Flood processes into the late Cenozoic: part 2—sedimentary rock evidence

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This paper summarizes seven general features of most Cenozoic sedimentary rocks best explained by Flood processes. These are the sometimes great thicknesses; sometimes widespread, relatively thin layers; sediment lithification; widespread and/or thick 'evaporites'; phosphorites; carbonates; and thick continental margin rocks.

Recently, John Whitmore has defended the thesis that post-Flood mass wasting processes have the potential to explain the majority of the Cenozoic rock record, thus justifying the placement of the Flood/post-Flood boundary at or near the Cretaceous/Tertiary (K/T) boundary.[1] This defence extends his previous articles on the subject from the 2008 International Conference on Creationism.[2,3] Whitmore has also done research on the Green River Formation, dated as early Cenozoic and the subject of his Ph.D. thesis, and participated in a forum with me on whether the Green River Formation is Flood or post-Flood in the *Journal of Creation* issue 20(1) in 2006.[4] Although there are problems with both interpretations, Whitmore believes the Green River Formation is the product of post-Flood lakes,[5] while I believe it is a Flood deposit.[6]

Whitmore argues that post-Flood mass wasting of generally unlithified sediments during mountain uplift, heavy precipitation, a lack of vegetation, giant earthquakes, meteorite impacts, and massive volcanic activity can explain the geology, paleontology, and geomorphology deduced from believing the Cenozoic is post-Flood. Mass wasting or mass movement refers to all the processes by which soil and rock are eroded and transported downslope by gravity.[7] It includes slow displacements such as creep and rapid movements such as rockfalls, rockslides, and debris flows. Although Whitmore's scenario for post-Flood catastrophism seems plausible, there are numerous problems. Mass wasting occurs today and would have been more intense early in the post-Flood period, but it is the *magnitude* of these features, deduced from the Cenozoic, that is the main problem. Thousands of metres of mountain uplift and basin sinking, and thousands of metres of erosion and deposition occurred in the Cenozoic, which Whitmore acknowledges and places *after* the Flood:

> "In short these processes should have either taken off hundreds to thousands of meters of sediments from that surface or buried that surface with hundreds to thousands of meters of sediments."[1]

Furthermore, the scenario fails to explain the unique geomorphological features left on the earth's surface after erosion. This series of articles will elaborate on many features prevalent in the Cenozoic rock record, which often extend into the very late Cenozoic, that are better explained by Flood processes than post-Flood catastrophism,[8] starting with sedimentology in this part (table 1). In the final paper, I will address Whitmore's major arguments in more detail.

Huge volume of Cenozoic sedimentary rocks

It has been claimed that the Cenozoic erathem is post-Flood because it has less sedimentary extent than the Mesozoic and Paleozoic erathems.[9] However, the volume of Cenozoic rocks in the world is still sufficiently large to make this a poor argument for locating the end of the Flood.[10,11] Besides, even those who place the post-Flood boundary in the late Cenozoic expect less global and more local and regional sedimentation to have occurred later in the Flood. And ironically, if we compare erathems, the collective Cenozoic erathem, based on data from secular geologists, actually contains a larger volume of sedimentary rocks than any of the other nine Phanerozoic systems (figure 1).[11]

It is not only the huge volume of Cenozoic rocks that challenge post-Flood explanations of much of the Cenozoic but also the thickness of Cenozoic sedimentary rocks at individual locations. Thickness is a subjective term, but the thickness magnitudes are in some cases beyond comprehension—for a post-Flood scenario. Cenozoic deposits can be very thick in basins and very widespread on plains near uplifts.[6] Many basins around the world contain thousands of metres of Cenozoic sedimentary rocks. Whitmore mentions 10,000 m of Cenozoic sedimentary rocks in the large valley of south-east California,[1] but 6,000 m of this is *late Cenozoic*.[12] He believes these sediments must be deposited after the Flood. Other basins in southern California have just as much Cenozoic sedimentary rocks. The Los Angeles, California, basin subsided in the late Cenozoic collecting about 6,000 m of sediment, now sedimentary rock.[13] The Santa Clara Valley, north-west of Los Angeles also contains about 6,000 m of late Cenozoic strata that has been uplifted along the edges, deformed, and the top eroded off.[14] The South Caspian Basin, north-east of Iran, is about 450 km in diameter and has a total thickness of 26,000–28,000 m of sedimentary rocks.[15] Most of the sedimentary rocks in this basin are considered Cenozoic, with only the bottom layers possibly being Cretaceous.[16] The top 10,000 m alone are regarded as Pliocene and Quaternary, the very late Cenozoic.[17,18] All this huge amount of Cenozoic strata would have to be eroded from the surrounding mountains and transported in some cases hundreds of kilometres over low slopes. These magnitudes are powerful evidence of Flood activity and not of post-Flood catastrophism.

Thin, widespread Cenozoic sedimentary layers

Many relatively thin, widespread layers are evident in the sedimentary rocks.[19] *Thin* and *widespread* of course are subjective, but the *magnitude* of some Cenozoic layers seems to defy any post-Flood mass wasting scenario. A layer a few hundred metres thick and covering 200,000 km^2 could be considered a thin, widespread layer. Some Cenozoic layers are of similar geographical extent and thickness to some Mesozoic formations, considered Flood sediments by Whitmore and myself.

For example, the Fort Union Formation, assigned to the early Cenozoic, is composed of sandstone, shale, and coal, and outcrops over an area of about 150,000 km^2 (figure 2). If we include the area where it is supposed to have been eroded away, it is found to cover an additional 300,000 km^2, making its total area 450,000 km^2. The Fort Union Formation is about 300 m thick in eastern

Table 1. Summary of seven general features present in most Cenozoic sedimentary rocks best explained as a result of Flood processes. The strength measure against post-Flood formation and for Flood formation is based on the strength of current post-Flood explanations of these features.

