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Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh.—Exodus 20:11

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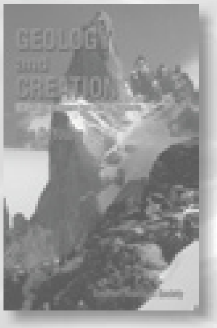

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Don DeYoung. 2004. CRS books, 163 pages. $12.00.

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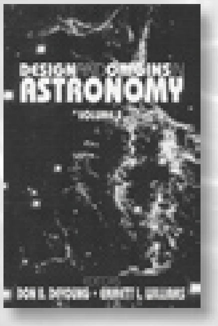

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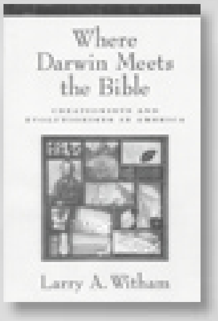
Don B. DeYoung and Emmett L. Williams (editors). 2002. Creation Research Society, 163 pages. $11.00.

This is number 12 in the monograph series and the second volume on astronomy that is a compilation of articles from the *Creation Research Society Quarterly.* Topics include the age of the sun, impact craters in Arizona and on the moon, planets and magnetism, speed-of-light studies, stellar evolution, the destiny of comets, and mysterious dark matter.



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Larry A.Witham. 2002. Oxford University Press, 330 pages. $25.00 (hard cover).

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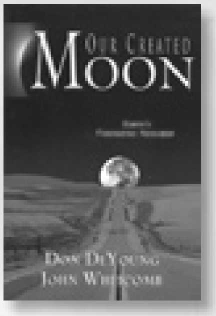

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Don DeYoung and John Whitcomb. 2003. Master Books, 144 pages. $11.00.

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The Mutation Repair Systems: A Major Problem for Macroevolution

Jerry Bergman*

Abstract

The ultimate source of all variation from which natural selection can operate is genetic mutations. Numerous cellular genetic repair systems exist to ensure that mutational expression is extremely rare. These repair systems pose major problems for evolution because virtually all genetic innovations caused by base pair changes will be corrected (and thus not expressed), or the cell itself will be destroyed. If genetic repair systems were perfect, then all macroevolution clearly would be impossible. These genetic repair systems argue against macroevolution, at least as caused by the accumulation of mutations.

Introduction

Evolutionary naturalism teaches that the creator of all forms of life is ultimately mistakes in DNA replication known as genetic mutations. As Eldredge (1982) argues:

> the *only truly significant force* underlying genetic, hence evolutionary, change is natural selection...genetic change is largely a function of natural selection working on a field of variation presented to it each generation. *New* features from time to time appear, *ultimately brought about by mutation*. Most mutations are harmful; some are neutral, or even beneficial. The neutral or beneficial ones hang on, and one day might prove to be a real advantage as the environment provides new challenges to the organisms.... Given enough time–and remember that geologists tell us that the earth is fully 4.5 billion years old–*all manner of change will accrue* (p. 69, emphasis added).

The problem of evolution via mutations has been summarized as follows:

> The evolution of mutation rates is governed by two opposing forces: the costs imposed by deleterious mutations, and the ability to adapt to a changing environment. In contrast to asexual populations, selection acting within a sexual population will always favor a mutation rate of zero (McVean and Hurst, 1997, p. 388).

Deleterious mutations can cause not only major health problems, but also can result in the extinction of the species if unrepaired: "If these mistakes are not fixed, harmful mutations can accumulate, so the error-correcting-mismatch-repair-proteins are crucial" (Kolodner, 2000, p. 678). The number of mutations is reduced enormously by both the high fidelity of DNA replication and by the numerous highly effective repair systems. Depending on the specific organism, its environment, and other factors, unrepaired mutation rates are estimated to be only around 10^{-5} per gene per cell division (Puck et al., 1996; 1998; Mader, 1998), although such estimates will vary depending on the method used.

Mader (1998) concluded the proofreading process consists of a mechanism that achieves such high level of accuracy that "in the end, there is only one mistake for every one billion nucleotide pairs replicated" (p. 247). Other estimates differ, but all agree that the rate is extremely low. The proofreading accuracy of this system reduces the reproduction error rate estimated from approximately one mistake per 100,000 base pairs to about one per 10-billion base pairs–an astoundingly high level of accuracy (Radman and Wagner, 1988).

This low rate is reduced even further by several repair mechanisms built into the genetic system of all prokaryotes and eukaryotes to ensure that mistakes are very rare. Even organisms such as viruses that lack repair enzyme systems are protected to some degree because they use the cellular enzymes of their host for mutation repair. The arsenal of repair mechanisms are so accurate that they correct an esti-

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mated 99.9 percent of initial errors (Friedberg, 2003; Jorde et al., 1997; Yang et al., 1996; Radman and Wagner, 1988). And those mutations that are not repaired often are fixed by cell maintenance mechanisms (Ridley, 2001; Harwood and Meuth, 1995).

As a result of these repair systems, the fidelity of replication is so high that fewer than an estimated three errors occur during the replication of an entire human being (three billion base pairs on the average). This "phenomenal accuracy" level "is ensured by several DNA repair enzymes, including some forms of DNA polymerase, that 'proofread' each daughter strand during and after its synthesis" (Audesirk and Audesirk, 2000, p. 130). The directionality of DNA allows the proofreading and repair enzymes to recognize the parental strand and then identify mismatches and, ultimately, correct the daughter strand, which runs in the opposite direction. This repair system is required because "in order for an organism to keep functioning, protecting the integrity of its genetic material is of utmost importance. The reason is simple: Accumulation of damage to the DNA can lead to harm, including cancer" (Marx, 1994b, p. 1321).

The accuracy of DNA repair is indicated in a study of 76,000 offspring of the survivors of the Hiroshima and Nagasaki atomic bomb blasts, who were exposed to a massive amount of radiation. The study found "no detectable effect could be seen for germ cells [and] DNA repair is at least in part responsible" (Jorde et al., 1997, p. 37). This was true even though substantial evidence of radiation effects was found in the survivors' somatic cells.

This fact is critical in the origins controversy because neo-Darwinism requires mutational change in germ-line cells, and the studies indicate that gametes are especially resistant to base-pair alteration mutations.

Preventing Mutations: The Buffered Code

The genetic code is said to be buffered, which means that the third letter of most amino acid codes can change with no effect on the results of the code. An example is GGU, GGC, GGA and GGG, all of which code for glycine. Consequently, if a mutation changes the third base in all cases, glycine will still be coded—negating or minimizing the effect of many point mutations (Ritter, 1996). For this reason, a mutation in the third base of the codon often does not change what amino acid is placed into the polypeptide being synthesized. Furthermore, if a mutation in the third position does occur, the result often codes for an amino that has a similar function, thus enabling the resulting new protein to have the same (or very close to the same) conformation as before. As a result, "a change in the third base in a codon . . . usually leads to a new codon for the same amino acid or a similar amino acid" (Ritter, 1996, p. 660). Of course, a mutation occasionally can result in an amino acid from a different family, or even a stop codon. In this case disease or death can result.

Also called the wobble effect, this mechanism enables anticodons on the tRNA to hydrogen-bond to more than one codon. In situations where a tRNA can pair with multiple codons, *all* of the codons specify the *same* amino acid. In humans, the wobble effect reduces to 32 the number of nuclear tRNAs required to read the 61 transcribed codons, saving the energy that would have been required to assemble the full set of 61 tRNAs. This system also reduces the size of the genome required because different genes usually are required to encode each unique tRNA. It also lowers the time needed to match a codon with an appropriate anticodon during translation. The mitochondrial translation mechanism allows the genetic code in mitochondria mRNAs to be decoded by only 24 tRNAs.

Furthermore, even a change in the first base in a code (the five prime base) often—but clearly not always—generates "a new codon that encodes an amino acid whose side chain is similar in polarity to the side chain of the amino acid specified by the original codon. Consequently, the polypeptide produced from the information in a gene with a point mutation is either commonly identical to the normal peptide or is similar in conformation and biological activity" (Ritter, 1996 p. 660). As a result, Ritter (1996) concludes "the polypeptide produced from the information in a gene with a point mutation is commonly identical to the normal peptide or is similar in conformation and biological activity. Since most organisms accumulate mutations over time, the buffering of the genetic code is of *major significance* from the standpoint of survival" (p. 660, emphasis added).

The code-buffering mechanism also is a major problem for macroevolution because it ensures that most of the comparatively rare, unrepaired mutations do not produce amino acid or conformational changes in the protein. Macroevolution by mutations *requires* changes in the protein's shape. Once an initiation codon is read, each consecutive nucleotide sequence usually represents another intact codon–and it is uncommon for the reading frame to shift once translation has begun, guaranteeing an extremely high fidelity of translation (Ritter, 1996).

Also, in placental mammals many gamete mutations do not result in hereditary changes because they prevent the fetus from developing to term. Partly for this reason, about one-third of all human embryos miscarry, ensuring that most unrepaired expressed germline mutations are not passed on. Non-neutral expressed mutations generally cause somatic cell disease and death. Likewise, mutations in other life forms often cause the organism to die early in development, preventing it from passing the mutation onto offspring.

The DNA Proofreading and Repair System

The three major mechanisms to reduce errors are error avoidance (primarily due to the effectiveness of nucleotide selection), error correction during DNA replication (or proofreading), and advanced error correction to repair errors missed by the first two systems (Radman and Wagner, 1988).

Replicases play a primary role in error avoidance by accurately directing nucleotide pairing. They are also involved in the proofreading mechanism that removes mispaired nucleotides. Use of RNA primers and their automatic removal and replacement is another error-avoidance mechanism. Error frequency is slightly "greater during the joining of the first few amino acid residues in a new polypeptide strand" (Ritter, 1996, p. 725) than during its elongation. As a result, most unreported errors are removed during the last steps of protein processing, which usually clips off or modifies the first few nucleotides.

The high fidelity of DNA replication is also, in part, due to the various complex enzymatic repair processes completed by the DNA polymerase complex itself. The first level of polymerase repair is built into the structure of the DNA base pairs themselves. The DNA code consists of four chemical bases: thymine, adenine, cytosine, and guanine (RNA uses uracil instead of thymine). Adenine normally bonds stably only to thymine or uracil, while cytosine bonds only to guanine. If a nucleotide triphosphate selected by DNA polymerase from the cellular pool of nucleotides is complementary to the template nucleotide (A is complementary to T and C to G), it is converted to a nucleotide monophosphate. The energy released from this conversion is used to hydrogen-bond the two nucleotides according to the template provided by the nucleotide pattern. If the *wrong* nucleotide is bonded, the fit is unstable and the nucleotide generally is restored to its triphosphate form and released. Mader (1993) estimates that a mismatched nucleotide "slips through this selection process only once per 100,000 base pairs" (p. 243).

Another reason for the astounding replication accuracy is the existence of several different proofreading and repair systems that involve several dozen different complex enzymes (Sutherland and Woodland, 1990). As Ritter (1996) notes: "The survival of individual organisms and species of organisms depends upon the accurate replication of the genetic information" (p. 725). Multiple DNA repair pathways exist, each specializing in a specific type of damage (Culotta and Koshland, 1994). In addition most organisms manufacture numerous enzymes that can repair certain kinds of DNA damage. In humans, about 50 enzymes are known to be involved in DNA repair.

The internal errors that occasionally occur during DNA replication usually are corrected because the DNA polymerase complex also functions as a proofreader. Mismatch repair involves a multiprotein complex that recognizes mismatched bases and utilizes multiple enzymes to replace the mismatched nucleotide residue with the correct residue. One factor that can trigger the repair is the fact that a mismatch produces a base pair complex of the *wrong diameter*, and as a result the mismatched nucleotide causes a pause in replication. This triggers a process that usually results in the mismatched nucleotide being excised from the daughter strand.

The correct pair is one pyrimidine (a single-ring molecule) and one purine (a double-ringed molecule); an incorrect pair would consist of two purines (producing a pair larger than normal) or two pyrimidines (producing a pair thinner than normal). After this level of proofreading has occurred, "the error rate is only one mistake per 10 million base pairs" (Mader, 1993, p. 243). Normally, only if a purine pairs with the wrong pyrimidine (A-C, G-T) can the mistake slip by, but, even in this case, the mistake is often repaired by other repair mechanisms.

Mutations usually can cause permanent base-pair changes only in the unlikely event that both bases are changed simultaneously, such as in a double strand break. The DNA polymerase repair system uses the original DNA strand to determine the correct base (the copying machinery can determine which is the original and which is the compliment), and also which repair bases are required (Ridley, 2001). In addition, the repair system can distinguish the daughter (the copy) and parent (the original) strands by mechanisms such as their extent of methylation–the newly synthesized DNA strand is not tagged with methyl groups until after it is checked (Radman and Wagner, 1988). Parent-daughter strand discrimination is critical because the replacement of the parent-strand nucleotides would cause error propagation instead of error correction. Consequently, if *both* strands of the DNA molecule are damaged in the same region, correct repair is less likely–and if the cell divides and reproduces, the mutation will be passed on. Thus, in order for a mutation to slip by this repair mechanism, damage must occur on both DNA strands—an extremely unlikely situation.

Even the most deadly type of damage, the double strand breaks—where both phosphate backbones are severed—can be repaired by yet another repair mechanism (Bartek and

Lukas, 2003; Bakkenist and Kasten, 2003). This system induces intermolecular auto phosphorylation of several target proteins that are linked to signaling networks. These networks slow the cell's progression through cell-division and also stimulate the repair of the double strand break (Bartek and Lukas, 2003). Yet another mechanism is able to repair the Y chromosome. Since it does not have a corresponding chromosome (i.e., part of a chromosome pair), as does every other chromosome, it has back-up copies of critical genes (Rozen et al., 2003; Skaletsky et al., 2003; Willard, 2003). The chromosome then forms a loop so that the defective gene can use the copy as a template to make repairs.

If the spell-checker gene is damaged and the corrector protein is not properly able to scan for genetic errors (or detect and repair them) mistakes will accumulate rapidly in the genes that the checker system was designed to check. If the genes that prevent cells from dividing uncontrollably are affected adversely, cancer often will result. Colon cancer owes its prevalence to the fact that intestinal-lining cells divide at such a rapid rate that the entire intestinal track lining is replaced in about three days. This vividly illustrates the crucial role served by the spell-checker system.

Damage to Repair Systems Causes Disease

Many other diseases appear to result from defects in the repair system, which allow mutations to go uncorrected. The repair mechanism is critical for life because the harm caused by mutations can be enormous, and includes numerous diseases such as cancer (Bakkenist and Kasten, 2003; Aldhous, 1995). For example, a defective "mismatch repair" protein causes non-polyposis colon-cancer (Modrich, 1994). The hereditary defect involving one of two genes called hMLH1 and hMSH2 found on chromosomes 3 and 2 respectively may cause as many as 22,000 cases of colon cancer annually (Culotta and Koshland, 1993). These two genes are part of a DNA repair pathway "that may provide one of the fundamental routes to cancer when it is disrupted," and the two gene products "spot mismatches and orchestrate the enzymes that effect repairs" (Service, 1994, p. 1559). Many diseases such as *Fanconi's anemia*, *ataxia-telangiectasia*, and *Cockayne's syndrome* occur as a result of a defective repair mechanism.

Tumor Suppressor Control Systems

Some systems can block the reproduction of cells with DNA damage and direct its repair or, if the damage cannot be repaired, destroy the cell by apoptosis (discussed below). These systems can correct the damage that can cause tumors or cancer, and for this reason are called tumor suppressor systems. A protein known as pRB operates by controlling the cell cycle, specifically by functioning as a signal transducer to connect the "cell-cycle clock" with the transcriptional machinery (Weinberg, 1995, p. 323). If pRB function is impaired, full cell-cycle control is lost and, consequently, this important mechanism for controlling cell proliferation also is impaired. For this reason, pRB serves as a tumor suppressor, specifically in retinoblastoma and certain other tumors.

The p53 Repair Mechanism

Among the numerous mechanisms involved in repairing or preventing the damage from altering the phenotype or being inherited, the most well-known example is the p53 tumor suppressor gene. P53 plays a critical role in cell-cycle regulation during times of genomic stress (Wang et al., 1995; Culotta, 1993). The cell cycle involves four major stages. The first, called Gap 1 (G-1), involves the synthesis of RNA and proteins in preparation for the next stages. DNA synthesis occurs during the second stage, called Synthesis (S). During the next stage, Gap 2 (G-2), the cell readies itself for cell division and completes any repairs needed. The last stage is either mitosis or meiosis and cell division (cytokinesis).

If a cell's DNA is damaged, p53 normally causes the cell to stop growing at the G-1 stage and triggers the repair process. The p53 gene is called the "guardian angel" of the genome because it protects the body from mutations by repairing them or, if they cannot be repaired, by destroying the affected cell, thereby preventing the mutation from being passed on to its offspring (Marx, 1994b). The p53 protein does this by monitoring the G-1 cell cycle check point and halting the cell cycle by expressing proteins that directly or indirectly trigger the DNA repair machinery and by interacting directly with repair proteins.

For example, DNA damage caused by ionizing radiation and certain chemical mutagens or ultraviolet radiation (which cause DNA strand breaks) can trigger p53 accumulation that may induce G-1 cell growth cycle arrest. This allows the cell to repair the DNA damage before replication; or, if it cannot be repaired or if repair fails, p53 triggers a self-destructive mechanism designed to destroy the defective cell by apoptosis (Marx, 1994b; Sancar, 1994).

p53 controls the cell cycle partly by encoding a transcription factor that activates the p21 gene to produce p21 protein. The p21 protein blocks the cell cycle by inhibiting all cyclin-Cdk complexes until the cell is repaired. The p21 protein also prevents the synthesis of long stretches of DNA, but will not block the manufacture of the shorter segments that are required for repair (Marx, 1994b). p21 also is involved in suppressing the transcription of various promoters that lack p53 binding sites, and even inhibits helicase activity (DNA unwinding proteins), thus blocking DNA replication.

More is known about p53 than about any other cellular control protein, partially because its clear importance has produced an enormous amount of research on this gene in the past decade (Friedberg et al., 1995). The p53 gene, and likely many others that control the cell cycle, are pleiotropic; consequently, damage to the p53 gene affects several biochemical pathways. The protein produced by this gene also functions in the maintenance of genomic plasticity and cell integrity. It binds to several transcription-repair factors, including XPD (Rad3) and XPB, and is involved in strand-specific DNA repair via its C-terminal domain (Wang et al., 1995).

Apoptosis

If a cell cannot be repaired, p53 sends the cell into a complex programmed destruction cycle called apoptosis (Culotta and Koshland, 1993). Part of the means the cell uses to produce apoptotic cell destruction is to direct lysosomes to function as "suicide bags" by causing their membrane to break. As a result, their contents spill into the cytosol, causing the digestion of the cell from the inside out. If DNA mutations occur, the p53 molecule normally will repair or destroy the cell before the mutation causes problems. If a mutation occurs that causes p53 to malfunction, the damaged cells will not be destroyed, and consequently will be able to reproduce themselves and pass the mutation on to the cell's progeny. Even in this case, beneficial results hardly ever occur, and if the mutation is expressed, the result is usually disease (such as cancer).

Breeding a line of genetically altered mice that did not produce p53 protein has helped researchers to understand how this mechanism functions. In one study, mice were all born appearing perfectly normal, but after several weeks all mice lacking the p53 protein contained tumors–and by six months, all were dead or dying of tumors. Other studies have found that, of the 6.5-million people diagnosed with cancer last year, at least fully half had p53 mutations (Modrich, 1994).

A p53 mutation in a gamete is passed on to future generations by germ cells, while those originating in somatic cells can cause cancer or another disease. Persons who inherit this condition (called *Li-Fraumeni Syndrome*) usually have healthy childhoods, but by age 30 over half develop one or more cancers, including brain tumors, osteosarcoma, leukemia, and breast cancer. The inheritance of a defective p53 gene invariably causes cancer while the victim is quite young (often before they reproduce), and over 90 percent die of cancer before age 70 (Malkin, et al., 1990). Regardless of the cause of a cancer, p53 appears to function as a safeguard. Consequently, cancer often does not develop unless the p53 safeguard mechanism is damaged. Certain chemicals in tobacco, for example, disrupt the p53 gene and/or the protein repair process, which is why the use of all types of tobacco is a major cause of a wide variety of cancers (Service, 1994).

The body's mutation defense system often can help prevent mutated genes from causing damage even if one of the cell's tumor-suppressor systems is damaged. For example, a large set of repair systems is the heat shock protein family, such as hsp 90 (Ridley, 2001). These proteins help give the cell protection against damage that can be caused by heat or other stress. All of these protection mechanisms ensure that the mutations usually cannot cause problems in cells that have been exposed to mutagens. Like a triple set of brakes, if the first set fails, the second or third can take over. The Creator knew how the cell mechanisms could go wrong, and thus built in these complex mechanisms to repair or destroy mutated cells to prevent macroevolutionary changes and disease.

Pyrimidine Dimer Repair

Even a DNA pyrimidine dimer mutation (where two adjacent thymine or cytosine bases inappropriately bind together) can be repaired. Such dimer mutations typically are caused by ultraviolet light and are fairly common in skin cells. One repair method is termed light repair or photoreactivation repair because the process is initiated by visible light. Visible light activates an enzyme that breaks the pyrimidine dimer bonds, thus repairing the mutation (Black, 1999). When bacterial cultures are irradiated with ultraviolet light in order to induce mutations, they must be stored in a dark location in order to prevent the light-dependent cellular-repair mechanisms from reversing most of the new mutations.

Another type of repair called dark repair requires several enzyme-controlled reactions to trigger the necessary repair process (Black, 1999). Specifically, a restriction endonuclease cuts the damaged pyrimidine dimers at a precise location, and an exonuclease removes the dimers and nearby nucleotides (Jorde et al., 1997). Then a polymerase repairs the area, using the correctly positioned complementary DNA strand as a master template. After DNA polymerase synthesizes new DNA to replace the defective segment, a third enzyme rejoins the old and new sections. Once these are joined, DNA ligase repairs the nucleotide side framework structure. At least seven different genes code for the repair enzymes used in this repair system. First identified in *E. coli*, research has found that similar repair mechanisms are employed in many animals and humans (Rosenfeld, 1983).

Mutations in any one of these dimer repair genes can produce a defective repair mechanism, causing diseases such as xeroderma pigmentosum or skin cancer. In xeroderma pigmentosum patients, extensive freckling begins before age 10, followed by skin tumors, mostly on the Sun-exposed parts of the body. Severe cutaneous malignancies then develop, causing death as early as age 20. Avoiding all sources of ultraviolet light can reduce the incidence of tumors, but cannot permanently prevent the development of cancer.

Chromosome Breakage Repair

Chromosome breakage that occurs during either meiosis or mitosis is repaired by a mechanism that usually fixes the break "perfectly with no damage" (Jorde, 1997) to the daughter cells. These breaks can be caused by a variety of clastogens (chemicals or energy that break chromosomes), including ionizing radiation or even viral infections. Faulty chromosome repair causes, or is part of the cause of, many diseases, including *ataxia-telangiectasia*, *Bloom's syndrome*, *Fanconi's anemia* and others (Bakkenist and Kastan, 2003).

Ataxia telangiectasia is a rare-but-fatal childhood disease that adversely affects both neurological and immunological function (Savitsky, 1995). The gene, a somatic gene that directs repair of double-strand DNA breaks, requires mutations in both copies in order to produce the disease (Bakkenist and Kastan, 2003). An estimated 2 million Americans carry a damaged ataxia telangiectasia gene.

Many Other Repair Systems Exist

Yet another recently discovered repair mechanism, the nonsense-mediated mRNA decay repair pathway, repairs mRNA before it can be used to synthesize protein (Chin, 2001). Any mutation that causes exon skipping results in the mRNA being shifted into the nonsense-mediated mRNA decay repair pathway for repair (Liu et al., 2001). Or, if a defect in mRNA results in a damaged stop codon, the ribosomes cannot be released and all the ribosomes behind it will be stalled. This problem is detected by a specific RNA structure called a tmRNA, which binds near the defective mRNA. This step adds a specific mRNA section to the defective mRNA that allows the process of protein synthesis to continue until the ribosome reaches the new stop codon added by the tmRNA. The release factor then dissembles the ribosome, allowing the ribosomes that were piled-up to finish translating the mRNA strand. The protein made by this modified mRNA has an extra set of amino acids that must be cut off, a step completed by an enzyme referred to as a tail specific protease (Silber et al., 1992; Beebe, 2000; Pallen and Wren, 1997).

Still other repair systems exist that we do not yet fully understand. During the development of an animal, the organism somehow "knows" how many and what body parts are part of the design and where each one is to be located. This system can actually override an error in the DNA instructions to ensure proper development (Ridley, 2001). Cells even have "internal-care mechanisms that fix a further fraction of the errors that have made it through the proofreading and repair enzymes filters" (Ridley, 2001, p. 96).

This system also repairs damage due to background radiation, free radicals, and other sources. The current estimate is that each cell in the body takes about 10,000 hits daily from free radicals alone (which means each DNA strand is exposed to approximately 5,000 hits daily) (Autry, 2003). This equals about 630 quadrillion free-radical hits for each person every day. It is clear that without this repair system, life above the bacterial level could not survive. Although not discussed in this paper, all of these repair systems are "irreducibly complex" (Behe, 1996)—meaning that each component of a system cannot function independent of the remaining components of that system. Behe (1996) argues that neo-Darwinian evolution cannot account for the origin of such inter-dependent biological systems. In addition, several of these repair systems are enormously complex, and despite intense study, are still not fully understood.

The Repair Process Opposes Evolution

The repair process ensures an extremely low mutation rate that works against macroevolution because mutations are "essential for evolution" and ultimately "all genetic variation" originated from random changes in DNA base sequences, which represents the raw material for the evolutionary process (Audesirk and Audesirk, 1999, p.167). This conclusion implies that an increase in the mutation level will be beneficial because more germ-cell-line mutations produce more variations, all which provide the raw material that enables evolution to occur. Although Darwinists claim that, ultimately, mutations are the original source of all genetic variation, all informed societies have taken elaborate pains to do whatever is feasible to reduce the mutation level in their society to as low as possible. An extensive body of research since the turn of the century has concluded that the harm of mutations far outweighs any hypothetical benefits that they may confer to the organism (Bergman, 1995). In fact, a clearly beneficial mutation that results in a gain of "genetic information" has never been documented (Rust, 1992).

It is not yet known how effective the mutation repair system is for all life and may be less effective in lower life forms (Selby, 1998). In these lower level organisms, such as bacteria, mutations are not always repaired as effectively as in most organisms, and even contribute to the genetic variability of the population (Anderson, 2003). Some mutations in bacteria evidently can even induce proteins that allow replication past double strand breaks, which introduces *more* mutations in certain genes and lower replication fidelity (a similar process in higher organisms may be occurring with the hsp90 protein). This increased maintenance of mutants in a bacterial population is believed to be a survival mechanism that allows at least some variants to survive in a hostile environment (Anderson, 2003).

Darwinists argue that enough mutations occur that are not repaired to allow evolution to occur. Some non-deleterious variance found in life no doubt is due to mutations. Given the significance of mutations for naturalism, though, it would seem that evolution would select for any mechanisms that increased the level of non-lethal mutations. According to neoDarwinism, the more of these mutations that occur, the greater the chance of producing structures that facilitate improving both survival and the animal's reproduction rate, and, consequently, evolution. A mechanism that reduces the mutation rate would impede the production of variations, which is the only ultimate source of macroevolution. Of course, mutations also would increase the likelihood of unfavorable changes, but most of these would be selected against quite rapidly. Thus, in the long run, these mutations would not be a concern.

The critical factor in driving macroevolution is the occurrence of genetic mutations that are advantageous, but these changes usually are possible only if many mutations occur–and Darwinists teach that, in the long run, the more mutations that occur, the greater the chances of producing a positive mutation. Consequently, they conclude, the negative mutations are a necessary but small price to pay for improvement.

Conversely, a creation model postulates that the genome was originally perfect, as were the many mechanisms designed to produce controlled genetic variety, such as genetic crossing over during meiosis, and sexual reproduction. Random genetic changes would virtually always disrupt the original design of the genome, and thus those that are expressed almost always would be harmful (Marx, 1994a, 1994b). The existence of the complex "elaborate machinery" to ensure high fidelity of DNA replication is fully consistent with a creation model. The repair system has been studied most thoroughly in bacteria, but the mechanism used is similar in most other organisms including mammals (Aboussekhra et al., 1995).

Evolution also would seem to select *against* highly effective repair mechanisms because they oppose the process that allows macroevolution to occur. Without sufficient genetic raw material, selection cannot take place to improve a species. Evolutionists counter by claiming that too many mistakes at one time are counter-productive. McVean and Hurst (1997) argue that the mutation rate is not zero due to a trade-off between "the benefits of reducing the deleterious mutation rate, and the costs imposed by increasing fidelity (such as the time and energy spent proofreading). Alternatively, there might be a physiological limit to the degree of accuracy in DNA replication" (p. 388).

Yet, minor genomic changes are useless, and only major genetic changes in several genes can produce sufficient innovation to generate complex new structures that will function as a complete, integrated unit. A literature search of over 15 million entries located neither a single article that attempted to explain the evolution of any of the mutation-repair mechanisms, nor an article that attempted to present evidence for a theory of how the repair mechanisms could have evolved. This finding confirms the conclusion of Behe (1996) that a complete lack of evidence exists for the biochemical evolution of nearly all cell structures, systems, and proteins.

