



What I Wish My Pastor Knew About ... **Rocks, Fossils and Geologic Time**



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*Lord, you have been our dwelling place
throughout all generations.
Before the mountains were born
or you brought forth the earth and the world,
from everlasting to everlasting you are God.
You turn men back to dust,
saying, "return to dust, O sons of men,"
for a thousand years in your sight
are like a day that has just gone by,
or like a watch in the night.*
(Psalm 90:1-4, NIV)

1. Introduction

For thousands of years, humanity has sought the resources of the Earth: salt, fertilizers, jewels, construction materials, metals for weapons, and fuel to burn for heat or power. For example, salt has been mined at or near Salzburg, Austria for perhaps 5000 years ("Salzburg" translates as "Salt castle"). Copper has been mined on the island of Cyprus for at least 3000 years. (In fact, the word "copper" is synonymous with "Cyprus" in the original Greek.) The oldest surviving treatise on rocks and minerals is the short work by Theophrastus, *On Stones*, written sometime around 300 B.C. Theophrastus was an assistant to Aristotle at the research institution that he founded in Athens, the Lyceum, and served as its director for over 20 years after Aristotle left Athens. For well over a thousand years after Theophrastus, the study of Earth slowly made progress. Beginning in the 1600's, the discipline of geology "took off" as an empirical and theoretical science. In the late 1900's, geology became a planetary discipline, as missions to other planets (including Earth's Moon) permitted a truly *comparative* "Earth science" to emerge. The discipline has a fascinating history of which most people are ignorant. Many of its most prominent early practitioners were Christians, including William Buckland, first professor of geology and mineralogy at Oxford University; Adam Sedgwick, the first professor of geology at Cambridge University; and Georges Cuvier, the founder of the discipline of vertebrate paleontology. Another prominent Christian was James Dwight Dana, professor of geology at Yale

University during the middle 1800's, who created the system of mineral classification and wrote the leading minerals textbook, perennially updated by contemporary geologists and still in use.

In the United States, students learn something about rocks in grade school, usually during the fourth, fifth, or sixth grade. They learn that there are sedimentary rocks, igneous rocks and metamorphic rocks. I've given many guest lectures to children this age, and have seen terrific enthusiasm for natural history, including the understanding of Earth and rocks. Unfortunately, in the United States, this enthusiasm is not exploited; the standard high-school curriculum does not build on this foundation of instruction about the Earth, its materials, or its organization and history. This has led to a general ignorance on the part of our citizenry concerning where the raw materials for our civilization and our power sources come from, and of the intellectual and physical effort that is required to obtain these. As a case in point, we now import well over 50% of the oil consumed in this country, but citizens continue to seem surprised that gasoline prices are rising so steeply. Most citizens know nothing about the soils their crops are grown in, where their metals come from, or the geologic hazards typical of their region.

The three types of rocks mentioned above—sedimentary, igneous, and metamorphic—form in different ways and in response to different conditions. Each type provides *evidences*, interpreted by means of basic principles of chemistry, physics, and biology, which testify to elapsed time during the history of the particular rock. Some of these will be discussed and illustrated in sections 2, 3 and 4 of this paper. Sedimentary rocks host *fossils*. The word "fossil" has an interesting history but has come to mean the remains of once-living creatures (or their traces, like footprints). Investigation over the past 300+ years has revealed that fossils come in groups or "suites" which reflect past ecological environments like shallow ocean floors, lowland forests, lakes, or rivers. Furthermore, the vertical placement of these suites in the rock record

demonstrates a history of life.