Sedimentary Rock Evidences	Strength
1. Huge volume of Cenozoic sedimentary rocks	strong
2. Thin, widespread Cenozoic sedimentary layers	moderate
3. Consolidated Cenozoic sedimentary rocks	moderate
4. Deposition of widespread and/or thick Cenozoic ‘evaporites’	strong
5. Cenozoic phosphorites	weak
6. Formation of Cenozoic carbonates	moderate
7. Tremendous Cenozoic continental margin sedimentary rocks	strong

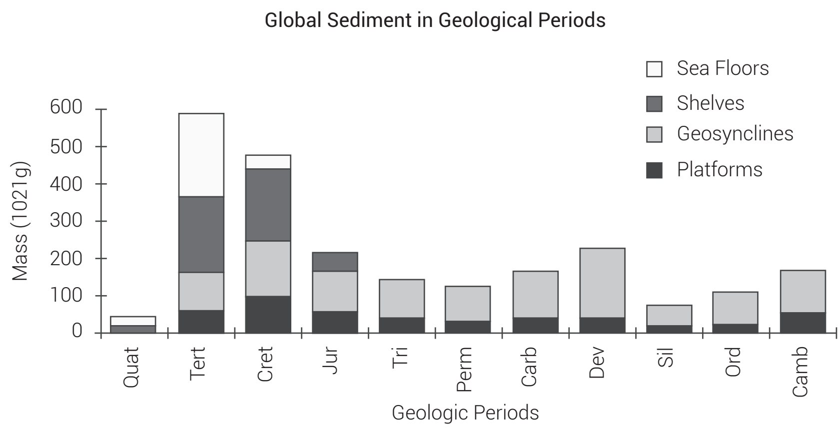

Figure 1. Global distribution of Phanerozoic sediments by geological periods for four postulated paleoenvironments. The Cenozoic has been split into the Quaternary and Tertiary (from Holt[11]).

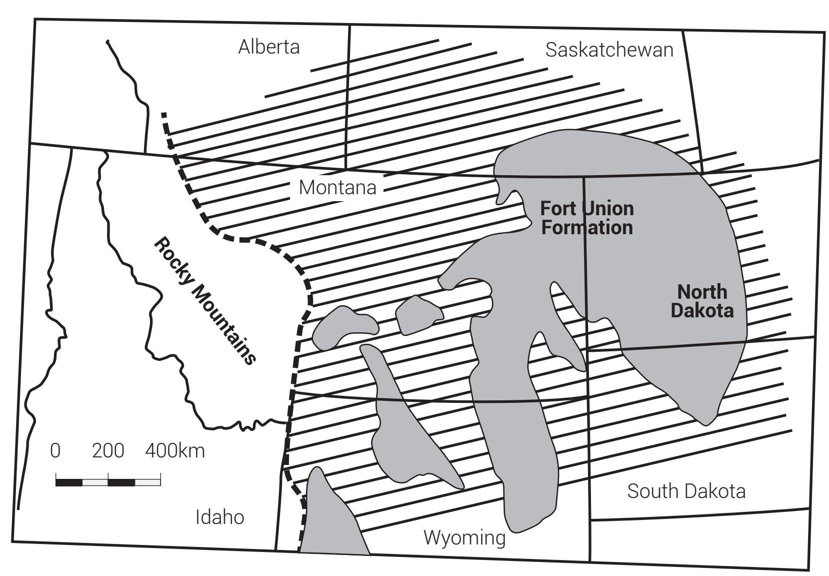

Figure 2. Extent of the Fort Union Formation (solid pattern) and the area from which uniformitarian scientists believe it was eroded (slanted pattern). The combined area is about 450,000 km^2 (drawn by Melanie Richard).

Montana and western North Dakota,[20] so it is relatively thin compared to its area. Whitmore and Garner have interpreted this formation as post-Flood, partly based on the presence of terrestrial fossils.[2] However, the Fort Union Formation covers a similar geographical area as some of the widespread, thin Mesozoic formations. The pre-erosion size of the Fort Union Formation was larger than the Shinarump Conglomerate (250,000 km^2), similar in size to the Navajo Sandstone and its equivalents (400,000 km^2), and half the area of the huge Morrison Formation (1 million km^2). All of these latter three formations are assigned to the Mesozoic and all are considered Flood deposits.

Just because a formation contains terrestrial fossils does not mean that it was deposited in a terrestrial environment. This is an uniformitarian deduction, but in biblical earth history a terrestrial fauna can be catastrophically transported in the Flood and buried in a setting with few if any marine animals. And fossils that are normally considered marine are given a freshwater interpretation, such as 'freshwater' dinoflagellates and sponges found in the Miocene Clarkia beds of west-central Idaho.[21]

Moreover, there is additional evidence based on *isolated* erosional remnants above the Fort Union Formation that at least another 300 m of sedimentary rock, and probably much more (see section on lithification of sediments below), once laid on top of the Fort Union Formation and were subsequently eroded over a wide area. Sentinel Butte, just east of the Montana/North Dakota border, is a 300 m tall erosional remnant of horizontal strata (figure 3) that represents a much larger area of deposition over eastern Montana and western North Dakota.

Here is what must have happened if the Fort Union Formation is post-Flood. First, the deposit has to mass waste from some high area likely due to tectonic uplift. The Rocky Mountains, many hundreds of kilometres to the west and south-west, seem like the only major source of the huge volume of the Fort Union Formation before erosion (150,000 km^3). The mountains east of the continental divide seem much too small to produce all this strata, not including the strata that once lay above the formation. Second, the mass wasting debris must spread out over an area of about 450,000 km^2 on the High Plains that have a low easterly slope. Mass wasting debris is generally considered of mixed particle sizes, while sandstone and shale are not normally considered mass wasting debris. Heavy precipitation could have caused fluvial sorting to produce the fine-grained sediments, in which case we should see abundant evidence of channels and other fluvial features. Mass wasting also produces thick deposits near the source, which thin distally. These features are rare at best in the Fort Union Formation. Third, dozens of nearly pure coal layers, some up to more than 60 m thick and laterally extensive, had to form during mass wasting (Cenozoic coal will be discussed in a later part). Fourth, more strata was deposited on top of the Fort Union Formation—more than 300 m deep over at least eastern Montana and western North Dakota. Fifth, the strata must be lithified because near-vertically walled erosional remnants (figure 3) would not exist on top of the Fort Union Formation, if unconsolidated. Sixth, erosion by some mechanism (mass wasting?) takes away practically all the strata on top of the Fort Union Formation and the majority of the Fort Union Formation. Seventh, the erosional debris is not found downslope towards the Gulf of Mexico, but apparently has been completely swept off the continent and likely forms part of the strata down the topographic slope in southern Texas and the Gulf of Mexico. The Cenozoic strata younger than the Fort Union Formation downslope along the northern and central High Plains, the White River and Arikaree Groups, are predominantly volcaniclastic sediments reworked by water.[22] The surficial Miocene Ogallala Formation is predominantly sand and gravel eroded from the central and southern Rocky Mountains to the west. Without the sheer volume of water the Flood provided, such a scenario is quite implausible. Therefore, thin, widespread sedimentary layers in the Cenozoic present moderate difficulties for any attempt to explain them by post-Flood catastrophism.