Summary

Evolutionary naturalism teaches that the ultimate source of all genetically produced traits are mutations that occur in the germ-cell line. Thus, according to this theory, the human genome is comprised mainly of mutations that were selected because they provided a survival advantage in a given environment. A major problem with this postulate is that nearly all changes in the coding genes, the exons, and evidently also many other base pairs, will be corrected by the gene-repair system or will be prevented from being expressed. Furthermore, when this repair system is not functioning properly, the eventual result is mutations that cause biological problems, not progress (Hanawalt, 1994; Modrich, 1994). Thus, gene mutations in exons or other genetic malfunctions are, as a whole, clearly regressive and not beneficial or progressive.

Unless mutations can be repaired effectively, serious or lethal health problems usually result. We now know that faulty repair systems are the cause of many diseases, such as cancer. Even bacteria, which generate more "beneficial" mutations than higher organisms, still contain complex DNA repair systems. Without such repair systems, mutations would soon have extinguished all life that might have evolved. Without the mutation repair systems, UV light alone would have rapidly destroyed all animal life. All of these repair mechanisms are major impediments in allowing the expression of the genetic mistakes that allegedly provide the raw material for macroevolution. Without these complex repair mechanisms, the organism would undergo a rapid mutational meltdown. Thus, the recent discovery of the many DNA mutation-repair systems is yet another scientific stumbling block to Darwinian macroevolution.

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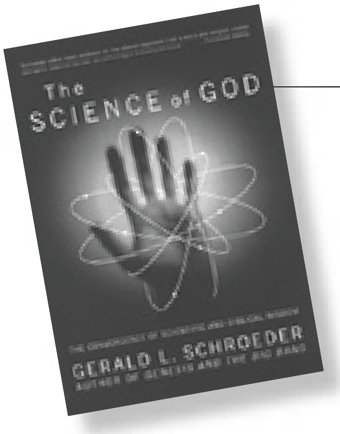

Book Review

The Science of God by Gerald Schroeder

Broadway Books, New York, 1998, $14.95

Don B. DeYoung (1998) gave an excellent review of the hardback edition of this book. Another excellent review of an earlier, similar book by Schroeder entitled *Genesis and the Big Bang* was given by Eugene F. Chaffin (1996). I will add further comments.

This book has become a classic in the field exploring the relationship between Scripture and science. For that reason it is must reading. Schroeder's attempt at reconciliation between the two is a "mixed bag" to Young Earth Creationists. As a positive point, he does a superb job in pointing out many inconsistencies in the commonly held Darwinism/gradualism concepts held so long in evolutionary circles.

Schroeder notes the significance of the tens of thousands of fossils found in the Burgess shale by Walcott in 1909 that were reburied in the Smithsonian museum for 80 years. These well-preserved fossils illustrate an "explosion" of every phyla of life at the very time life should have been gradually evolving. Schroeder shows how Darwin's concept of an evolutionary tree is totally missing from the fossil record. Transitional forms simply do not exist even after much exploration by earth scientists since Darwin's day. Rather, sudden appearance of new life forms is the trademark of paleontology.

While Schroeder holds to a literal six-day creation, it is from a *cosmic* viewpoint only. On earth billions of years are passing, while from the vantage point of one in the universe only six days elapse. This view is exactly opposite from Humphreys cosmological model (1994) that holds to the traditional and Scripturally-obvious understanding that Genesis 1 is primarily written from the viewpoint of one *on the earth*.

Ultimately, Schroeder's concept of "creation" boils down to merely another form of theistic evolution. He envisions God giving the earth to have within it "the special properties to orchestrate the beginning of life" and for life thereafter to flourish and suddenly leap into other types (p. 29, see also pp. 5 and 12 and elsewhere).

Thus, while Schroeder acknowledges that a reading of the Scriptures leads to "less than 6,000 years" (p. 33) since Adam's creation, the existence of older fossil remains of "humans" must be reckoned as remains of human-like animals not yet possessing the human soul (Chap. 9). Only when writing becomes evident in the archeological record can we be sure we are dealing with true human beings (p. 143). Man's "qualitative leap" (p. 143) with the introduction of the soul takes on almost a New Age flavor.

All of this becomes necessary because Schroeder never questions dates derived from radioisotopes. Naturally, the speed of light is assumed to have been constant throughout all geologic time (p. 162). It is understandable that Jewish scientist Schroeder would delve into the Scriptural account using 800-year-old Jewish records of such scholars as Nahmanides and Moses Mainonides. I would prefer to use the still more ancient Jewish records of Jesus, the apostles and other inspired men of the First Century whose words are recorded in the New Testament and whose words confirm the traditional, Young Earth Creation story of Genesis.

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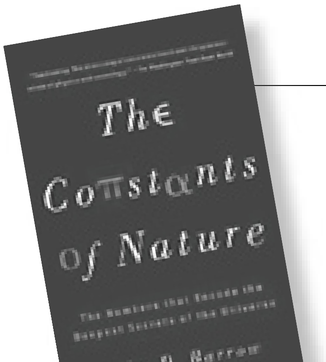

Book Review

The Constants of Nature: From Alpha to Omega

by John D. Barrow

Pantheon Books, New York, 2002. 352 pages, $26.00.

John Barrow received his Ph.D. in astrophysics from the University of Oxford, England in 1977. He is presently professor of mathematical sciences, University of Cambridge, and professor of astronomy, Gresham College, England. He has written a long list of research publications and books in both areas. In the Preface he describes this book, "But gradually we have identified a collection of mysterious numbers which lie at the root of the consistency of experience. These are the constants of Nature" (p. xiii). Barrow uses the word mysterious because there is no known materialistic theory that describes where these numbers come from or why they remain constant in this changing world. Barrow is a devout evolutionist as indicated by his capitalization of Nature and his belief that future scientists will solve these mysteries and develop a Theory of Everything from which constants can be derived. Later in the book he reveals the areas of research on which he is bases this belief, namely string theory and quantum gravity.

The book subtitle is "The Numbers that Encode the Deepest Secrets of the Universe." Under that theme he explains how constants were first discovered and how their originators interpreted their role in the universe. The book is well organized with notes on each chapter including references for further reading and an index. The first five chapters provide the basic history of the familiar constants such as the speed of light, the quantum of energy, electron charge, gravitational constant, and the mass of a proton. The author also adds two pure numerical constants (ratios with no dimensional units) the fine structure constant and the cosmic structure constant derived from the other constants. These two numerical constants together explain the density of structures in the universe all the way from atoms to galaxies of stars. All that is left out of this constant density are black holes and quantum (subatomic) particles. It is interesting that the author uses words such as "ultimate reality" and "superhuman standards" to explain the discovery of these constants by men such as Maxwell, Planck, Einstein and others. These men expressed their belief in a designer who transcends the physical universe. The author writes, "The illuminating exchange of letters with Rosenthal-Schneider on constants ends on 24 March 1950 with Einstein reiterating his 'religious' view that God did not have any choice when it came to the fundamental constants and their values" (p. 40).

The remaining chapters speculate on the origin of constants. Barrow begins with Arthur Eddington's large numbers that he attempted to relate to the cosmological constant. Paul Dirac took three of these large numbers and showed how they could be related to the age of the universe based on naturalistic assumptions. But it helped persuade many biologists and geologists that they were on the right track in proposing a long age for the earth and its life. Barrow attempts to relate how biological development is related to the constants and where the anthropic principle fits his idea of evolutionary development. He also discusses the recently proposed multiverse concepts where the constants take on different values in other universes. Of course the existence of any other universe has never been shown but the latest theories like "string" or "brane" require them. The whole idea is to increase the odds that life developed somewhere as the author states, "The contemplation of slightly changing the constants of Nature requires the invention of different past histories for the Universe, some of which have the novelty of neither containing ourselves nor any other sentient beings" (p. 194). The final chapters develop this theme as fully as the evolutionary imagination can conceive at this point in history.

I found one interesting concept in the author's discussion of more than four dimensions of spacetime that is applicable to cosmologies based on general relativity. In Russ Humpheys' book *Starlight and Time* (p. 93) he describes the Big Bang and his related "white hole" cosmology as adding a fourth dimension of space to get the curvature or stretching that is detected by the cosmological redshift. The normal theories of gravity, both Newton's and Einstein's, involve only three dimensions of space and one of time. The theory that has been developed to physically allow more spacial dimensions is called Kaluza-Klein after its originators. It uses a trick as this author describes, "The trick was simply that dimensionality had to be undemocratic: there could be more than three dimensions of space but they had to be small and unchanging if they were to avoid altering the character of the world that we experience" (p. 226). That seems to rule out the fourth spacial dimension (stretching or curvature of space) because of the size of the universe and its expansion to produce the redshift. It is interesting that this difficulty seems to be ignored or conveniently "swept under the rug" whenever general relativity is used in cosmological theories. It may be the main reason that even "string and brane" theories have not been successful. Both are working with multiple dimensions that are less than a millimeter in extent. A very large number are required to fill the volume of the universe.

I recommend this book to anyone who wants to see the precision and magnitude of God's creation. There are many constants that are designed in concert because if they vary by less than five percent our whole universe would be different and would not support life. Evolutionists really do not have an explanation how this could have just happened. The multiple universe theory simply is proposed without observable evidence.

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Sequatchie Valley Tennessee and Alabama: A Different Approach

Emmett L. Williams and A. Jerry Akridge*

Abstract

The origin of Sequatchie Valley is viewed from a uniformitarian approach. In contrast, the origin of the valley is proposed from a young earth-Flood perspective. Also considered are the Tennessee River water gap in Walden Ridge, Tennessee, the Mississippian-Pennsylvanian boundary problem in the region and evidences of high-energy deposition on Walden Ridge and Sand Mountain, Alabama.

Introduction

Sequatchie Valley is a long, relatively narrow valley in Tennessee and Alabama and in places it is quite picturesque. Geological studies have been conducted on the many features as well as the structure of the Valley. These studies will be reviewed and an origin of the Valley from a Flood-young earth perspective will be postulated.

Miller (1974, p. 4) noted that Sequatchie Valley "...is one of the largest and most spectacular anticlinal valleys in the world." See Figure 1. The valley extends approximately 200 miles from east-central Tennessee almost in a straight line into northeastern Alabama (Mills, 2002; Smith, 2000, p. 4; Martin 1940, p. 15). See Figure 2. Harris and Milici (1977, p. 24) also commented on the beauty of the valley. "Breached by erosion along most of its length the Sequatchie anticline forms one of the most scenic valleys in east Tennessee."The extension of the valley into Alabama is sometimes called Browns Valley which is less prominent than the section in Tennessee. The damming of the Tennessee River forming Guntersville Lake also covers much of the valley in Alabama.

The valley is located within the Cumberland Plateau and is bounded on the southeastern side in Tennessee by an escarpment, Walden Ridge, which in Alabama is called Sand Mountain. The Tennessee River separates the two heights by a water gap cut into the ridge. The Cumberland Plateau forms the boundary on the northwestern side of the valley in Tennessee and Alabama. The valley is within the Appalachian Plateaus physiographic province (Mills, 2002; Raymond, et al., 1988, pp. 1, 2; Milici, 1960, p. 79). It is considered by some investigators to be one of the most perfect or classic examples of an anticlinal valley in the world (Crawford, 1989, p. 1; Martin, 1940, p. 16).

Figure 1. A portion of Sequatchie Valley near Dunlap, Tennessee. The Cumberland Plateau escarpment can be seen in the background.

Topography of the Valley

Milici (1960, p. 3) described the topography of the valley in Tennessee as:

> ...the relief and pronounced linearity of the valley, and the consistently rugged valley walls, are the most striking topographic features of the structure. Maximum eleva-

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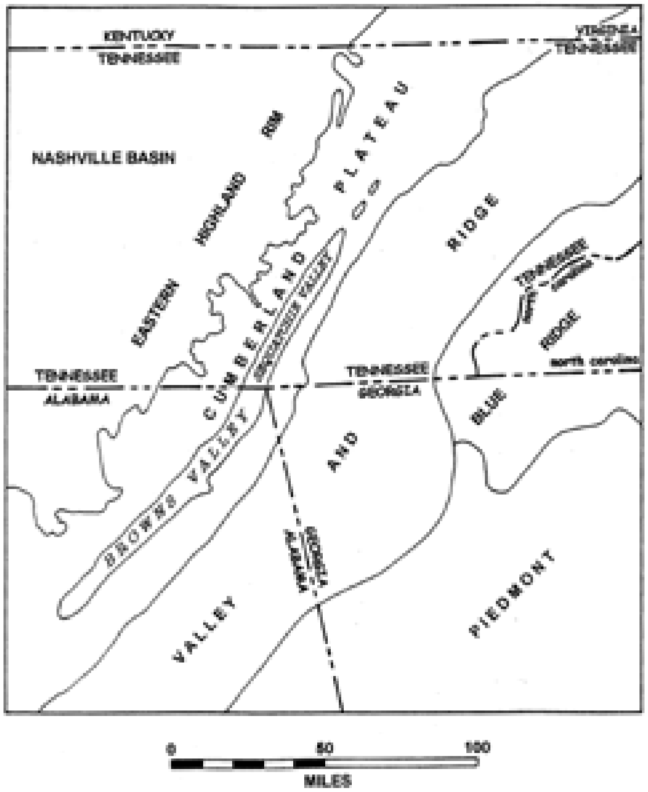

Figure 2. The location of Sequatchie Valley in Tennessee and Browns Valley in Alabama (after Milici, 1963, p. 816). Drawing by Mary Elizabeth Akridge.

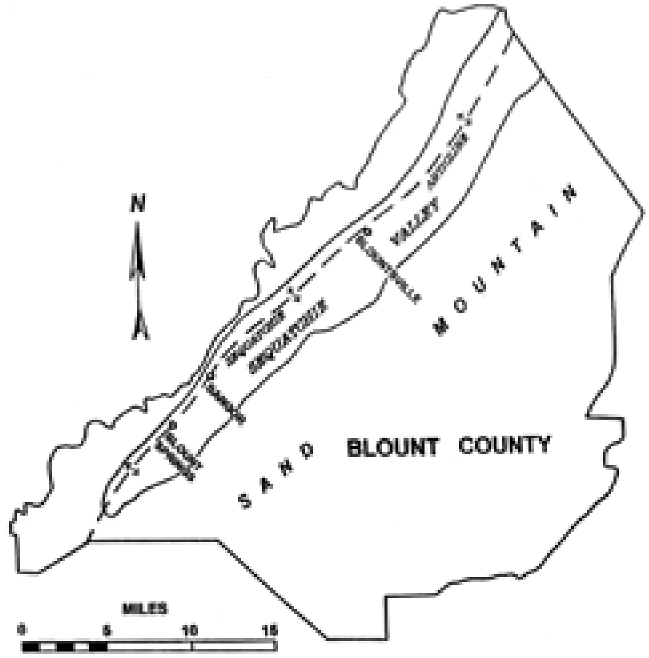

Figure 3. The terminus of Sequatchie Valley in Blount County, Alabama. Note that the modern terminology is Sequatchie Valley in Alabama (after Faust, 1984, p. 2). Drawing by Mary Elizabeth Akridge.

> tions of the eastern valley wall, which ranges in altitude from 2000 feet in the southern part of the area mapped to 3000 feet at the head of the valley, are generally 100 to 400 feet greater than those at the western side of the valley. The relief from the top of the Cumberland Plateau to the floor of the valley is consistently greater than 1000 feet throughout the length of the Sequatchie Valley from the Tennessee-Alabama state line to the head of the valley.

The width of the valley in Tennessee varies from 4 to 5 miles (Miller, 1974, p. 4).

Sand Mountain in northeast Alabama has an altitude of 1400 to 1500 feet and is 1000 feet above the valley floor (Wilson, 1975, p. 20) which is approximately four miles in width at Stevenson, Jackson County (approximately 8 miles directly south of the Tennessee-Alabama state line). Further southwest, the valley floor widens in places to about five miles. (It is difficult to determine the width of the valley floor where Guntersville Lake is ponded.) Then in Blount County the floor width begins to decrease as the valley ends below Blount Springs (Figure 3). The height of Sand Mountain decreases to approximately 1000 feet, whereas Blount Springs has an altitude of 500 feet above sea level near the termination of the valley. "Sequatchie Valley [in Alabama] is characterized by the presence of sandstone ridges and moderate relief"(Raymond et al., 1988, p. 1) [Brackets added].

Sequatchie Anticline

Milici (1967, p. 179) stated that the:

> Sequatchie anticline is an isolated Valley and Ridge-type structure situated in gently dipping and only locally deformed rocks of the Cumberland Plateau of Tennessee and Alabama...The structure...parallels the regional trend of the Appalachians...

Also see Crawford (1989, p. 1; 1981, p. 18).

The anticline (Figure 4) is reflected along most of its length by Sequatchie Valley, however on the northeastern end of the valley, the anticline formed Crab Orchard Mountains which consist of massive unbreached sandstone. "The anticline dies out to the northeast and disappears at Emory River fault zone" (Gaydos et al., 1982, p. 8) [Figure 5]. Southwestward, the surface effects of the anticline end in western Blount County, Alabama (Figure 3), where as Thomas (1972, p. 7) described "...Mississippian rocks plunge beneath the Pennsylvanian." The anticline has been traced subsurface across western Jefferson County, Alabama where it apparently ends (Figure 6).

Figure 4. An outcrop of St. Louis Limestone in the gently-dipping southeastern limb of the Sequatchie anticline along Tennessee Highway 30 near Pikeville. The valley is to the left of the photograph indicating the convex upward nature of the fold.

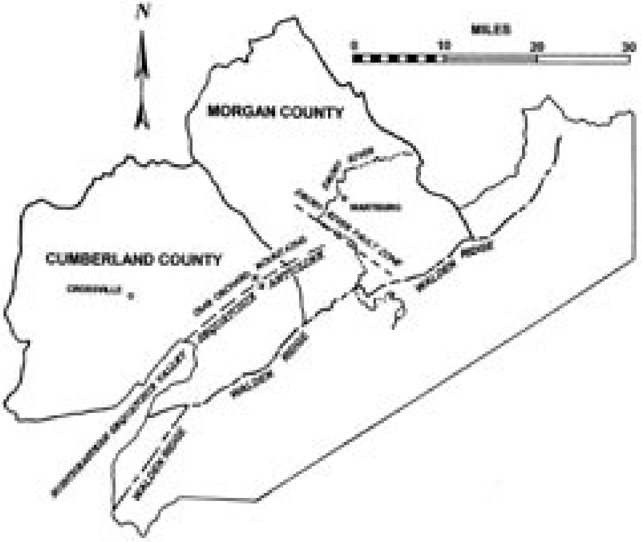

Figure 5. The northeastern termination of Sequatchie anticline at the Emory River fault zone in Morgan County, Tennessee (after Gaydos et al., 1982). Drawing by Mary Elizabeth Akridge.

Miller (1974, p. 42) commented that generally the axis of the anticline in Sequatchie Valley, Tennessee is parallel to that of the valley. Earlier, Martin (1940, pp. 101–102) suggested that the axis of the anticline is well over toward the northwestern flank of the fold and cannot be definitely placed. Rogers (1950, p. 674) was impressed by the isolation of the anticline since the feature is related to the folds of the Appalachian Valley and Ridge province yet it is the most northwestern of such folds separated from the others by Walden Ridge and Sand Mountain which are at least seven miles wide and are underlain by undisturbed, flat Pennsylvanian rocks.

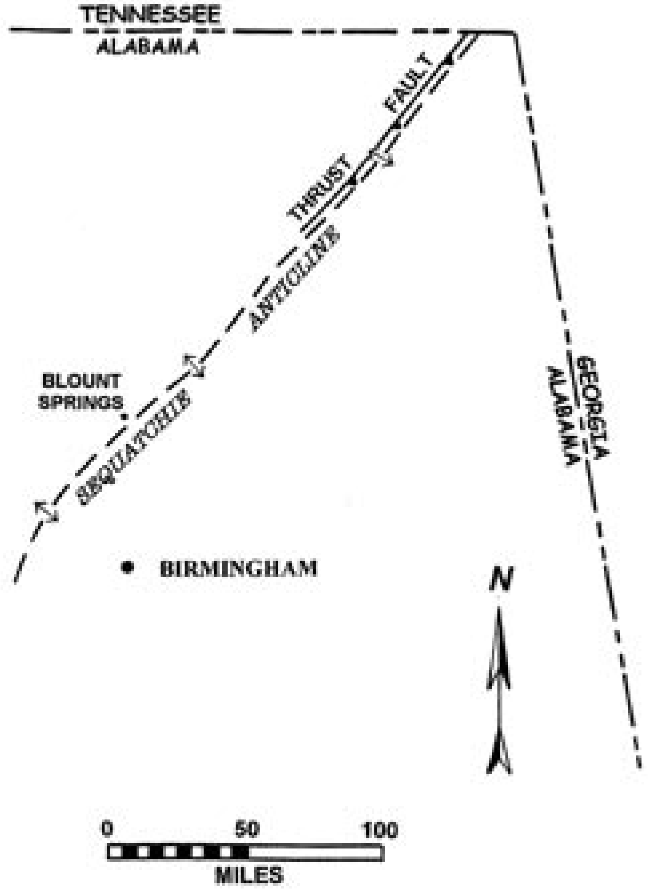

Figure 6. Trace of the Sequatchie anticline in Alabama (after Thomas and Neathery, 1980, p. 473). Drawing by Mary Elizabeth Akridge.

In discussing the Cumberland Plateau, Rogers (1970, p.23) explained that:

> ...the Plateau is split lengthwise by Sequatchie Valley... where the straight Sequatchie anticline...has lifted up the resistant Carboniferous...sandstone layers and exposed the less resistant strata beneath.

At the crest of the anticline, resistant Pennsylvanian sandstones were breached by erosion. The underlying Mississippian and Ordovician limestones which then occupied a structurally higher position than normal in the core of the anticline core were more extensively eroded (Mies, 1999, p. 3).

An excellent overview of the anticline is given by Thomas and Bearce (1969, p. 26):

> The Sequatchie anticline is the most northwesterly structure of the southern Appalachians. It is an elongate

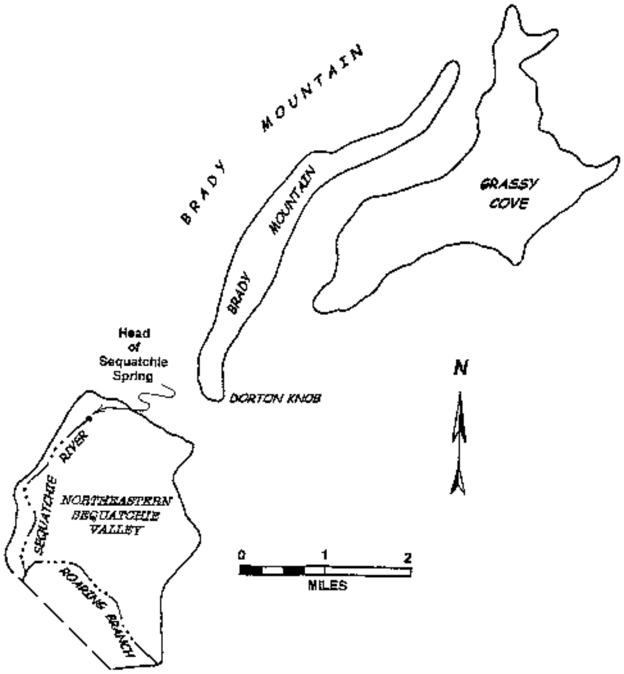

Figure 7. Location of Grassy Cove in relation to Sequatchie Valley. Only the uppermost heights of Brady Mountain are shown. Outlines are only approximate (after Crawford, 1989). Drawing by Mary Elizabeth Akridge.

> asymmetric anticline that extends 250 miles from Morgan County, Tennessee, to Jefferson County, Alabama... [This distance includes the known subsurface trace of the anticline]. The northwest limb of the anticline is steep along its entire length; and, a thrust fault extends along the northwest flank of the anticline from near its northeastern end 150 miles southwestward... The anticline is essentially non-plunging except within a few miles of each exposed end. It maintains uniform structural relief relative to the beds in the Cumberland Plateau ...South of Grassy Cove, Tennessee, [Figure 7] the anticline rises to its maximum structural relief which is maintained for more than 150 miles southward beyond Guntersville, Alabama... [Brackets added].

Figure 8 illustrates the asymmetric nature of the Sequatchie anticline.

Sequatchie Thrust Fault

The Sequatchie anticline was formed by thrust faulting (Milici, 1967, p. 191). "The western flank of the anticline is broken along most of its length by a generally southwestward-dipping overthrust" (Milici, 1963, p. 819). The overthrust has been traced on the surface from Devilstep

Figure 8a. Steeply-dipping Pottsville strata on northwestern limb of the asymmetric Sequatchie anticline.

Figure 8b. Gently-dipping Bangor Limestone over a tongue of clay shale on the gently-dipping southeastern limb of the asymmetric Sequatchie anticline. These photographs were taken along Interstate 65 in Blount County, Alabama, near exit 287.

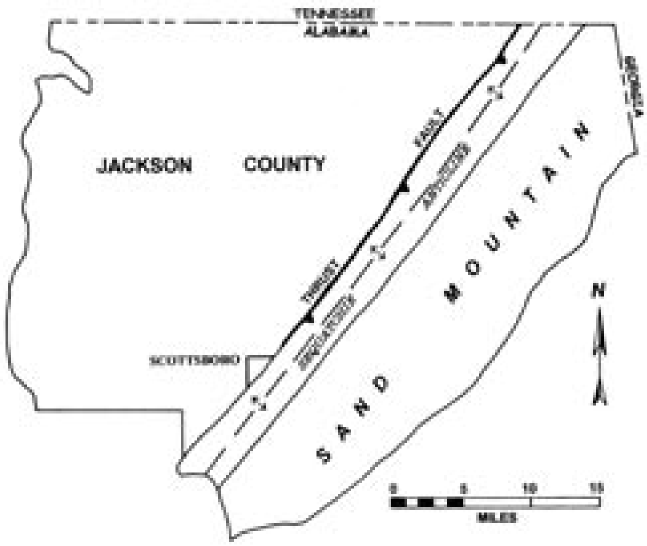

Figure 9. Trace of the Sequatchie thrust fault as it apparently ends north of Scottsboro, Alabama (after Thomas, 1972). Drawing by Mary Elizabeth Akridge.

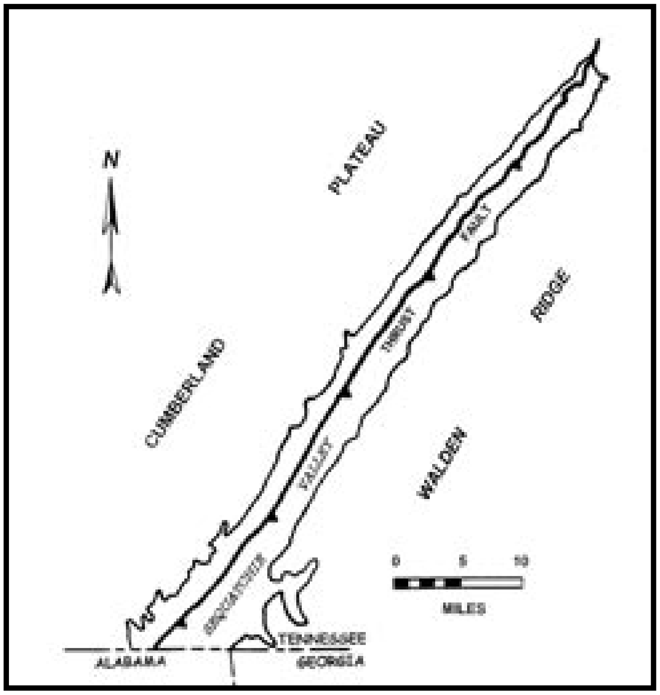

Figure 10. Trace of Sequatchie thrust fault in Tennessee (after Milici, 1960, p. 55). Drawing by Mary Elizabeth Akridge.

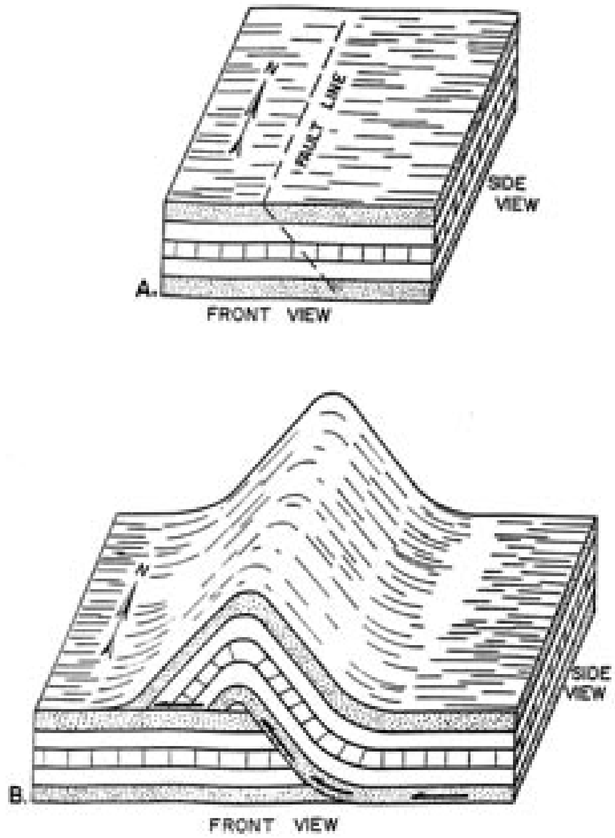

Figure 11. Block diagrams illustrating possible mechanism of formation for Sequatchie anticline; A. Trace of fault before thrusting; B. Resultant anticline after thrusting. Erosion of the anticline would expose older formations in valley floor (after Churnet, 1997, pp. 48, 49). Drawing by Mary Elizabeth Akridge.

