Not enough rocks: the sedimentary record and deep time

John K. Reed and Michael J. Oard

Since its inception, uniformitarian geology has argued that the Genesis Flood could not have deposited the volume of sedimentary rocks found in Earth's crust. This rhetoric has effectively diverted attention from the problem the sedimentary record creates for uniformitarian geology. An actualistic comparison of observed modern sedimentation rates to the total volume of Earth's sedimentary rock demonstrates that the real volume is surprisingly small relative to modern rates. This problem is reinforced by observed rates of erosion, which should have produced a much greater volume of rock than observed. Auxiliary explanations are advanced to account for these discrepancies, but the fact remains that the volume of the sedimentary record is no friend of uniformitarians. This discrepancy offers them three unpalatable choices: (1) Earth is not billions of years old, (2) the rock record is not a representative record of history, or (3) actualism is a poor forensic assumption.

What is the relationship between the sedimentary rock record and Earth's past? It is not presently clear, thanks to a long history of polemics against the Genesis Flood and for gradualist deep time:

> "Much more persuasive was … the huge piles of Secondary[[1]] strata that were being described in certain parts of Europe. A century earlier, when such rocks had yet to be studied closely, it had been quite plausible to suppose … that the entire pile of sediments could have been laid down all at once… . However, once the sheer thickness of the Secondary formations was fully appreciated, and detailed fieldwork suggested that many of them must have been deposited layer by layer under tranquil conditions, that kind of diluvial interpretation was quietly abandoned by most savants."[2]

In other words, there are 'too many rocks' for the Flood. In a short time, this questionable argument[3] became a rhetorical flourish, resonating with the public via the visual appeal of large-scale outcrops, like those at Grand Canyon or in the Alps. Despite logical rigour, many Christians have also been successfully diverted from uniformitarian problems by this old argument:

> "The question is whether minimally seven miles of fine-grained sediments and volcanic rocks accumulated in only one and a half millennia [*sic*]. We would be talking about an average sedimentation rate of about 20 feet per year for 1,656 years! If these rocks were all deposited during a one-year planetary Flood, however, then the sedimentation rate was seven miles or at least 36,000 feet per year! Do Flood geologists really expect anyone to believe that?"[4]

Such polemics preclude an objective examination of the relationship between rocks and history. Logic allows five possible relationships between the sedimentary record and the opposing paradigms of natural history (figure 1). Since uniformitarian rhetoric has long obscured these, let us reverse the argument and examine how well *secular* history explains the sedimentary record.

In evaluating any relationship between the sedimentary rock record and Earth's past, the hard data available include: (1) estimates of the total volume of sedimentary rocks, and (2) observed sedimentation rates in modern settings. Observed sedimentation rates should produce a much greater volume of sedimentary rock over deep time.This problem puts secularists in a corner. They must choose between: (1) a younger Earth, (2) an unrepresentative historical record, or (3) the rejection of actualism and its claim that modern processes are alone representations of the past. Any of these choices is fatal to pure uniformitarian geology.

Earth's sedimentary record—the big picture

The first factor is the volume of Earth's sedimentary record. Despite its complexity, it can be examined as a whole, and has been by geologists. Ronov[5] described the sedimentary rock record as the 'stratisphere'—the sedimentary and volcanic outer shell of Earth's crust, occupying some 11% of the crust by volume. Geologists estimate a range for this 'stratisphere', but many[6] cite Ronov's estimate of 1,100,000,000 km^3. Ronov[5] differenced maps between the land surface and the igneous and metamorphic basement to obtain a total volume, and then fleshed it out with voluminous lithologic data from wells, cores, and the literature. His detailed work examined rocks by lithology, age, and depositional environment. In doing so, he included all sedimentary rocks (including sediments and metasedimentary rocks) of the Archean, Proterozoic, and Phanerozoic eons.

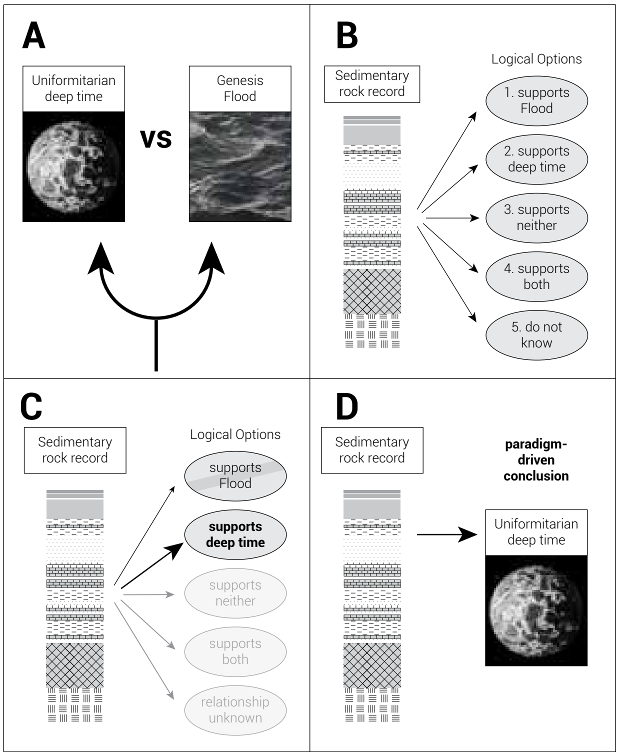

Figure 1. While stratigraphy focused on the paradigmatic debate between uniformitarianism and the Flood (A), geologists ignored the five actual logical options (B). This obscured three options, and a fourth—the possibility of a supportive relationship between the Flood and the rocks—was rejected *a priori* (C). Thus, geologists have wrongly concluded that the sedimentary rock record unilaterally supports deep time (D).

