability disappears, the gravitational potential energy driving the process vanishes (having been converted to other forms), the deformation rates plunge, the rock strength approaches its pre-catastrophe values, and the high velocities plummet. Very little plate motion and subduction can occur under these latter circumstances.

When this scenario is considered in the context of the Biblical record, it seems likely the runaway episode coincides with the 40 days of intense rain. Much, if not most, of the runoff phase of the Flood then must occur after almost all the subduction has taken place. Therefore, in the context of catastrophic plate tectonics, most of the sediments observed in the trenches today should be terrigenous in character, washed from the continents, and should not display any significant evidence of horizontal compression. With the primary source of sediment from the continent side of the trench, it is then not surprising to find slope failure, including listric normal faulting and other evidence of extension, on the continent side of trenches. On the other hand, trenches not adjacent to continents involve subduction of ocean plates formed extremely rapidly during the runaway stage of the Flood with little time for settling and accumulation of ocean sediments. One would not expect to find large amounts of sediment in this context. The observations from trenches adjacent to continents as well as from trenches far removed from them therefore provide powerful support in favour of the catastrophic model and against the uniformitarian one.

### Issues unique to catastrophic plate tectonics

Michael Oard ends his initial contribution with several issues he views as problematic for catastrophic plate tectonics. The first is the large amount of heat generated by plate sliding. I realize visco-plastic solid deformation is a nontrivial subject, representing a graduate level topic in fields like mechanical engineering, and therefore requires some effort to understand. But the simple answer here is that the heat generated in deforming a solid material is directly proportional to its strength. In the runaway process, the strength drops by as much as 8–10 orders of magnitude, and therefore the deformational heating remains modest. Deformational heating was included in the runaway calculation presented in my initial contribution in this forum. No extreme temperatures are generated.

In regard to pre-Mesozoic plate motions, the lack of pre-Mesozoic seafloor to tell us what these motions may have been leaves everyone, uniformitarian and creationist alike, with precious little to work with beyond a few clues in the continental record and one's own imagination. This is an area for future research and not a problem unique to catastrophic plate tectonics.

The cooling of the entire basaltic ocean crust within the time constraints of the Genesis Flood is indeed a serious concern. However, I contend it is a problem for any credible Flood model because of the compelling evidence that all the current ocean crust has been created through igneous processes since sometime during the Flood itself. In my initial contribution I pointed out the supersonic steam jets that occur along the mid-ocean ridge system during the phase of rapid plate motions appear to be able to cool the basaltic crust at the time it is forming. Work is in progress on this topic.

On the issue of when the Flood catastrophe ended relative to the geology we observe today, I personally correlate the end of the year of the Flood with the later Cenozoic. I side with Oard on this question. But it really does not bear directly on the catastrophic plate tectonics mechanism.

### A genuine alternative to catastrophic plate tectonics?

Michael Oard leaves the reader with the impression he has an alternative mechanism that accounts for most if not all the observations he has dealt with relative to the plate tectonics framework and also satisfies the time constraints of the Biblical record. Is this a correct impression? It is not, if by mechanism we mean a clearly defined means that harnesses a clearly defined source of energy to perform the specific geological and tectonic changes observed to have occurred at the Earth's surface since the onset of the metazoan fossil record. In a parenthetical comment Oard alludes to meteorite impacts as a possible energy source. But here he is surely grasping at straws, because large meteorites deliver their energy in a fraction of a second in a highly localized area, like a giant explosion. We can observe their crater generating effects on other bodies in the solar system as well as on Earth.

So far as I can determine, Oard does not have a plausible energy source, much less the set of mechanical processes to produce the required tectonic and geological change in a short amount of time. Such processes would need to account for such basic and obvious features as mid-ocean ridges, transform faults, hot spot volcanoes, the ocean sediment distribution, deep ocean trenches, chains of volcanoes associated with Wadati-Benioff earthquake zones, and rapid formation of continental mountain belts including the Himalayas, Alps, Andes, and Rockies. In addition, the mechanism would need to account for the post-Mesozoic age for today's ocean floor. Does he have even an outline for such a mechanism? No. His only appeal is to vertical tectonics. But what is the mechanism that drives his vertical tectonics? He has none. Dramatic vertical tectonics, on the other hand, is an integral part of the catastrophic plate tectonics paradigm. This is clearly discussed in my paper of more than seven years ago.[1] It is baffling to me why he does not even acknowledge or reference this paper in any of his own publications.

### Conclusion

To make progress in reconstructing truthfully the Earth's past and interpreting correctly the massive quantity of geological observations now available, specifically in light of what God Himself has revealed on this topic, we simply cannot afford as creationists to be careless in how we approach this task. We cannot indulge in building straw man illusions. We cannot pick and choose what data we address and what data we ignore. Rather, we must do our best to bring all the data to bear on any candidate model we construct. Without question we must be discerning as we draw upon work done by researchers who view the world through evolutionary glasses. But God gives such discernment. I personally believe the plate tectonics revolution of the 1960s, together with just a bit more physics insight, has now provided Christians the key to re-establish Biblical authority by demonstrating the early chapters of the book of Genesis, and especially the account of the Flood, is authentic history. I am persuaded we are now able to do this in a way that has not been possible for almost two centuries. As young-Earth creationists, I believe we must begin to pull together, communicating with one another, to bring to fruition a vibrant and credible defence for the hope that is in us, relevant to the time in which we live.

### References

1. Baumgardner, J.R., Computer modeling of the large-scale tectonics associated with the Genesis Flood; in: Walsh, R.E. (Ed.), *Proceedings of the Third International Conference on Creationism, Technical Symposium Sessions,* Creation Science Fellowship, Pittsburgh, pp. 49–62, 1994.
2. This runaway phenomenon has been the focus of much of my own time and energy over the past 15 years. The crucial observational data is experimental in nature and involves the measurement of the deformation properties of various silicate minerals found in mantle rocks under a wide range of temperatures and deformation rates. The experimental studies have been conducted in laboratories around the world for well over 30 years. Deformation properties obtained from these studies imply that silicates, like metals, weaken in a highly nonlinear manner as a strong function of temperature and deformation rate. The potential for runaway behaviour is clear, I believe indisputable. A great challenge has been to develop numerical methods that can cope with the potent nonlinearities and extreme gradients that arise when runaway begins to occur in the numerical calculations. This has now largely been achieved (see Ref. 26 in my first contribution).