Hollow (Vandever and Grassy Cove Quadrangles) at the southwestern base of Brady Mountain in Tennessee (Figure 7) into northeastern Alabama where it ends just north of Scottsboro (Figure 9) [Thomas, 1972, plate 8; Thomas and Neathery, 1980, p. 473]. The fault has been found subsurface in an oil test well near Crab Orchard, Tennessee about 10 miles southeast of Crossville.

> Stratigraphic displacement along the fault increases from a few hundred feet in the northern portion of Sequatchie Valley to approximately 2500 feet near Dunlap, Sequatchie County, Tennessee. This displacement persists southwestward to the Tennessee-Alabama line. In Alabama the displacement decreases from approximately 2200 feet near Stevenson, Jackson County, to nil at the southwestern terminus of the fault (Milici, 1963, p. 820).

A trace of the thrust fault in Tennessee is seen in Figure 10. A suggested sequence for the development of the anticline by thrust faulting is illustrated using block diagrams (Figure 11).

The relationship of the Sequatchie overthrust to the Cumberland Plateau has been discussed by geologists. Wilson and Stearns (1958, p. 1286) noted that: “The thin

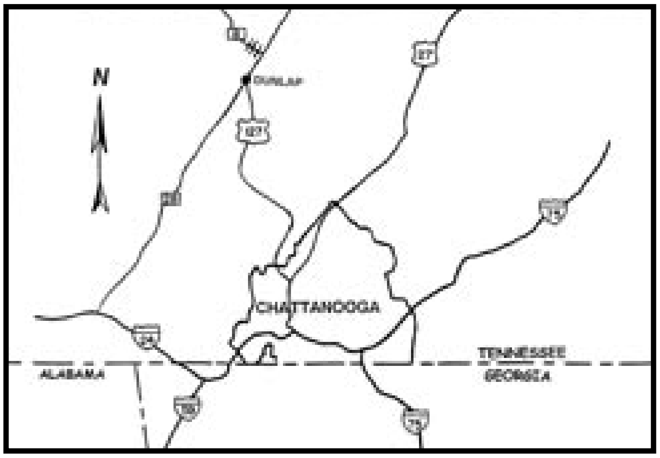

Figure 12. Location (dashed lines) of decollement zone in Cumberland Plateau adjacent to Sequatchie Valley. Drawing by Mary Elizabeth Akridge.

Cumberland Plateau overthrust sheet is interrupted by the deeper-seated prominent Sequatchie Valley anticline." Milici (1963, p. 824; 1960, p. 72) felt that the two overthrusts are the same structure. Wilson and Wojtal (1986, p. 143) consider that:

> ...the Cumberland Plateau is split by the Sequatchie Valley. This valley over 1600 ft...deep for most of its length, has also breached the Cumberland Plateau sheet and divides it into two parts. The trailing edge of the western part of the Cumberland Plateau sheet, the Cumberland Plateau thrust, is exposed along the west wall of the Sequatchie Valley. The leading edge of the eastern part of the Cumberland Plateau sheet, the Sequatchie Valley thrust, crops out along the west side of the valley floor... The two faults join at the north end of the Sequatchie Valley indicating that the Cumberland Plateau thrust is an upper glide horizon associated with the steeply dipping Sequatchie Valley thrust...

Evidence of tectonic activity along the Cumberland Plateau thrust can be seen in a decollement zone at Dunlap, Tennessee along Tennessee Highway 8 from the intersection of U.S. Highway 127 for approximately two miles (Figures 12 and 13). Differences in opinion exist concerning the folding and faulting in the region of the Sequatchie anticline and Cumberland thrust sheet which are beyond the scope of this paper (Hawkins, n.d.; Wilson and Wojtal, 1986).

It has been conjectured that during the massive Appalachian faulting and folding, Walden Ridge and Sand Mountain were transported westward closer to the main Cumberland Plateau (Rogers, 1950, p. 677). Churnet et al., (1985, p. 34) claim that: "Walden Ridge is an allochthonous block which moved to the west on the Sequatchie thrust fault. The westward movement was accompanied by folding."

Uniformitarian Model for the Development of Sequatchie Valley

It is assumed that forces associated with the Allegheny orogeny during the late Paleozoic Era extended as far west as the present location of Sequatchie Valley. The Sequatchie anticline was formed by thrust faulting during this orogeny. Sequatchie Valley in Tennessee is believed to have developed during a period of Mesozoic erosion which reduced the anticlinal structure to a valley (Miller, 1974, pp. 42–44). Miller's model is illustrated in Figure 14 using block diagrams.

Milici (1967, p. 179) believed that: "Sequatchie Valley drainage is tributary to the Tennessee River, which flows through part of the valley, and is intimately related to the development of that river." He suggested that "The Tennessee River probably eroded headward across the Sequatchie anticline during the Mesozoic and initiated formation of the Sequatchie Valley"(Milici, 1967, p. 180). Thus considering Figure 14 with Milici's postulation that the Tennessee River captured the Sequatchie Valley drainage, this sequence of events started the northeastward advance of the valley into east Tennessee by headward erosion.

The process of headward erosion occurred in the following manner "...Pennsylvania formations were breached and the Pennington shales were exposed along the crest of the structure [Sequatchie anticline]..." (Milici, 1967, p. 183) [Brackets added]. Once the resistant Pennsylvanian mate-

Figure 13. Folding caused by faulting in decollement zone in the Lower Gizzard Group along Tennessee Highway 8 (automobile for scale).

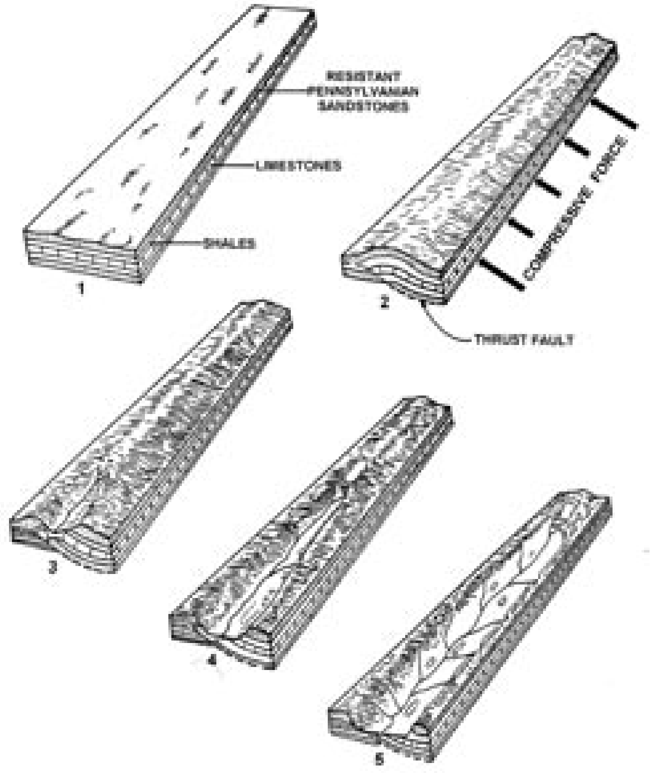

Figure 14. Uniformitarian model for the development of Sequatchie Valley using block diagrams (after Miller 1974, p. 33). Drawing by Mary Elizabeth Akridge.
1. Flat-lying sediments prior to Allegheny Orogeny.
2. Anticline formed by thrust faulting during orogeny.
3. Tennessee River begins to erode headward after capturing drainage from ancestral Sequatchie River on crest of anticline.
4. Resistant sandstones have been removed in lower valley as sinkholes form at head of valley as headward erosion continued.
5. Present headward erosion continued up the valley by the same means as 4. Present valley configuration showing karst valleys (coves) at head of valley.

Figure 15. Grassy Cove, Tennessee.

Figure 16. Head of Sequatchie Spring or McWhorter Spring at northeastern head of Sequatchie Valley. This spring is on private property.

rial has been penetrated, the underlying less resistant shales and limestones were easily eroded or dissolved, continuing the advance of the valley toward the northeast. Once water entered the structurally elevated limestones along the anticline, underground solution of these rocks undermined overlying strata as the valley advanced headward.

Proof offered for this erosive and solutional action is the continuing slow process of valley advance. At the northeastern head of the valley (Figures 5 and 7), the Sequatchie River begins at the Head of Sequatchie Spring [Vandever Quadrangle] (Figure 7) and other springs which are fed by underground movement of water from coves northeast of the valley head. These coves, the largest of which is Grassy Cove, (Figure 15) are karst valleys or large sinkholes floored by Mississippian carbonates. Milici (1967), Miller (1974) and Lane (1957) predict that these karst valleys will eventually become part of Sequatchie Valley as the solutional cavities increase in size, eventually undermining the overlying sediments in a continuing headward growth of the valley.

In a recent field study centering on Grassy Cove [which Crawford (1989, p. 1) thinks is the largest karst depression in North America], it was noted that the cove is drained by Cove Creek into Mill Cave with the water flowing underground below Brady Mountain [Grassy Cove Quadrangle] (Figure 7) and resurfacing at Head of Sequatchie Spring (Figure 16) in the Sequatchie Valley. Crawford (p. ix) claimed that:

> ...conduit caves form by subterranean invasion of aggressive caprock streams as they breach the clastic Pennsylvanian caprock of the Cumberland Plateau and invade the underlying Mississippian carbonates. If the gradient of a caprock stream is less than the dip of a structural high (such as an anticline), it will eventually cut through the caprock into the underlying limestone. As the water of the caprock stream which is aggressive to calcium carbonate, begins to flow through the joints and bedding planes of the underlying limestone to a resurgence near the base of the Cumberland Plateau Escarpment, corrosion and corrasion will enlarge the most efficient route, thus creating a conduit cave. Slope retreat by the sapping of underlying limestones from under the sandstone caprock will proceed in all directions...resulting in a karst valley...

Continuing this line of reasoning, Crawford (p. ix) concluded:

> Along the Sequatchie anticline, subterranean stream invasion, conduit cavern development, and the growth of karst valleys have played and continue to play a major role in changing anticlinal mountain into anticlinal valley, The anticlinal mountain is first reduced to karst valleys as surface-flowing streams are diverted underground, and finally the karst valleys are assimilated into the Sequatchie Valley itself as it advances headward up the Sequatchie Anticline.

Sapping of the Pennsylvanian strata along the Cumberland Plateau escarpment can occur with subsequent collapse of large blocks of Pennsylvanian rocks onto the valley floor (Figure 17). Over 60 years ago Martin (1940, p. 125) found an oval-shaped sink west of Grassy Cove that was 75 ft. by 300 ft. where portions of Pennington and Gizzard material had collapsed into a large cave in the underlying Bangor Limestone indicating the recent occurrence of the sapping phenomena. Also solution cavities (Figure 18) were seen along the limestone outcrop mentioned earlier (Figure 4). Such solution tubes would likely become enlarged with continued water flow through them.

If the present is the key to the past, all that is necessary for such a process to form Sequatchie Valley is enough time—approximately 65–230 million years would have elapsed to reduce the anticline to the present valley and the headward erosion continues slowly in the present.

Consider the southwestward development of Sequatchie Valley in Alabama. Assuming that the intense Mesozoic erosion breached the anticline in northeast Alabama, the flow of the Tennessee River may have been trapped in the breached anticline (Milici, 1968, p. 477) and its flow would continue the headward erosion process downstream. However about 60 miles downstream near present-day Guntersville, crustal movements possibly blocked the southwest flow and caused the river to change course to a northwest direction. Weathering continued to erode the valley in a southwest direction until the resistant Pennsylvanian Pottsville was not breached where the valley ends in Blount County (Figure 3). Another factor that would inhibit further valley extension is that the anticline plunges at the southwestern end of the valley (Thomas and Bearce, 1969, p. 26) just as it plunges at the northeastern end of the valley.

Tentative Flood—Young Earth Speculations: Sequatchie Valley

Sediments in the Sequatchie Valley region were deposited during the Flood. The clastic sandstones were derived possibly from eroded antediluvian mountains (Whitcomb and Morris, 1963, p. 215) or from erosion of the recently-uplifted

Figure 17. Cumberland Plateau escarpment. Sections of the face likely removed by cliff sapping are seen in foreground.

Figure 18. Solution cavity in St. Louis Limestone at outcrop along Tennessee Highway 30.

Appalachians (Froede, 1998, p. 70). During the recessional stage of the Flood, as the level of water dropped, the crust of the earth likely would rebound. This effect could have caused mountains such as the Appalachians to be uplifted. Subsequently, the Sequatchie Valley anticline may have developed in the latter period of the Appalachian thrusting and folding event.

During this time frame the recently deposited sediments were water-laden and probably quite plastic as overthrusting produced the structural height (anticline). If such a process did occur, there possibly would have been cracking or faulting along the anticlinal crest (see Oard, 2001, p. 86) as a result of the considerable strain placed on the crest by the upward movement.

As Floodwater continued to recede, the rapidly moving fluid containing abrasive particulate material would carve a channel along the crest of the anticline. This erosive action would deepen the channel into a valley. The almost straight line of Sequatchie Valley may be testimony to this action. Once the anticline plunged where massive sandstone deposits were formed (at each end of the valley), little erosion occurred and the headward advance of the valley was terminated. In the lower reaches of the valley in Alabama beyond where the Sequatchie thrust died out, channelized Flood currents would carve a depression not as spectacular as the valley is along the thrust fault since the thrusting caused the elevation of easily-erodible shales and carbonates closer to the anticlinal crest.

During the warm, wet post-Flood ice age (Oard, 1990), the coves above the northeastern terminus of the valley started forming. The consolidated, dewatered resistant sandstone caprock may have been breached in places. The less resistant shales and carbonates below the surface strata would act as ideal channels for water entering the breached sections to form solution cavities. Sinkholes also formed and subterranean water-flow would enlarge existing cavities into caves. Eventually the aggressive water would emerge at the head of Sequatchie Valley. In many places the sandstone surface cover would collapse into sinkholes or suffer cliff sapping after being undercut. Thus the coves expanded and Sequatchie Valley continued forming headward. This process likely slowed after the ice age to the present rate of valley headward erosion.

Appendix I

Lithology of Certain Formations in Sequatchie Valley Region

Brief lithogies of the geologic formations discussed in this paper are given by state and in descending order from youngest to oldest.

ALABAMA

System	Formation	Lithology
Pennsylvanian	Pottsville	sandstone, shale, siltstone containing coal beds (a)
Mississippian	Pennington	succession of shale, dolostone and limestone (b)
Mississippian	Bangor Limestone	bioclastic and oolitic limestone (c)

TENNESSEE

System	Group	Formation	Lithology
Pennsylvanian	Gizzard	Signal Point Shale	shale, siltstone, sandstone, coal beds (d)
Pennsylvanian	Gizzard	Warren Point Sandstone	sandstone containing quartz pebbles, shale, coal beds (d)
Pennsylvanian	Gizzard	Raccoon Mountain	shale, siltstone, sandstone, coal (d)
Mississippian		Pennington	dolomite, limestone, shale, sandstone, conglomeratic sandstone (e)
Mississippian		St. Louis Limestone	gray limestone with lenses or nodules of gray chert (f)

(a) Smith, 1979, p. I26; (b) Thomas, 1979, p. 113; (c) Thomas, 1979, pp. I9, I10; (d) Milici et al., 1979, pp. G19-G21; (e) Milici et al., 1979, p. G18; (f) Milici and Finlayson, 1967.

Appendix II

Tennessee River Water Gap in Walden Ridge

The course of the Tennessee River has interested geologists for over 100 years. Milici (1968) and Mills and Kaye (2001) have reviewed the various ideas of whether the ancestral Tennessee River was an antecedent or consequent stream or was originally the postulated "Appalachian River." Arguments over the reason why the river goes through Walden Ridge instead of continuing southward also were discussed. This latter "problem"is the subject of this Appendix.

We approach the formation of the water gap from a Flood viewpoint employing the model devised by Oard (2001, pp. 82–84). After considerable sheet erosion occurred during the early stages of Flood retreat, eventually the water level decreased below the tops of various mountains and ridges. The flowing water may have cut into weaker sections of these heights and the retreating water was channeled into these gaps. As the water level decreased further, the channelized flow would continue to cut the gap to lower levels forming a "water gap."In this model the "ancestral" Tennessee River would have developed as the volume of the channelized flow became smaller and the regional strata more consolidated by providing a "path" for the river as it was trapped into flowing through the gap.

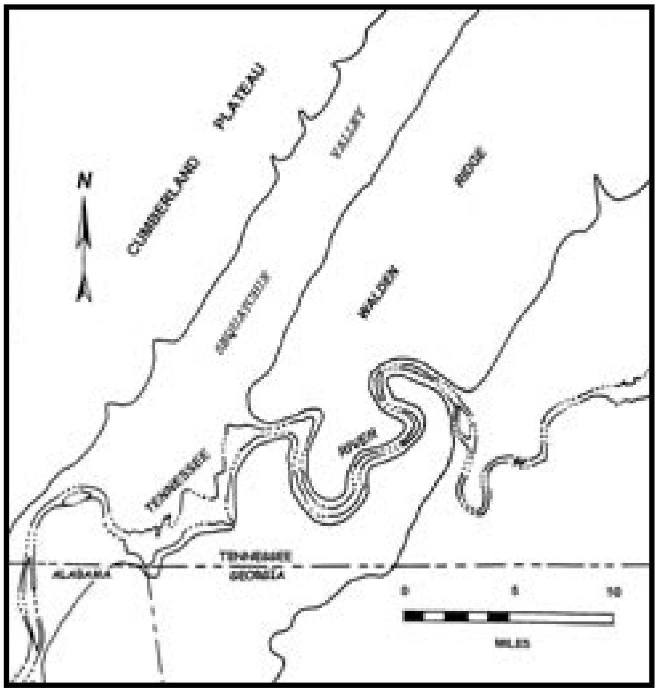

Figure 19. Meanders in Tennessee River as it winds its way through Walden Ridge. Drawing by Mary Elizabeth Akridge.

What about the meanders (Figure 19) in the present course of the river as it winds through Walden Ridge? Milici (1968, p. 477) using an uniformitarian approach noted that:

> The winding pattern in and near Walden Ridge gorge ignores major structural features and may be traced westward from Chattanooga over formations of contrasting topograph expression,....

He reaches the conclusion that "... the river probably developed its meandering course over largely unconsolidated Pennsylvanian sands and muds of the Mesozoic Coastal Plain..." (p. 477). We agree that the meanders developed by water flowing over soft, water-laden strata. Morris and Wiggert (1972, pp. 502–523), in discussing entrenched meanders claimed:

> ...it would seem necessary to postulate much greater volumes of water in the streams than now present, together with much less resistant walls than the rocks of which they now consist (p. 523).

In explaining the consecutive meanders in Kanab Canyon in Arizona and Utah, Williams et al. (1997, pp. 162, 164–165) adopted the same view.

Appendix III

The Mississippian-Pennsylvanian Boundary Problem

After doing field work on the northern part of Sand Mountain, Wilson (1975, pp. 23, 24) observed:

> On Sand Mountain the position of the boundary between Mississippian and Pennsylvanian rocks is difficult to determine with any degree of assurance. There is no evidence of large-scale erosion at the contact; rather, the beds appear to be entirely gradational. The transition from sandy, light brown to gray shales of the Pennsylvanian System to the maroon, brown and greenish-gray shales of the underlying Mississippian Pennington Formation can be detected in the field only in a few selected localities. Ideal sites for observation of the systemic boundary are commonly found along highway road cuts. In areas where the exposures are poor, the top of the Mississippian is placed arbitrarily at the highest appearance of maroon and green shales (p. 23).

Thus, the Pennington Formation is actually considered a transitional formation where Pennsylvanian shales grade into Mississippian shales. The boundary between the Mississippian and Pennsylvanian is based on arbitrary lithologic characteristics. "The absence of adequate faunal occurrences makes this task [at northern Sand Mountain] very difficult in a given exposure" (Wilson , p. 24) [Brackets added]. Milici et al. (1979, p. G1) noted that the Pennington Formation is a transitional unit, "...composed of many lithologies". The Pennington is discussed later in detail (p. G18). Thomas (1979, pp. I15–I17) discussed the problem of the Mississippian-Pennsylvanian boundary also stating, "However available biostratigraphic data do not precisely define the Mississippian-Pennsylvanian boundary" (pp. I15, I16). Thomas hoped that future studies of outcrops in Alabama would shed light on this problem (p. I17).

A gradational contact between two formations could be explained by rapid deposition within a matter of hours or days, not millions of years (Williams, 1994). A rapid sequence of deposition would account for the lack of an erosion surface. If the deposition of strata were separated by a long period of time, probable erosion during these intervals would clearly delineate individual formations.

Froede (in press) claims "The purported passage of millions of years of Earth history should be represented by more than color or lithologic change." Are the postulated millions of years between these depositional sequences real or imaginary?

Appendix IV

Sand Mountain and Walden Ridge: Possible Flood Evidences

Young earth Flood proponents are constrained by a short interval of time in which considerable geologic activity must occur. The Flood and its aftereffects provide the basis for most of this envisioned activity. Thus those who accept the tenets of a young earth and dynamic Flood usually propose very high-energy geologic processes for that period of time. We will employ some of these processes as possibilities for the origin of formations and features on Sand Mountain and Walden Ridge.

Cross-bedding is considered to form in a high-energy situation involving either water or air currents. We found examples of cross-bedding near the crest of Sand Mountain (Figure 20) in the Pottsville Formation and in Warren Point Sandstone at the southern town limits of Signal Mountain, Tennessee on Walden Ridge. [Mies (1999, p. 4) referred to the latter as spectacular cross-beds.] Since both of the above-mentioned formations are sandstone, we discuss a mechanism for the development of cross-beds in sandstone from a Flood perspective. Austin (1994, pp. 33–36) proposed that in the depths of the Floodwater, currents flowing over sand deposits generated cross-bedding. After uplift and with the decreasing base level of the water, the sand containing cementing agents such as iron oxides, silica, and various carbonates, would be exposed and later lithify as sandstone. Wilson, a uniformitarian geologist, suggested (1975, p. 21) that, “The Pennsylvanian strata on Sand Mountain are an erosional remnant of formerly more extensive coal-bearing rocks which covered a large part of the Eastern United States.”[This would also apply to Walden Ridge.] Dynamic currents in deep Floodwater probably formed huge sand waves that exhibited cross-bedding and were interspersed with lenses of plant material, clay (mud) and silt. Upon lithifaction and induration, sandstone, shale and siltstone containing coal layers would be found over a considerable land mass.

Several outcrops of Pennsylvanian rock on Walden Ridge were examined by Churnet et al., 1985; Churnet and Bergenback, 1986. Most of the sections contained upward-fining sequences or graded bedding (decrease in the coarseness of grains from the base to the upper surface of a layer of sediment). Graded bedding can be emplaced by high-energy turbidity currents (Nevins, 1970, pp. 6–8; Froede, 1998, pp. 63–71). During the Flood as sand waves were forming to considerable heights, water movement could have generated many turbidity currents producing upward-fining sequences of sedimentary materials.

An outcrop of Sewanee Conglomerate containing rounded, milky quartz pebbles in sandstone was observed near the top of Walden Ridge. Milici (1979, p. G22) stated that the formation”... is the most persistent stratigraphic unit in Tennessee coal measures.”The conglomerate can contain a large number of pebbles per unit volume at a given location and very few at another. The rock is massively-bedded at Cumberland Falls, Kentucky (Wanless, 1942, p. 4) compared to the loosely-cemented material at Walden Ridge. The formation is found from Kentucky to Georgia. Rivers transport sand and pebbles, but they do not generally deposit pebbles and sand at the same location as well as over such a wide area. Could highly-turbulent Flood currents deposit pebbles and sand grains together over great distances? All of the mechanisms presented from the Flood viewpoint in this appendix are tentative speculations.

Figure 20. Cross-bedding in Pottsville Formation on Sand Mountain near Geraldine, Alabama.

Acknowledgments

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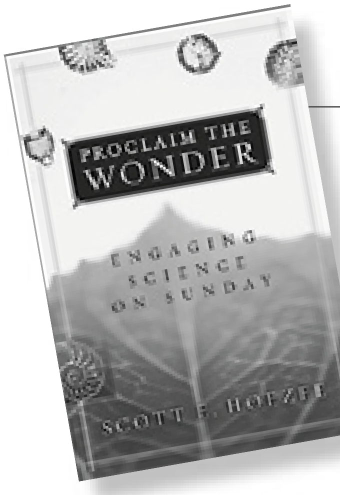

Book Review

Proclaim the Wonder by Scott E. Hoezee

Baker Books, Grand Rapids. 2003, 238 pages, $17.00.

Author Scott, a graduate of Calvin College and Seminary, pastors a Christian Reformed Church in Grand Rapids. The book is directed toward pastors and encourages the insertion of science topics into sermons. Hoezee rightly identifies the twin themes of creation and redemption throughout Scripture with creation often ignored or diminished. The suggestions for pastors are several: Take up an aspect of nature as a hobby, clip science articles, and walk in the woods now and then.

The intelligent Design movement is emphasized. A wonderful "poker game" quote comes from philosopher Alvin Plantinga regarding the attempt to explain apparent design as a result of multiple universes, "Waal, shore, Tex, I *know* it's a leetle mite suspicious that every time I deal I git four aces and a wild card, but have you considered the following? Possibly there is an infinite succession of universes, so that for any possible distribution of possible poker hands, there is a universe in which that possibility is realized; we just happen to find ourselves in one where someone like me always deals himself only aces and wild cards without ever cheating. So put up that shootin' arn and set down 'n shut yore yap, ya dumb galoot" (p. 127).

Unfortunately when author Hoezee gives examples of sermon science illustrations, weaknesses abound. He assumes the big bang (p. 123), shows sarcasm toward a young earth, and totally confuses carbon-14 dating (p. 82), nuclear fission/fusion (p. 110), and light years (p. 196). A "modified process theology" view is suggested. That is, God does not foresee all future events, but he has the power to intervene in history when he so desires. The author is correct that "science on Sunday" can help generate effective Bible study and worship. This book is helpful after its weaknesses are filtered out.

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Drifting Interpretations of the Kennedy Gravel

Peter Klevberg and Michael J. Oard*

Abstract

Poorly stratified deposits of coarse gravel cover Kennedy Ridge and several other planation surfaces east of Glacier National Park in north-central Montana, U.S.A., and adjacent Alberta, Canada. These gravel deposits, commonly called "Kennedy drift" and classified as glacial drift, are composed primarily of lithologies identical to Belt Supergroup rocks observed in the Rocky Mountains immediately to the west. In recent years, the Kennedy gravel has been described as a series of tills containing paleosols documenting several glacial and interglacial episodes over the course of approximately two million years. Fabric measurements and paleomagnetic surveys have been taken and the evidence interpreted in support of the multiple till interpretation. However, these data are far from unequivocal, and alternative genetic interpretations may be superior to the multiple till interpretation.

Introduction

The Kennedy "drift" or Kennedy Formation is a discontinuous body of diamict[1], generally poorly sorted (well graded) gravel, that caps the relatively flat tops of high ridges east of Glacier and Waterton National Parks in Montana and Alberta (Figure 1). While the dominant lithology is quartzite (high grade, various colors and patterns, mostly identifiable as Belt Supergroup), argillite (mostly green and maroon Belt Supergroup) is common. Diorite and carbonate clasts (mostly dolostone) constitute up to about ten percent of the total mass, while subjacent lithologies are poorly represented. Although sometimes obscured, subjacent lithologies do outcrop at or near all of the study sites. These outcrops appear properly mapped (Cannon, 1996, Sheet 2) and consist of weak sandstones and mudrocks. The quartzites, argillites, carbonates, and diorite all outcrop in the rugged mountains of Glacier Park to the west. This implies transport, and the mystery then becomes how and when that transport occurred.

Genetic interpretations of the deposit by establishment geologists have evolved over the past century. Recently, the Kennedy Formation has been interpreted as a stratigraphically significant sequence of glacial tills and paleosols. Magnetostratigraphy and fabric analyses have been used to develop a stratigraphic column. "Paleosol" characteristics have been used to infer paleogeographic and paleoclimatologic conditions. Some believe portions of the Kennedy Formation represent "…some of the oldest glacial deposits in North America"(Karlstrom, 2000, p. 1496).