Although most Archean rocks are igneous or metamorphic in lithology, Ronov included those he deemed to have been at some time sedimentary.

The sedimentary record is marked by several interesting discontinuities. The most obvious is the disproportionately high volume on the continents and continental margins. Together, they contain 82.8% of sedimentary rocks, even though they occupy less than 42% of the total surface area. Ronov estimated Earth's total surface area to be 510,072,000 km^2, with a little more than 29%, or 148,940,000 km^2, as dry land. Of the 361,132,000 km^2 under water, 12.7%, or 64,779,144 km^2 comprised continental margins (figure 2).

After estimating the distribution of Earth's sedimentary rocks, Ronov calculated the average thickness of the sedimentary shell in a variety of crustal settings. On continents, he estimated the average thickness to be 5 km. This decreased to 2.5 km on the continental margins, and 0.4 km on the sea floor (figure 3). His averages include everything from exposed continental shields to deep basins like the Southern Caspian Basin, where the sedimentary column thickness reaches 25 km,[7] and the western Gulf of Mexico, where it locally exceeds 16 km.[8]

Others have estimated significantly lower average thicknesses and volumes. Blatt *et al.*[9] estimated an average thickness of 2.7 km on continents and 2.8 km on continental margins—an increase from Blatt's[10] earlier estimate of 0.82 km globally, 1.82 km on the continents, and 0.24 km on the ocean floors. Nelson[11] reported a continental average of only 1.8 km, very similar to that of Blatt.[10] One difference in these estimates may be that Ronov[5] focused on the entire

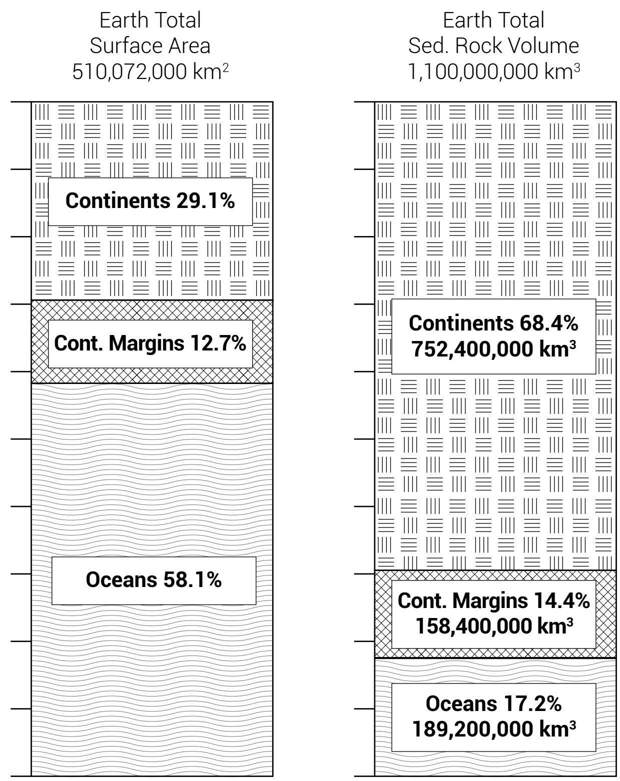

Figure 2. Oceans and submarine continental margins occupy most of Earth's surface area (left), but the bulk of Earth's sedimentary rocks occur on the continents (right), according to Ronov.[5]

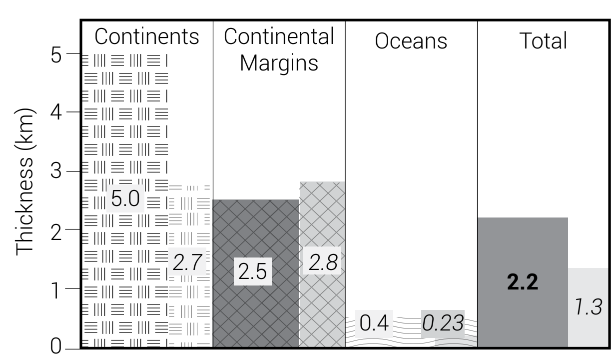

Figure 3. Comparison of calculations of Ronov[5] and Blatt *et al.*[9] for the average thickness of sedimentary rocks on continents, continental margins, ocean floors, and the entire planet. Ronov's estimates are shown in the darker patterns and font.

section above igneous and metamorphic basement, including metasedimentary rocks. However, the likely cause of the varying measurements is simply the difficulty of the task.

Modern sedimentation rates are too high

The second data point is the range of observed rates at which sedimentary rocks accumulate. That too can be difficult to determine, due to observational limits and because modern rates vary by up to eleven orders of magnitude.[12,13] These processes range in magnitude from a clay particle settling in the ocean to mass wasting events, and in time from a single wave on a beach to the infilling of a large cratonic basin. Unfortunately, many 'observed' rates are often *inferred* rates, based on measurements of stratal thickness and dates for the base and top. This, of course, is circular—it assumes uniformitarian deposition between the deep-time dates of the top and bottom. Moreover, observations showing that much sedimentation is the result of disproportionately rare, high-energy events call into question the old gradualist model of sedimentation. Bailey and Smith[14] question if there is *any* significant continuous deposition represented in the rock record, agreeing with Ager[15] that there is "more gap than record", and although Miall[12] admits that the record is a set of 'frozen accidents', he still affirms confidence in uniformitarian stratigraphy.