Consolidated Cenozoic sedimentary rocks

Another sedimentary criterion that can help determine the location of Flood/post-Flood boundary is the process of hardening or consolidation of sediments into sedimentary rocks.[19] Sediments are converted into sedimentary rock by a combination of compaction caused by burial (usually deep burial by hundreds of metres of sediment) and the

Figure 3. Sentinel Butte, western North Dakota, USA, is a flat-topped mesa about 300 m above the Fort Union Formation.

precipitation of cement within the pores around sediment grains.[23] However, cementation rarely occurs today because it requires special conditions and many variables.[24,25,26]

In order for cementing agents to permeate the sediments, water within the sediments containing dissolved chemicals must readily flow through the pore spaces, leaving a chemical residue behind. Cement attaches to the sedimentary grains and gradually fills up the pore spaces, decreasing the flow around the grains (figure 4). As the flow decreases, it is able to transport less cement into the sediment, so the process of cementation slows down with time. Sometime during this process, the sediment can be cemented enough to be considered a sedimentary rock. As such, it is possible for a sedimentary rock to vary in degree of cementation and in hardness due to the extent of cement growth, the type of mineral doing the cementation, the availability of cementing agents, and other variables. Time is only one of the many variables involved in lithification. The speed of cementation depends on the *right conditions*, and that is why even some pre-Cenozoic strata are poorly consolidated.

Calcite and silica, two very common minerals often found in cracks and veins in rock, are the main cementing agents. Iron oxides, other carbonate minerals, and clay minerals are minor agents. These dissolved minerals must flow through the pore spaces and precipitate in the voids between the grains. Sometimes even the grains themselves can dissolve in the lithification process and be re-deposited as cement or transported out of the particular sediment. For instance, after depositing a calcite cement, the pore water could change chemistry and dissolve the calcite or replace the calcite with another cementing mineral, such as dolomite.

The Genesis Flood rapidly deposited thick sediments, which were

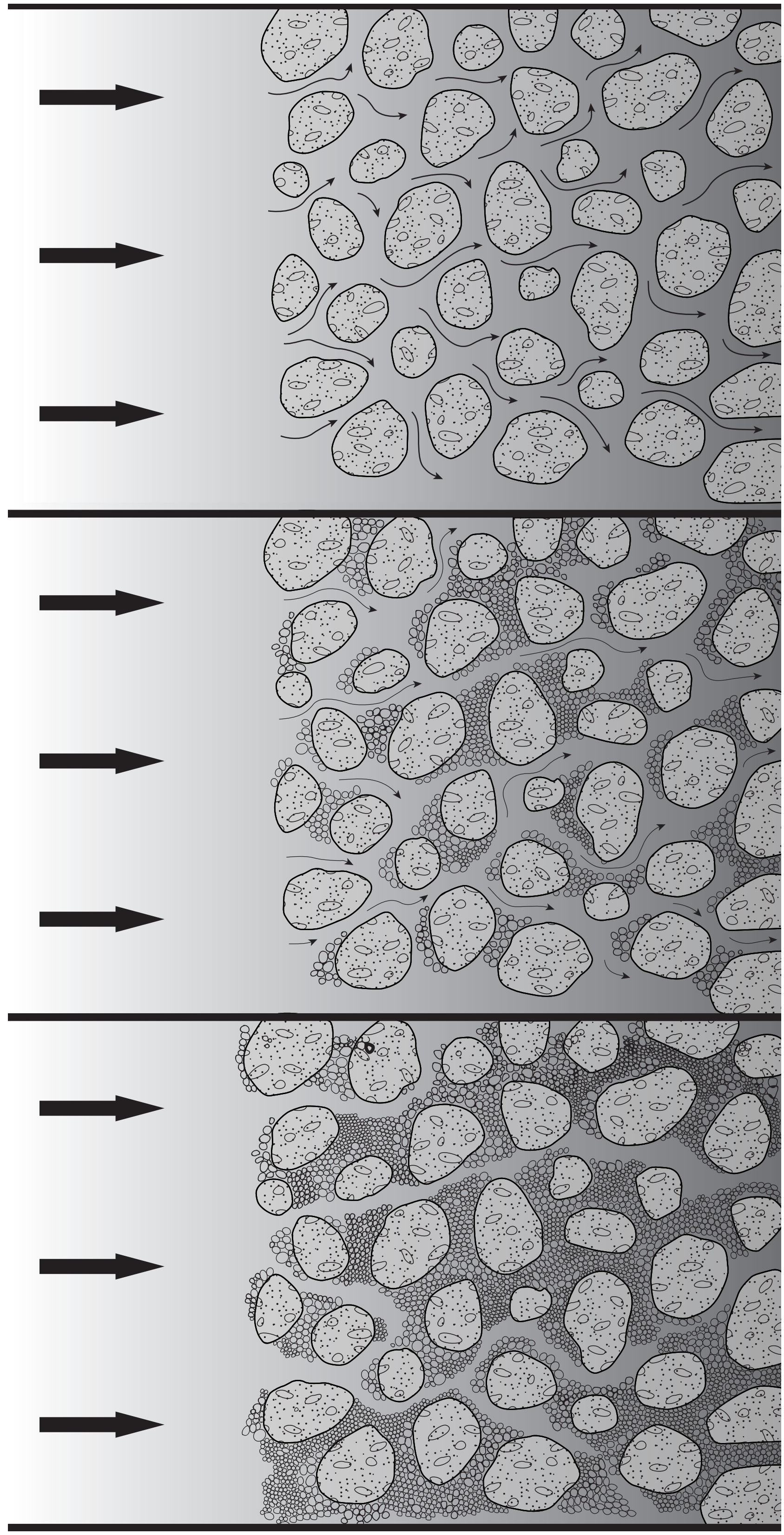

Figure 4. Schematic of the cementing of sand into sandstone by water flowing through the pores and depositing cementing chemicals (drawn by Melanie Richard)

compacted rapidly because of the accumulation of hundreds to thousands of metres of sediments. The Flood would also have trapped abundant water within the sediment during deposition. Cementing chemicals could easily have been dissolved in hot water, both within the Flood water and in the water within the sediments. The rapid accumulation of sediments would force the chemically charged water to flow through the sediments under high overburden pressure.