The climate of the area is quite variable with warm, short summers and long, cold winters. The average temperature is about 4°C (Horberg, 1956, pp. 202–203). Annual precipitation is about 75 cm (30 in), half of which falls as snow. It is extremely windy east of Glacier Park, especially on the ridges where the Kennedy "drift" is located. Winds in excess

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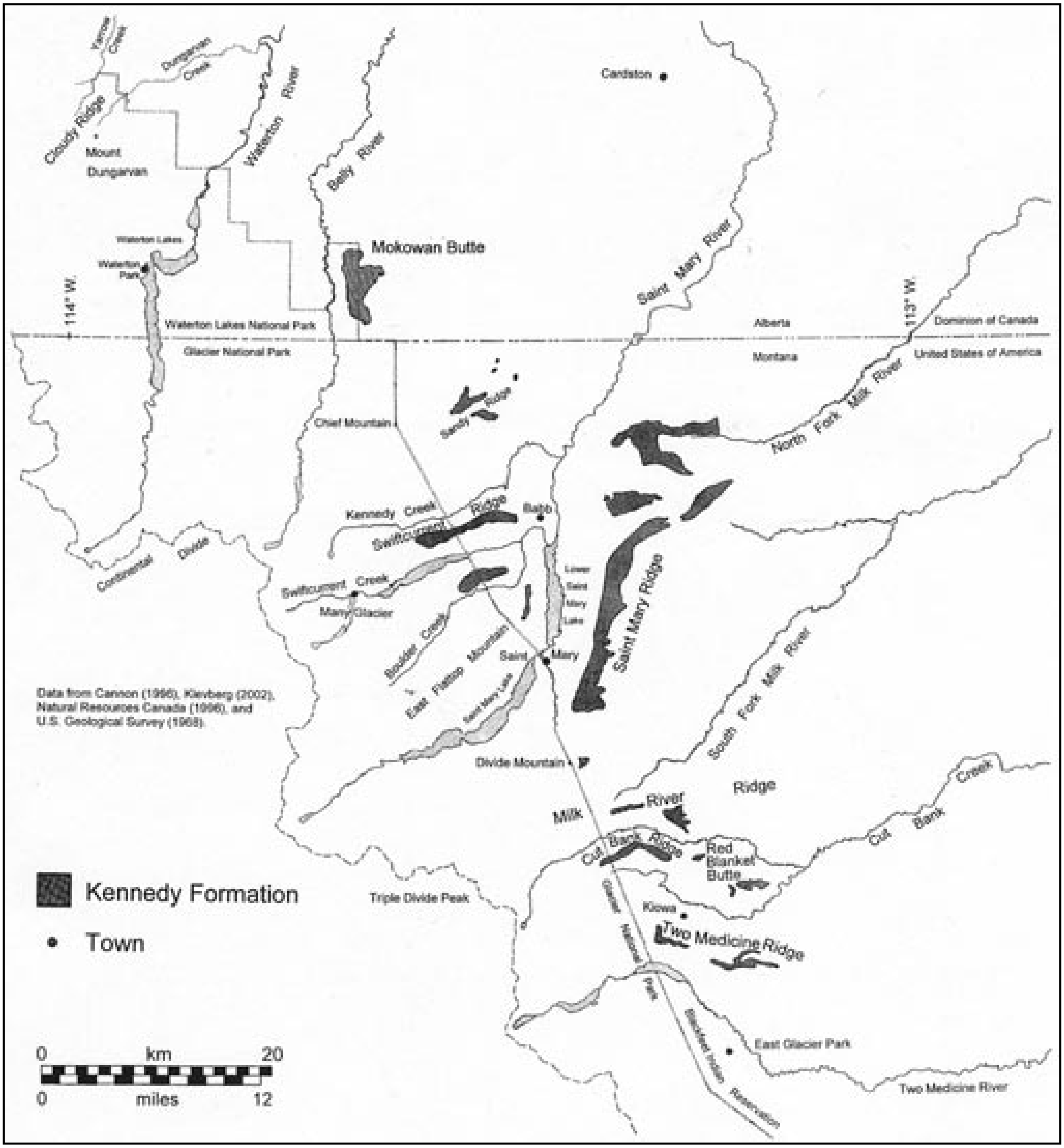
[1] Important terms are included in the glossary near the end of this paper.



Data from Cannon (1996), Klevberg (2002), Natural Resources Canada (1996), and U.S. Geological Survey (1968).

Figure 1. Map of study area showing Kennedy gravel distribution.

of 50 m/s (110 mph) occur every winter (Oard, 1993).

The Kennedy "drift" caps the western edge of remnants of planation surfaces that begin just east of Glacier and Waterton National Parks and continue eastward for hundreds of kilometers (Oard and Klevberg, 1998, p. 422, Figure 1). A planation surface or erosion surface is defined as: "A land surface shaped and subdued by the action of erosion, especially by running water. The term is generally applied to a level or nearly level surface" (Bates and Jackson, 1984, p. 170). The reason water is included in this definition is

Figure 2. Striated clasts, Two Medicine Ridge.

because the planation surface is usually capped by rounded or subrounded rocks indicative of water action. Thus, it is apparently the action of water that planes the surface. It is likely that the original planation surface was widespread east of the parks, the original planation surface having been dissected and leaving isolated, generally flat-topped ridges (Alden, 1932). The summits are 185 to 490 m (600 to 1,600 ft) above present drainage in the study area (Horberg, 1956, p. 204).

The gravel cap on the planation surfaces east of the park was at first considered fluvial by Bailey Willis (1902). Based on striated rocks (Figure 2), Alden (1932, pp. 31–40) believed that the gravel cap was laid down by glaciers debouching out of Glacier Park. He called the gravel capping the planation surfaces the Kennedy drift, *drift* being a term for any glacial deposit[2]. Most workers since Alden have considered the gravels glacigenic. Horberg (1956) saw what he thought were deep weathering profiles in the Kennedy "drift." Such a deep weathering profile is generally thought to have developed over a long period of time. So Horberg (1956) dated the Kennedy "drift" as from the Yarmouth interglacial stage, within the now-defunct four-ice-age scheme of the Pleistocene. The Yarmouth interglacial stage is the middle of the three postulated interglacials and was considered about 440,000 years old within the uniformitarian time scale. He saw no evidence of a warmer, more humid climate than at present.

Richmond (1957) later recognized what he thought were three buried paleosols within the Kennedy "drift" and so subdivided the gravel into three tills. Based on normal paleomagnetism, he considered all three tills younger than 0.78 Ma (Karlstrom, 2000, p. 1496). Karlstrom (1982; 1987; 1988; 1991; 2000) has since revised Richmond's chronology, recognizing gravel of "reversed paleomagnetism." He has postulated at least seven superposed till/paleosol units dated as old or older than about 2 million years. He believes it is possible that the oldest "till" on Mokowan Butte is 3.7 to 2.7 million years old (Karlstrom, 2000, p. 1505). Whereas Horberg could see no evidence of a warmer climate in the "paleosols," Karlstrom (1991) concludes the paleosols represent interglacial periods with a mean annual temperature and precipitation at least 6–8°C warmer and 40 cm (16 in) wetter than today.

Geomorphology

The planation surfaces just east of Glacier and Waterton National Parks have been correlated by William Alden (1932, p. 31) to the Flaxville Plain (planation surface) in north central and northeast Montana. While Alden may not have been first to recognize these plateaus as planar erosion surfaces, he was apparently the first to perform a systematic, published study of them. The Flaxville Plain is Alden's second from the highest planation surface (and the first he encountered) in northern Montana and adjacent Canada. He called it the Number 1 bench. He followed this planation surface to the Rocky Mountains, showing that the accordant summits defined a roughly exponential profile clear to the Front Range. The highest planation surface, the Cypress Hills of southeastern Alberta and southwestern Saskatchewan (Klevberg and Oard, 1998; Oard and Klevberg, 1998), since it was discovered later, was named the Number 0 bench. Alden also described two lower planation surfaces in the region: the Numbers 2 and 3 benches. The Number 2 bench includes the 120-km-long Fairfield Bench north of Great Falls, Montana, which stretches from just east of the Rocky Mountain Front to Fort Benton. The eastern end of the Fairfield Bench is the area that especially inspired William Morris Davis to develop his idea of the "cycle of erosion" or "geographical cycle" in 1883 that became so popular for more than half a century (Chorley, Beckinsale, and Dunn, 1973, p. 160). Davis's scheme has mostly been rejected since the 1960s, although it still appears in some textbooks and college courses.

The Cypress Hills and Flaxville planation surfaces are especially noteworthy for their cap of well-rounded quartzite cobbles and boulders. Quartzite does not outcrop on the high plains. Based on paleocurrent indicators, this coarse

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[2] The term is genetic; thus, it is historiographic, not scientific. That genetic definitions belong to the realm of history and not science has been amply demonstrated elsewhere (Adler, 1965; Klevberg, 1999; 2000a; 2000b; Reed, 2000; 2001).

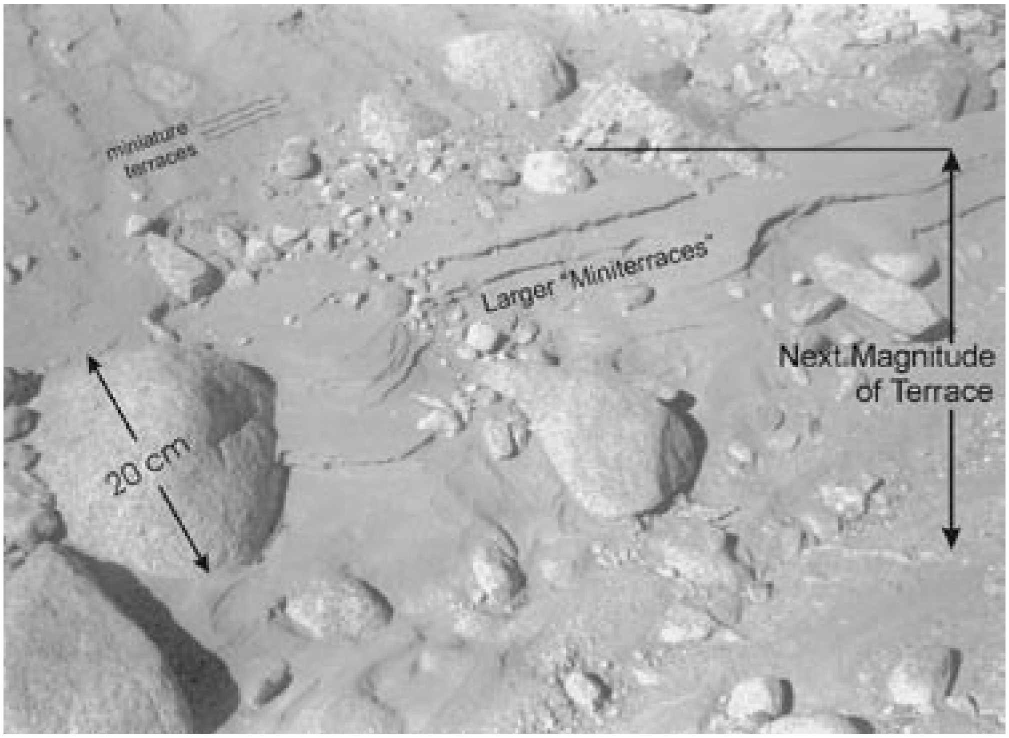

Figure 3. Terrace formation at various scales in a dry wash (Fish Creek Wash, Anza Desert, Southern California). The "miniterraces" occur in the sides of other "miniterraces" roughly an order of magnitude larger.

gravel originated from the Rocky Mountains or central Idaho (Oard and Klevberg, 1998). In the western and central Cypress Hills, the cobbles and boulders are mostly massive and about 30 m (100 ft) thick. The rocks have been transported distances of at least 700 km (400 mi) (Oard and Klevberg, 1998). Percussion marks, semicircular cracks on the rock surface, are found on at least half of the rocks in the Cypress Hills. These percussion marks likely represent the banging of rocks against each other while falling from suspension in a fast, turbulent water flow[3]. Based on open flow channel equations, the minimum velocity was estimated at 30 m/s (65 mph) and the minimum depth of flow at 55 m (180 ft) deep (Klevberg and Oard, 1998). Since the Cypress Hills average about 15 km (9 mi) wide, the gravel cap represents a current at least 15 km wide and 55 m deep rushing off the Rocky Mountains. Based on concordant and similar erosional remnants north and south, it seems likely the Cypress Hills planation surface was continuous north and south; the current, therefore, would have been hundreds of kilometers wide. Currents traveling over 30 m/s are very erosive, so it is reasonable that the original huge area of the Cypress Hills planation surface was quickly eroded, leaving the Cypress Hills as a prominent erosional remnant. A similar sequence can be postulated for the lower three planation surface remnants.

Multiple planation surfaces lead naturally to the inference of multiple events. However, we have become increasingly aware of contrary evidence to this intuitive bias (which one of us previously shared). Continuous drawdown in reservoirs and rivers frequently produces distinct terraces (Figure 3) (Williams, 1988). Benches, even when distinct over long distances, are observed to ramp into each other at scattered locations (e.g. Judith Basin, Judith Mountains, Sweetgrass Hills). Thus, we recognize that the inference of multiple events is subject to question in tectonically inactive eastern Montana. Tectonic explanations in the Kennedy gravel study area are possible, though most faults are inferred stratigraphically (Cannon, 1996, Sheet 2), and the exponential concavity of the summit planation surfaces often results in concordance farther east from the mountain front.

Fabric Analysis

Identification of fabrics in clastic sediments is a fundamental part of paleocurrent analysis (Potter and Pettijohn, 1977). These fabrics are often the basis for inferring the degree of energy in the depositional environment. However, interpretation of these fabrics can be equivocal. Plane beds, for example, can develop at very low current speeds and at very high speeds, but not at intermediate speeds (Julien, 1995, pp. 138–146). Diamict, with a very poorly developed fabric, can result from glacial, mass wasting, and turbidity current

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[3] One of us is doing additional research on formation of percussion marks. It is possible (if unlikely) that percussion marks can be formed by cavitation but, if anything, this would probably imply even stronger currents than those estimated using traditional paleohydraulic assumptions.

processes (Oard, 1997). Subtle differences can sometimes be discerned using macroscopic, microscopic, and statistical analyses that can suggest that one possible depositional mechanism is more likely than others.

Karlstrom (2000) claims that fabrics in the Kennedy Formation are indicative of a glacial origin for the deposit. He collected long axis (a-axis) orientation data for 50 prolate pebbles per "paleosol" at 17 locations on Two Medicine Ridge, Milk River Ridge, Saint Mary Ridge, Mokowan Butte, and Cloudy Ridge (Figure 1). He concluded that the fabrics could generally correspond to what might be expected for basal till, deformed or undeformed lodgement till, or glacigenic sediment gravity flows, but argued for a glacial till explanation. He rejected the sediment flow explanation: "Thus, fabric and sedimentological properties, as well as the distance of the Mokowan Butte and Saint Mary Ridge sections from the nearest mountain (5–10 km), seem to rule out a strictly colluvial origin. Mudflow deposits, by contrast, could be expected to include fewer lithologies and more angular clasts and to be less extensive horizontally and vertically" (p. 1505). We find his arguments most unpersuasive for the following reasons:

- The sampling program was very limited and highly selective.
- The eigenvalue ranges for various depositional fabrics are not very distinct.
- Eigenvalue ranges for nonglacial depositional fabrics were not used for comparison.
- Karlstrom's dismissal of gravity flow mechanisms exhibits a profound uniformitarian bias.

Karlstrom's method is derived from previous work by others (Dowdeswell and Sharp, 1986; Hart, 1994) that includes modern and historic glacial deposits in Iceland and elsewhere. This is understandable, not only from practical considerations, but also because of his hypothesis that these deposits represent till (or at least drift). Nonetheless, to reach this conclusions, Karlstrom's sampling program appears somewhat arbitrary and possibly at variance with accepted statistical analyses (ASTM, 1993; Koch and Link, 1980), not least because of the single data set collected from each assumed paleosol. Although the eigenvector method of determining preferred orientation and the strength of this development is very useful, much more information is needed to determine the extent to which these results are applicable to the deposit as a whole or inferred trends across the deposit. For nonglacial deposits, the c-axis orientation of oblate pebbles could be expected to provide more information than the a-axis orientation of prolate pebbles, and the oblate clasts should, at a minimum, have their a-axis orientations compared with those of the prolate clasts. These data should be considered within the context of a grain-size distribution, and variations of the grain-size distribution should be investigated vertically and laterally. Angularity and aspect ratio would also bear investigation, and a large number and diversity of historic deposits should be examined to provide control. To do justice to the type of statistical analysis attempted by Karlstrom and others would require an enormously labor intensive data acquisition effort to determine clast orientation for all sizes larger than granules in an adequate sample population. "Adequate sample population" means enough data to generate confidence intervals "tighter" than the relatively small differences observed between different fabrics such as those studied by Dowdeswell and Sharp (1986) and Lawson (1981). This must be done meter-by-meter vertically and horizontally across each scarp, avoiding the ubiquitous effects of colluvial (down slope) movement. Photogrammetric methods might be useful, but the data are needed in three dimensions, probably requiring at least partial excavation. It would be a daunting task for the most statistically minded

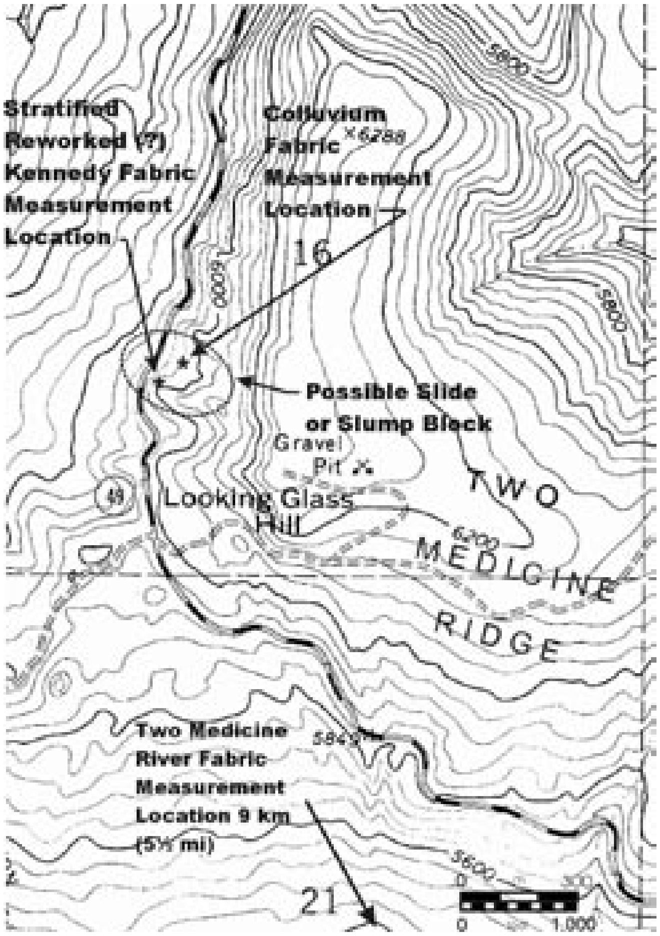

Figure 4. Map of Two Medicine Ridge area showing control sample locations. Contour interval is 40 ft (12.2 m). U.S.G.S. Kiowa 7.5' quadrangle map base.

Figure 5. Photograph of colluvium fabric measurement location, northwest side of Two Medicine Ridge.

Figure 6. Photograph of folded strata of Kennedy composition (inferred slide or slump block), northwest side of Two Medicine Ridge.

researcher. Hence, Karlstrom has—as would virtually any other researcher—approached the fabric study only semiquantitatively.

To evaluate the applicability of the method employed by Karlstrom to the Kennedy deposits, eigenvalue ranges for clearly nonglacigenic sediments in the same area (viz. Two Medicine Ridge) were measured and analyzed in accordance with the specific technique of Mark (1973) and ordinary eigenvector analysis (Anton, 1981; Danielson, 1997; Koch and Link, 1980, pp. II:119–150; Pipes and Harvill, 1970, pp. 104–106). Since this method (Dowdeswell and Sharp, 1986) was developed specifically for glacial sediments, data from nonglacigenic deposits were necessary to provide controls for Karlstrom's data. One data set was collected from seasonally generated colluvium consisting of Kennedy gravel on the northwest side of Two Medicine Ridge (Figures 4 and 5). Carbonate cement provides a relatively solid base upon which colluvium up to half a meter thick moves during the warmer months, particularly during the spring thaw. The second control sample location was from a single gravel stratum within a dramatic outcrop adjacent to the colluvial slope (Figures 4 and 6). This outcrop consisting of gravel and silt-dominated alternating strata (rhythmic bedding), is weakly consolidated, and may represent part of a slide or slump block composed primarily of stratified Kennedy Formation (redeposited Kennedy?) as illustrated in Figures 7 and 8. A rhythmic sequence such as that observed at this location bespeaks turbulent deposition in a fluvial environment (Berthault, 1986). The strata have been "righted" in Figure 8 to their approximate inferred initial attitude, and the approximate orientation of the primary fabric eigenvector (S_1) does resemble a typical fluvial attitude for this stratum. The third control sample was measured from a cut bank deposit of the Two Medicine River in the valley bottom upstream from Two Medicine Canyon (Figure 4). Soil formation in the upper half meter or less of the gravel floodplain deposit was ignored and prolate clasts for the entire profile included in the measurements (Figure 9).

Figure 7. Stratified "slide" or "slump block," northwest side of Two Medicine Ridge. Field crew chief points at gravel fabric sample stratum.

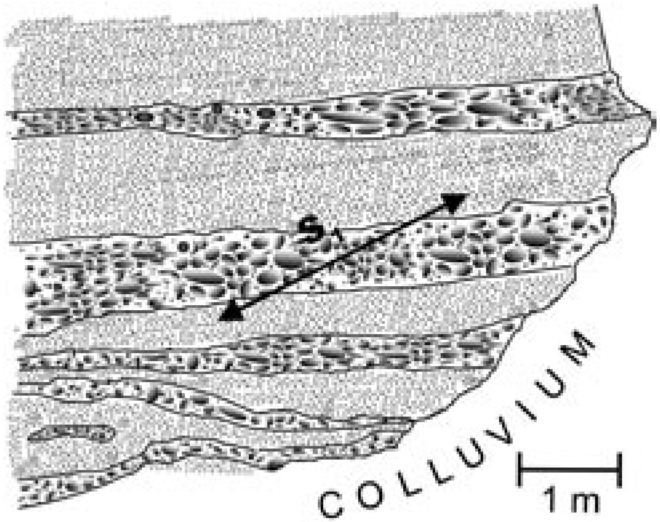

Figure 8. Diagram of sand and gravel rhythmite interpreted as stratified reworked Kennedy Formation. Section has been "righted" to inferred orientation at deposition. Approximate orientation of primary fabric axis (S_1) indicated for stratum measured in this study.

Figure 9. Photograph of Two Medicine River fabric measurement location. Protruding prolate clasts are more likely to fall from bank, potentially skewing orientation data.

Two hypothetical data sets were included for comparison. The first represents a traction current or bed load deposit such as could be expected to form along a stream bed, and the second represents prolate pebbles deposited from suspension. Fifty orientation data were generated for each set using a random number generator and assuming a Gaussian normal distribution for each variable (Moore and McCabe, 1993). The traction current data were generated using a mean a-axis azimuth of 090°/180° with σ equal to 15° and a plunge of 0° with σ equal to 15° from the horizontal. The suspended deposition data set was generated using a mean plunge of 60° from the horizontal and no preferred azimuth; the value of σ was 15°. Eigenvalue analysis was performed on these coordinate data in the same manner as the field data to generate major and minor orientation axes (S1 and S3, respectively). The ratio of these is also listed in Table I and is the primary value used to judge fabric strength[4].

As shown on Figure 10 and in Tables I and II, the eigenvalue ranges for measured fabrics in a variety of glacigenic and nonglacigenic sediments differ far less from each other than the variation within each depositional environment, and the persuasive value of Karlstrom's results is underwhelming. The colluvium and cyclic reworked Kennedy show poorer fabric development (based on the method of

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[4] Minor discrepancies between the value of S1/S3 and the quotient of the separate values in the table are indicative of rounding error.

Table I
Comparison of Several Depositional Fabrics

Depositional Process	**Fabric Characteristics**						
	S_1		S_3		**Mean S_1/S_3**	**Reference**	**Remarks**
	mean	**σ**	**mean**	**σ**			
Basal melt-out till	0.820	0.045	0.035	▨	23.43	1	
Undeformed lodgement till	0.687	0.060	0.078	0.040	8.81	1	
Deformed lodgement till	0.588	0.090	0.119	0.040	4.94	1	
Glacigenic sediment flow	0.570	0.050	0.126	▨	4.52	1	
Mean lodgement and ploughed till	0.837	▨	0.030	▨	27.90	2	
Mean high strength fabric soft bed till	0.768	▨	0.057	▨	13.47	2	
Mean intermediate strength fabric soft bed till	0.686	▨	0.076	▨	9.03	2	
Mean low strength fabric soft bed till	0.532	▨	0.122	▨	4.36	2	
Mean soft bed till	0.641	▨	0.101	▨	6.35	2	A
Cloudy Ridge	0.677	0.051	0.080	0.019	8.42	3	B
Mokowan Butte	0.574	0.051	0.088	0.022	6.51	3	C
Milk River Ridge	0.637	0.110	0.074	0.008	8.67	3	D
Saint Mary Ridge	0.602	0.055	0.086	0.026	6.98	3	E
Two Medicine Ridge	0.588	0.086	0.117	0.034	5.02	3	F
Kennedy colluvium	0.499	▨	0.198	▨	2.52	4	G
Cyclic reworked Kennedy	0.443	▨	0.262	▨	1.69	4	H
Floodplain gravel	0.667	▨	0.094	▨	7.06	4	I
Hypothetical traction carpet	0.709	▨	0.077	▨	9.25	4	J
Hypothetical suspended load	0.521	▨	0.046	▨	11.27	4	J

Shading indicates insufficient data.

References:

1 Dowdeswell and Sharp, 1986; Lawson, 1979. Also cited in Hart, 1994; Karlstrom, 2000.
2 Hart, 1994.
3 Karlstrom, 2000; data composited by Klevberg for each site (cf. Table II)
4 Klevberg, 2002.
A “not very meaningful” (Hart, 1994)
B Northeast gully
C Pole Heaven
D South slope
E Central scarp
F South outcrop
G Two Medicine Ridge
H Two Medicine slump
I Two Medicine River
J Prolate clasts

Table II
Fabric Data For Kennedy Formation
Karlstrom (2000)

"Unit"	S_1	S_3	S_1/S_3	"Unit"	S_1	S_3	S_1/S_3
Cloudy Ridge				*Saint Mary Ridge*			
1 (Bt)	0.757	0.070	10.81	5	0.651	0.085	7.66
1 (Bk)	0.618	0.111	5.57	4	0.693	0.055	12.60
1 (b)	0.655	0.600	10.92	3 (a)	0.614	0.096	6.40
Comp.*	**0.677**	**0.080**	**8.42**	3 (b)	0.606	0.063	9.62
Mokowan Butte				2 (a)	0.564	0.124	4.55
5	0.671	0.073	9.19	2(b)	0.515	0.135	3.81
4	0.573	0.116	4.94	1(a)	0.530	0.068	7.79
3	0.508	0.119	4.26	1(b)	0.645	0.064	10.08
2	0.532	0.062	8.58	**Comp.***	**0.602**	**0.086**	**6.98**
1	0.588	0.071	8.28	*Two Medicine Ridge*			
Comp.*	**0.574**	**0.088**	**6.51**	4	0.695	0.109	6.38
Milk River Ridge				3	0.665	0.062	10.56
2	0.772	0.064	12.06	2	0.462	0.167	2.77
1	0.502	0.083	6.05	1	0.529	0.130	4.07
Comp.*	**0.637**	**0.074**	**8.67**	**Comp.***	**0.588**	**0.117**	**5.02**

Data from Karlstrom (2000), p. 1499

*Composite result calculated by Klevberg from Karlstrom's data by treating these as multiple data from a single composite section, not separate units.

Dowdeswell and Sharp) than both glacial and Kennedy Formation values. This is certainly not surprising in the case of the colluvium, which could be expected to provide minimal fabric development[5]. One could expect maximum fabric development from a well-sorted traction carpet or bed load deposit. Note, however, that the method of Dowdeswell and Sharp (1986) may not provide a clear indication of such fabric development. The Two Medicine flood plain fabric strength is slightly less than the hypothetical traction carpet fabric strength; these values compare favorably with both the glacigenic and Kennedy Formation fabric strengths. The Two Medicine floodplain deposit exhibits a fabric strength less than the composite values for Cloudy Ridge and Milk River Ridge, greater than the composite values for Mokowan Butte and Two Medicine Ridge, and approximately equal to the composite value for Saint Mary Ridge. The hypothetical traction carpet and suspended load fabric strengths fall near the middle of the range of undeformed glacigenic sediment values.

The composite values are averages of all of Karlstrom's data from a given outcrop and treat the Kennedy Formation as a single unit with multiple samples. Karlstrom sampled inferred units from each outcrop singly. These data are presented in Table II, where the wide variations in fabric values are apparent. These variations may result from greatly different depositional processes for the individual units distinguished by Karlstrom, they may reflect natural variation in clast attitudes ("noise"), or they may be data collection artifacts. The differences between the values of the various data sets from each outcrop are expressed as standard deviation units in Table I.

If the c-axis of oblate pebbles had been measured instead of the a-axis of prolate pebbles, a measure of imbrication could have been made. This could be expected to be a minimum for the colluvium and a maximum for the traction carpet deposit. Without additional data such as these, separation of glacigenic from nonglacigenic sediments on the basis of fabric strengths is impossible. We therefore conclude that the fabric strengths of Kennedy Formation outcrops determined by Karlstrom using the method of Dowdeswell and Sharp lack persuasive value relative to the question of a glacial origin for the Kennedy Formation. Karlstrom (2000, p. 1499) himself admits that fabric data alone are not diagnostic. Some researchers have demonstrated that the data collection stage itself introduces systematic errors when measurements are made from outcrops, that preferential weathering introduces errors, and that even an eigenvalue analysis of many data can produce meaningless results (Benn and Ringrose, 2001; Bennet et al., 1999; Dreimanis, 1999; Klein, 2002; Millar and Nelson, 2001). It may be possible that measurement of all three axes from all coarse

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[5] Domack and Lawson (1985) argue for an ice-rafted origin for a diamicton on Whidbey Island, Washington. This diamicton exhibits extremely weak fabric strength similar to the Two Medicine colluvium and rhythmite gravel stratum.