In fact, uniformitarian sedimentation rates appear to be a product of faith overcoming fact. Geologists can measure modern rates, and make good inferences about others, but these are routinely much higher than those considered 'typical' for geologic history. In fact, Sadler[13] posited a power law decrease in the rate of sediment accumulation back through time because of these kinds of observations. And others[16] recognize the necessity of this auxiliary hypothesis to lower 'older' rates. The unspoken assumption is deep time. When that condition is ignored, observed 'high' rates appear more normal than believed.

Sedimentation vs accumulation rates

The journey from sediment to preserved sedimentary rock involves several physical factors that can reduce the volume of freshly deposited sediment. These include compaction, dewatering, dissolution, and other diagenetic changes, such as changes in clay mineralogy. Diagenesis refers to all chemical, physical, and biological changes in sediment after deposition. In addition, large-scale physical factors, such as uplift and erosion, affect the final volume. Erosion is usually assumed to be the primary reason for the reduction in expected volume.[17]

Because sediment can be transported, deposited, and re-eroded and transported again relatively quickly, most geologists see *accumulation* as being most directly related to the rate of subsidence of sedimentary basins, which produces what is called *accommodation space*. Modern sedimentation rates suggest that particles are supplied in excess of this space; the final product is a function of how much and how quickly the basin's crust subsides to capture and preserve the sediments cycling through that area. Bailey[18] referenced Smith's[19] concept of a self-organized 'Stratigraphy Machine' that teeters on the edge of chaos, allowing occasional preservation and accumulation of eroded waste as sedimentary rocks.

Scale creates enough complexity to obscure the basic point that there are not enough rocks. Given uniformitarian history, we will examine the gross aspects of the record in terms of what this 'Stratigraphy Machine' might produce over 4.5 Ga.

A shortcut: comparing a variety of rates to accumulated thicknesses

When comparing the data points of observed sedimentation rates to the global volume of the sedimentary record, we use thickness as a surrogate for volume, since most sedimentary processes produce local geometric bodies of limited volume, but measurable thickness. Before examining modern rates, we first must find a way to relate a *range* of thicknesses to a *variety* of rates. This sets boundaries, creating a theoretical template against which measured and interpreted rates can be calibrated, and by which thickness ranges for particular periods of time can be quickly matched to minimum rates.

Figure 4 shows seven hypothetical rates, ranging from 0.1 mm/1,000 years (ka) to 10,000 mm/ka. Although all rates are normalized to mm/ka, resulting thicknesses are presented in accumulated *metres* of sediment for the four left columns, and accumulated *kilometres* of sediment for the right three columns for convenience. For the same reason, headers also include conversions to cm and m.

Figure 4 shows that a rate of 0.1 mm/ka is very low and supplies a total thickness of sediment less than 0.5 km over deep time. A rate of 1 mm/ka more than doubles the 2.2 km thickness of Ronov's 'stratisphere'. One of 10 mm/ka would fill the South Caspian Basin in about 2.5 Ga, and once rates move into ranges of 100–10,000 mm/ka, the resulting total thickness would range up to tens of thousands of km! At a rate of 1 m/ka, the total thickness of the accumulated record would be over *4,500 km*, and today's 2.2 km average would thus represent only 0.05% of that record.

Observed rates range across this spectrum but are on average much higher than required to supply the gross rock record. High rates create problems for uniformitarian geologists, even when lower inferred rates (assuming deep time) are used. For example, Schwab[20] estimated rates at a variety of basins (assuming deep time) reaching into hundreds of mm/ka. Although the rates in basins are higher than those outside basins, no basin reaches the predicted tens to hundreds of km, and such thicknesses call into question the necessary erosion or compaction needed to reduce that thickness. Sporadic accumulation, erosion, and subduction are the most common auxiliary hypotheses to explain the discrepancy, but the point is that there is a discrepancy of such magnitude to explain in the first place. That calls into question the relationship shown in figure 1D.

Although actual sedimentary processes are complex, the range of rates is sufficient to demonstrate that at any rate exceeding 1 mm/ka the present volume of sedimentary rocks represents a very small fraction of those ever deposited. This theoretical envelope helps us understand both modern rates and ancient thicknesses.

Reported sedimentation rates

Although sedimentation rates in the past cannot be measured, there are a surprising number of scientific observations and measurements of sedimentation occurring today. There are two classes of these: (1) actual observations and measurements, and (2) inferences in the 'recent' past based on stratigraphic methods, usually radiometric dating.

A sample of these is shown in figure 5. Some are of ongoing processes; others were unique events. However, geologists have stated that the unusual events are those most likely to be preserved—Ager[15] called them 'frozen accidents'. An additional column is included to normalize all rates to figure 4's measurements in mm/ka. What is immediately apparent is that modern rates are *much* higher than those proposed for the past, and that actual observed rates tend to be much higher than those that presuppose deep time and use stratigraphic methods. For example, Coleman[21] *observed* crevasse splay deposits forming at rates of 300,000 mm/ka in the Mississippi delta. But, assuming they formed during the 2.5 Ma of the Pleistocene, he concluded that deltaic deposits in the Gulf of Mexico formed at 'only' 1,440 mm/ka.

But even rates that assume deep time are quite high, like those reported in the Mediterranean Basin by Cita *et al.*[22] They calculated rates of 90–300 mm/ka for sediments below and above the Messinian 'evaporites' and rates of 1,000,000 mm/ka for the 'evaporites' themselves! Even processes assumed to be slow—like coral reef growth—are not. Based on modern observations, Roth[23] noted rates of up to 414,000 mm/ka for reefs, and Read and Snelling[24] thought that the Great Barrier Reef of Australia was growing at a rate of 15,300 mm/ka. Overbank flooding on the central Amazon River produced rates of over 12,000,000 mm/ka, and even assuming deep time, Kuehl *et al.*[25] estimated deposition on its delta was proceeding at rates up to 100,000 mm/ka.