In the early 1970's, I was pursuing an undergraduate degree in biological anthropology at a large state university. During this time, I was presented with the gospel and placed my trust in Jesus Christ. I completed my degree but at the suggestion of many friends, read a great deal of the literature put out by the Creation Research Institute and other "Young-Earth" sources. This literature promoted and still promotes the view that much of the rock record, including most or all sedimentary rocks containing fossils, was formed through the action of the catastrophic year-long Flood of Noah—a view termed "Flood Geology". Unfortunately, like most Americans, I had never had the option of taking a course in geology at the high-school level and had passed by the opportunity at college. I had very little personal experience of field-based geology. For a few years, I found many of the claims of the Flood Geology literature appealing. A choice between a secular, materialistic science and a Creation-based, supernatural one seemed an easy one to make. It took me several years of visiting rock outcrops, quarries, and highway roadcuts to see the wealth of evidence that *time* must have elapsed during their formation. Like the early geological investigators of the 1600's, 1700's, and 1800's, I became convinced by the internal characteristics of rock bodies and their spatial relationships that the Earth is very old. I had been misled by the literature I had trusted. I came to realize that many of the Flood Geology authors I had read had very little acquaintance with rocks in the field. Most were not professional geologists at all. Among their ranks were biologists, psychologists, veterinarians, engineers, professors of pharmacy, physical chemists, or high-school science teachers, all of whom were competent at their own disciplines but knew little about rocks. Mainstream geologists who take the time to read the Flood Geology literature often react with scorn, which perhaps does not help matters.

I graduated with my degree in anthropology in 1975. By 1982, I had completed some coursework in geology at my home university and had seen enough rocks to realize that I could proceed

with graduate studies in sedimentary geology and paleontology. During my graduate studies, books written by Calvin College geologists Davis Young and Clarence Menninga proved to be very helpful to me and many of my friends. Later, in 1992, I was hired at Calvin and got to know Dave and Clarence well as colleagues. In 2008, Dave Young and I completed a 500+ page book, *The Bible, Rocks and Time*, published by InterVarsity Press, which attempts to explain the historical, empirical, and biblical evidences disfavoring Flood Geology. The book contains many illustrations. The reviews have been good and I recommend this volume to any reader who would like more information.

In the three sections which follow, I will briefly look at evidences for elapsed time in sedimentary and igneous rocks, and then comment on the fossil record of life. For length considerations, I omit discussion of meta-morphic rocks (although another entire paper could be written on the evidences for elapsed time in metamorphic rocks!). Because I am trained primarily in sedimentary geology and in paleontology, these subjects are much more easily discussed here. I have also invested a modest amount of effort in examining igneous rocks, including a visit to Hawaii to see modern volcanic processes in action.

2. Evidences for time in sedimentary rocks

Sedimentary rocks, like limestone, sandstone, and shale, come in discreet layered packets, termed "formations" by the sedimentary geologist. The figure below demonstrates two very different formations from the Grand Canyon: the Coconino Formation (top), a pure quartz sandstone, and the Hermit Formation (underneath), a soft red mudstone. Rocks in these large formations are characterized by consistency in color, texture, mineral content, fossil content, porosity, and physical structures like layers or ripples. Formations are separated from one another by boundary surfaces, such as surfaces that appear to have been eroded between episodes of sediment formation. Sedimentary rock formations can be consistent over hundreds of miles, and can be

quite thick in total. Some sedimentary sequences, comprised of multiple formations, are around 50,000 feet thick, including the big pile of sediments on the continental shelf off New Orleans, and the thick stack of sedimentary rock exposed in mountains in northeastern Utah. In the state of Michigan, the sedimentary formation under our feet is typically 10,000 feet thick and gets up to 17,000 feet thick in the center of the state.

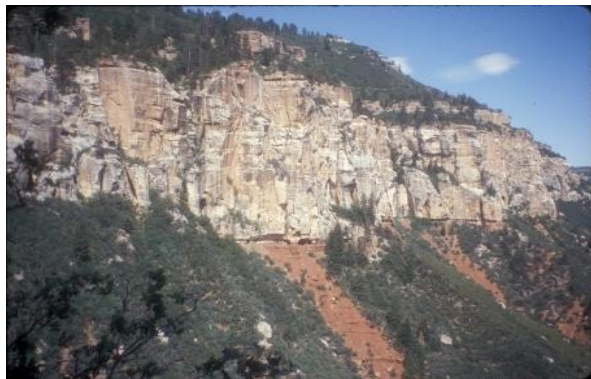


Figure 1: Sedimentary rock in the Grand Canyon.¹

Even in flat areas, like Illinois, underground layers are well-known through drilling. Information is obtained from water well drilling and, more significantly, hydrocarbon wells. As of 2005, over 800,000 wells were producing fossil hydrocarbons in the United States; there were many additional wells no longer in production. When such wells are drilled, data from the subsurface can be recovered in many ways, such as using a hollow drill bit to extract a long sample of rock. Another method is to lower instruments into the drill hole that record physical properties of the rocks, such as electrical conductivity or natural radioactivity. Additional data comes from seismic investigations, in which vibrations are pulsed into the ground and their reflections timed to measure the depths to the tops or bottoms of rock beds. Thus, when the knowledge obtained from samples