In today's environment, both compaction and cementing agents are lacking,[27] creating a severe uniformitarian problem. Pettijohn states that in the lithification of a 100 m thick layer of sand, 25–30 m of cement must be deposited within the pore spaces (assuming little compaction).[27] But, the origin of this cement, and how and when the sediment is cemented, is unresolved:

> "Cementation, moreover, is the last step in the formation of the sandstone, and our knowledge is incomplete and unsatisfactory unless the origin and manner of emplacement of the cement are fully understood. ... The problems of how and when sands become cemented and the source of the cementing material are still unresolved."[28]

So, cementation by presently observed processes (uniformitarianism) is very difficult to explain. It has happened in the past under unexplained special conditions involving a lot of cementing agents; e.g. water with high concentrations of calcite or silica in some mines or hot springs.

Could deposition after post-Flood mass wasting in local to regional post-Flood catastrophes of Flood-laid sediments result in thick, lithified deposits? First, it is unlikely sediments at the end of the Flood would be thickly unconsolidated because *intense* Flood run-off, caused by the strong continental uplift and margin subsidence, would erode any unconsolidated sediment, leaving behind mostly lithified sediments. So, post-Flood mass wasting would be minor and could not erode and accumulate thousands of metres of sediments, either within the continental or along the continental margin. Second, the depositional products from mass wasting would have to be cemented. Chemicals need to be dissolved and flow through the pores of the mass wasted debris. Third, it is also impossible to know whether post-Flood catastrophes can create the special conditions required to dissolve cementing agents. It may be possible that the lower mass wasted sediments could be consolidated by compaction and cementation, but how would the top of the mass be also lithified?

Fully lithified sediments would likely have occurred during the Flood, while thin unconsolidated sediments would more likely occur after the Flood. Since Cenozoic sedimentary rocks are often lithified, such as the Fort Union Formation and Rocky Mountain basin strata, they present moderate difficulties for any attempt to explain them by post-Flood catastrophism.

Deposition of widespread and/or thick Cenozoic 'evaporites'

There are large and thick accumulations of 'evaporites' across the earth,[29] including salt (NaCl), anhydrite ($CaSO_4$), and gypsum, which is the hydrated equivalent of anhydrite. These are found in layers and diapirs throughout the Phanerozoic sediments, including the Cenozoic. Unlike uniformitarian scientists, creationists do not believe these 'evaporites' represent evaporation from drying bodies of water but believe they were laid down rapidly by precipitation. Creationists, of course, need a detailed explanation for precipitates, and a few ideas have been posited, one being the igneous origin hypothesis.[30]

The largest 'evaporite' in the world is believed to be at the bottom of the Mediterranean Sea and has been locally uplifted a few thousand metres and exposed on land. It covers 2.5 million km^2 and averages 1 km deep.[19] The deepest section is about 3.5 km thick in the Herodotus Basin in the eastern Mediterranean Sea.[31] Uniformitarians call it the Messinian Salinity Crises and date it to the very late Miocene (late Cenozoic), about 5.5 million years ago. These evaporites are further overlain by about 1 km of Pliocene sediments or sedimentary rocks, indicating that significant geological activity occurred *after* the deposition of the salt and anhydrite.

This evaporite has inspired uniformitarian scientists to postulate that the Mediterranean Sea dried out dozens of times in the late Cenozoic. In a similar manner, the Red Sea also has thick late Miocene salt deposits that were probably deposited at the same time as in the Mediterranean Sea. Creationists, on the other hand, assume this 'evaporite' layer was deposited differently and in a shorter timeframe. However, the post-Flood argument falls short of explaining how such widespread deposits of salt and anhydrite were deposited, and it fails to explain how in turn they are overlain with a further 1 km of sediment. Such Cenozoic deposits present strong difficulties for any attempt to explain them as a result of post-Flood catastrophism.

Cenozoic phosphorites

Phosphorites are sedimentary rocks that contain a high concentration of phosphate, mostly as P_2O_5. The definition of a phosphorite is rather arbitrary, generally defined as over 19.5% phosphate, but high phosphate sedimentary rocks between 7.8% and 19.5% are of interest also. Many geologists would consider a rock as phosphatic if it contained 10 to 100 times more phosphate than normal. There are extensive layers of phosphorites, such as the Permian Phosphoria Formation and its equivalents in the northern Rocky Mountains of the United States that cover about 225,000 km^2.[32] Uniformitarian scientists believe that phosphorites originated as marine biochemical sedimentary rocks. They are believed to take thousands of years to form, and are rarely observed forming today.[33] Phosphorous (P) today is added to the sediments by coastal upwelling of P-rich bottom water and is extracted by marine organisms. When these organisms die, P is accumulated in the organic-rich bottom mud.[34] Bacteria help break down organic matter, forming phosphate in the sediments.[33]

Although phosphorites occur in the rock record as early as the early Proterozoic, they are especially concentrated in the Cretaceous and Cenozoic erathem, especially the Miocene series of the late Cenozoic (figure 5).[35,36] Föllmi and colleagues state:

> "The Miocene was an epoch of preferential phosphogenesis and accumulation of phosphate-rich deposits, and Miocene phosphorites are widespread … ."[37]