In 1964, construction on the Aswan Dam reached the point that the river began infilling the new Lake Nasser, which reached an aerial extent of over 5,000 km^2. Based on the nearly 5 billion cubic metres of sediment deposited since 1964, the sedimentation rate in the lake is approximately 18,800 mm/ka. And this rate is small compared to that in Lake Mead, which, over the past 80 years, has reached nearly 250,000 mm/ka. Catastrophic events, such as the levee break in the Lower Ninth Ward of New Orleans during Hurricane Katrina,[26] or the lahars on the North Fork of the Toutle River after the 1980 eruption of Mount St Helens, have yielded rates in the billions of mm/ka.

Some of these are clearly unusual and highly localized events and processes, yet every modern rate is much higher than those proposed for the past. The uniformitarian principle would lead us to apply what is seen in the present to the rock record. Figure 4 shows that rates exceeding 1 m/ka would result in a complete rock record of *thousands of kilometres* in 4.5 Ga. The difference between those values and the approximated < 2 km is stark. Uniformitarian geologists claim that historical rates were lower, but it is hard to conceive of rates being several orders of

	Avg. thickness (m) rates = mm/1,000 years				***Avg. thickness. (km) rates = mm/1,000***		
Time	**0.1**	**0.5**	**1**	**10** (1 cm)	**100** (10 cm)	**1,000** (1 m)	**10,000** (10 m)
Per Ma	0.1	0.5	1	10	0.1	1	10
Per 10 Ma	1	5	10	100	1	10	100
Per 100 Ma	10	50	100	1,000	10	100	1,000
Per 500 Ma	50	250	500	5,000	50	500	5,000
Per 1 Ga	100	500	1,000	10,000 Max. Earth=25km	100	1,000	10,000
Per 4.55 Ga	*455*[3]	*2,275*[1]	*4,550*[2]	45,500	455	4,550	45,500
Cenozoic (65.5 my)	6.6	32.8	65.5	655	6.55	65.5	655
Mesozoic (185.5 my)	18.6	92.8	185.5	1,855	18.55	185.5	1,855
Paleozoic (290 my)	29	145	290	2,900	29	290	2,900
Proterzoic (1,959 my)	196	979.5	1,959	19,590	196	1,959	19,590

Figure 4. Comparison of accumulations shown as average thicknesses for a range of sedimentation rates. Superscript notes for comparison: 1 = Earth's average of 2,200; 2 = Continental average of 5,000 m; 3 = Ocean floor average of 400 m.[5] Grey box in centre: Earth's greatest known thickness of sedimentary rocks in the South Caspian Basin—a minimum of 10 mm/1,000 years for 2.5 Ga. Note that higher rates result in thicknesses far in excess of any observed rates; those of just 1 mm/year (1 m/1,000 years) result in *an average* of over 4,500 km, or nearly *15 million vertical feet* of sedimentary rock!

Observed or Inferred Sedimentaion Rate							
Location	**Description**	**Min.**	**Max.**	**Units**	**Corrected to mm/ka**	**Ref.**	**Assumes deep time**
Deep ocean	Red clay deposition	3	3	mm/ka	3	9	Y
Central Atlantic	Vema fracture zone	1.2		m/ka	1,200	9	Y
Mediterranean Basin	Pre-Messinian seds.	2.5	9	cm/ka	90		
Mediterranean Basin	Messinian evaporites	1,000		m/ka	1,000,000	2	Y
Mediterranean Basin	Plio-Plestocene seds.	0.1	30	cm/ka	300	22	Y
Bahamas Platform	Carbonate platform	23		mm/ka	23	9	Y
California	Ridge basin	11		mm/ka	11	9	Y
SW South Dakota	Stock ponds (35 mm rain)	60	850	mm/ka	850,000	9	N
Rocky Mountains	Alluvial fans	0.1	1	m/ka	1,000	9	Y
California	Submarine fans	0.05	1.2	m/ka	1,200	9	Y
Mississippi Region	Clastic basin	200		mm/ka	200	9	Y
Mississippi Delta	Pleistocene Gulf of Mexico		0.00144	m/ka	1,440	21	Y
Mississippi Delta	Crevasse splays		0.3	m/ka	300,00	21	N
Mississippi River	2001 flood overbank silts	30	80	mm/wk	4,160,000	28	N
Brazil	Central Amazon floodplain	0.3	3.3	cm/day	12,045,000	29	N
Brazil	Amazon fan		25	m/ka	25,000	30	Y
Brazil	Amazon fan (interglacial)	5	10	cm/ka	100	31	Y
Brazil	Amazon fan (glacial)	1	50	m/ka	50,000	31	Y
Brazil	Amazon delta		10	cm/yr	100,000	25	Y
Swiss Alps	Molasse basin	150	400	mm/ka	400	9	Y
Coral Reefs		0.8	414	mm/yr	414,000	23	N
Max. growth rate of coral organisms							
Antipathes sp.			143	mm/yr	143,000	23	N
Acropora palmata			99	mm/yr	99,000	23	N
Acropora cervicornis			432	mm/yr	432,00	23	N
Acropora pupucchra			226	mm/yr	226,000	23	N
Australia	Great Barrier Reef		15.3	mm/yr	15,300	24	N
New Orleans, LA	Levee break (Katrina)		1.25	m/hr	10,950,000,000	26	N
Mt St Helens	Toutle River lahar		183	m/day	66,795,000,000	34	N
Indonesia	2004 tsunami	0	30	cm/hrs	876,575,000	36	N
New York	Cayuga Lake	2.4	8	mm/yr	8,000	32	Y
India	Himalayan foothills lake	1.4	3.7	mm/yr	3,700	33	Y
Nevada	Lake Mead	0	250	ft/80 yr	238,125,000	35	N
Michigan	Lake Michigan	0.04	0.28	cm/yr	2,800	34	Y
Egypt	Lake Nasser		0.94	m/50 yr	18,000	12	N
Colorado	Bijou Creek flood	1	4	m/12 hr	18,000	12	N
Texas	Rio Grande valley	16	35	cm/yr	350,000	12	N
Wabash River	Wabash River point bars		1,000	m/ka	1,000,000	12	N
Miss. River, SW Pass	Distributary bars		730	m/ka	730,000	12	N
France	Rhone River delta front		35	cm/yr	350,000	12	N
China	Yangtze River mouth		4.4	cm/mo	528,000	12	N
Vietnam	Red River mouth	10	940	m/ka	940,000		
Indian Ocean	Bengal fan		1	m/yr	1,000,000	12	N
Texas	Colorado River valley fill	0.35	1.7	m/ka	1,7000	12	Ge
Georgia	Sapelo Island tidal inlets		4.5	m/ka	4,500	12	Y
Various	Modern alluvial fans	0.08	50	m/ka	50,000	12	Y
Gulf of Mexico	Plio-Pleistocene sediments	0.16	6.45	m/ka	6.450	12	Y
Galveston Island, TX	Barrier island		3.4	m/ka	3,400	12	Y