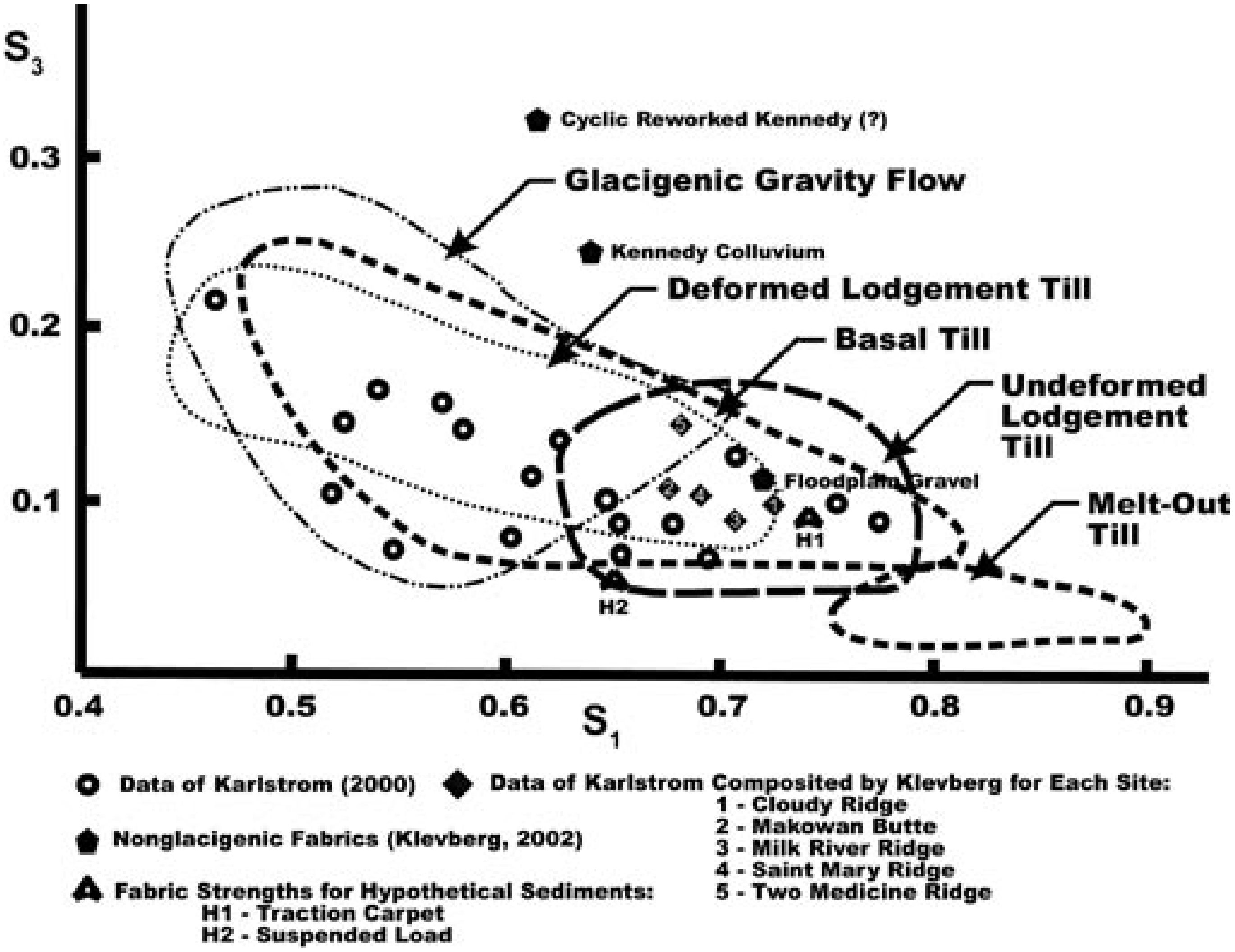

Figure 10. Plot of fabric data. The strongest fabric development is at the lower right of the diagram, and the weakest fabric development is at the upper left.

particles in randomly selected but uniformly sized volumes (not areas) of a formation may obviate at least some of these errors, but the immensity of this task intimidates the vast majority of geologists. The result is no conclusive standard by which to evaluate these fabric data.

Karlstrom's dismissal of the possibility of a debris-flow origin for the Kennedy Formation bespeaks the depth of his uniformitarian bias. Examination of the data in Tables I and II shows that variability in S1/S3 values is too great to convincingly argue that a glacial sediment flow or nonglacial mechanism can be discounted based on the S1/S3 values from the Kennedy Formation. As pointed out by Dowdeswell and Sharp (1986), among others, there is also a paucity of data. Fabrics in mudflows may develop rapidly and cycle through phases of greater and lesser fabric development. The final degree of development is determined by the state at the instant the flow "freezes," and the final fabric can be indistinguishable from a till (Lindsay, 1968). Karlstrom (2000) argues that the sheer scale of the Kennedy Formation makes a debris-flow origin impossible. This is crass uniformitarianism. We find this argument much more weakly developed than the Kennedy Formation fabrics themselves.

Figure 11 shows fabric in lime-cemented conglomerate on a landslide scarp on the northwest slope of Saint Mary Ridge (Figure 1). The nearly random orientation of clasts is apparent. From a distance (Figure 12), gross stratification is evident in parts of the Kennedy Formation, and this is also present on a submeter scale in zones dominated by sand. A few planar cross-beds can even be found in the

Figure 11. Lime-cemented conglomerate on a landslide scarp on the northwest slope of Saint Mary Ridge. Note rounded boulders. Soil scientist is 180 cm (6 ft) tall.

Figure 13. Planar cross-beds and sand interbeds in sandy gravel zones of Kennedy Formation exposed on central landslide scarp, Saint Mary Ridge.

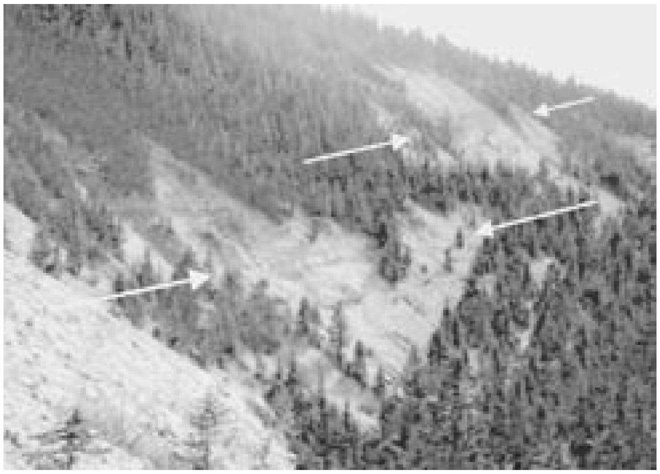

Figure 12. Gross stratification (indicated by arrows) evident in parts of the Kennedy Formation exposed on Saint Mary Ridge.

sand-dominated zones (Figure 13). Figure 14 shows fabric in soil exposed in a gully in the northeast side of Cloudy Ridge (Figure 1). Stratification, cross-bedding or preferred clast orientation is not apparent. Table III compares the properties of these outcrops with characteristics typical of several depositional processes. While tills can display fabrics similar to those of Saint Mary and Cloudy Ridges, these fabrics are far from diagnostic of tills (i.e. only formed as debris deposited by glacial ice). On the other hand, the limited stratification that is evident on Saint Mary Ridge appears more likely to favor a fluvial or fluid debris flow depositional mechanism.

Evidence Favors Deposition by Water

It is doubtful that the Kennedy "drift" represents till left over from any glaciation, ancient or modern. The so-called till lies fairly flat on the planation surface remnants (Figures 15 and 16) and slopes eastward, tapering to the other planar erosion surfaces farther out on the plains (Alden, 1932). This was noted long ago by Willis (1902, pp. 328–329), who considered this evidence for a fluvial mechanism:

> The typical occurrence of Kennedy gravels is illustrated [end plates]. There one may note the size and form of the constituent boulders and pebbles, the incoherent water-washed nature of the gravel shown by the slopes, *the level top which falls into the horizon line of the Plains*, and the elevated position of the gravel mass…the high-level gravels of the Plains and the Kennedy formation are *alike* in genesis and derivation from the Lewis Range" [emphasis added].

This smoothness contrasts with normal glacial deposits that form end, lateral and ground moraines with relief (Figures 17, 18, and 19). Glacial outwash, on the other hand, usually has a planar surface (Figure 20), but outwash is usually clast supported with rounded clasts. The texture of the Kennedy "drift" is mostly matrix supported. The clasts near the surface of the deposit are generally angular (Figure 21). There are also rounded clasts disseminated throughout the deposit. Karlstrom (2000, p. 1501) admits that locally such clasts can predominate and possibly indicate fluvial deposition.

Are not the striated rocks positive proof[6] of glaciation? The answer to this question is a clear, No! Striated and even

Table III

Depositional Characteristics of Sediment Transport Processes and Kennedy Formation

Transport Processes Depositional Characteristics	Fluvial/Traction Current	Turbidity Current	Glacial Drift	Mudflow/Debris Flow	Fluidized Sediment Flow/ Hyperconcentrated Flow	Grain Flow/Debris Flow	Falls/Slides	Soil	Kennedy Formation (observed)
Stratification	▨	╲			╲			▨	╲
Grading*	▨ N	╲ N R		╲ R	╲ N				
Sorting	▨	╲							
Imbrication	▨								
Cross-Bedding	▨	▨							▨
Rounding	▨				?				╲
Angular or FacetedClasts		▨	▨	▨	?				▨
Striated Clasts		▨	▨	▨	?	?			▨
Clast-Supported Fabric	▨		╲	?	▨	▨			
Matrix-Supported Fabric	╲	▨	▨	▨	▨	▨	▨	▨	▨
Downstream Fining	▨								╲
Boulder Pavement or Stone Line	?	▨	╲		▨		▨	▨	?

Shading indicates process produces deposits exhibiting given attribute.

Diagonal line indicates process sometimes produces deposits exhibiting given attribute (or is sometimes observed) depending on other variables.

*N - normal grading (fining upward)

*R - reverse grading (coarsening upward)

References:

1 Blatt, Middleton, and Murray, 1972; Julien, 1995; Selley, 1976; Tucker, 1990.

2 Carter, 1975; Ghibaudo, 1992; Lowe, 1979; 1982; Middleton, 1993; Nardin et al., 1979; Pierson and Costa, 1987.

3 Dowdeswell and Sharp, 1986; Hart, 1994; Karlstrom, 1990; 1991;2000; Lawson, 1979; Oard, 1997; Tarbuck and Lutgens, 1984.

4 Hampton, 1979; Iverson, 1997; Pierson and Costa, 1987; Smith, 1986.

5 Beverage and Culbertson, 1964; Costa, 1984; Hampton, 1979; Iverson, 1997; Pierson and Costa, 1987; Pierson and Scott, 1985; Smith, 1986.

6 Costa, 1984; Hampton, 1979; Iverson, 1997; Major, 1997; Pierson and Costa, 1987; Smith, 1986.

7 Coussot and Meunier, 1996; Tarbuck and Lutgens, 1984;Tschebotarioff, 1951.

8 Brady, 1974; Birkeland, 1974; 1984; Klevberg and Bandy, 2003.

9 Cioppa et al., 1995; Horberg, 1956; Karlstrom, 1982; 1987; 1988; 1990; 1991; 2000; Karlstrom and Barendregt, 2001; Klevberg, 2002.

Figure 14. Fabric in soil exposed in a test trench in the northeast side of Cloudy Ridge. Scale is marked in tenths of a foot.

Figure 15. Exposure of Kennedy Formation on north side of Two Medicine Ridge. Note planarity of upper (depositional) surface.

Figure 16. View north from west end of Two Medicine Ridge toward Milk River Ridge showing tabular geometry of Kennedy Formation conforming to Flaxville erosion surface.

faceted rocks can form under a variety of circumstances (Oard, 1997, pp. 41–47). A common mechanism for forming striated and faceted clasts is mass movement (Schermerhorn, 1974). Apparently many geologists have ignored these other mechanisms and hence indiscriminately have defined "ancient glaciations" within the rocks:

> To repeat the most important point, great caution is urged in the use of striated stones as glacial pointers. It is a point that has been stressed time and again by many stratigraphers, without apparently leaving much impression (Schermerhorn, 1974, pp. 681–682).

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[6] We use this term facetiously, recognizing that "scientific proof" is an oxymoron and that the striation issue is a mixed question.

Figure 17. Primarily glacial deposits from the Athabaska Glacier, Alberta, Canada.

Figure 18. Athabaska Glacier: the sign marks the extent of ice in 1890; deposits between sign and glacier terminus in distance were formed after 1890.

Figure 19. End moraine complex, Skeiðarárjökull, Iceland.

Figure 20. Skeiðarársandur, Iceland, an active glacial outwash plain.

Karlstrom (2000) also points to a boulder pavement in an outcrop on Saint Mary Ridge and bullet-shaped boulders in the Kennedy "drift" as further proof of glaciation. We thoroughly searched the outcrop on Saint Mary Ridge and did not find a boulder pavement. Bullet-shaped rocks, on the other hand, are sometimes found (Figure 22). Boulder pavements and bullet-shaped rocks are associated with modern and ice age glaciers. Researchers then assume that they are diagnostic of glaciation, that they form only in glacial environments. However, glacial geologists do not know how glaciers form these features, and they have been found in nonglacial deposits (Oard, 1997, pp. 45, 54–56). It is likely that both boulder pavements and bullet-shaped clasts can form in debris flows, and stone lines (of which boulder pavements are a type) can form diagenetically and pedologically (Birkeland, 1974, pp. 193, 194; Paton, Humphreys, and Mitchell, 1995). This is yet another example of the widespread tendency to seize upon one *possible* explanation and lose sight of other possibilities (Klevberg, 2001).

The so-called Kennedy drift has an appearance and geomorphology not greatly different from other gravel caps on the planation surfaces that are so common in Montana east of the continental divide and vicinity (Alden, 1932; Klevberg and Oard, 1998; Oard and Klevberg, 1998). As shown in Figure 23, the Kennedy gravel-capped planation surface

Figure 21. Angularity of Kennedy gravel—picture from Two Medicine Ridge. Scale is 16 cm (6 in) long.

Figure 22. "Bullet-shaped" rock observed in Kennedy Formation, Saint Mary Ridge. Lens cap is approximately 6 cm (2.5 in) in diameter.

blends smoothly with the Flaxville erosion surface farther east, a fact previously noted and admitted by Willis (1902) and Alden (1932, pp. 31–40). The gravel is thicker in the Kennedy Formation than on the planation surfaces farther east. Clasts farther out on the plains are more rounded. The Kennedy gravel is more matrix supported than the typical gravel cap farther out on the plains, which one might expect if its source were just to the west in the Rocky Mountains. However, we have also noted patches of matrix-supported gravel and conglomerate on the Cypress Hills. Even farther east, in the Flaxville Formation near Turner, Montana, statistical analysis of gravel samples suggests the effects of current winnowing (Klevberg and Oard, 1998, p. 372), as

Figure 23. View northeast from Cut Bank Ridge, showing the smooth transition from surfaces capped by the Kennedy Formation (at left) to extensive remnants of the Flaxville Plain (at right).

Figure 24. Typical unstable slope with carbonate-cemented erosional knob, southwest side of Two Medicine Ridge.

Table IV
Comparison of Kennedy Formation Genetic Arguments

Characteristic	Argument for Glacial Origin	Alternative Explanation
Striated Clasts	Striations commonly form from glacial movement.	Striations form from many mechanical processes, including mass wasting.
Diverse lithologies	Varied lithologies are evidence of glacial transport.	Varied lithologies may result from lithologically diverse source areas or polygenetic histories.
Primarily angular clasts but with some rounded	Mudflows should produce all angular, fluvial deposits all rounded, but glacial deposits may have both.	The source area may have contained some rounded clasts; soft lithologies may round even during mass wasting, while hard lithologies transported short distances fluvially may remain angular.
Fabric Strength	Fabric strengths observed fall into range observed for glacigenic and inferred glacigenic sediments.	Fabric strengths are not diagnostic; same values may be obtained for nonglacigenic deposits.
Faceted clasts	Faceted clasts result from glacial transport.	Faceted clasts are known to form from mass wasting processes and can even form in certain fluvial environments.
Bullet-shaped clasts	Bullet-shaped clasts result from glacial transport.	The manner in which bullet-shaped clasts form is not known and may also result from mass wasting or debris flow processes.
Matrix support	Matrix support is indicative of deposition as glacial till.	Matrix support is typical of debris flows and other mass wasting processes and sediment-laden fluvial processes.
Boulder pavements	A horizon of boulders and cobbles is indicative of a glacial origin.	Similar nonglacial features (stone lines) are known; boulder pavements can be formed by certain mass wasting processes.*

*The authors have not been able to confirm the existence of a boulder pavement in the Kennedy Formation.

does the average pebble size in the Cypress Hills Formation from west to east.

Arguments for a strictly glacial origin of the Kennedy Formation are not strong. Evidence against a glacial origin is considerable. Glacigenic arguments and alternatives to these are summarized in Table IV.

Multiple Ice Ages?

Another problem with the Kennedy "drift" being left over from a "late Pliocene" ice age is that only one glaciation is now recognized over much of southern and central Alberta (Young et al., 1994; Oard, 1995). This glaciation is dated within the uniformitarian time frame as late Wisconsinan, which is the youngest. It is true that the supposed glaciation that laid the Kennedy "drift" would have come from the vicinity of today's Glacier and Waterton National Parks. However, this area represents the southeast edge of the Cordilleran Ice Sheet, and it is doubtful that this area would have been glaciated without a Laurentide Ice Sheet in southern Alberta.

Furthermore, there are supposed to be at least seven separate glaciations that laid down the supposed alternating till-paleosol sequence. Glaciers are highly erosive of soft, unconsolidated sediments. How could any of these paleosols survive even one attack of an ice sheet coming off the mountains from the west? Even the supposed till would have been reworked by each glacier. Each glacial advance should churn any supposed previous till-paleosol sequence into chaotic debris. This reworking and destruction of previous supposed ice age deposits is employed as the typical uniformitarian excuse for why most formerly glaciated areas show evidence for only one ice age. They say the last ice sheet churned up all the evidence of previous ice ages. This is the reason researchers appeal to oxygen isotope ratios from deep-sea cores to infer the "real" number of ice ages, which is claimed to be around 30 in the late "Cenozoic" (Oard, 1990). One might argue that this would not apply if the glacier were frozen to its bed, but if the ground had been frozen, we would expect to see evidence for permafrost features: ice wedge casts, sharply demarcated boulder pavements with striated clasts, patterned ground, etc. We have not seen such features in the Kennedy "drift."

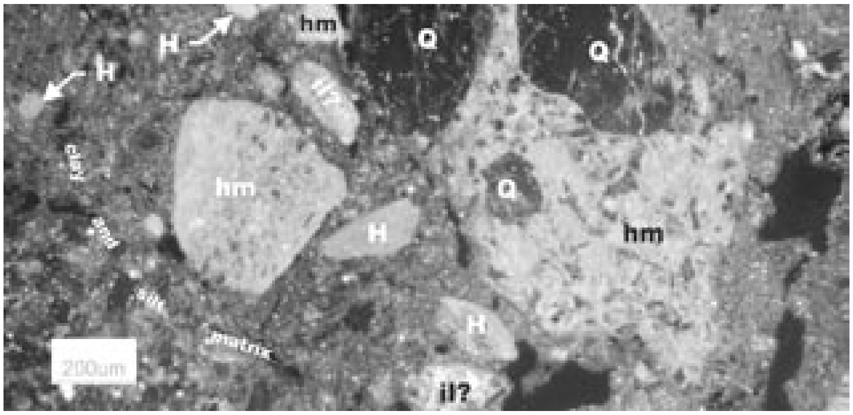

Figure 25. False color photomosaic of reflected light micrographs of Kennedy Formation from trench SM-5, Saint Mary Ridge (sample SM5-157), showing detrital grains containing hematite and smaller inclusions of hematite that may be authigenic. Hematite is indicated by light color.

Paleomagnetism

Paleomagnetism provides a potentially powerful argument for the passage of significant time in the formation of these sections of unconsolidated sediments. This has not escaped the attention of previous establishment researchers (viz. Richmond and Karlstrom). There are at least three possibilities:

- If magnetochronostratigraphy[7] is valid, and the alleged paleosol horizons can be matched to these "chrons," then the ages Karlstrom has assigned these "paleosols" apply, whether or not his paleosol interpretation of their genesis is accurate. This would "disprove" the biblical chronology.
- If magnetochronostratigraphy is in error, but the remanent magnetization measurements are accurate, then the potential remains to match the lithologic section with reversals of the Earth's magnetic field through the course of Earth history. Such reversals may have been rapid (Brown, 1989; Humphreys, 1987; 1990; 2002) and, if so, may not be in conflict with biblical chronology.
- If the remanent magnetization measurements are not valid, they are irrelevant to both the multiple-event question and the question of how much time was required to deposit the Kennedy Formation. Spurious magnetic data neither affirm nor deny the multiple glaciation theory or, for that matter, biblical chronology.

We suspect that the discrepancy between Richmond (1957) and Karlstrom (2000, p. 1496; 1982; 1987; 1988; 1991) may result from at least four complications faced by those attempting remanent magnetization measurements in the Kennedy Formation:

- All of the slopes evince significant instability (Figure 24). All are blanketed by colluvium, some to considerable thicknesses. Calcium carbonate is also abundant, allowing the sediments to be recemented when conditions permit. Both random and systematic errors in mineral grain orientation can result, and thin section analysis suggests that this has, in fact, occurred in at least some outcrops of the Kennedy Formation (Figure 25).
- The statistical method of dealing with paleomagnetic data is similar to that employed in analyzing glacigenic fabrics, though it is not prone to the same degree of difficulty (Koch and Link, 1980, pp. II:132–150). Nevertheless, paleomagnetic data may exhibit small signal-noise ratios and present some difficulty in obtaining a "standard deviation" for the data set. One must be cautious in accepting paleomagnetic "data" without the qualification of a confidence interval. Such "data" are not "raw," and one cannot be sure of just how they were "cooked." They may not, in reality, be representative of actual in situ remanent magnetization.

However, measures of statistical strength are presented by Karlstrom (2000, pp. 1502, 1504) graphically. They appear quite weakly developed to us, especially those for reversed magnetization, though they do seem to at least indicate that few of the samples had been tilted toward the vertical. Measurements by Cioppa et al. (1995) appear to be good, direct measurements, but we lack full confidence in efforts to eliminate results of "overprinting." More recent work by Karlstrom and Barendregt (2001) has addressed some of these problems.

- Statistical strength of inferred paleomagnetism from paleomagnetic data is also dependent on the quantity of data collected. Insufficient data result in large deviations. However, the number of data collected by Karlstrom (2000, p. 1496), a total of

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[7] Magnetochronostratigraphy is not a scientific stratigraphic method, since it begins with a scheme for the history of the Earth's magnetic field and fits the data into this scheme.

34 from Saint Mary Ridge and 246 from Mokowan Butte, appears adequate.

- Cioppa et al. (1995) determined that much of the remanent magnetization resides in hematite in the matrix of the Kennedy Formation and stated that the strength and directionality of the measured remanent magnetization were often poor. The poor quality of these data is probably a reflection of the actual situation rather than a result of the mineralogy (see Appendix A).
- Cioppa et al. (1995) inferred that the hematite hosting most of the remanent magnetization of

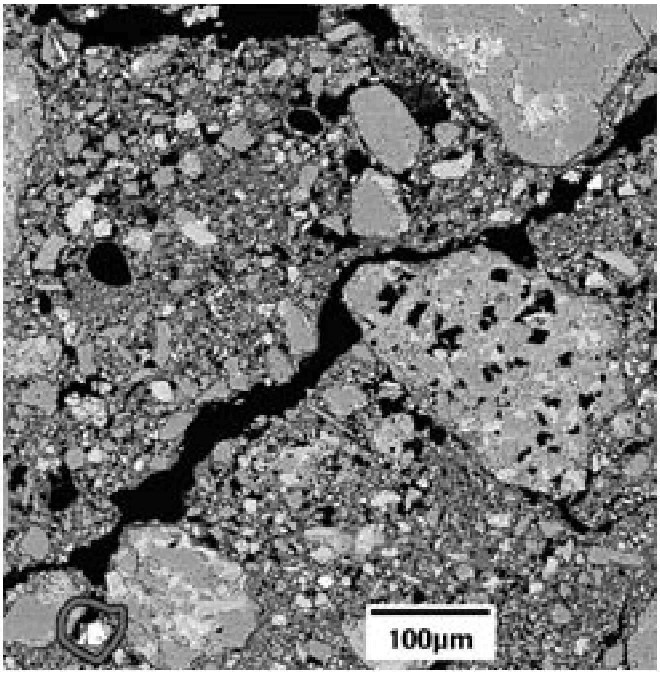
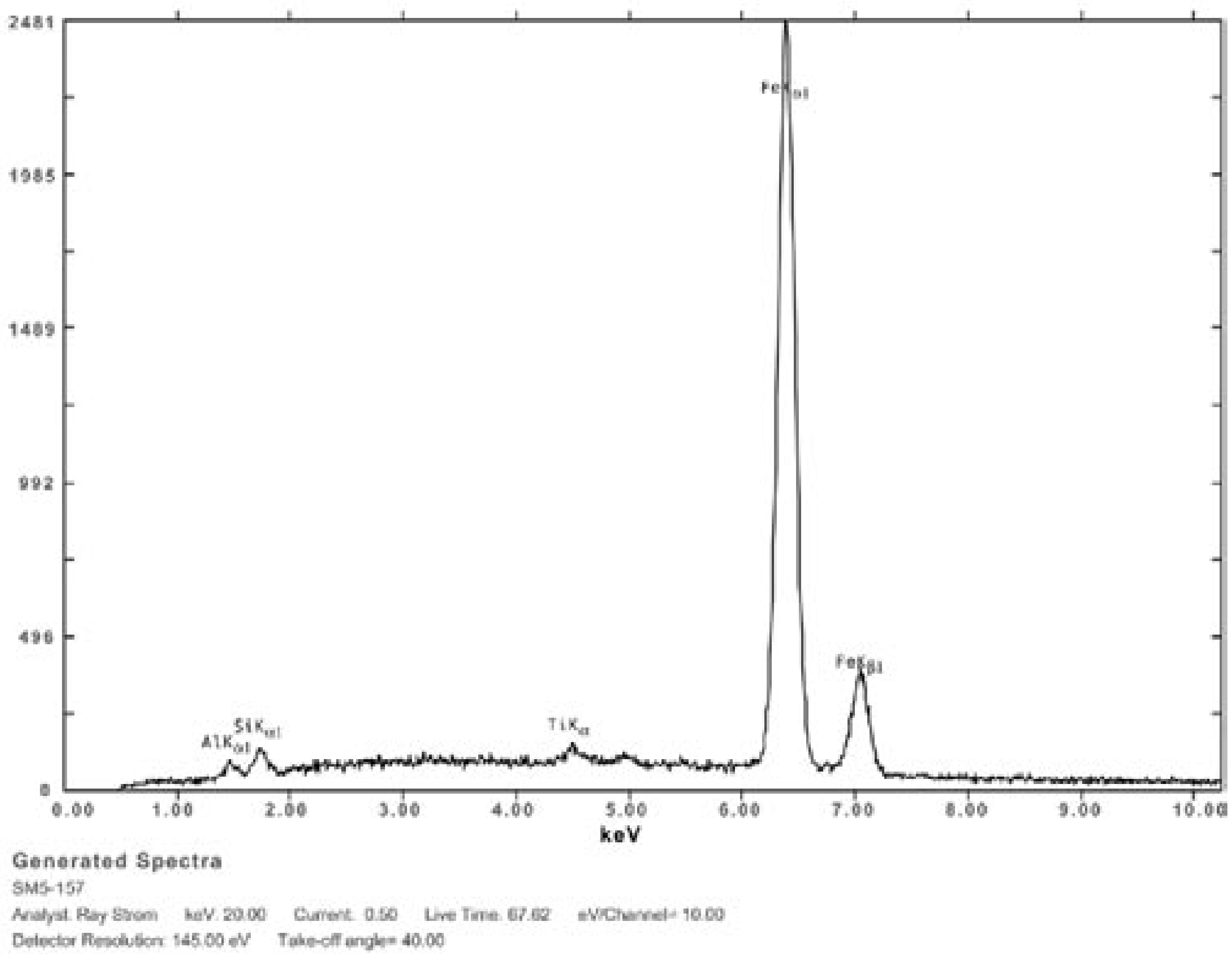


Figure 26. Backscatter scanning electron micrograph with electron diffraction spectrum of circled grain. Spectrum is indicative of magnetite, probably with ilmenite, which is likely detrital. The micrograph also shows hematite incorporated into detrital grains.



> the Kennedy Formation was syndepositional and therefore representative of the contemporary terrestrial magnetic field, but it is also possible that it is diagenetic or authigenic, or that it represents a more complex history. It is known that remanent magnetism in sediments can reflect the terrestrial magnetic field accurately in some cases, while reflecting depositional current directions in others (Rouse, 1983a, p. 32).

Evaluating Remanent Magnetism in the Kennedy Formation

Most readers are probably familiar with the general concept of thermoremanent magnetization, whereby a ferromagnetic mineral forms from magma or lava and inherits the orientation of the local magnetic field. This also assumes that minerals below the Curie point are not reoriented by lava or magmatic motions or geomechanical effects. This does not apply to the Kennedy Formation, of course, since it is sedimentary. However, the terrestrial magnetic field will have been one of the force fields that acted on particles transported by whatever fluid deposited the Kennedy Formation, and hematite formed since deposition (i.e. diagenetic or authigenic) would presumably have inherited the orientation of the contemporary terrestrial magnetic field. It is therefore important to closely examine the Kennedy Formation for evidence of diagenetic or other factors that may affect the orientation of magnetic minerals.

Paleomagnetic measurements were not collected as part of this investigation and, as stated above, we have a reasonable degree of confidence in the data of Cioppa et al. (1995) and Karlstrom and Barendregt (2001). Instead of duplicating these earlier efforts, we collected oriented samples from several locations on landslide scarps where these researchers had collected their samples: Cloudy Ridge, Milk River Ridge, Mokowan Butte, Saint Mary Ridge, and Two Medicine Ridge (Figure 1). These samples were submitted to Continental Rocktell Services of Calgary, Alberta, for analysis. Approximately 160 thin-section images were produced from 21 samples, many of which exhibit detrital characteristics and microfabric evidence of grain rotation and fracture propagation indicative of soil creep. Of particular relevance to this paper is sample SM5-157, which was collected from approximately halfway down the south side of the middle landslide scarp on Saint Mary Ridge (Karlstrom's Trench V, 1988). This sample corresponds to the "B horizon" of Karlstrom's Soil 3 (or possibly Soil 2), which is reversely magnetized.