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is integrated with seismic data, we find that we can map the three-dimensional spatial geometry and characteristics of the sedimentary rocks under our feet

Many shapes and structures in these sedimentary rock show evidences for *particular events*, each requiring *time*. Such events can be of physical, chemical, or biological origin. For example, some rock formations show evidence that rocks dissolved and formed ancient sinkholes before the upper layers were deposited. Another example would be soil horizons, where ancient soil accumulated on a rock layer before sedimentation resumed to form the upper layers. Other rocks show fossils traces of roots belonging to plants which grew in place, traces of burrowing activity, or fossilized coral which obviously grew in place. Figures 2 and 3 illustrate the LaFarge Limestone Quarry in Alpena, Michigan, and the quarry wall with corals in growth position. The coral heads appear as the fan-shaped, pale-colored objects in Figure 3. The upward-fanning of these coral heads is produced by budding and branching within the colony.



Figure 2: Limestone Quarry



Figure 3: Coral fossils in limestone

Long before the development of radiometric clocks for measuring ages of rocks, students of the Earth realized that a) the characteristics of individual layers and/or their boundaries indicated that multiple, diverse events had occurred at any location, forming a local *history*; and furthermore b) lots of time was required for these events to occur. A single, global, year-long flood cannot account for the many diverse kinds of events which must have occurred at a given geographic location, and it does not provide the time necessary to account for these recorded events. Geologists, theologians, and Biblical scholars grappled with these realizations in the early 1800's and came up with several schemes for the harmonization of a Biblical view of God's creative activity and geologic time. Many Christians today are unaware of the intellectual effort expended by their early 1800's counterparts. (The volume, *The Bible, Rocks and Time*, referred to above, extensively reviews this substantial early history of geology.)

For more evidences of time, we turn to igneous rocks.

3. Evidences for time in igneous rocks

The rock, *basalt*, is a dark, fine-grained igneous rock relatively rich in iron and magnesium. If you visit the big island of Hawaii you can watch basalt in the process of forming from molten lava. The U.S. Geological Survey has maintained the Hawaii Volcano Observatory on the rim of Kilauea volcano since 1912, monitoring many

eruptions. Basaltic lava (i.e., lava which will form basalt upon solidifying) is being produced at fissures as I write this paper. Melting temperatures and flow characteristics of basaltic lava can be observed in the field, and laboratory experiments can mimic and model these actual conditions. Basalt forms at about 1150 to 1200 degrees Celsius. If one finds a layer of basalt that is solid and at room temperature, then that rock cooled by 1100+ degrees over some period of *time*.

Figure 4 illustrates a gorge in Washington State along the Palouse River that my wife and I visited this past summer. Several stacked, horizontal basalt layers can be seen, each corresponding to a flow of lava. As each of the layers cooled, it contracted internally, forming fractures. The fractures then weathered, to form the vertical columns visible within each horizontal layer. (Similar processes produced the Palisades cliff along the Hudson River in New York and the "Devil's postpile" in California.) Thus, these columns testify to an interval of *time* during which the lava cooled. Several features make it easy to identify individual basalt flows. For example, as basalt lava flows over a land surface, gas bubbles out and forms many blatant bubble-like cavities at the top of the flow, termed *vesicles*. The tops of flows are thus marked by zones of vesicles. (In Michigan, the individual basalt flows in the Keweenaw region and Isle Royale are easily identified by vesicle zones.)