Figure 5. Samples of modern sedimentation rates from a variety of depositional settings.[9,12,21–26,28–37] Note some rates were measured and others inferred for 'recent' history using stratigraphic methods that assume deep time. Almost all modern rates far exceed those expected for ancient sediments based on volume of strata. Measured rates are usually far higher than those that infer rates based on deep time.

magnitude lower, especially with the evidence for large, rapid deposition in the rock record. They offer a variety of explanations for the much lower volumes of historical strata,[27] but the fact remains that explanations are required, and that present-day observations do not approach these historical low rates, even when deep time is assumed and rates estimated in environments like the abyssal ocean floor.

Continental erosion rates and volumes: another perspective

Another way to approach the problem is to examine the rate at which sediment might be formed by erosion. Do modern erosional rates reflect elevated depositional rates, or do they align with ancient sedimentation rates? Like sedimentation rates, we will examine erosion on a gross scale and ask how much time would be needed to erode the volume of the present-day continents to sea level.

Land above sea level averages 835 m in elevation and occupies over 148 million km^2.[38] That yields a volume of nearly 124 million km^3. Figure 6 shows the present relationship between land and sea in a hypsometric curve, showing the far greater volume of the world's oceans to dry land. Only a rough calculation is possible; erosion would slow as gradient decreased and isostasy would uplift continental crust as it thinned, but geologists have provided estimates of how long it would take to erode the continents to sea level using observed rates of denudation.