Sample SM5-157 was further analyzed in several vertical sections using reflected light, transmitted plane light, transmitted light with crossed polars, scanning electron microscopy back scatter electron imaging (SEMBSE), and electron diffraction spectroscopy (EDS) to locate and characterize the ferromagnetic minerals in the sample. Figure 25 is a reflected light image of sample SM5-157. Small inclusions of hematite may be detrital or authigenic (or diagenetic), while the larger particles are clearly incorporated into detrital grains of the sedimentary matrix. Thus, the majority of remanent magnetization is contained in detrital particles that represent not the terrestrial magnetic field at the time of deposition of the Kennedy Formation, but the present orientation of hematite crystals in grains that may have been deposited with attitudes very different from their original orientations. This may explain why Cioppa et al. (1995) considered their paleomagnetic data to be of poor quality: while eigenvector calculations resulted in a "reversed" principal direction for these data, such a result could easily be obtained by chance. Figure 26 is a SEMBSE image with EDS spectrum for the most iron-rich grain in the image field. The spectrum indicates this is probably magnetite with some ilmenite, both of which have much larger magnetic susceptibilities than does hematite. Note that this also more closely resembles a detrital grain than a crystal that has grown since deposition of the Kennedy Formation.

Stratigraphic Agreement?

As presented elsewhere (Klevberg, Oard, and Bandy, 2003), while stratigraphic methods that agree may both be wrong, methods that do not agree cannot both be correct. Some popular stratigraphic methods are not descriptive (i.e. scientific), either, which means they cannot provide an independent source of data for comparison with paleopedologic interpretations[8]. Magnetochronostratigraphy is one such unscientific stratigraphic method (Klevberg, 2000a) and is very popular among paleopedologists. Magnetochronostratigraphy begins with a global chronological scheme. It should be possible to measure remanent magnetism without reference to this scheme and create a stratigraphic section based on paleomagnetic properties, which would produce a

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[8] Several papers have been published which elucidate the important distinctions between scientific and nonscientific approaches to stratigraphy (Froede, 1998; Froede and Reed, 1999; Klevberg, 1999; 2000a; 2000b; Reed and Froede, 2000; 2003; Reed, Froede, and Bennett, 1996; Woodmorappe, 1981; 1996). Readers who fail to see the importance of this distinction would benefit greatly from these papers.

scientifically valid magnetostratigraphic section. Such a section may or may not coincide with a paleopedologic section from the same outcrops or magnetochronostratigraphy[9].

Adherence to magnetochronostratigraphy requires a faith commitment which we are not prepared to make. Nor are we convinced that there is an unequivocal correspondence between paleomagnetic measurements and the various paleosols claimed by Karlstrom. As we have summarized above, remanent magnetism measurements can be problematic, and some of the results for Kennedy Formation samples are ambiguous or interpreted as displaying overprinting (Cioppa et al., 1995). The lack of completely random or near-vertical paleomagnetic data can be expected if most magnetic grains were deposited in a relatively fluid medium and not subjected to significant cryoturbation. Research on debris flow fabrics and paleomagnetism has shown considerable variability, with most particles oriented parallel to the inferred paleoslope (thus flow direction), and with fewer sites showing transverse orientation and some neither (Gravenor, 1986). While magnetite has an octahedral crystal habit that would tend to form equant grains, if it (and possibly hematite) were contained in prolate and oblate agglomerations or clasts, its final orientation might be related to whatever forces determined the final orientation of these agglomerations. Syndepositional magnetite in debris flow deposits may therefore indicate paleocurrent direction, not the contemporary direction of the earth's magnetic field. If some of the hematite in the matrix of the Kennedy Formation is syndepositional, it may also be oriented with paleocurrent directions. Thus there is clearly no "solid" case for a trustworthy paleomagnetic dating scheme for the Kennedy Formation. In the light of the technical difficulties outlined above, we leave it to the reader to determine whether compromise of the historically attested biblical chronology is warranted based on magnetochronostratigraphic speculation.

While we decry the naturalistic inconsistencies of magnetochronostratigraphy, we do not dismiss paleomagnetic data as spurious or unimportant. While some creationists have argued against terrestrial reversals from a few exceptional cases (Barnes, 1973; Brown, 1989; Rouse, 1983b), many diluvialists believe that the Earth's magnetic field has reversed direction multiple times, probably during the year-long global flood cataclysm (Brown, 1989; Humphreys, 1986; 1988; 1990; 2002) and perhaps some time thereafter (Appendix B). If one assumes that the remanent magnetization data published for the Kennedy Formation are valid, and that these data are actually representative of the contemporary terrestrial magnetic field, then such magnetic field reversals provide a reasonable explanation for reversed polarity in some of the Kennedy Formation units. Diluvialists following this line of reasoning would not face the establishment geologic paradigm (EGP) temptation to constantly expand the chronology to accommodate ever increasing numbers of chrons.

One could expect a relatively small number of reversals which might make correlation of many geomagnetic and archaeomagnetic data possible (however, see Appendix B for reservations). The reversals would dissipate the terrestrial dipole field strength, and should therefore show decreasing strength of magnetization (holding all other variables constant) the more recent the date of magnetization (Humphreys, 2002, p. 5), assuming such measurements are possible[10]. It may be that paleohydrologic or other methods can be applied to the Kennedy Formation to estimate minimum or maximum times for deposition; if so, it may be possible to estimate the rapidity of magnetic field reversals. All of this analysis hinges, of course, on the veracity of the remanent magnetization data as terrestrial magnetic field indicators and some solid historical data to pin the measurements to.

If the remanent magnetization measurements are accurate but do not represent the contemporary terrestrial magnetic field, then they are just as irrelevant to the multiple-event question and the time question as are spurious data. Remanent magnetization data that are not indicative of the terrestrial field neither affirm nor deny the multiple glaciation theory or biblical chronology. Data helpful to determining the likelihood of paleohydraulic influences on remanent magnetization may help to clarify this question. In light of the laboratory evidence presented here, alternative explanations for the paleomagnetic data appear not only

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[9] Typically, if fossils are present, the presumed evolutionary succession is used to "date" everything else. Since many alleged paleosols do not contain fossils, magnetostratigraphy is often the only other method used in comparison with pedostratigraphy. Unfortunately, instead of using magnetostratigraphy as a geophysical method to look for physical boundaries between units, it is typically used to reference the local section to a magnetochronostratigraphic column, i.e. a presumed magnetic history of the Earth, similar to the manner in which fossils are used to "date" units.

[10] While some show confidence in efforts to measure paleointensity (Rouse, 1983b, p. 78), paleointensity can be very difficult to measure with any accuracy (Barnes, 1973), and some of the classic measurements have been shown to be statistically meaningless (Smith and Smith, 1993).

possible, but likely. It therefore behooves diluvialists not to blindly accept assertions about paleomagnetic directions for given formations. The skepticism with which geologists should consider the even more tenuous inferences of terrestrial field reversals during distinct stages of earth history should go without saying.

Conclusions

Based on the evidences presented above, we conclude the following:

- Early research on the Kennedy Formation by EGP geologists resulted in disparate explanations for the deposit, including fluvial and glacial mechanisms, genesis during an interglacial, and as the result of multiple glaciations. Arguments against a debris flow origin hinge on the lateral extent and volume of the formation.
- The extensive, planar erosion surfaces on which the Kennedy Formation rests are continuous with surfaces stretching far east onto the Great Plains. These vast planation surfaces are almost certainly diluvial (Klevberg and Oard, 1998; Oard and Klevberg, 1998). The scale and magnitude of the event necessary to produce these surfaces would have been more than adequate to erode, transport, and deposit the Kennedy Formation.
- The lithologies contained in the Kennedy Formation correspond with those observed in the Rocky Mountains to the west and were probably derived from them. The mixture of rounded and more angular clasts indicates a combination of transport mechanisms over a relatively short distance, which fits well with the Rocky Mountain source area inference.
- Analysis of depositional fabric based on observations of Karlstrom, Klevberg, and others is inconclusive. While fabric strengths do not rule out a glacial origin, neither do they rule out mass wasting or fluvial transport mechanisms.
- Evidence for multiple glaciations hinges on paleosol and paleomagnetic interpretations. Both of these are mixed questions, not strictly scientific issues, and they are hampered by a number of technical difficulties.
- Remanent magnetism measurements vary greatly in quality. Magnetochronostratigraphy has been used by previous researchers to create an interpretive framework which the data are insufficient to support. Paleomagnetism does not provide unequivocal evidence for the amount of time or the various soil-forming intervals Karlstrom and others espouse. It may, in fact, indicate rapid deposition of the Kennedy gravel during a time of wildly fluctuating terrestrial magnetism. Paleomagnetism is a field as yet poorly researched by diluvialists.
- Laboratory analysis of 21 samples from five landslide scarps indicated that a wide variety of microfabrics is present, many of which are indicative of soil creep. Additional analysis of sample SM5-157, from a reportedly magnetically reversed stratum, showed that most of the mineral grains hosting the remanent magnetism are detrital, not authigenic, and are present as randomly oriented inclusions within randomly oriented sedimentary grains. The reverse magnetism of this stratum therefore appears to be a statistical artifact and probably unrelated to the contemporary terrestrial magnetic field.

Speculations Regarding the Origin of the Kennedy Formation

We believe the evidence indicates a combination of debris flows and traction flows coming off the Rocky Mountains as a sheet when the Flaxville surface was one continuous plain abutting the mountains. Following the sheet erosion and deposition of the gravel, increasingly channelized flows eroded the areas between, leaving the erosional remnants high above the surrounding area. Streams–both of water and of ice–would naturally flow in the lowest areas. This scenario is typical of the Abative (sheet flow) and Dispersive (channelized flow) Phases of the Recessive Stage of the Genesis Flood (Walker, 1994; Oard and Klevberg, 1998; Oard, 2001a; 2001b; see Appendix C). Following the Deluge, the short-lived Ice Age (Oard, 1990) would have placed a veneer of till with moraines in the valleys surrounding the erosional remnants. The erosional remnants themselves appear to have been nunataks, high remnants sticking out of the ice that moved out of Glacier Park during the postdiluvial ice age. We believe this natural history scenario corresponds considerably better with the data than does Karlstrom's or the uniformitarian scenarios that preceded it.

Appendix A

By far the most important magnetic mineral on earth is, naturally, magnetite. Ilmenite is also ferromagnetic, though weaker than magnetite, and hematite (with which ilmenite is often associated) is not listed by some mineralogists as a ferromagnetic mineral (Dietrich and Skinner, 1979, pp. 70–73), while others describe it as "weakly magnetic"

Event/Era	*Stage*	*Duration*	*Phase*
Postdiluvian Era		4,000 years	Modern
		300 years	Residual
The Deluge	Recessive	220 days	Dispersive
			Abative
	Inundatory	110 days	Zenithic
			Ascending
		40 days	Eruptive
Antediluvian Era		1,700 years	Antediluvial
The Creation Event	Formative	2 days	Biotic
		2 days	Derivative
	Foundational	2 days	Ensuing
		0 days	Primordial

Figure 27. Walker's geochronologic paradigm as revised by Oard and Klevberg

(Nesse, 1991, p. 129). However, Strangeway (1970, p. 31) states:

> The most interesting point about hematite in rock magnetism is that it has a very high coercive force. The fine-grained material with no ferromagnetism develops a TRM [thermoremanent magnetization] which is extremely stable. The coarser-grained material with superimposed ferromagnetism has a definite hysteresis with a coercive force of several thousand oersteds. Either type of remanent magnetization shows extreme stability when compared with most other magnetic materials. It is for this reason that hematite, although weakly magnetic, has considerable significance in paleomagnetism.

The techniques used by Cioppa et al. (1995) and Karlstrom and Barendregt (2001) included collection of oriented samples, measurement of remanent magnetization using a spin magnetometer, and step-wise demagnetization. While there is inevitably room for error in each of these steps, we do not find fault with this procedure and retain confidence in their remanent magnetization data. Differing opinions between researchers as to the precision of the data may result primarily from the eigenvalue analysis and interpretation of the strength of trends expressed by the eigenvectors.

While several possible causes for reversed remanent magnetization besides the terrestrial magnetic field have been identified (Barnes, 1973), the terrestrial field remains the most compelling explanation for many of these data. The actual conditions responsible for the formation of the remanent magnetization in the past are, of course, matters of historical speculation and far from certainty.

Appendix B

Humphreys (1990; 2002) suggests migration of flux loops outside the core into the mantle as a means of generating reversed magnetism. Evolutionists are wont to argue that exchange of energy between Earth's dipole field and nondipole field explains the apparent decrease in the terrestrial dipole field so much in conflict with the evolution worldview and so strongly emphasized by Barnes (1973). However, if enough energy were actually transferred to the nondipole field, the temporarily strong quadripole and octopole fields could result in a temporarily reversed regional rather than global magnetic field. This might also result from Humphreys' proposed flux loops. If the reversed field were stronger than the normal field over part of the Earth's surface, then normally magnetized rocks could be formed in one region, reversed in another. The ramifications of this possibility for magnetostratigraphy should be obvious!

Appendix C

Various researchers have proposed diluvial chronostratigraphic outlines, probably the best known being Froede's (1995) and Walker's (1994). We have here used Oard's and Klevberg's modification of Walker's geochronologic paradigm (Oard, 2003) as illustrated (Figure 27), which closely reflects previous work by the authors of this paper and ideas introduced long before (Whitcomb and Morris, 1961).

Oard's and Klevberg's changes are relatively minor. We have altered slightly the duration of the phases to conform as strictly as possible to the historic account in the Bible. We have also altered some of Walker's terms. We have replaced Walker's "Lost World Era" and "New World Era" with their traditional time designations, asserting that the former sounds much like a popular movie, while the latter term has been consistently applied to the Western Hemisphere for many decades (e.g. "Old World warblers," "New World flora," *New World Symphony*). The word "flood," or even "Flood," may be too weak and general (potentially confused with other floods), while "mabbul" (the Hebrew word in the Old Testament for this unique event) is probably too obscure; "Deluge" seems a suitable and traditionally employed compromise. The use of widely understood words such as "antediluvian" and "Deluge" is also consistent with Walker's other terms, nearly all of which are derived from Latin ("zenithic" is Greek). This also serves to make the terms less anglocentric, which is a good thing in Klevberg's opinion. Otherwise, the framework used here is very close to Walker's original timescale, which is a logical and practical one. Readers interested in studying historical geology and diluvial paradigms further should consult Walker (1994), Froede (1995), and an important recent paper by Barrick and Sigler (2003).

Glossary

authigenic: grown in place; formed in situ.

chron: an interval of earth history during which the earth's magnetic field had a particular orientation, i.e. normal or reversed polarity.

chronostratigraphy: a geochronologic paradigm or natural history timescale used to organize geologic data into a stratigraphic relationship. It is important to note that chronostratigraphy begins with an assumed historical scenario and fits the scientific data into this historical construct.

Curie point: the temperature below which permanent magnetization is possible.

Deluge: the global Flood cataclysm during Noah's time as described in Genesis 6–8.

detrital: resulting from physical weathering and transport; not formed in situ.

diagenetic: resulting from processes acting on a geologic unit subsequent to deposition.

diamict: any heterogeneous, unstratified sediment; the term is descriptive (scientific), not genetic (historical), and includes till and debris flow deposits.

diluvial: formed by or during the Deluge.

diluvialist: one who interprets geologic history in terms of the primacy of the Deluge.

drift: a general term for all glacial deposits, including various kinds of till.

magnetic susceptibility: the property of a material that measures its tendency to acquire a permanent magnetic orientation.

magnetostratigraphy: stratigraphic correlation based on remanent magnetization patterns.

paleomagnetism: remanent magnetic properties preserved in earth materials.

rounded and subrounded: the degree to which edges of a clast are smooth and subdued. It differs from shape designations, e.g. a slate boulder that is quite flat could be well rounded if the edges were smooth, free from projections or sharp profiles.

syndepositional: contemporary with and resulting from the processes responsible for deposition of a geologic unit.

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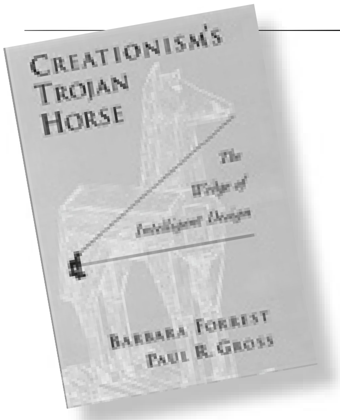

Book Review

Creationism's Trojan Horse: The Wedge of Intelligent Design by Barbara Forrest and Paul R. Gross

Oxford University Press, New York, 2004, 401 pages, $40.00.

From time to time I read books and articles from the pro-evolution camp. I do not particularly enjoy this but I think it is important to know what the other side is saying and how they think. *Creationism's Trojan Horse* was a somewhat painful, yet at the same time fascinating, read. It purports to tell the history of the modern intelligent design (ID) movement, albeit from the perspective of writers who are members of the Darwinian choir. Throughout the book Forrest and Gross use the term "Wedge" for the ID movement. The Wedge is really a strategy, not the ID movement itself, but that is a fairly minor point.

The father of the ID movement is law professor Phillip Johnson who started the modern discussion of design with his book *Darwin on Trial* in 1991. Johnson also coined the term "Wedge." *Trojan Horse* describes the Discovery Institute in Seattle as the key player in the movement's growth over the past ten years or so. Forrest and Gross go into some detail about a number of the Wedge's key contributors—particularly Johnson, Michael Behe, William Dembski, and Jonathan Wells. These and other ID theorists are skewered mercilessly and unfairly throughout the book, but I will not go into detail here.

Forrest and Gross have three major themes they keep hammering on. One aim is to convince the reader that ID is really a religious movement, not a scientific one. They refer to ID as "an upgraded form of the religious fundamentalist creationism long familiar to America" (p. 6). Their purpose in using this tactic is to try to persuade the reader that ID is something to be feared and stamped out since its "ultimate goal is to create a theocratic state" (p. 11).

Forrest and Gross are concerned that "the Wedge is associated with some of the most extreme factions of the Religious Right network" (p. 273). They point out, for example, that the movement is supported by such "theocratic extremists" (p. 270) as James Dobson, D. James Kennedy, and Beverly LaHaye. (These are people I have always admired!) Forrest and Gross may fear a takeover by people of faith; I am more concerned about a takeover by people *without* faith (*i.e.*, supporters of naturalism).

A second theme echoed throughout the book is that ID has no scientific evidence to back it up. Forrest and Gross claim the movement has "produced no original scientific data" (p. 39) and that the Wedge has had a "total failure in scientific productivity" (p. 314).

A lot of space is devoted to the fact that ID scientists have not published their work in peer-reviewed science journals. According to Forrest and Gross, "It is *not* hard to get a hearing in regular science journals for ideas like ID" (p. 39). The implication is that if ID had anything important to offer, then the journals would rush to publish it. It is painfully obvious that this is just not true. The reason you do not see pro-ID articles in the journals is that the editors and reviewers will not permit it. They censor ID because it is not naturalistic. Forrest and Gross make no mention of this detail.

Evidence is in the eye of the beholder. *Trojan Horse* discusses in very negative terms such major ID tenets as the sudden appearance of new species and the lack of transitional forms in the fossil record, irreducible complexity at the cellular level, making design inferences based on specified complexity, and the extreme improbabilities associated with the naturalistic origin of complex biomolecules. Forrest and Gross brush off all of these lines of evidence by simply declaring that "real" scientists have adequately refuted them. This kind of reasoning only makes sense, of course, if you have a prior commitment to naturalistic explanations for biological phenomena.

A third major theme is that the ID movement is making real progress in the public arena. The Wedge, according to Forrest and Gross, is therefore an annoyance that should be refuted and dealt with severely. From my viewpoint, if there is any encouraging news in *Trojan Horse*, this is it: the Wedge is having an impact.

Forrest and Gross complain that the ID movement "is already too well organized and funded" (p.8). They sum up their concern: The issue is that the public relations work, but not the 'science,' of the Wedge and of ID 'theorists' is proving all too effective. It would seem that the science establishment is becoming a bit uneasy about the influence of the Wedge. The evolution-only status quo is beginning to feel the heat, and from my point of view, that is good!

Forrest and Gross certainly do not feel that the science establishment is losing its grip, however. They consider it a "fact that theistic science [including ID] will never overthrow legitimate [*i.e.*, naturalistic] science" (p. 312). In what seems like a bit of a concession, they add: "Just getting the subject [ID] accepted as academically and culturally *conventional*—even as it is attacked—is the initial step toward victory" (p. 312).

So is the science establishment really starting to fear ID? Forrest and Gross would say "no," because they truly believe that the status quo will prevail. But books like this, perhaps inadvertently, are raising real concern among pro-evolutionists about the effect of the ID movement. The Wedge is, indeed, starting to put some real cracks in the façade of macroevolution. While I do not particularly like the comparison between the ID movement and the Trojan horse, one has to remember that the original Trojan horse was effective!

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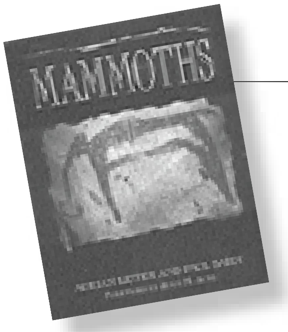

Book Review

Mammoths by Adrian Lister and Paul Bahn

Macmillan, New York, 1994, 168 pages, $30.00.

Scientist Lister and archeologist Bahn have teamed up for an interesting interdisciplinary study of mammoths combining observations of fossils, living elephants, and Ice Age artistic representations. The first chapter describes the evolutionary family tree of the Proboscidea. Creation scientists would concur that these living and fossil species came from variation within a single created *baramin*, though not that they share a common ancestor with the dugong and hyrax (pp. 20-21). The first mammoth fossil to be mounted was the Adams skeleton, in St. Petersburg, Russia, during 1808 (p. 43). The first frozen specimen, an adult found at Beresovka, Siberia, in 1901 (p. 44), added greatly to our knowledge of mammoths.

The consistent representation of the mammoth's profile in dozens of geographically and temporally independent depictions indicate it was genuinely observed and not a result of artistic imagination (p. 68). The following characteristics of ancient cave-drawings, primitive sketches or sculptures have been confirmed by comparison with frozen mammoths or living elephants:

- long coarse tail hairs (pp. 72, 98-99)
- two projections at the tip of the trunk, the outer being longer (p. 76)
- the foot swelling when weight is placed on it: like elephants (p. 76)
- anal flap (p. 72)
- protuberance on feet above the floor: like elephants (p. 98)
- a small ear to conserve heat in a cold climate (p. 97)
- adults' backs descending steeply to tail; domed backs on the young (p. 97)

- social bonding: like elephants (p. 86)
- shaggy body hair (p. 97) and hair on sides of trunk (p. 70)
- tail raised for a mammoth in a fight: a sign of aggression among elephants (p. 87)

These same investigations could be done for dinosaurs and other extinct creatures, many of which were represented by cultures far more advanced than the cave men who depicted the mammoth. A limitation for dinosaurs is that we do not have frozen fossils or living cousins to compare the representations with, only the skeletal fossils, trackways and occasional skin impressions.

It is uncertain if mammoths became extinct from climate change or hunting. Their demise is usually linked with that of 80% of earth's other megafauna at ca.40,000–10,000 years ago. However, this is not certain. Spassov (1991) has found osteological and archeological evidence for the survival of the Eurasian musk ox until recent centuries, though it is usually thought to have gone extinct with the other megafauna. Perhaps the hypothesized time of the megafauna extinction theory is wrong for other species as well. Though there is evidence mammoths were hunted, it is not conclusive that that caused their extinction. There were higher human population densities that exploited bison, pronghorns, deer, and wild sheep, though they did not become extinct (p. 130).

The extinction of the dinosaurs is said to have been certainly caused by climate change because, according to old-earth geological theory, they died out 65 million years ago before man had evolved. This is mentioned as a precedent for mammoth extinction due to climate change. However, the question is raised why warm climate at the close of the last Ice Age caused extinction, though not the 22 earlier interglacial periods believed to have occurred during the Pleistocene (p. 134). The creation hypothesis for a single Ice Age, though with fluctuations, could help resolve that question.

In 1993 C-14 dating established that dwarf mammoths had survived on Wrangel Island, in the Arctic Ocean, until only 3,700 years ago. The earliest human occupation there is dated to at least 3,400 years ago, so that hunting may have caused this extinction (p. 137). It is believed that Wrangel Island was connected to Siberia 12,000 years ago. By 7,000 years ago the mammoths had become fully dwarfed. Therefore, the maximum time for the dwarfing process was 5,000 years or 500 generations, "one of the shortest evolutionary transitions found in the fossil record" (p. 35). Evolutionists often criticize creation scientists for believing that speciation after the Flood occurred too quickly to be scientifically possible. The dwarf mammoth's speciation may be a useful verification for this hypothesis of creation science.

The present reviewer helped excavate a mastodon at Ada, Michigan, with CRS member Doyle Dacus, in a dig led by Calvin College's Professor Stearley during 1999. A rib was found with a notch; however this is not yet certainly known to be from a spear or tusk wound.

During 1992 a "living fossil" resembling a stegodon with a prominent double dome on the head, steeply sloping back, and a bridge in front of the eye was photographed in western Nepal (Wieland, 1997). Roesch (1995) wrote that these creatures are "more likely to be mutant versions of the normal Asian elephant, rather than a stegodon, or even a separate, new species of elephant." The reason for this "more orthodox solution" is that the stegodon, ancestor of both the African and Asian elephants as well as the mammoths, died out more than a million years ago according to the evolutionist interpretation of the fossil record. Once again it appears that a "living fossil" is an embarrassment to evolutionary theory and an unlikely alternative explanation is sought.

At the end of the 16th century, a traveler beyond the Ural Mountains reported seeing "a large hairy elephant" that natives said was a source of food (p. 138). In 1920 a hunter from Siberia said he observed "an enormous elephant, with white, very curved tusks" that had long hair. It appears he did not know of fossil mammoths, therefore he identified the creature as an elephant.

Mammoths is lavishly furnished with pictures and illustrations. An appendix provides a helpful summary of recent scientific advances in paleontology and the study of ancient climates by observations from Greenland/Antarctic ice cores and sea floor sediments. There is also a glossary, index, extensive bibliography, a guide to interesting sites and museums, and maps of where the fossil and archeological evidence has been found.

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Is Bacterial Resistance to Antibiotics an Appropriate Example of Evolutionary Change?

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Abstract

Evolutionists frequently point to the development of antibiotic resistance by bacteria as a demonstration of evolutionary change. However, molecular analysis of the genetic events that lead to antibiotic resistance do not support this common assumption. Many bacteria become resistant by acquiring genes from plasmids or transposons via horizontal gene transfer. Horizontal transfer, though, does not account for the origin of resistance genes, only their spread among bacteria. Mutations, on the other hand, can potentially account for the origin of antibiotic resistance within the bacterial world, but involve mutational processes that are contrary to the predictions of evolution. Instead, such mutations consistently reduce or eliminate the function of transport proteins or porins, protein binding affinities, enzyme activities, the proton motive force, or regulatory control systems. While such mutations can be regarded as "beneficial," in that they increase the survival rate of bacteria in the presence of the antibiotic, they involve mutational processes that do not provide a genetic mechanism for common "descent with modification." Also, some "relative fitness" cost is often associated with such mutations, although reversion mutations may eventually recover most, if not all, of this cost for some bacteria. A true biological cost does occur, however, in the loss of pre-existing cellular systems or functions. Such loss of cellular activity cannot legitimately be offered as a genetic means of demonstrating evolution.

Introduction

Because of their rapid rate of replication, ease of laboratory analysis, and the wide diversity of laboratory-generated mutants that can be obtained, bacteria have been described as an excellent model for studying the processes of evolution (Mortlock, 1984). Acquiring resistance to a specific antibiotic provides a clear benefit to the bacterium when exposed to that antibiotic. Thus, the acquisition of antibiotic resistance is commonly cited as an example of "evolutionary change," and has become a popular example of so-called "evolution in a Petri dish." Miller (1999) refers to the development of antibiotic resistance as an example of evolution's "creative force." Barlow and Hall (2002) refer to it as "the unique opportunity to observe evolutionary processes over the course of a few decades instead of the several millennia that are generally required for these processes to occur." (p. 314)

Evolution is often described simply as 'change' or 'change in gene frequency over time' (Dillon, 1978; Johnson, 2000; Patterson, 1978), and evolutionists have almost

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universally maintained that any change in genotype (or even phenotype) is an "evolutionary change." As such, any biological change of an organism, including antibiotic resistance, would fit within this definition. However, mere biological change also fits within a creation model, and thus this "vanilla" definition does not readily distinguish itself from creation. This definition also does not specify the type of change (such as deleterious versus beneficial), thus it fails to offer any predictive value to the theory.

What is more, any change that appears to provide a so-called "beneficial" adaptation is commonly seen as a driving force of evolution. Indeed, some mutations, such as antibiotic resistance, can be beneficial since they may provide the organism an increased ability to survive under very specific environmental conditions. Thus, evolutionists typically conclude that genetic examples of "evolutionary change" are abundant and that creationists are forced to deny this readily observed evidence.