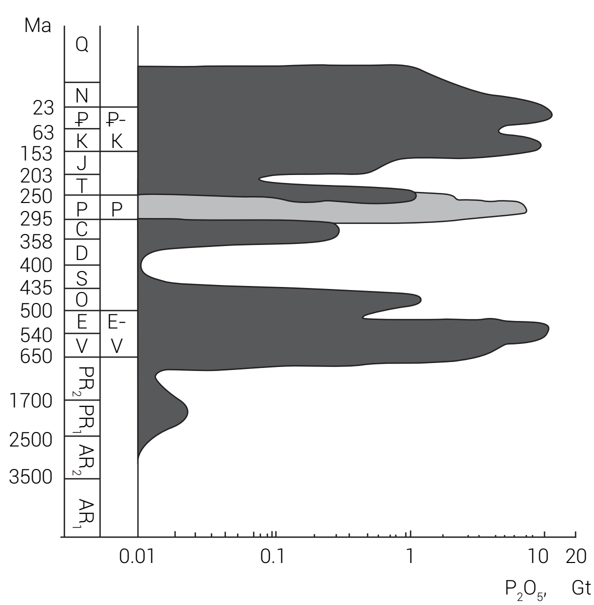

Figure 5. Distribution of economic phosphorus resources in Earth history according to the evolutionary/uniformitarian timescale (modified by Melanie Richard from Kholodov and Butuzova[36])

For instance, phosphate-rich sedimentary rocks of late Oligocene to late Miocene are found in Malta and south-east Sicily.[38] The early late Cenozoic (Miocene) Monterey Formation that outcrops over numerous areas of the coastal section between Los Angeles and San Francisco, California, has many high phosphate-rich layers.[39] Some of these are thin, persistent laminae.[40] Catastrophic deposition has been suggested:

> "The concept of local catastrophic burial as a favourable prerequisite for the triggering of phosphogenesis embodies a small-scale example of the importance of nonreversible, catastrophic events on geological and biological processes … ."[41]

Moreover, it is not enough to simply bury phosphate-rich organisms, as the phosphate needs to be *concentrated* in layers by transport within the interstitial water of the sediments. Evidence of subsurface movement of phosphate in pore water is shown by numerous examples of phosphatized fossils, coprolites (fossil dung), burrows, hardgrounds (hard cemented layers), etc.[33,38]

Could post-Flood catastrophes cause the quick formation of phosphorites? It seems rather doubtful that these catastrophes could bury enough organisms to result in much organic phosphate and be able to concentrate the phosphate into layers. Chances are such catastrophes would result in phosphate being randomly disseminated within the sediment, so that the concentration of P would be limited. Nonetheless, these difficulties for a post-Flood explanation are comparatively minor to other sedimentary features of the Cenozoic explored here, thus only provide modest evidence for Flood processes in the Cenozoic.

Formation of Cenozoic carbonates

According to sedimentologist Francis Pettijohn, carbonates make up about 8% of all sedimentary rocks.[42] Carbonates are mostly calcite ($CaCO_3$) and dolomite ($CaMgCO_3$), which are minerals that precipitate out of water or are the remains of organisms with a carbonate shell extracted from seawater. They are abundant in the Paleozoic erathem and the Proterozoic (late Precambrian) and decrease upward in the geological column.[43]

Early Cenozoic carbonates can be widespread on the continents.[44] In North America, all of Florida is covered by early Cenozoic carbonate. In Central America, the Yucatan Peninsula is mostly early Cenozoic carbonate. In the Eastern Hemisphere, Saudi Arabia has large areas of early Cenozoic carbonates and larger areas are found in West Africa, East Africa, around the Mediterranean Sea, south-west Russia, and the Ukraine. Widespread Miocene carbonates of the late Cenozoic are found in the Caribbean Islands and the south-east United States in the Western Hemisphere.[45] Miocene carbonates are also found around the Mediterranean Sea, south-west Russia, and the Ukraine, but they are patchier than in the early Cenozoic. Some significant Miocene carbonates show up in Indonesia and southern Australia, as in the very flat Nullarbor Plain of South Australia covering 200,000 km^2.[46]

An example of a late Cenozoic carbonate considered deposited in a terrestrial environment[47] is the top member of the Muddy Creek Formation of south-east Nevada and north-west Arizona, the Hualapai Limestone Member.[48]

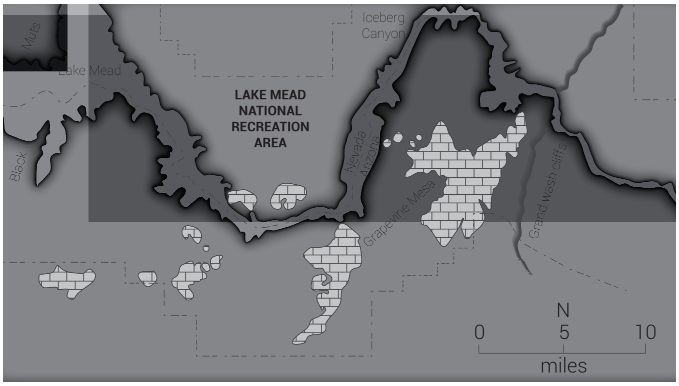

Figure 6. Outcrops of the Hualapai Limestone Member of the Muddy Creek Formation in the Lake Mead area (drawn by Melanie Richard)

The Muddy Creek Formation is a basin-fill deposit that was deposited after uplift of the mountains.[49] The Hualapai Limestone Member is exposed in the Lake Mead area as limited erosional remnants that were originally deposited over a much larger area (figure 6). It not only forms thick masses but also is inter-bedded with other types of rocks, such as the conglomerates and sandstones of the Muddy Creek Formation.[50]

The Hualapai Limestone is over 300 m thick.[51] The volume of the current mass of limestone is over 100 km^3.[52] However, its original volume would have been many times this volume since much of it has eroded. Its fine-grained nature suggests inorganic precipitation in water, although most uniformitarian scientists believe the carbonate originated from organisms because that is the type of carbonate predominantly forming today.[53] The limestone contains various types of fossils, including plant fossils of grasses, reeds, and rushes, and is one reason why some scientists have proposed a terrestrial origin.

Significant inorganic carbonates are not forming in terrestrial environments today, but could they be deposited in postulated post-Flood catastrophic conditions? This is unlikely, as mass wasting would not result in thick, widespread, pure carbonates. But what of post-Flood lacustrine conditions? How can one explain where the carbonate came from? Given the nature of mass wasting processes one would think that any post-Flood limestone would be well mixed with other sediments, but these Cenozoic carbonates are relatively pure. Moreover, the top of the Hualapai Limestone has been eroded, so not only do advocates of post-Flood catastrophism need to deposit the limestone, but also to erode off the top. As such, large-scale Cenozoic carbonate deposits present moderate difficulties for any attempt to explain them by post-Flood catastrophism.