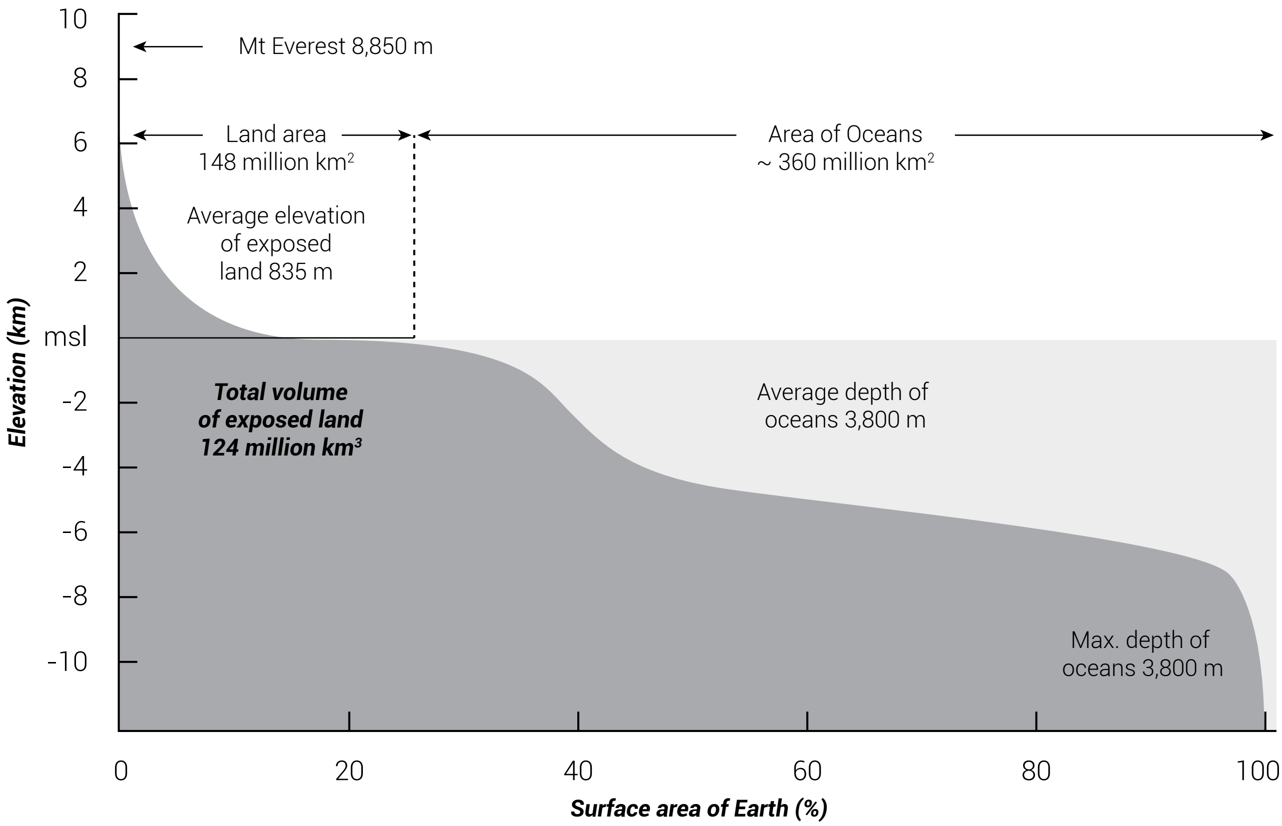

Figure 6. Hypsometric curve showing area of Earth above and below sea level. Total land area multiplied by average exposed land elevation yields average volume to be eroded of ~124 million km^3.[41]

This, in turn, would be an estimate of how long it would take to turn 124 million km^3 of crustal rock into sedimentary particles. The first step in this analysis is to examine present-day erosional rates.

Blatt *et al.*[9] and many others have studied erosion in a variety of settings. Erosion rates depend on many variables and are difficult to estimate.[39,40] Blatt *et al.*[41] reported erosion rates ranging from 41–48 mm/ka in the Appalachians, rates ranging from 70–910 mm/ka in the Alps, and up to 720 mm/ka in the Himalayas. The erosion rate in the Himalayas has recently been calculated to be much higher.[42] They noted that 5–10% of the continental mountainous terrain supplies 80% of erosional load; erosional rates increase with increasing slope at an exponential rate.[43]

Chen *et al.*[44] found an average landslide erosion rate of 2,650–5,170 mm/ka for one basin in Taiwan. This is high, but represents basin erosion in a mountainous area with occasional extreme events. The Teton Mountains of northwest Wyoming provide an example of a similar modern setting with lower precipitation. Hillslope erosion was calculated at 800 mm/ka, while the basin averaged 200 mm/ka.[45] Yet all these rates are much higher than the long-term rates based on cosmogenic isotopes (which assume deep time), thought to be 20 mm/ka.

Another modern study was performed for a mountainous region with low precipitation and negligible human impact; the northeast edge of the Tibetan Plateau.[46] Over an area of 3,000 km^2 with a mean elevation of 4,000 m, the rate was estimated at 80 mm/ka for the arid to semi-arid region that gets most of its precipitation from summer storms. This rate incorporated all three fluvial erosional parameters: suspended load, bed load, and dissolved load, but it is still much higher than 'long-term erosion rates' that assume deep time.

An accurate measure of actual erosion was found by Lazzari *et al.*[47] They measured the accumulation of sediment at a dam at the exit of a basin when the reservoir in southern Italy was drained. The basin has medium to high relief, and landslides are the dominant erosional mechanism. This study provides a representative rate for the Mediterranean area. Based on 38 years of storage and assuming a density of 2.5 g/cm^3 for the eroded rock, their erosion rate was 645 mm/ka. A variety of erosion rates are shown in figure 7.

If we apply the minimum rate of Blatt *et al.*[41] of approximately 40 mm/ka to the average continental elevation of 835 m, the total volume would be gone in a little more than 21 Ma. This corresponds to estimates of scientists who have calculated that complete denudation would take between 10 and 50 Ma. Roth[48] evaluated similar estimates and assumed total denudation within 10 Ma. His estimate was based on the quantity of suspended load in rivers flowing into the ocean.[49] Other variables could change these estimates. Human activity seems to have increased erosion, but that contribution to the suspended load deposited on deltas is unknown, since dams restrain erosion. Even if human activity has halved the natural erosion rate, the time needed to completely erode the continental volume remains at only 20 Ma. This does not account for bedload and dissolved load entering the oceans or for coastal erosion. Discharge during floods—which account for the bulk of sediment transported—is often not measured.[50] Unknown variables could increase erosion. On the other hand, the decreasing gradient would significantly decrease the erosion rate. If we use elevated rates shown in figure 7, such as hundreds of mm/ka, the time needed to erode the continents could be as little as one million years. Isostatic and tectonic uplift would offset the decrease in rate from the decrease in gradient. At any rate, the maximum feasible erosion rate of the continents' volume would be less than 50 Ma.

Continental crust has an average density of 2.7 g/cm^3. Sedimentary rocks have lower average densities, due to space occupied by porosity as a function of grain packing, and to differences in mineralogy. For that reason, the minimum amount of sediment derived from the 124 million km^3 of continental crust would be at least the same, and most likely greater, ignoring chemical dissolution and precipitation. While rocks can be changed from one type to another, their matter cannot simply appear or disappear. Therefore, continental denudation would yield a minimum of 124 million km^3 of sedimentary rock.

If we assume Ronov's[5] estimate of the volume of the global sedimentary record of 1,100 million km^3, then the 124 million km^3 from today's continents would yield about 11% of the total sedimentary record, and would thus require nine episodes of uplift and denudation to produce the global sedimentary rock record. Given Roth's rate of 10 Ma,[51] it would then take 90 Ma to reproduce the volume of the rock record. At a slower rate of 50 Ma, it would take 450 Ma to reproduce the rock record. These are estimates *based on uniformitarianism*—the extrapolation of present-day processes and their rates. This principle is what geologists continue to assert as their fundamental principle.[12] Earth's sedimentary rocks could then have formed in as little as 2% of deep time or as much as 10%.