However, the theory of evolution proposes that all life on Earth had a common origin. Hence, all life shares a common evolutionary ancestry from which it has descended, i.e., the "common descent" of life. In a summarizing statement, Darwin (1936) states that "the theory of descent with modification embraces all the members of the same great class or kingdom … all animals and plants are descended from some one prototype." (p. 370). Therefore, through this overall common "descent with modification," the theory of evolution claims to account for the origin and diversity of all biological development on Earth. Thus, common "descent with modification" provides a more appropriate and functional definition of the theory of evolution, and this article will refer to evolution in this context. This definition also entails several "predictions" regarding the types of genetic change necessary for common evolutionary descent (predictions that are in sharp contrast to the "predictions" of a creation model). Such changes must provide more than mere changes in phenotype; they must provide a genetic mechanism that accounts for the origin of cellular functions and activities (i.e., regulatory systems, transport systems, enzyme specificity, protein binding affinity, etc.).

Genetic changes that reduce or eliminate any of these cellular systems provide no genetic mechanism for common "descent with modification." Rather, such changes are actually the antithesis of this descent, reducing or eliminating a pre-existing system of biological complexity (a reversal of "descent with modification"). Therefore, these genetic changes offer no example of a genetic mechanism for the "evolutionary" acquisition of flight by non-flying organisms, cognition by non-cognitive organisms, photosynthesis by non-photosynthesizing organisms, etc. Yet the theory of evolution requires such events to have occurred, and requires mutations capable of such genetic changes. Hence, the predictions of evolution require specific types of changes, not just so-called "beneficial" mutations. Therefore, despite the great claims that have been made, it is imperative to question whether acquisition of antibiotic resistance is a valid example of evolutionary change that supports the predictions of the evolutionary theory (i.e., the theory of common "descent with modification").

Horizontal Gene Transfer

One means by which bacteria can acquire antibiotic resistance is via the horizontal transfer of antibiotic resistant genes. Such transfer of resistance genes is common (Gómez, 1998; Top et al., 2000), accounting for many examples of resistant bacteria. But, horizontal transfer merely involves the transfer of resistance genes already present in the bacterial world.

While horizontal acquisition of resistant genes is "beneficial" to those bacteria exposed to a given antibiotic, such gene transfer does not account for the origin or the diverse variety of these genes. As such, it fails to provide a genetic mechanism for the origin of any antibiotic resistance genes in the biological world. Evolution, through the process of common "descent with modification," predicts it can account for the origin and diversity of life on earth; however, the mere shuffling of pre-existing genes between organisms via gene transfer does not provide the necessary genetic mechanism to satisfy this prediction. Nor can it readily account for the simultaneous development of both the antibiotic biosynthesis and resistance genes—an evolutionary enigma (Penrose, 1998). Thus, horizontal transfer of resistant genes cannot be offered as an appropriate example of "evolution in a Petri dish."

Mutations

Mutations, defined as any changes in the DNA sequence (Snyder and Champness, 2003), provide the only known genetic mechanism for producing new genetic activity and function in the biological world. In light of this, only mutations have the potential to provide evolution a mechanism that accounts for the origin of antibiotic resistance. Thus, only that resistance resulting from a mutation is a potential example of "evolution in action" (i.e., common "descent with modification").

In the presence of a particular antibiotic (or other antimicrobial), any mutation that protects the bacterium from the lethality of that compound clearly has a "beneficial" phenotype. Natural selection will strongly and somewhat precisely select for those resistant mutants, which fits within the framework of an adaptive response. But, molecular analysis of such mutations reveals a large inconsistency between the true nature of the mutation and the requirements for the theory of evolution (Table I).

Table I. Mutation Phenotypes Leading to Resistances of Specific Antibiotics

Antibiotic	Phenotype Providing Resistance
Actinonin	Loss of enzyme activity
Ampicillin	SOS response halting cell division
Azithromycin	Loss of a regulatory protein
Chloramphenicol	Reduced formation of a porin or a regulatory protein
Ciprofloxacin	Loss of a porin or loss of a regulatory protein
Erythromycin	Reduced affinity to 23S rRNA or loss of a regulatory protein
Fluoroquinolones	Loss of affinity to gyrase
Imioenem	Reduced formation of a porin
Kanamycin	Reduced formation of a transport protein
Nalidixic Acid	Loss or inactivation of a regulatory protein
Rifampin	Loss of affinity to RNA polymerase
Streptomycin	Reduced affinity to 16S rRNA or reduction of transport activity
Tetracycline	Reduced formation of a porin or a regulatory protein
Zittermicin A	Loss of proton motive force

Bacterial resistance to the antibiotic, rifampin, can result from a commonly occurring spontaneous mutation. Rifampin inhibits bacterial transcription by interfering with normal RNA polymerase activity (Gale et al., 1981; Levin and Hatfull, 1993). Bacteria can acquire resistance by a point mutation of the β-subunit of RNA polymerase, which is encoded by the *rpo*B gene (Enright et al., 1998; Taniguchi et al., 1996; Wang et al., 2001; Williams et al., 1998). This mutation sufficiently alters the structure of the β-subunit so that it loses specificity for the rifampin molecule. As a result, the RNA polymerase no longer has an affinity for rifampin, and is no longer affected by the inhibitory effect of the antibiotic.

In fact, the level of rifampin resistance that a bacterium can spontaneously acquire can be extremely high. In my laboratory, we routinely obtain mutant strains with a resistance level that is orders of magnitude greater than that of the wild-type strain. When rifampin is present, this mutation provides a decided advantage for survival compared with those cells lacking these specific mutations. But, each of these mutations eliminates binding affinity of RNA polymerase for the rifampin. As such, these mutations do not provide a mechanism accounting for the origin of that binding affinity, only its loss.

Spontaneous resistance to fluoroquinolones (such as ciprofloxacin or norfloxacin) is also a frequent mutation in some bacteria. The primary target of the antibiotic is the enzyme, DNA gyrase, which is comprised of two proteins encoded by the genes, *gyr*A and *gyr*B (Hooper and Wolfson, 1993). Genetic analysis has found that resistance to this class of antibiotics can result from a point mutation in either of these genes (Barnard and Maxwell, 2001; Griggs et al., 1996; Heddle and Maxwell, 2002; Heisig et al., 1993, Willmott and Maxwell, 1993). These mutations of the gyrase subunits apparently cause a sufficient conformational change to the gyrase so that its affinity for the fluoroquinolones is reduced or lost (Figure 1). Again, despite their “beneficial” nature,

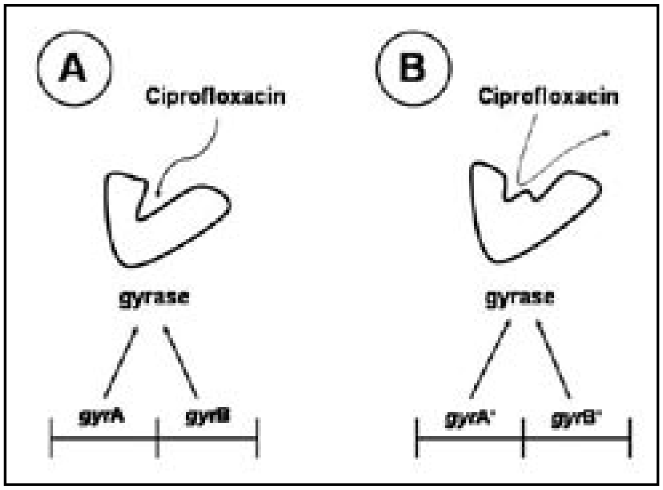

Figure 1. Mechanism of ciprofloxacin resistance. (A) Ciprofloxacin interacts with gyrase, inhibiting its enzymatic activity. (B) A mutation in either of the genes, *gyr*A or *gyr*B, can change the conformational structure of gyrase, and reduce the binding affinity of the enzyme for ciprofloxacin. This results in an inability of the antibiotic to inhibit the gyrase, and the cell becomes resistant to the antibiotic.

these mutations provide no useful model that explains the origin of the gyrase's affinity for the fluoroquinolones.

Resistance to streptomycin can also result from spontaneous bacterial mutations. In this case, streptomycin blocks bacterial protein synthesis apparently by binding to the 16S rRNA segment of the ribosome and interfering with ribosome activity (Carter et al., 2000; Leclerc et al., 1991). Resistance to the antibiotic can occur by mutations in the 16S rRNA gene, which reduces the affinity of streptomycin for the 16S molecule (Springer et al., 2001). Reduction of specific oligopeptide transport activities also leads to spontaneous resistance of several antibiotics, including streptomycin (Kashiwagi et al., 1998). In these examples, resistance occurred as a result of the loss of a functional component/activity.

Loss of enzymatic activity can result in metronidazole resistance. Interacellular metronidazole must be enzymatically activated before it can serve as an antimicrobial agent. This activation is achieved by the enzyme, NADPH nitroreductase (Figure 2). If the metronidazole is not activated it has no inhibitory effect on the bacterium. Thus, if NADPH nitroreductase activity is absent in the cell metronidazole remains inactive. Loss of the reductase activity can occur by nonsense or deletion mutations in *rdx*A (Debets-Ossenkopp et al., 1999; Goodwin et al., 1998; Tankovic et al., 2000). In addition, NADPH nitroreductase activity can be severely reduced by a single missense mutation (a single amino acid change), which reduces its ability to activate metronidazole (Paul et al., 2001). All these mutations result in loss of the enzyme activity necessary for the drug to be effective in the cell, hence the cell becomes resistant to metronidazole. But, loss of enzymatic activity does not provide a genetic example of how that enzyme originally "evolved." Hence, mutations that provide resistance to metronidazole cannot be offered as true examples of "evolution in a Petri dish."

Several bacteria, including *Escherichia coli*, construct a mulitiple-antibiotic-resistance (MAR) efflux pump that provides the bacterium with resistance to multiple types of antibiotics, including erythromycin, tetracycline, ampicillin, and nalidixic acid. This pump expels the antibiotic from the cell's cytoplasm, helping to maintain the intracellular levels below a lethal concentration (Grkovic et al., 2002; Okusu et al., 1996) (Figure 3). The MAR pump is composed of the proteins MarA and MarB, whose synthesis is inhibited by the regulatory protein, MarR (Alekshun and Levy, 1999; Poole, 2000) (Figure 3). Mutations that reduce or eliminate the repression control of MarR result in overproduction of the MarAB efflux pump, which enables the cell to expel higher concentrations of antibiotics or other antibacterial agents (Oethinger et al., 1998; Poole, 2000; Zarantonelli et al., 1999).

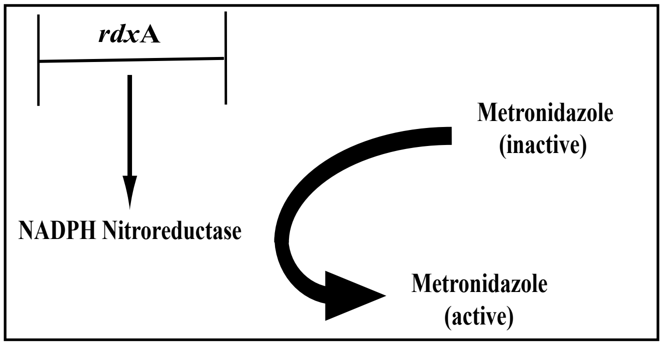

Figure 2. Activation of the antimicrobial agent, metronidazole. After being transported into the cell, metronidazole requires structural modification to obtain its active, antimicrobial form. This activation is achieved by the enzyme, NADPH nitroreductase, which is a product of the *rdx*A gene. Mutations in *rdx*A can prevent synthesis of a functional NADPH nitroreductase activity, which prevents metronidazole from becoming activated.

The protein MarA also acts as a positive regulator by stimulating increased production of both MarA and MarB proteins (Alekshun and Levy, 1999) [Figure 3]. In addition, the MarA protein indirectly inhibits the production of the porin, OmpF, a channel in the membrane that allows entry of some antibiotics into the cell (Cohen et al., 1988). Therefore, increased expression of MarA increases the efflux of antibiotics out of the cell, and reduces the transport of some antibiotics into the cell (Figure 3). Mutations of *mar*R that reduce expression or activity of the MarR protein will thus enable over-expression of the MarAB efflux pump (Linde et al., 2000; Okusu et al., 1996), and provide an increased resistance of the bacterium to various antibiotics (Eaves et al., 2004; Hans-Jorg et al., 2000; Notka et al., 2002) [Figure 3]. MarR defective mutants also possess increased bacterial tolerance to some organic chemical agents, such as cyclohexane (Aono et al., 1998).

Mutations that increase production of this efflux pump enable these bacteria to survive exposure to various antibiotics. As such, this is a beneficial mutation when the antibiotic is present in the environment. However, a mutation that causes loss of regulatory control (in this case the repressor protein, MarR) does not offer a genetic mechanism that can account for the origin of this regulatory control.

In other examples, resistance to erythromycin can also result from the loss of an 11 base pair segment of the 23S rRNA gene (Douthwaite et al., 1985), or a mutation that alters the confirmation of the 23S rRNA—reducing the affinity of the ribosome for the antibiotic (Gregory and Dahlberg, 1999; Vannuffel et al., 1992). Chloramphenicol resistance was obtained by deletion of a 12 base pair region

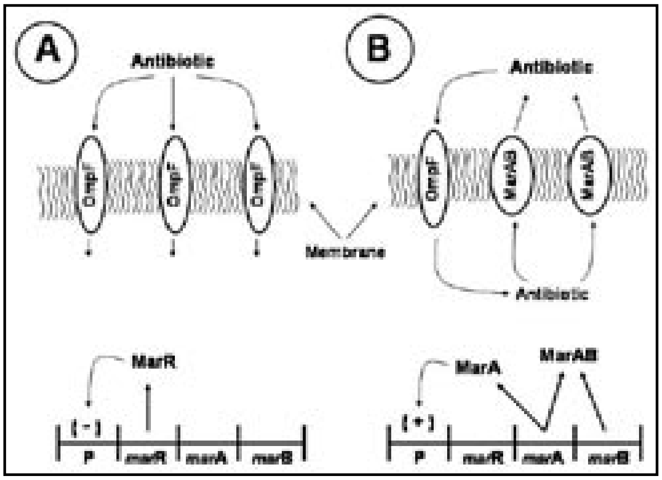

Figure 3. Multidrug resistance efflux pump. (A) Antibiotic sensitive bacterium. The antibiotics enter the cell through various portals, including the OmpF porin. Expression of the *mar*R gene produces the regulatory protein, MarR. This protein binds to the promoter (labeled as P) of the multidrug resistant operon, inhibiting expression of genes *mar*A and *mar*B. (B) Antibiotic resistant bacterium. A mutation of *mar*R that reduces the activity of MarR enables the promoter to function constitutively. Both *mar*A and *mar*B are now expressed. These two proteins form an efflux pump, which transports antibiotic molecules out of the cell's cytoplasm. MarA also binds to the promoter (labeled as P) and increases the transcription rate of the operon, which increases production of both MarA and MarB. In addition, production of MarA indirectly reduces the synthesis of the OmpF porin, thereby reducing the number of these porins in the membrane. The combination of fewer porins for transport of an antibiotic into the cell, and the increased number of MarAB efflux pumps removing the antibiotic out of the cell, provides the bacterium an increased tolerance to several antibiotics.

in domain II of the peptidyltransferase gene (Douthwaite, 1992). Resistance to cephalosporins has been linked to a dramatic alteration of membrane transport kinetics that is similar to porin-deficient strains (Chevalier et al., 1999). Actinonin resistance in *Staphylococcus aureus* results from mutations that eliminate expression of the *fmt* gene (Margolis et al., 2000). Zwittermicin A resistance in *E. coli* is associated with loss of proton motive force (Stabb and Handelsoman, 1998). For *Streptococcus gordonii*, penicillin tolerance may involve loss of regulatory control of the *arc* operon (Caldelari et al., 2000). And, *E. coli* can survive the presence of ß-lactams, such as ampicillin, by halting cell division, making the cell less sensitive to the lethal affect of the antibiotic (Miller et al., 2004).

These resistance mutations described above cause the loss of a pre-existing biological system, including cell division and proton motive force. Even though antibiotic survival is a "beneficial" phenotype, these mutations fail to provide a genetic example of how each of these systems originated. As such, they fail to provide a genetic means to fulfill the predictions of "descent with modification."

Resistance to other antibiotics, such as kanamycin, can result from loss or reduction of synthesis of a transport protein (OppA) [Kashiwagi et al., 1998]. Ciprofloxacin and imipenem resistance can result, at least in part, from the decreased formation of the outer membrane porin, OmpF (Armand-Lefèvre et al., 2003; Hooper et al., 1987; Yigit et al., 2002). An increase in meropenem and cefepime resistance is also associated with loss of OmpF, and another porin, OmpC (Yigit et al., 2002). And, *Enterobacter aerogenes* can become resistant to various antibiotics when a mutation dramatically reduces the conductance of a membrane porin (Dé et al., 2001).

Each of these resistances described in the previous paragraph result from the reduction or loss of a transport system. However, genetic mechanisms necessary for evolution would need to account for the origin of these various transport systems. Thus, these antibiotic resistance mutations do not provide the necessary genetic changes for "common descent." Rather, they are genetically inconsistent with the requirements of evolution, each involving the loss of a pre-existing transport activity.

As a group, the mutations associated with antibiotic resistance involve the loss or reduction of a pre-existing cellular function/activity, i.e., the target molecule lost an affinity for the antibiotic, the antibiotic transport system was reduced or eliminated, a regulatory system or enzyme activity was reduced or eliminated, etc. (Table I). These are not mutations that can account for the origin of those cellular systems and activities. While these mutations would certainly be "beneficial" for bacterial survival when an antibiotic is present in the environment, this benefit is at the expense of a previously existing function. This is analogous to removing an interior wall of a house to make a larger dining room. While this larger dining room may be desirable (i.e., beneficial), the mechanism of removing this wall cannot legitimately be offered as an example of how this interior wall was originally built. Hence, the survival benefit of a mutation is only a portion of the genetic characteristics necessary for mutations to achieve "evolution in a Petri dish." Such mutations must also provide the genetic basis for common "descent with modification." While this directly contradicts the claims made by many proponents of evolution, the molecular data for antibiotic resistance are very clear.

These mutations also cannot provide a mechanism that continues to "evolve" the level of protein specificity or protein activity that is necessary for normal cellular function. While such mutations are excellent examples of bacterial adaptation, they are actually the antithesis of the mutational change necessary for evolution. Yet, these are the very examples evolutionists offer as verifiable demonstrations of "evolutionary change." Ironically, these mutations are, in fact, verifiable examples of a creation model—initial complexity being mutated to a level of greater simplicity.

The spontaneous acquisition of antibiotic resistance is often referred to as "gaining" resistance, but it is more appropriately identified as a loss of sensitivity. Thus, antibiotic resistance results from the loss of pre-existing systems in the bacterial cell. Such changes clearly provide no genetic mechanism for the origin of such cellular features as enzyme specificity, transport activity, regulatory activity, or protein binding affinity. Yet, evolutionists consistently claim that mutations do provide a genetic mechanism for the origin of biological activity and common "descent with modification," and consistently offer the types of mutations described above as examples.

Fitness Cost of Antibiotic Resistance

While mutations that provide resistance to an antibiotic can be considered "beneficial," they often come with a physiological cost (Andersson and Levin, 1999; Maisnier-Patin et al., 2002). In fact, Björkman et al. (2000) conclude that most types of antibiotic resistance will impart some biological cost to the organism. For example, rifampin resistance in *Mycobacterium tuberculosis* (Billington et al., 1999), *E. coli* (Reynolds, 2000), and *Staphylococcus aureus* (Wichelhaus et al., 2002) resulted from mutations to the RNA polymerase that also reduced the relative fitness of most of the mutant strains. Although the biological cost reported by these researchers was generally not severe, it was measurable.

Mutations resulting in clarithromycin resistance in *Helicobacter pylori* reduce the relative fitness of the organism (Björkholm et al., 2001). Resistance to high levels of fluroquinolone by *Salmonella enterica* involves mutations that impart a high fitness cost to the organism (Giraud et al., 2003). And, *fus*A mutations that provide fusidic acid resistance to *Staphylococcus* sp. impose a significant loss of "relative fitness" (Gustafsson et al., 2003; MacVanin et al., 2000). Resistance to actinonin by *S. aureus* also accompanies a dramatic loss of "fitness" resulting in significant growth impairment (Margolis et al., 2000). *E. coli* resistance to streptomycin may dramatically reduce the rate of protein biosynthesis (Zengel et al., 1977). And, some bacteria suspend cell division to minimize their sensitivity to ampicillin (Miller et al., 2004), which clearly reduces the overall fitness of the organism.

This cost of "relative fitness" appears to vary considerably depending on both the organism and the antibiotic. Many of the resistant mutants that have been studied, however, including some of those mentioned above, can subsequently eliminate some or much of the fitness cost by reversion or suppression mutations, which also stabilizes the mutation (Andersson and Levin, 1999; Lenski, 1998; Massey et al., 2001). The degree that a reversion mutation restores fitness probably depends on the location of the mutation and whether a single mutation is able to restore some or all of the wild-type "fitness."

Clearly the fitness of some mutant strains is permanently reduced (sometimes dramatically), and evolutionists have typically ignored such affects in their rush to promote antibiotic resistance as "evolution in the Petri dish." In fact, they often test relative fitness of these mutants under very narrow cultivation parameters, which minimizes the detectable loss of fitness for a given mutation. On the other hand, the fitness loss of some mutants is negligible (esp. following reversion mutations). So, the effect of spontaneous resistance on bacterial fitness appears to vary from mutant to mutant. Thus, creationists have probably tended to over-stress the significance of reduced "fitness" in antibiotic resistant bacteria by applying the concept to all such mutants.

Resistant mutations do impose a biological cost, though, in the loss of pre-existing biological systems and activities. Such biological cost is not compensated by reversion or suppression mutations. Even though such mutations may not always result in detectable levels of reduced "fitness," they stand as the antithesis of common "descent with modification."

Summary

Resistance to antibiotics and other antimicrobials is often claimed to be a clear demonstration of "evolution in a Petri dish." However, analysis of the genetic events causing this resistance reveals that they are not consistent with the genetic events necessary for evolution (defined as common "descent with modification"). Rather, resistance resulting from horizontal gene transfer merely provides a mechanism for transferring pre-existing resistance genes. Horizontal transfer does not provide a mechanism for the origin of those genes. Spontaneous mutation does provide a potential genetic mechanism for the origin of these genes, but such an origin has never been demonstrated. Instead, all known examples of antibiotic resistance via mutation are inconsistent with the genetic requirements of evolution. These mutations result in the loss of pre-existing cellular systems/activities, such as porins and other transport systems, regulatory systems, enzyme activity, and protein binding. Antibiotic resistance may also impart some decrease of "relative fitness" (severe in a few cases), although for many mutants this is compensated by reversion. The real biological cost, though, is loss of pre-existing systems and activities. Such losses are never compensated, unless resistance is lost, and cannot validly be offered as examples of true evolutionary change.

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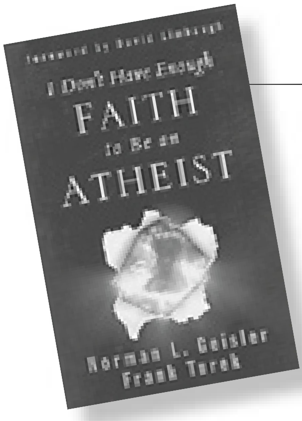

Book Review

I Don't Have Enough Faith to Be an Atheist

by N.L. Geisler and F. Turek

Crossway Books, Wheaton, IL. 2004, 447 pages, $16.00.

Which requires the believer to have more faith, Christianity or atheism? This is the intriguing question asked by the authors. We often think it takes great faith to believe that the Bible is the true Word of God, that Jesus is God and rose from the dead, and that we are products of intentional design. But authors Geisler and Turek assure us that there really is an abundance of compelling evidence, both from the natural world and from scriptural history, for our faith.

I Don't Have Enough Faith deals with the subject of *apologetics*, arguments in defense or justification of Christianity. At first glance apologetics may seem like a dull, esoteric topic. Indeed, that was the first thought when I picked up the book. Fortunately, initial misgivings were laid aside as I started reading. This book is intended both for laymen and skeptics. The authors' arguments, though logical and compelling, are written with simple language and an engaging style. I agree with David Limbaugh, writing in the Foreword to the book, this "is the best single book I've seen to prepare believers to give the reasons for their faith, and for skeptics who are open to the truth" (p. 7).

Geisler and Turek start by discussing the subject of *truth*. We are present in a postmodern culture where there is no such thing as truth. What is true for you may not be true for me. This leads to new definitions: "Tolerance now means that you are supposed to accept every belief as true!" (p. 46). Geisler and Turek expose this nonsense with clear logic and reason. "Despite the relativism that emanates from our culture, truth is absolute, exclusive, and knowable" (p. 49). People who espouse relativism and pluralism can easily be exposed for they "are just as dogmatic and close-minded as anyone else making truth claims in the public square" (p. 47). While they tell us to be tolerant of the beliefs of others, they are actually intolerant of the Christian's right to believe in absolutes.

The aspect that first attracted me to *I Don't Have Enough Faith* was its presentation of evidence for intentional design in the natural world. This book has as good an introduction as I have seen to the scientific case for intelligent design in the universe. There is not much detail, but the authors give an excellent overview of the evolution versus design topic.

Geisler and Turek use the acronym *SURGE* to show that compelling evidence exists for the universe having a beginning. "If the universe had a beginning, then the universe had a cause [a designer]" (p. 75). The *S* in *SURGE* stands for the Second Law of Thermodynamics which in simple form states that "nature tends to bring things to disorder" (p. 77). This law implies that "the universe cannot be eternal, because if it were, we would have reached complete disorder (entropy) by now" (p. 77). *U* stands for the expanding universe, and *R* stands for the cosmic background radiation. These are two strong pieces of evidence for the Big Bang, which most cosmologists say is the starting event of the universe. G stands for galaxy formation which can only be explained by careful tweaking of the explosion and expansion of the universe. *E* is for Einstein's Theory of General Relativity which "demands an absolute beginning for time, space, and matter" (p. 84).

Proponents of a literal six-day creation will not like Geisler and Turek's apparent acceptance of the Big Bang and the extreme age of the universe. They do not dwell on this topic, however, and state that "the more important point is not *when* the universe was created but *that* it was created" (p. 165). They agree that "the age of the universe is an interesting theological question," but "we must be sure not to obscure the larger point that this creation requires a Creator" (p. 165).

Geisler and Turek deal with the question frequently asked by skeptics: If God created the universe, who made God? The answer is clearly stated, "No one made God… As an eternal being, God did not have a beginning, so he didn't need a cause" (p. 92).

The book next describes the Anthropic Principle, the idea that "the universe is extremely fine-tuned (designed) to support human life here on earth" (p. 96). Geisler and Turek briefly describe a few of the more than 100 very narrowly specified constants that point to an intelligent designer. "The extent of the universe's fine-tuning makes the Anthropic Principle perhaps the most powerful argument for the existence of God" (p. 105).

Geisler and Turek deal with the question of the initial appearance of life on earth. "The supreme problem for Darwinists is explaining the origin of the *first* life" (p. 115). Believers in the naturalistic origin of life state that the first living cell was very simple, so simple that it could have formed spontaneously from chemicals. We now know, however, that the "simplest life consists of amazing specified complexity..." (p. 135). And the only source of specified complexity (information) is intelligence. Nothing as complex as a living cell will arise spontaneously.

Geisler and Turek address the concept of *macroevolution*, or (as they put it) "from the goo to you via the zoo" (p. 137). After dealing with such issues as the fossil record and the development of new features in living organisms, the authors conclude that "there's not only a lack of evidence for macroevolution; there's positive evidence that it has not occurred" (p. 155).

The last half of the book covers apologetics from the viewpoint of spiritual and historical evidence for God. The authors deal with moral or natural law. "The fact that a moral standard has been prescribed on the minds of all human beings points to a Moral Law Prescriber [God]" (p. 170). Miracles are acts of God that have occurred at certain points in history "to confirm a message from God" (p. 217).

Geisler and Turek state that we have accurate copies of the original New Testament documents, and that we have numerous verifications of Biblical events and people from historical (non-Christian) sources. Considerable space is devoted to the Resurrection, the key event related to our Christian faith. Specific arguments scholars have used in attempts to refute the Resurrection are logically rebutted. Geisler and Turek argue that Jesus' claim to be God was confirmed by (a) his fulfillment of Old Testament prophecies, (b) his sinless life and miraculous deeds, and (c) his accomplishment of his Resurrection. Jesus taught that the Bible is the Word of God, a claim only he could make and verify.

In conclusion, the authors argue that atheism and other non-Christian belief systems are not reasonable based on the evidence. The message to readers is boldly proclaimed: Accept Christianity as the one true religion. "It takes too much faith to believe anything else!" (p. 388).

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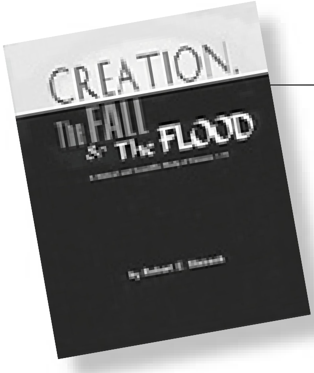


Book Review

Creation, the Fall & the Flood; A Biblical and Scientific Study of Genesis 1–11 by Robert E. Slabach

Evangel Press, Nappanee, IN. 2003, 84 pages, $8.00.

This book was written to fill what is a large gap in the literature, a lesson booklet that covers the general subject of creation. It was developed from author Slabach's decade of experience teaching creation in Sunday School classes at various churches including the First Mennonite Church of Middlebury, IN. Little else is available that is designed specifically for this market.