Figure 4: Basalt flows on the Palouse River

The multiple basalt layers visible in Figure 4 are part of a larger group of basalt layers collectively termed the Columbia River Basalts by geologists. These Columbia River Basalts cover large areas of southeastern Washington, eastern Oregon, and westernmost Idaho. Individual lava flows mapped within the group contain up to 200 cubic miles of lava, spread out over tens of thousands of square miles. The Columbia River Basalts can be split into subgroups based on the chemistry of the lavas, their geographic coverage, and their connections to mapped fissures which provided the source lavas. There are geologists working in Oregon, Idaho and Washington who have spent decades of their lives walking the breadth of the basalt layers, locating and mapping individual volcanic fissures, and drilling vertical sequences, all to decipher the history of this large packet of rocks. Time elapsed between individual flows, during which the lavas cooled to rock. In some cases, an individual flow is capped by an intensely-weathered zone which was created by soil-forming processes over time; that layer in turn is covered by the subsequent flow.

During the summer of 2008, my wife and I stopped at a highway pullout southeast of Yakima, Washington and discovered two ancient layers of basalt separated by a band of white sandy lake beds. There were vesicles at the top of the lower basalt flow, and a baked and chemically altered zone at the contact of the upper basalt flow with the lake beds. The upper basalt layer probably flowed directly into the lake while water still occupied the basin, but I have not been back to investigate thoroughly. I took several photographs and show these to geology students to demonstrate the blatant evidence of elapsed time during the formation of this layer of basalt. And that is just one relatively small-scale feature contained within the LARGE stack of basalts in the Columbia River Plateau.

Another type of igneous rock is granite, which is used as an ornamental stone for structures like countertops and grave markers. Granite is a much more coarse-grained rock. Laboratory experiments show that granite, which forms by cooling slowly, will contain larger mineral crystals

than a comparable rock which cools quickly (other factors can enter into crystal size, but this is a good first approximation.) Slow cooling times occur naturally when granite forms out of melted rock that is “squirted” or intruded into a surrounding rock body, and then crystallized at some depth within the Earth. It took geologists a few decades of deciphering the spatial relationships of granite bodies to their surrounding rocks, plus undertaking experiments involving the melting of granite in laboratories, to come to this realization.

Large masses of granite are present in the Sierra Nevada mountains of California and elsewhere. In our book, *The Bible, Rocks and Time*, Dave Young and I document the spatial extent and the requisite time for cooling of these rock bodies in the Sierra Nevada. The time required for the *production* of this vast amount of granite sums to millions of years. The granite has *since* been uplifted to form the mountains, then exposed and eroded, requiring yet more time. And the geologic history of this region of California is much more complicated than this simple summary, requiring an even longer period of time to collectively account for all the events in its record.

Thus, just as in the case developed in section 2 for sedimentary rocks, students of the Earth realized that: a) the characteristics of individual igneous rock bodies, their spatial extent, and their boundaries testified that multiple, diverse events had occurred at any location, forming a local *history*; and furthermore b) lots of time was required for these events to occur; thus a protracted local history. This history was known long before the development of radiometric clocks for measuring ages of rocks. Furthermore, in some regions such igneous rock bodies occur *within* fossil-bearing sedimentary rock sequences, indicating that the sedimentary rock formed even earlier (these are the same sediments that Flood Geologists claim formed during the year-long flood of Noah). These thick regional piles of rock show extended histories that are nested or embedded within even larger histories.

4. The fossil record of life

During the 1790's and first decade of the 1800's, field geologists and civil engineers made a profound discovery: fossils occurred in a regular order within sequences of layered sedimentary rocks. This order was found to remain consistent over broad regions of Europe and was then discovered to extend to North America. The established order to the fossils is now known to be consistent worldwide. The empirically-documented notion that fossils follow a particular order has been labeled the "Law of Faunal Succession". In any given region, there will be gaps in the order corresponding to time periods in which no deposition occurred—which is what one expects when a region was not receiving sedimentary deposits during a particular time – but the remaining fossils follow the same order worldwide.