Observed or Inferred Sedimentaion Rate						
Location	**Description**	**Min.**	**Max.**	**Units**	**Ref.**	**Assumes deep time**
Appalachian Mtns		41	48	mm/ka	9	Y
Mississipi River		43		mm/ka	9	Y
Alps		70	910	mm/ka	9	Y
Himalayas			720	mm/ka	9	Y
Southern Africa			77	mm/ka	54	N
Amazon	River drainage basin		93	mm/ka	53	N
Amur	River drainage basin		93	mm/ka	53	N
Brahmaputra	River drainage basin		688	mm/ka	53	N
Chiang Jiang	River drainage basin		131	mm/ka	53	N
Colorado	River drainage basin		96	mm/ka	53	N
Columbia	River drainage basin		52	mm/ka	53	N
Danube	River drainage basin		93	mm/ka	53	N
Dnieper	River drainage basin		5	mm/ka	53	N
Ganges	River drainage basin		273	mm/ka	53	N
Huang He	River drainage basin		54	mm/ka	53	N
Indus	River drainage basin		136	mm/ka	53	N
Southern Italy	Mountain basin		645	mm/ka	48	N
Kolyma	River drainage basin		4	mm/ka	53	N
La Plata (Parana)	River drainage basin		14	mm/ka	53	N
Lena	River drainage basin		11	mm/ka	53	N
MacKenzie	River drainage basin		32	mm/ka	53	N
Mekong	River drainage basin		99	mm/ka	53	N
Mississippi	River drainage basin		77	mm/ka	53	N
Murray	River drainage basin		13	mm/ka	53	N
Niger	River drainage basin		8	mm/ka	53	N
Nile	River drainage basin		11	mm/ka	53	N
Ob	River drainage basin		6	mm/ka	53	N
Orange	River drainage basin		28	mm/ka	53	N
Orinoco	River drainage basin		75	mm/ka	53	N
Rio Grande	River drainage basin		19	mm/ka	53	N
Shatt El-Arab	River drainage basin		26	mm/ka	53	N
St. Lawrence	River drainage basin		14	mm/ka	53	N
Taiwan	Mountain basin, hi precip	2,650	5,170	mm/ka	46	N
Tetons, Wyoming	Mountain basin, med predip		200	mm/ka	47	N
Tibetan Plateau	Mountain basin, lo precip		80	mm/ka	41	N
Yenisei	River drainage basin		9	mm/ka	53	N
Yukon	River drainage basin		44	mm/ka	53	N
Zaire	River drainage basin		7	mm/ka	53	N
Zambezi	River drainage basin		15	mm/ka	53	N

Figure 7. Modern erosion rates from a variety of settings.[9,46–49,51,52] Some are inferred using the assumption of deep time; others are measured or inferred independent of deep time.

Either way, erosion rates indicate that only a fraction of deep time would be needed to produce the rock record.

Discussion: the sedimentary record and time

Since the earliest days of geology, the sedimentary rock record has been viewed from the perspective of its purported incompatibility with the Genesis Flood. Geologists claimed that the volume of rock was too great to have been deposited in a year-long flood, but then drew the flawed conclusion that if the sedimentary record does not support the Flood, it automatically supports uniformitarian deep time (figure 1). That was a case of belief driving interpretation. The inherent circular reasoning in that train of thought remains an unacknowledged flaw of 'historical science'.

Geologists have become so accustomed to arguing in this circle that they rarely, if ever, re-examine their assumptions. If one assumes uniformitarian history, then one will automatically conclude that the sedimentary record 'proves' uniformitarianism, and the circle perpetuates itself. This circular reasoning is evident at all scales; even calculations of rates based on a measured thickness and stratigraphic ages of the top and base show this flaw. Schwab[20] compared depositional rates of 75 basins, but in every case he *derived* rates from a thicknesses/time calculation that assumed uniformitarian history. Needless to say, his 'rates' were much lower than those observed today.

Furthermore, the uniformitarian method assumes gradual slow deposition and often ignores field realities. Reed[53] showed how this kind of 'rate' calculation could not explain field features of basalt flows at the Midcontinent Rift System. Supposedly, these flows took more than 21 Ma to form, but the physical constraints on the flows and the sizes of their vents indicate actual emplacement of each flow in hours, similar to those of the Columbia River Basalt. In Kansas, the basalt flows—the actual rock record—would require ~120,000 years of 'dead time' between each flow in order to reach the assumed 21 Ma. And yet all evidence of erosion between subsequent layers is lacking to support that 'dead time'. The basalts are merely flow atop flow. More than 99.99% of deep time is thus unrecorded by the actual rock record in that case.

In similar cases, where thick sections of sedimentary rock formed quickly or where the bulk of the stratigraphic section is composed of hiatuses, the same problem occurs. And these sedimentary layers also show little, if any, evidence of erosion between one layer and the next. The physical evidence to support the claims of deep time between the layers is missing, just like between the lava flows described above.