Extensive Cenozoic continental margin sedimentary rocks

The continental margin includes the shallow, seaward-dipping continental shelf, the continental slope, and in offshore areas without trenches the continental rise (figure 7). The continental margin represents a thick accumulation of sedimentary rocks that form a continuous ring around the continents and large islands of the earth. The profile is very similar across the earth with the depth close to 130 m at the 'slope break', except the Antarctic margin that is isostatically depressed from the ice sheet. The continental shelf can be very wide; e.g. up to 1,500 km wide north of Siberia. Below the continental margin sedimentary rocks there are many buried rifts or basins that were caused by extension and subsidence. The Cenozoic and late Mesozoic sedimentary rocks reach over 20 km deep in places.[54] Based on seismic profiles, it appears that many of the sediments were deposited by transport *off* the continents, not by the longshore currents that commonly run parallel to most shorelines today. Monteverde *et al.* state:

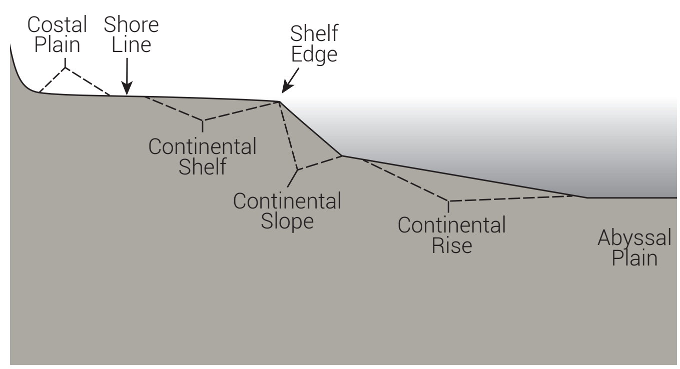

Figure 7a. Schematic of an Atlantic-type continental margin (drawn by Melanie Richard)

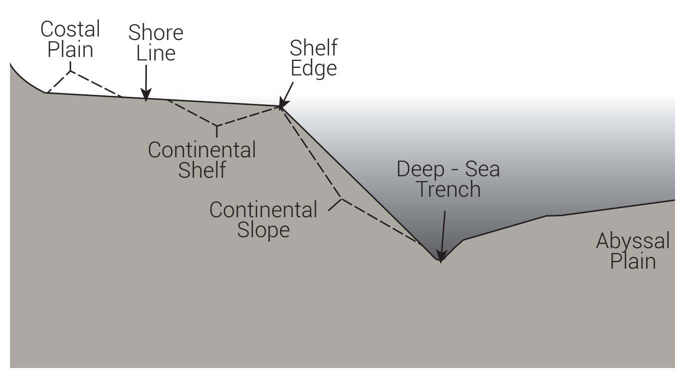

Figure 7b. Schematic of a Pacific-type continental margin (drawn by Melanie Richard)

> "Seismic profiles show that the New Jersey continental shelf contains a thick record of prograding clinoform wedges. … Similar prograding clinoform wedges are observed in Neogene [late Cenozoic] sediments of passive and active margins throughout the world … ."[55]

This prograding wedge of sedimentation implies currents that rushed directly off the continents and can readily be explained by sheet flow, resulting in sheet deposition in waning currents, during Flood run-off from the continents.

Continental margins contain a large proportion of Cenozoic sedimentary rocks. The rest are from the upper half of the Mesozoic. For instance, off the central East Coast of the United States it has been estimated that out of a total volume of 1.34 million km^3 of sedimentary rocks about 30% are of Cenozoic age.[56] The very thick continental margin in the northern Gulf of Mexico is filled with about 12 km of Cenozoic sedimentary rocks.[57] The central Argentine continental margin, 150–500 km wide, contains one of the thickest accumulations of sedimentary rocks in the world.[58,59] Based on the inferred age of the sedimentary rocks from seismic profiles, about 50–75% of these sediments are dated as Cenozoic. The Mediterranean Sea off Israel has a maximum of about 5 km of Cenozoic sedimentary rocks.[60] Two basins on the South China Sea continental margin contain Cenozoic sedimentary rocks greater than 10 km thick.[61] It appears that about 40% of the sedimentary rocks on the continental margin off the west coast of South Africa are Cenozoic deposits.[62]

Therefore, Cenozoic strata along the continental margin represents at least a few thousand metres of deposition. If these strata were deposited after the Flood, mass wasting would have to remove thousands of metres of rock from the uplifting continents. The sediments must then be transported to the continental margin. Along some continental margins, such as north of Siberia, mountains where mass wasting could occur are generally far from the coast. The deposition would have to form a *continuous* sheet around all the continents and large islands with a near constant depth for the slope break. How can the universal characteristics of the continental margin possibly be explained after the Flood with local or regional mass wasting events and giant floods? In light of the stiff difficulties facing any potential post-Flood explanation of the sheer amount of Cenozoic sedimentary rocks on the continental margin, this counts as strong evidence for these Cenozoic rocks resulting from Flood processes.

Conclusion

Whitmore and other creation scientists have claimed that the main evidence for attributing most of the Cenozoic to Flood processes relies on geomorphology. However, there are numerous non-geomorphological features of the Cenozoic rocks that suggest most were formed by Flood processes. Sedimentary features of the Cenozoic rock record are better explained with reference to Flood processes than post-Flood catastrophism including: the sometimes great thicknesses; sometimes widespread, thin deposition; the consolidation of sediments; widespread or thick 'evaporites'; phosphorites; carbonates; and thick continental margin strata. All these features support the contention that the Flood/post-Flood boundary is predominantly in the late Cenozoic, and likely in the very late Cenozoic in many areas.