The initial discoveries leading to the generalization of the Law of Faunal Succession were made a generation prior to the publication of Darwin's *The Origin of Species*. Many of the Flood Geology authors whom I read in the 1970's and since have made the claim that the order to the fossils is contrived by geologists to support evolution. This is simply not the case. The order was documented in the early 1800's by a generation of hard-working field geologists, most of whom were practicing Christians. Many of these were emphatically opposed to the notion of biological evolution. Adam Sedgwick, for example, was Charles Darwin's tutor in geology at Cambridge University, and while remaining Darwin's friend, opposed the notion of organic evolution. It is important to realize that this order is empirical. Thousands of amateur rockhounds and professional paleontologists can attest to it.

One often sees the claim in the Flood Geology literature that the past cannot be examined by experiment. This is not true. As I write, I'm preparing to take a class of college students and some guests to the limestone quarry at Alpena, Michigan, which was illustrated in Figures 2 and 3. We will perform an experiment simply by collecting fossils. I predict that we will not find any fossil alligators, dinosaurs, or reptiles of any

kind. In fact, I predict that we will not find any quadrupedal vertebrate fossils of any kind. I further predict that all corals we find will belong to the extinct orders Rugosa and Tabulata and not the living order, the Scleractinea. I could add up a long list of predictions which we will test by experiment. Such experiments are repeated frequently at this particular quarry by grade-school groups, rockhound clubs, and groups of college students studying paleontology. Thus, the Law of Faunal Succession is subject to test. My own experience, obtained now over three decades of fossil collecting, is that the order to the fossil record is real. Whatever one's view on biological evolution may be, an honest appraisal of the fossil record must acknowledge this.

During the late 1800's, paleontologists who studied the history of life gradually came to accept the notion that descent of different organisms from a common ancestor was verified, but many thought that Darwin's notion of "natural selection" was insufficient to account for this history to life. During the 1900's, most professional paleontologists—but not all—have generally subscribed to a view that natural selection is important but certainly not the whole answer to the changes in life over time documented in the record of geologic strata. While some materialistic scientists (including, unfortunately, some well-known popularizers of science) have broadcast the notion that the long fossil record indicates a huge waste, other scientists like me feel the opposite. I see instead a prolific abundance of ancient life. God's providential oversight of Nature appears to involve a superabundance of kinds and numbers of living things, in which He takes delight. Yes, these creatures died, but creaturely death is an issue related to "natural evil", faced by Christian theologians since the time of Augustine and before. Psalm 104 and other passages of the Wisdom literature deal with God's design for nature's economy, which includes such items as fangs and claws. We are best not to second-guess God on what is proper for a functioning and fascinating natural world.

5. Why is this important?

An understanding of our world, which we obtain from the science of geology, is important for all citizens, both Christian and non-Christian. We need to understand the sources of energy for our civilization, and the economics of the exploration and development process for these energy sources. We need to understand where the raw materials come from for our homes, cars, roads, appliances, and many other things we take for granted. We need to know how rivers function and why they flood. We need to understand why earthquakes occur in some places and not others. How many people even understand how the glass in their windows was made, how the electrical wires in their homes were manufactured, or what the source of their drinking water is? Why is a penny worth more than one cent? Should the United States take the same road as France did, and decide to generate most of its electricity by nuclear power? (I think so.) The development and extraction of raw materials and energy sources require intellectual and physical labor. Many people are employed at these labors; some become fatalities in the enterprise. Thus, to deride these professions (as some Christians do) while taking advantage of the comforts and blessings they offer is an exercise in ingratitude and hypocrisy.

The science of the Earth is really an attempt to understand how God set it up and the regularities with which He endowed it. Even if many geologists have other motivations, their results can tell the Christian something of how God made the Earth. Furthermore, if it is true that God used abundant amounts of *time* to create these structures and their functions, then we are “arguing with God” in the manner of the apostle Peter with Jesus (“may it never be, Lord”) if we deride time. Several passages in the Bible explicitly reference God’s sense of time (e.g., Psalm 90) and it is clear that His time is not constrained or subservient to the time measured by the human life-span.