Geologists, committed to uniformitarian deep time, thus demonstrate themselves to be dogmatists, not empiricists. Clues to that dogmatism were manifested early on, with an unwavering support for deep time, even when its quantity was increasing by *orders of magnitude* between the mid-18th to mid-20th century. Buffon challenged biblical history with a 75,000-year-old Earth. Werner thought it over a million, and Kant, in 1790, estimated many millions of years.[54] In 1860, John Phillips placed the base of the Cambrian at 96 Ma and Darwin estimated that natural selection would require a billion years to produce the tree of life. Kelvin restrained these speculations with physical calculations that ranged down from 400 Ma in 1863 to 24 Ma in 1897. But Holmes (1913) used a radiometric geochronology to set Earth's age at 1.6 Ga, and Claire Patterson calculated the current accepted date of 4.55 Ga in 1953.[55] Even though the jump from Buffon to Patterson was nearly four orders of magnitude, stratigraphers were always able to reconcile that remarkable range of ages with uniformitarian sedimentation, simply because their frame of reference was 'anything but the Bible'. The stratisphere[5] was shoehorned into tens of thousands of years and then stretched to fit billions, all the while telling the same story—no Flood. If today's sedimentary record is supposed to illustrate billions of years, those earlier accommodations were impossible, and thus the original reasons for rejecting the Flood are shown to have been subjective and flawed.

In evaluating the relationship between the sedimentary rock record and Earth's past, the hard data available are limited to estimates of the total volume of Earth's sedimentary rocks and observed sedimentation rates. The severe disjunction between these two empirical data points yields one inescapable conclusion—*there are far fewer sedimentary rocks on Earth than should have been deposited over 4.5 Ga*. Uniformitarian geologists facing this reality have only bad options to explain the discrepancy. One is higher rates on a younger Earth. That is unacceptable. The other, and most commonly used, is that the record is mostly missing sections, thanks to erosion. However, the unintended consequence of this solution creates the question-begging scenario of an unrepresentative record. That strikes a blow at the heart of the idea that earth history is known with scientific certainty. The only other option would be for geologists to accept the discrepancy between rates and volume as an indication that their core method of actualism is wrong.

Attempts to work around this problem abound, although many geologists like Ager[15] simply seemed to accept it as a feature of the rocks and ignore the consequences. Others are more concerned and advance explanations. Rocks were eroded.[13] Rocks were subducted. Rocks did not have sufficient accommodation space, or sediment accumulation rates have increased over time.[12] Rates today are anomalously high. Any or all may be correct, but all these ideas reason in a circle, refuse to consider the possibility that the assumptions of deep time and uniformitarianism might be the problem, and argue from a lack of evidence, thanks to the fact that most of Earth's history is written on the blank pages of hiatuses in the record.

Before evaluating any of these hypotheses, it is first essential to understand the role of the assumptions that drive them. The stated bedrock of modern geology is the actualistic method of uniformitarianism, but more often than not that assumption is a hindrance because modern geological environments are not good analogs for the rock record. Auxiliary hypotheses are tools such geologists use to *work around* actualism, not use it. This demonstrates that the real bedrock of modern geology is negative—it is a convoluted attempt to dismiss divine providence from history, beginning with the Genesis Flood.

The volume of the sedimentary record does not support the 4.5 Ga of uniformitarian geology. Because these geologists have historically been fixated on the relationship between the volume of rocks and their estimates of what could be deposited during the Flood, they are belatedly realizing that the rock record is not kind to uniformitarianism. Since diluvialists are not similarly constrained by actualism or by pristine empiricism, one could argue that the rock record is *much less kind* to uniformitarianism than to diluvialism. For the purposes of this paper, however, it does not matter whether the Genesis Flood can explain the rocks. The issue before us is that uniformitarianism cannot. If the rocks justify only a small part of history, then the history of secular geology cannot possess the certainty assigned to it. Forensic confidence in the rock and fossil records is therefore misplaced. Absent the revelatory record of the Bible, uniformitarian geologists—advocates of empiricism and actualism—are left with data that convey very little about the past. Ironically, geologists who are quite comfortable *lowering* observed rates to justify their uniformitarianism are completely unwilling to consider *higher* rates and larger scales associated with the Flood, even though the logic is the same.

Conclusion

Geologists since the 18th century have argued that the sedimentary rock record supports their paradigm of uniformitarian deep time because there are 'too many rocks' for the one year Flood. But the triumph of deep time was premature; it masked the fact that the sedimentary rock record does not support uniformitarian history. The gross volume of Earth's sedimentary rocks is not supported by the sedimentation rates observed in the present. At the most fundamental level, the gap between the sedimentary record and the proposed 4.5 Ga history of our planet suggests that either the actualistic principle is not a good method or that the volume of sediments on Earth was produced in much less than 4.5 Ga. That leads to two unpalatable options for uniformitarian geologists: (1) that Earth is much younger than 4.5 Ga, or (2) that the existing record is not representative of the past. The rock record constitutes a very poor forensic buttress for uniformitarianism. Consequently, the fossil record contained in these rocks is likewise deficient and is an equally poor support for evolutionary history. Stratigraphic methods that assume gradual and continuous sedimentation, like cyclostratigraphy, are also in trouble. The supposed happy marriage between uniformitarian deep time and the sedimentary record is in more trouble than people think.

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Michael J. Oard *has an M.S. in atmospheric science from the University of Washington and is now retired after working as a meteorologist with the US National Weather Service in Montana for 30 years. He is the author of* Frozen in Time, Ancient Ice Ages or Gigantic Submarine Landslides?, Flood by Design, Dinosaur Challenges and Mysteries, *and* Exploring Geology with Mr. Hibb.. *He serves on the board of the Creation Research Society.*

John K. Reed *earned B.S., M.S., and Ph.D. degrees in geology. He worked for several decades as a professional geologist in industry and academia. In 1998, John became the geology editor of the Creation Research Society Quarterly, and was subsequently elected to the CRS Board of Directors. He has written and edited numerous books and articles about creation and natural history.*