References

1. Whitmore, J.H., The potential for and implications of widespread post-Flood erosion and mass wasting processes; in: Horstemeyer, M. (Ed.), *Proceedings of the Seventh International Conference on Creationism*, Creation Science Fellowship, Pittsburgh, PA, 2013.
2. Whitmore, J.H. and Garner, P., Using suites of criteria to recognize pre-Flood, Flood, and post-Flood strata in the rock record with application to Wyoming (USA); in: Snelling, A.A. (Ed.), *Proceedings of the Sixth International Conference on Creationism*, Creation Science Fellowship, Pittsburgh, PA, pp. 425–448, 2008.
3. Whitmore, J.H. and Wise, K.P., Rapid and early post-Flood mammalian diversification evidences in the Green River Formation; in: Snelling, A.A. (Ed.), *Proceedings of the Sixth International Conference on Creationism*, Creation Science Fellowship, Pittsburgh, PA, pp. 449–457, 2008.
4. Oard, M.J. and Whitmore, J.H., The Green River Formation of the west-central United States: Flood or post-Flood? *J. Creation* **20**(1):46–85, 2006.
5. Whitmore, J.H., The Green River Formation: a large post-Flood lake system, *J. Creation* **20**(1):55–63, 2006.
6. Oard, M.J. and Klevberg, P., Green River Formation very likely did not form in a postdiluvial lake, *Answers Research Journal* **1**:99–107, 2008.
7. Neuendorf, K.K., Mehl, Jr., J.P. and Jackson, J.A., *Glossary of Geology*, 5th edition, American Geological Institute, Alexandria, VA, p. 397, 2005.
8. Oard, M.J., (ebook) *The Flood/Post-Flood Boundary Is in the Late Cenozoic with Little Post-Flood Catastrophism* 2014, michael.oards.net/PostFloodBoundary.htm.
9. Wise, K.P., Austin, S.A., Baumgardner, J.R., Humphreys, D.R., Snelling, A.A. and Vardiman, L., Catastrophic plate tectonics: a global Flood model of earth history; in: Walsh R.E. (Ed.), *Proceedings of the Third International Conference on Creationism,* technical symposium sessions, Creation Science Fellowship, Pittsburgh, PA, pp. 609–621, 1994.
10. Oard, M.J., Is the K/T the post-Flood boundary?—part 1: introduction and the scale of sedimentary rocks, *J. Creation* **24**(2):95–104, 2010.
11. Holt, R.D., Evidence for a late Cainozoic Flood/post-Flood boundary, *J. Creation* **10**(1):128–167, 1996.
12. Elders, W.A., Rex, R.W., Meidav, T., Robinson, P.T. and Biehler, S., Crustal spreading in Southern California, *Science* **178**:15–24, 1972.
13. Ingersoll, R.V. and Rumelhart, P.E., Three-stage evolution of the Los Angeles basin, southern California, *Geology* **27**(7):593–596, 1999.
14. Sharp, R.P., *Southern California*, Kendal/Hunt Publishing Company, Dubuque, IA, p. 13, 1975.
15. Knapp, C.C., Knapp, J.H. and Connor, J.A., Crustal-scale structure of the South Caspian Basin revealed by deep seismic reflection profiling, *Marine and Petroleum Geology* **21**:1073–1081, 2004.
16. Artyushkov, E.V., Formation of the superdeep South Caspian basin: subsidence driven by phase change in continental crust, *Russian Geology and Geophysics* **48**:1002–1014, 2007.
17. Pawlak, A., Eaton, D.W., Bastow, I.D., Kendall, J.-M., Helffrich, G., Wookey, J. and Snyder, D., Crustal structure beneath Hudson Bay from ambient-noise tomography: implications for basin formation, *Geophysical Journal International* **184**:65–82, 2011.
18. Richardson, S.E.J., Davies, R.J., Allen, M.B. and Grand, S.F., Structure and evolution of mass transport deposits in the South Caspian Basin, Azerbaijan, *Basin Research* **23**:702–719, 2011.