In the United States, our educational system

through the 12th grade is very deficient when it comes to understanding the science of the Earth. While television shows (like those on the Discovery Channel) and many fine children’s books undoubtedly help to alleviate our ignorance, this deficiency still leaves most citizens ill-prepared to address significant issues. It also leaves most ill-prepared to analyze the poor arguments of the Flood Geologists. Many Christians have thus been persuaded that, to “hold the line” against the incursions of godlessness, they must also defend the faith against the assertions of modern, “secular” geology.

Over the past few decades I have discussed rocks and fossils with many Christians of diverse viewpoints, including many pastors, pastors-in-training, and para-church workers. This past week I sat down with my current pastor (Christian Reformed) and discussed the serious concern that many Reformed Christians feel, that the foundations of Christianity are being undercut by the insidious activities of historical scientists such as astronomers, geologists, paleontologists, and archaeologists. My pastor grew up in an area of Ontario rich in fossil-bearing limestone quarries, and thus fossils had never seemed to be somehow threatening to his faith. He could not have predicted that, when he began his pastoral ministry, he would find many in his congregations deeply worried by these small but elegant testimonies to God’s delight in Creation. He warned that most (if not all) pastors would encounter strong sentiments in some congregation members, who place beliefs concerning time and Creation on the same level as those of the Apostle’s Creed or the Heidelberg Catechism.

Many resources are available for pastors. One that I find helpful is the report of a special committee of the Christian Reformed Church; the committee was convened in the late 1980’s and reported to Synod in 1991². The report clearly laid out a Biblical and theological rationale for the positive role of research into long spans of time

² *Acts of Synod, 1991, Report 28*

for God's creative activity. The Christian Reformed Church has also recently published a volume by Deborah and Loren Haarsma, *Origins: A Reformed Look at Creation, Design, and Evolution*. This volume is designed for use in congregational groups such as Sunday school settings and has been very well received; I highly recommend it to you. Another useful reference by a Reformed scientist is David Snoke's *A Biblical Case for an Old Earth* (Baker Books, 2006). For extensive and judicious Biblical textual analysis, I refer any reader to the writings of Reformed Old Testament scholars Bruce Waltke and C. John Collins.

But what about the Flood of Noah? Several theories have been proposed to harmonize this event recorded in the Bible with the actual geological record. Many Biblical scholars of past generations and the current generation are convinced that the Genesis account does not support a notion of a global flood, but rather that the flood was local to a small region in the Near East. On the other hand, if one assumes that it represents a planetary-wide catastrophe, then its geologic record must be minimal. *The Bible, Rocks and Time* includes extensive summaries of the views of past theologians from a variety of theological and denominational perspectives on this subject. The resources in the preceding paragraph dissect the pros and cons of variety of viewpoints regarding Earth history.

The long history of life on Earth that the fossil record documents is often related to theories of biological evolution. As noted in the concluding paragraph of section 4 above, some atheists have attempted to claim ownership of evolutionary theory. Christian responses have often not been helpful. A closer look at the multiple issues raised by varieties of evolutionary theory would require another article, or better yet, a book. For Christian reflection on evolution I recommend to you the following volumes: *Coming to Peace with Science: Bridging the Worlds Between Faith and Biology*, by Darrel R. Falk (InterVarsity Press, 2004); *Perspectives on an Evolving Creation*, edited by Keith Miller (Wm. B. Eerdmans, 2003); and *Creation or Evolution: Do We Have to*

Choose?, by Denis Alexander (Monarch Books, 2008).

The pastor will be called upon to provide guidance through these emotive topics. It may help to remind the parishioner of God's faithfulness and His patience, both in the long eons of natural history and in the long centuries of human history. We remind ourselves of God's patience in *creating and sustaining* us as individuals. David remarked that God knit him in his mother's womb. Why did God ordain that we should slowly develop in our mother's womb, then be helpless infants for years, then be trainable youths, then mature adults, and ultimately live with the Triune God in the New Jerusalem? Why did God not decide to create all of us instantaneously?? Should we complain that God took too much time to create each of us? The Bible also records many examples of God's patient slowness in *redemption*, including the seeming slowness in Jesus' return today! We understand that this slowness is *kindness*. There is a wideness in God's mercy, and that wideness includes eons of time and a redemptive plan beyond our ability to imagine.

SDG.