19. Oard, M.J., Defining the Flood/post-Flood boundary in sedimentary rocks, *J. Creation* **21**(1):98–110, 2007.
20. Belt, E.S., Hartman, J.H., Diemer, J.A., Kroeger, T.J., Tibert, N.E. and Curran, H.A., Unconformities and age relationships, Tongue River and older members of the Fort Union Formation (Paleocene), western Williston Basin, U.S.A., *Rocky Mountain Geology* **39**(2):113–140, 2004.
21. Oard, M.J., A uniformitarian paleoenvironmental dilemma at Clarkia, Idaho, USA, *J. Creation* **16**(1):3–4, 2002.
22. Terry, D.O., LaGarry, H.E. and Hunt, Jr., R.M. (Eds.), Depositional Environments, Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups (late Eocene to early Miocene, North America), *GSA Special Paper 325*, Geological Society of America, Boulder, CO, 1998.
23. Plummer, C.C. and McGeary, D., *Physical Geology*, 7th edn, Wm. C. Brown Publishers, Dubuque, IA, p. 117, 1996.
24. McBride, E.F., Quartz cement in sandstones: a review, *Earth-Science Reviews* **26**:69–112, 1989.
25. Haddad, S.C., Worden, R.H., Prior, D.J. and Smalley, P.C., Quartz cement in the Fontainebleau Sandstone, Paris Basin, France: crystallography and implications for mechanisms of cement growth, *Journal of Sedimentary Research* **76**:244–256, 2006.
26. Molenaar, N., Cyziene, J. and Sliaupa, S., Quartz cementation mechanism and porosity variation in Baltic Cambrian sandstones, *Sedimentary Geology* **195**:135–159, 2007.
27. Pettijohn, F.J., *Sedimentary Rocks*, 3rd edn, Harper and Row, New York, pp. 239–245, 1975.
28. Pettijohn, ref. 27, pp. 239, 242.
29. Warren, J.K., Evaporites through time: tectonic, climatic and eustatic controls in marine and nonmarine deposits, *Earth-Science Reviews* **98**:217–268, 2010.
30. Heerema, S., A magmatic model for the origin of large salt formations, *J. Creation* **23**(3):116–118, 2009; creation.com/magmatic-origin-salt-deposits
31. Rouchy, J.M. and Caruso, A., The Messinian salinity crisis in the Mediterranean basin: a reassessment of the data and an integrated scenario, *Sedimentary Geology* **188–189**:35–67, 2006.
32. Piper, D.Z., Marine chemistry of the Permian Phosphoria Formation and basin, south-east Idaho, *Economic Geology* **96**:599–620, 2001.
33. Föllmi, K.B., The phosphorus cycle, phosphogenesis and marine phosphate-rich deposits, *Earth-Science Reviews* **40**:55–124, 1996.
34. Nelson, G.J., Pufahl, P.K. and Hiatt, E.E., Paleoceanographic constraints on Precambrian phosphorite accumulations, Baraga Group, Michigan, USA, *Sedimentary Geology* **226**:9–21, 2010.
35. Nelson *et al.*, ref. 34, p. 17.
36. Kholodov, V.N. and Butuzova, G. Yu., Problems of iron and phosphorus geochemistry in the Precambrian, *Lithology and Mineral Resources* **36**(4):293, 2001.
37. Föllmi, K.B., Hofmann, H., Chiaradia, M., de Kaenel, E., Frijia, G. and Parente, M., Miocene phosphate-rich sediments in Salento (southern Italy), *Sedimentary Geology* **327**:55, 2015.
38. Föllmi, K.B., Gertsch, B., Renevey, J.-P., De Kaenel, E. and Stille, P., Stratigraphy and sedimentology of phosphate-rich sediments in Malta and south-eastern Sicily (latest Oligocene to early late Miocene), *Sedimentology* **55**:1,029–1,051, 2008.
39. Berndmeyer, C., Birgel, D., Brunner, B., Wehrmann, L.M., Jöns, N., Bach, W., Arning, E.T., Föllmi, K.B. and Peckmann, J., The influence of bacterial activity on phosphorite formation in the Miocene Monterey Formation, California, *Palaeogeography, Palaeoclimatology, Palaeoecology* **317–318**:171–181, 2012.
40. Föllmi, K.B. and Garrison, R.E., Phosphatic sediments, ordinary or extraordinary deposits? The example of the Miocene Monterey Formation (California); in: Miller, D.W., McKenzie, J.A., and Weissert H. (Eds.), *Controversies in Modern Geology: Evolution of Geological Theories in Sedimentology, Earth History and Tectonics*, Academic Press, New York, pp. 55–84, 1991.
41. Föllmi and Garrrison, ref. 40, p. 55.
42. Pettijohn, ref. 27, p. 22.
43. Pettijohn, ref. 27, p. 317.
44. Ronov, A.B., Khain, V.Ye. and Balukhovskiy, A.N., Paleogene lithologic associations of the continents, *International Geology Review* **21**(4):415–446, 1979.
45. Khain, V.Ye., Ronov, A.B. and Balukhovskiy, A.N., Neogene lithologic associations of the continents, *International Geology Review* **23**(4):426–454, 1981.
46. Twidale, C.R. and Campbell, E.M., *Australian Landforms: Understanding a Low, Flat, Arid and Old Landscape*, Rosenberg Publishing Pty Ltd, New South Wales, Australia, p. 153, 2005.
47. Hunt, C.B., Cenozoic Geology of the Colorado Plateau, *U.S. Geological Survey Professional Paper 279*, U.S. Government Printing Office, Washington, D.C., 1956.
48. Blair, W.N. and Armstrong, A.K., Hualapai Limestone Member of the Muddy Creek Formation: the Youngest Deposit Predating the Grand Canyon, South-eastern Nevada and North-western Arizona, *U.S. Geological Survey Professional Paper 1111*, U.S. Government Printing Office, Washington, D.C., 1979.
49. Dicke, S.M., Stratigraphy and sedimentology of the Muddy Creek Formation, south-eastern Nevada, M.S. thesis, University of Kansas, Lawrence, KS, 1985.
50. Young, R.A., Pre-Colorado River drainage in western Grand Canyon: potential influence on Miocene stratigraphy in Grand Wash Trough; in: Reheis, M.C., Hershler, R. and Miller, D.M. (Eds.), Late Cenozoic Drainage History of the South-west Great Basin and Lower Colorado River Region: Geologic and Biotic Perspectives, *GSA Special Paper 439*, Geological Society of America, Boulder, CO, pp. 319–333, 2008.
51. Hunt, ref. 47, pp. 33, 35.
52. Blair and Armstrong, ref. 48, p. 12.
53. Blair and Armstrong, ref. 48, p. 9.
54. Deptuck, M.E., MacRae, R.A., Shimeld, J.W., Williams, G.L. and Fensome, R.A., Revised Upper Cretaceous and lower Paleogene lithostratigraphy and depositional history of the Jeanne d'Arc Basin, offshore Newfoundland, Canada, *AAPG Bulletin* **87**(9):1,459–1,483, 2003.
55. Monteverde, D.H., Miller, K.G. and Mountain, G.S., Correlation of offshore seismic profiles with onshore New Jersey Miocene sediments, *Sedimentary Geology* **134**:111–127, 2000.
56. Poag, C.W., U.S. Middle Atlantic Continental Rise: Provenance, Dispersal, and Deposition of Jurassic to Quaternary Sediments; in: Poag, C.W. and de Graciansky P.C. (Eds.), *Geological Evolution of Atlantic Continental Rises*, Van Nostrand Reinhold, New York, pp. 100–156, 1992.
57. Bally, A.W., Phanerozoic basins of North America; in: Bally, A.W. and Palmer A.R. (Eds.), The Geology of North America—An Overview, *The Geology of North America, volume A*, Geological Society of America, Boulder, CO, pp. 397–446, 1989.
58. Hinz, K., Neben, S., Schreckenberger, B., Roeser, H.A., Block, M., Goncalves de Souza, K. and Meyer, H., The Argentine continental margin north of 48°S: sedimentary successions, volcanic activity during breakup, *Marine and Petroleum Geology* **16**:1–25, 1999.
59. Gruetzner, J., Uenzelmann-Neben, G. and Franke, D., Variations in sediment transport at the central Argentine continental margin during the Cenozoic, *Geochemistry, Geophysics, Geosystems* **13**(10):1–15, 2012.
60. Steinberg, J., Gvirtzman, Z., Folkman, Y. and Garfunkel, Z., Origin and nature of the rapid late Tertiary filling of the Levant Basin, *Geology* **39**:355–358, 2011.
61. Xie, X., Dietmar Müller, R., Ren, J., Jiang, T. and Zhang, C., Stratigraphic architecture and evolution of the continental slope system in offshore Hainan, northern South China Sea, *Marine Geology* **247**:129–144, 2008.
62. Wigley, R.A. and Compton, J.S., Late Cenozoic evolution of the outer continental shelf at the head of the Cap Canyon, South Africa, *Marine Geology* **226**:1–23, 2006.

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