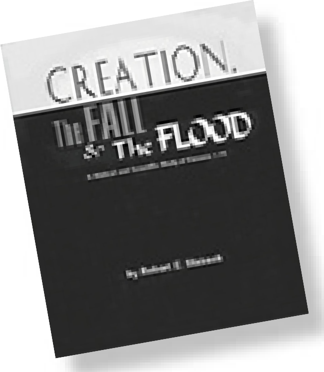
The author is well qualified to write this monograph. He has been actively involved for many years in the creation movement. He has a B.S. in biology from the University of Indianapolis and further training as a respiratory therapist. Slabach also studied French in Brussels, Belgium and worked in agriculture in Chad.

While intended for class study, this work is an excellent readable review of the evidence for creation and the problems of evolution. It is also a basic introduction to many of the current issues related to the creation-evolution controversy for anyone interested in the topic. Illustrated with a number of very helpful diagrams and charts, it covers a lot of material that young people (and many adults as well) are exposed to daily.

One of the more positive aspects about the book is the broad range of materials it covers. Included are controversies about if human tails, gill slits, vestigial organs, common explanations for life's diversity, Big Bang cosmology, and human life spans. The text not only covers the orthodox creation view but also includes discussion of the day-age position, progressive creation, and intelligent design. There is a list of recommended readings and a summary of the work of several major creationist organizations.

As would be expected from a brief review of a topic such as creation on which thousands of books have been written, the author does not go into detail on the issues and controversies. He deals with many basic questions about the Bible and science such as "where did Cain get his wife?" The study also reviews basic genetics and biology to help the reader understand creationist arguments. In summary, this is an excellent introduction to a wide variety of issues related to the origins debate that should at the least give students and others a good overview about some of the current thinking on general topics. This book is a highly recommended introduction to the controversy for both neophytes and seasoned researchers.

Jerry Bergman



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Creation, the Fall & the Flood; A Biblical and Scientific Study of Genesis 1–11 by Robert E. Slabach

Evangel Press, Nappanee, IN. 2003, 84 pages, $8.00.

Author Slabach is a respiratory therapist, a strong creationist, and a personal friend. Before moving from Indianapolis, Bob Slabach led a local creation group, the Indiana Creation Science Association. This small book has 13 lessons for group or individual study of creation. It would nicely fit a quarter year of weekly sessions. Study questions are included along with a pre and post test to measure the impact of the book. A surprisingly large amount of detail is presented. Some of the topics include the creation week, the Fall, the Flood, the geologic column, and the gospel. The book content is highly accurate and thoughtful. For example a caution is expressed regarding Intelligent Design since "ID is compatible with descent from a common ancestor" (p. 29). Concerning Galileo's conflict with the church, "Back in Galileo's day they were taking [biblical] texts that were meant to be poetic and making them have a literal meaning [geocentricism]. In our day, texts meant to be literal [Genesis 1, 2] are interpreted to have a poetic meaning so it will fit evolution" (p. 13). It is suggested that the word for gopher or cypress wood in Noah's Ark may refer to laminated wood which would give agreat strength (p. 48). This book should be considered by those needing a concise introduction to Creation issues.

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Notes from the Panorama of Science

Sensory Bristles of *Chrysomya rufifacies*

The intricacy of each living entity on Earth reflects the beauty of God's intimate love with His creation. This is noted from the complexity of the largest organisms on the Earth to the minutest forms of life. Here I present scanning electron microscope images of the sensory bristles of a very small creature, *Chrysomya rufifacies.* This is a blow fly recently established in Southern California, Arizona, Texas and the southeastern United States, having come from Central and South America (Baumgartner 1986).

This species is economically significant because its larvae often parasitize livestock and even the wounds and lesions of humans (Byrd and Butler 1996). The adult fly often lays its eggs in living flesh (Snow 1974, p. 65), and is thus considered not only a parasite, but also the cause of myiasis (the invasion of living tissue or organs by the immature stage [maggots] of flies). More frequently, however, eggs are laid on decaying flesh (Wells, et al. 2001).

Adult flies have strong predatory avoidance because of the massive array of sensory organs covering their bodies (Figure 1) (Lanham 1964, p. 88). These flies use movable, tactile hairs and bristles that are present (and "precisely situated", according to Wigglesworth 1966, p. 199) on the body surface and the appendages. Bristles are termed microchaetes (small) and macrochaetes (large) depending upon their size (Korey et al. 2001, Sawamoto et al. 1999, Tilney et al. 1998). Each macrochaete on the surface of the fly has a ball and socket base joined to the cuticle (See Figures 2, 3a). This design provides the fly with the ability to detect the slightest breeze by way of mechanical stimulation.

Additionally, smaller sensors (hairs) are arranged in precise longitudinal rows across the organism's thorax and abdomen (Figure 4) (Lanham 1964, p. 90). These hairs are anchored in separate disks of the cuticle, which are thin and flexible. Thus, they have the ability to shift their position, giving the fly information about wind currents and atmospheric conditions. When the bristle or hair is moved by a disturbance in the air, the base is pressed against a sensory receptor cell, which is stimulated, and alerts the fly (Wigglesworth 1964, p. 191). Supporting the bristle cell are a socket cell and a neuronal cell extending into the bristle cell shaft. These cells in turn are situated near a glial cell dedicated to communicate impulses to the nervous system of the fly (Korey et al. 2001).

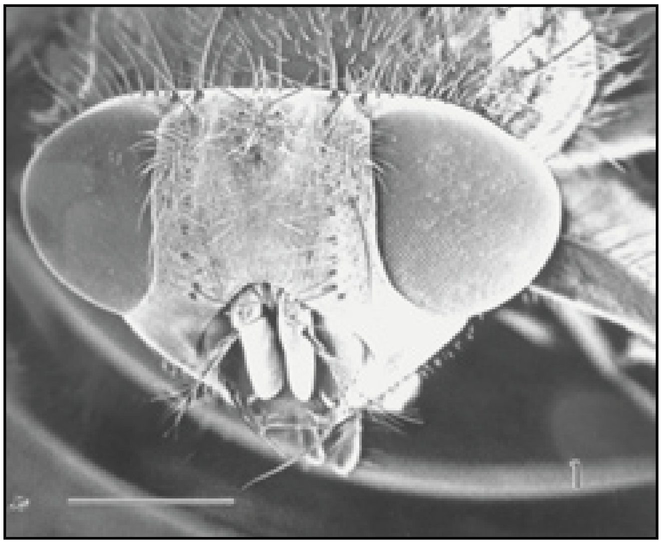


Figure 1. *Chrysomya rufifacies,* **adult fly, showing head and eyes. Note extensive covering of bristles. Scale bar = 1 mm.**

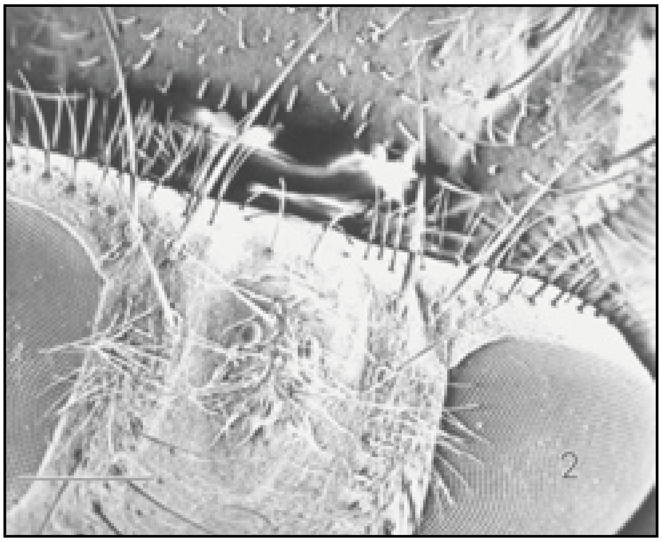


Figure 2. Close-up of eye showing massive array of large bristles (macrochaetes) and small bristles (microchaetes). These bristles sense movement, air currents and in some instances, chemicals. Scale bar = 0.5 mm.

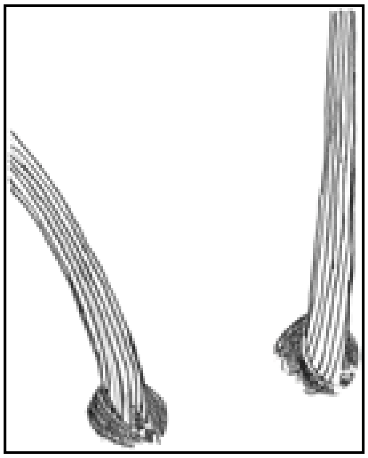


Figure 3. Extreme close-up of macro and microchaetes (see illustration of two macrochaetes in 3b at right). Each bristle has a ball and socket joint at the surface of the cuticle. The bristle is hollow inside with a neuron for sensing. Scale bar = 100 microns.

A complex array of actin bundles and microtubules assists in the extension of the bristle during fly development. Once each bristle is extended, a cuticle covering is secreted and the actin within is degraded, leaving a hollow tube within which the sensory fiber extends (ibid). Stimulation travels along this neuronal fiber to the fly's central nervous system using electrical impulses (Wigglesworth 1964, p. 190), but the sensory cells found at the bases of hairs on flies legs are stimulated mechanically via stretching and bending (Lanham 1964, p. 90).

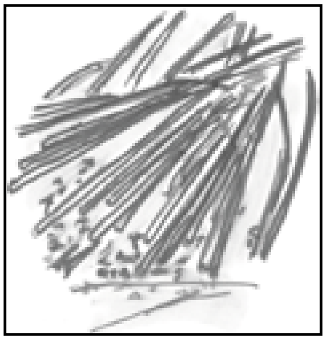


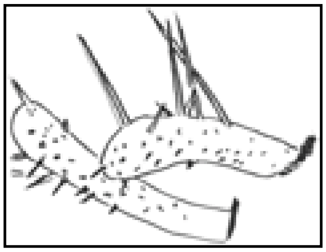
Figure 4. Rows of hairs on abdomen (see illustration of body hairs in 4b at right). These hairs on the body of the fly relay important information about body position and wind currents. Scale bar = 100 microns.

Many of the most delicate sensory hairs on the fly are found on the wings. These provide information that is used to control movement in flight (Cheeseman 1992, p. 20). The role of some of these sensors in insect flight has been discussed recently (Manning 2003).

In addition to these mechanical receptors, some bristles, probes, and even antennae serve as chemoreceptors (Figures 5,6), which can detect particular chemicals and compounds in the air (Lanham 1964, p. 91). This becomes important to guide a fly toward open or decaying flesh upon which to feed and lay eggs. Similar sensory receptors on the legs and antenna can resonate at certain frequencies to distinguish sounds—allowing the fly to even "hear."

As disgusting as this lowly creature may be to us, it is obviously well endowed with a sophisticated array of sensors, which allow it to thrive, and even expand into new territories, such as the southwestern U.S. As a cause of myiasis in livestock and humans, it can be troubling, but far greater is its helpful role in the decomposition of dead organisms back into the soil. It is so effective at this task that it is known to arrive on a body within 10 minutes after death (Byrd et al. 1996). Thus detail in even these blow flies provides support

Figure 5. Sensory probes on proboscis, or mouthparts of fly (see illustration of sensory probes in 5b at right). Each of these two tongue-like projections is a chemical sensor for the fly. Scale bar = 50 microns.



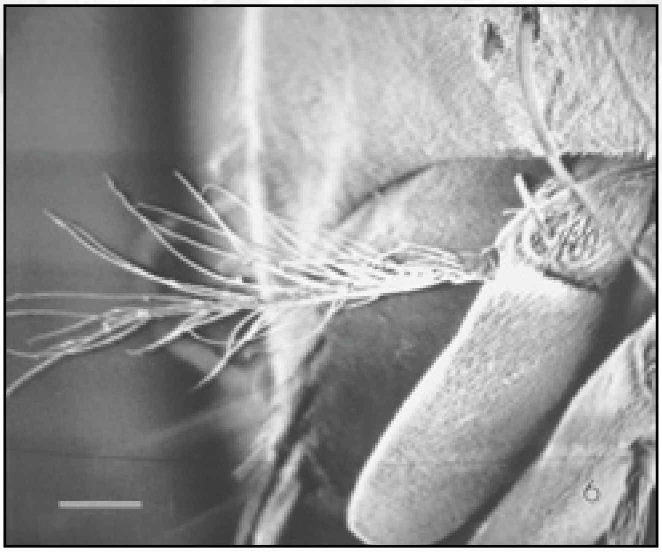
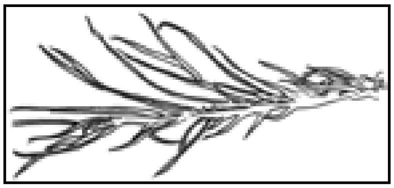


Figure 6. Antenna assembly (see illustration of antennae structure in 6b at right). This antenna can serve as a chemical or even an auditory sensor for the fly. Scale bar = 100 microns.



for Divine design in nature.

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The Origin of Grass

We are told that grasses evolved from ancestral diocotylenonous plants which changed into ancestral monocots and then finally evolved into grass (Sikula, 1979, p. 16). The oldest known macrofossils of grass are assigned an evolutionary "date" of 57 million years before present (BP) and the oldest known fossil reed mace plants are put at 38 million years (Jacobs, Kingston, and Jacobs, 1999). I am using these non-scientific "dates" to show that the evolutionary argument for grass origins can be refuted even if one uses such dates. Undisputed fossil grass pollen comes from strata put at 65–120 million years BP, but pollen that is strikingly like extant lily plants is found in strata assumed to be 160 million years old. This would put modern lily plants into rocks considered to be Jurassic.

Non-flowering plants such as horsetails, cycads, ginkgos, gnetales, clubmosses, and gymnosperms were also present. Most of these non-flowing plants form part of the present landscape but the living lily plants are clearly distinct from all of them—both then and now and both in structure and life style. There is nothing in the fossils capable of having evolved into modern lily plants which shows that evolution theory is bankrupt.

Then there are also some fossil plants which are now extinct such as seed ferns and bennettitales. But these and other extinct fossil plants are likewise quite distant from living lilies in particular and from other non-angiosperms in general. The lily plants at the supposed 160 million year level would have had to evolve 10 million years or more earlier—perhaps back at 170 million years BP.

Even more unwelcome for the evolutionary model is the discovery of other monocot angiosperms in strata labeled 220 million years BP. This would put them in the supposed Triassic time period and there would be even less of a prospect of finding anything good enough to have produced these other angiosperms from a pre-existing non-angiosperm source. Some of the non-angiosperms plants mentioned above either did not exist in Triassic strata or were themselves just getting started (according to evolution). The oldest known fossil water lilies (different than the true lilies) are at 125 million years which puts them back into Jurassic times as well (Brown, 2002). The fossil water lily had 99 percent of the features found in modern water lilies and all of the features of angiosperm plants. This would mean they were remarkably stable for all of this supposed time. It also means they were modern, just like the lily plants of the Jurassic. And the gap is just as great now as back then between water lilies and their supposed, non-angiosperm "ancestors."

The ancestor of dicotyledonous plants would need to go much farther back than 160 million years and perhaps even farther back than 200 million year to go through the requisite evolutionary changes. This would make the case for angiosperm evolution seriously inadequate. If one chooses instead to believe that these changes all occurred during Cretaceous "times", then the water lilies at 125 million years, the reed mace plants at 38 million years, the grasses at 65–120 million years, the modern angiosperm genera at 57 million years, and the lily plants at 50 million years all remained very stable over vast time periods up to the present. There would not have been enough time for all these evolutionary changes to have occurred in the Cretaceous. So in either case the evolution theory is seriously flawed.

Acknowledgements

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Errata

The following errors appeared in the December 2004 *CRSQ*:

Page 201, Figure 11: The note should read, "View towards the southwest across the Hualapai Plateau..."

Page 204, first column: A sentence reads, "Since we find similar structures at the White Wash Cliffs and Hualapai Plateau..." The word "White" should be "Grand."

Why Creationists Ought to Care about Biblical Chronology

Creationists face an impending crisis of credibility in the marketplace of ideas. When defending the reliability and historicity of the Bible against the attacks of agnostics and evolutionists or when addressing their doubts and honest questions, we tend to dwell either on the Flood or the earliest history of the origin of the universe, our planet, and life as we know it. This is the part of history covered by only the first ten chapters. What do we have to say about the rest of the Book? What about the rest of history?

Do we really expect skeptics to regard our claims about the remotest periods as quite reliable without a strong case for our contention that the Bible also accurately relates the history of more recent periods? It would be strange indeed for us to concede that the lengthy story of the Exodus and Conquest, for instance, might be pure fable, fiction, or fantasy, while dogmatically asserting that the sketchier "account of origins in Genesis is a factual presentation of simple historical truths" [CRS Statement of Belief, point 1].

By the same token, if skeptics are convinced that even the more recent Old Testament history is only make-believe, then no one should be astonished at their refusal to accept creationist claims about the origin of stars and sedimentary rock. Yet how and where do we bridge this gap between the Flood and New Testament times for them? Our general reluctance to address this issue may not amount to a concession, but we still ought to be embarrassed by our neglect of this challenge.

Generally speaking, this difficulty seems to fly below the radar of both creationists and those who question or oppose us. It is as though we hope a cogent case for the historicity of the earliest chapters of Genesis automatically validates all that follows. The notion that insurmountable difficulties with well-covered periods of verifiable history can cast doubt on the less readily verifiable coverage of earlier periods does not deter us from our habitual strategy. Our opponents typically know very little about biblical chronology, so they tend to join the battle just about where we are camped.

It may be high time to prepare for battle on another front, one where we ought to be even more confident of victory. The historicity issue will not just go away, and skeptics are all too happy to take advantage of any opportunity to embarrass us, once one is discovered. This one has certainly already been noticed. Look at popular magazines at Christmas and Easter time for cover stories that feature world class scholars attacking the historicity of the Bible. They will probably not be covering theories of the Flood or origins. (The dinosaur stories come at other times of the year.)

The interests and research directions of creationists can hardly be expected to converge on any single area, and current research in the typical fields seems helpful and important, but this crisis calls for a healthy interest in biblical chronology as well. It is all about dating events mentioned in the Bible and relating them to more or less accurately datable artifacts or events of established secular history. Sound chronology takes such events out of the realm of myth and earns them their rightful place in what everyone can agree is true history.

No matter how successful we may be in finding the required chronology, we may be sure that some skeptics will never be convinced or admit that we are right. On the other hand, advances on this front should weaken the onslaught of our critics engaged on the old front, where the battle is over origins and what allegedly happened much longer ago and maybe somewhere deep in outer space. Both camps ought to be humbled by the challenge of fathoming such remote events purely through secular studies. After recognized success in synchronizing the Bible with better-known history, we could press ahead with improved credibility and renewed confidence that our record of even those remotest times has really earned our trust in its truthfulness and divine inspiration.

The work of Edwin R. Thiele nearly sixty years ago provides an encouraging example of progress in this field. At that time, any attempt at constructing a credible chronology of the kings of Judah and Israel seemed "doomed to failure" (Thiele, 1983, p. 15). He wrote, "Every Old Testament scholar knows of the many chronological details in the biblical record that seem to be in hopeless disagreement with each other and with the chronological pattern of neighboring states. In spite of almost endless research and discussion, biblical chronology remained in a state of almost hopeless confusion" (Thiele, 1983, p.33). And yet, he successfully solved the puzzle, showing that the biblical details are both internally consistent and in harmony with secular data after all. It was only a matter of properly understanding various systems for chronicling reigns and when and where the systems were in use.

Few in our day know about Thiele or his work, but his success dooms to failure any modern attempt to paint the biblical record of the divided kingdom as pure fantasy. Thanks to Thiele, it can now be shown that it is real history with a verifiable chronology. Unfortunately, this advantage to our side ended where he left off, working back in time, at the start of the reigns of Rehoboam in Judah and Jeroboam I in Israel in 931/30 B.C. (Thiele, 1983). Earlier biblical events are still fair game to those who want to characterize the Bible as mostly a book of myths.

The part of the Bible in play is significant and well worth our concern, not only because thousands of years of ancient history hang in the balance, but also because that history lays the foundation for key doctrines of our faith. As far as the creationist movement is concerned, the Creation, Fall, Flood, founding of Israel, escape from bondage in Egypt, and conquest of Canaan all remain quite disconnected from the well-established chronology that Thiele elaborated and elucidated.

This neglect cannot be excused because of a lack of chronological data in the biblical narratives that cover this ancient period. In fact, the Bible is rich in such details. Based on Genesis alone, one chronology by a leading creationist includes 37 exact dates relative to Creation, stretching from that event to the death of Joseph 2,308 years later (Morris, 1976). The big problem with this Morris chronology is that it is floating. That is, it has no absolute (B.C.) dates that can be synchronized with events recognized as real history in the secular world at large. It is the kind of chronology that skeptics can easily dismiss as pure story telling.

Since Morris published his chronology, the creationist movement has matured, and much more has been published from a "young-earth" creationist perspective, but no widely accepted absolute date for the Creation, Flood, or any other event listed in the Morris chronology has yet emerged. In a recent creationist book on the age of the earth, for instance, one author says, "Yet, a literal interpretation of Scripture and much scientific evidence indicates that the Creation of the earth, the solar system, and the universe occurred a few thousand years ago" (Vardiman, 2000, p. 1). Another contributor suggests that the time since creation is currently "6000–10,000 years" (Chaffin, 2000, p.316). A recent creationist article concludes with a mention of "the 6,000-year timescale of Scripture" (Humphreys, 2002, p. iv). The latter figure is surely an echo of the famous 4004 B.C. date for the Creation put forth by James Ussher in the seventeenth century (Morris, 1976), but in modern usage it appears to survive as merely a rough estimate.

One can find exceptions to the general creationist reluctance to agree on precise dates before the first millennium B.C. Two CRSQ articles written years ago (Niessen, 1982; Vaninger, 1985) did offer exact dates in this early period. Much more recently, an excellent synopsis of creationist thought puts Abraham at about 2000 B.C., the Flood exactly 342 years earlier, and the Creation 1,656 years before the Flood, that is, at about 4000 B.C. (Wise, 2002).

While these three examples are all in excellent agreement with each other, the disappointing failure to demonstrate any credible fit with currently available secular data probably explains the lack of creationist consensus or widespread confidence in the accuracy of these dates. If our dates are correct, we ought to find new pieces of the puzzle all fitting in nicely without being forced. People of great faith may not require any such corroboration or substantiation, but generally speaking, the more of it we can find, the more credible our message to people of little faith.

It may appear, therefore, that the following rather gloomy assessment by Henry Morris over a quarter of a century ago still stands to this day: "Although a great number of men have labored diligently in the attempt to formulate a complete chronology of the Bible, the very fact that they all disagree with each other demonstrates that the problems are serious and the issue still unsettled" (Morris, 1976, pp. 42–43). Indeed, William Hales in 1830 listed well over a hundred different "opinions" about the date of Creation ranging from 6984 to 3716 B.C. (Aardsma, 2000). Given this degree of uncertainty, one may well wonder if creationists can possibly know anything at all about the age of the universe, even in the light of our written revelation from its Creator. Can even our rough estimates be credible?

If this sad state of affairs seemed likely to endure, it might be foolish to call attention to it, daring the skeptics to take advantage of our weakness in this area. Fortunately, we can point to a fairly recent breakthrough perhaps even more significant than the one due to Thiele, one that has yielded more viable dates for the Creation, Flood, and other ancient events of biblical history (Aardsma, 1998). It is based directly on a study of chronological data in the Bible and assumes a high view of Scripture, but what keeps it from merely adding to the pile of other such chronologies that do not agree with each other?

The key difference is that this one takes a high view of secular sources of data as well, and these are confirming its correctness as more and more synchronisms are discovered. The fact that so many biblical chronologies disagree does not prove that they are all wrong. Yes, it might be true that not even one of them is correct, but it is also quite possible that one correct chronology has been lumped together with all the rest. Aardsma's candidate is passing its tests. The puzzle pieces he found are fitting in nicely.

Three key dates in his proposed chronology and just one outstanding synchronism are mentioned here as an incentive to further reading. The Creation was completed in 5176±26, the Flood began in 3520±21, the Exodus took place in 2447±12, and these are all B.C. dates. Excellent, datable evidence for the Exodus has been found in the form of pottery shards scattered along the route, allowing discovery of what appears to be the real Mt. Sinai (Aardsma, 1995b).

The Exodus evidence was reported ten years ago but not immediately recognized as such, probably because the dates seemed far too old, but according to the Aardsma chronology, they are just right. Although some synchronisms discovered by Aardsma may seem less exciting, they combine to present a significant challenge to critics. They also involve more than archaeological evidence, ranging over a wide variety of research topics, such as ice cores, lake bottom varves, and pollen counts in carbon-dated peat moss samples.

The book (Aardsma, 1995a) is an excellent place to begin further reading, but a more recent article in a secular publication (Aardsma, 2001) provides a nice overview of the Aardsma breakthrough. Unfortunately, space here does not allow the full case for his chronology to be presented fairly. Many creationists will certainly find it controversial, but some of these may be surprised how difficult it is to find fault with his reasoning upon closer examination.

Even if some of Aardsma's ideas may eventually prove to be wrong or less than satisfactory, creationists would be well advised to understand his case, seriously consider what he has discovered so far, and search for additional confirmation or appropriate corrections, if any can possibly be found. Any other creationists actively seeking verifiable links between secular and biblical history also deserve our encouragement and a fair hearing of their successes.

In the 1963 preface to the second edition of his book, Thiele described two kinds of criticism received since he first published his chronology of the divided kingdom (Thiele, 1983, p. 20):

> On the one hand, certain members of liberal groups do not regard it possible for these numbers to have been handed down through so many years and so many hands "without often becoming corrupt." On the other, a few vigorously outspoken members of conservative groups view with horror any questions that may be raised concerning the absolute accuracy of any details in the Old Testament chronological data. ... Both categories have prejudged the questions at issue. ... Scholars impelled solely by a sincere desire for truth and an earnest effort to find it, and religious believers who find in God the very embodiment of truth and in the Hebrew Scriptures its most absolute expression, find little difficulty in putting aside early notions and accepting new light whenever and however it may come.

His insightful assessment of the intellectual climate of his day probably still applies to ours. May at least some of today's scholars, like Aardsma, accept the exciting challenge of extending a sound biblical chronology all the way back to the Creation, relating it convincingly to the rest of real history, and applying it effectively to apologetics. We ought to care about this.

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Manuscripts shall be computer-printed or neatly typed. Lines should be double-spaced, including figure legends, table footnotes, and references. All pages should be sequentially numbered. Upon acceptance of the manuscript for publication, an electronic version is requested (Word, WordPerfect, or Rich Text Format), with the graphics in separate electronic files. However, if submission of an electronic final version is not possible for the author, then a cleanly printed or typed copy is acceptable.

Submitted manuscripts should have the following organizational format:

1. Title page. This page should contain the title of the manuscript, the author's name, and all relevant contact information (including mailing address, telephone number, fax number, and e-mail address). If the manuscript is submitted by multiple authors, one author should serve as the corresponding author, and this should be noted on the title page.

2. Abstract page. This is page 1 of the manuscript, and should contain the article title at the top, followed by the abstract for the article. Abstracts should be between 75 and 200 words in length and present an overview of the material discussed in the article, including all major conclusions. Use of abbreviations and references in the abstract should be avoided. This page should also contain at least five key words appropriate for identifying this article via a computer search.

3. Introduction. The introduction should provide sufficient background information to allow the reader to understand the relevance and significance of the article for creation science.

4. Body of the text. Two types of headings are typically used by the *CRSQ*. A major heading consists of a large font bold print that is centered in column, and is used for each major change of focus or topic. A minor heading consists of a regular font bold print that is flush to the left margin, and is used following a major heading and helps to organize points within each major topic. Do not split words with hyphens, or use all capital letters for any words. Also, do not use bold type, except for headings (italics can be occasionally used to draw distinction to specific words). Italics should not be used for foreign words in common usage, e.g., "et al.", "ibid.", "ca." and "ad infinitum." Previously published literature should be cited using the author's last name(s) and the year of publication (ex. Smith, 2003; Smith and Jones, 2003). If the citation has more than two authors, only the first author's name should appear (ex. Smith et al., 2003). Contributing authors should examine this issue of the *CRSQ* or consult the society's web site for specific examples as well as a more detailed explanation of manuscript preparation. Frequently used terms can be abbreviated by placing abbreviations in parentheses following the first usage of the term in the text, for example, polyacrylamide electrophoresis (PAGE) or catastrophic plate tectonics (CPT). Only the abbreviation need be used afterward. If numerous abbreviations are used, authors should consider providing a list of abbreviations. Also, because of the variable usage of the terms "microevolution" and "macroevolution," authors should clearly define how they are specifically using these terms. Use of the term "creationism" should be avoided. All figures and tables should be cited in the body of the text, and be numbered in the sequential order that they appear in the text (figures and tables are numbered separately with Arabic and Roman numerals, respectively).

5. **Summary.** A summary paragraph(s) is often useful for readers. The summary should provide the reader an overview of the material just presented, and often helps the reader to summarize the salient points and conclusions the author has made throughout the text.

6. **References.** Authors should take extra measures to be certain that all references cited within the text are documented in the reference section. These references should be formatted in the current *CRSQ* style. (When the *Quarterly* appears in the references multiple times, then an abbreviation to *CRSQ* is acceptable.) The examples below cover the most common types of references:

Robinson, D.A., and D.P. Cavanaugh. 1998. A quantitative approach to baraminology with examples from the catarrhine primates. *CRSQ* 34:196–208.

Lipman, E.A., B. Schuler, O. Bakajin, and W.A. Eaton. 2003. Single-molecule measurement of protein folding kinetics. *Science* 301:1233–1235.

Margulis, L. 1971a. The origin of plant and animal cells. *American Scientific* 59:230–235.

———. 1971b. *Origin of Eukaryotic Cells*. Yale University Press, New Haven, CT.

Hitchcock, A.S. 1971. *Manual of Grasses of the United States*. Dover Publications, New York.

Walker, T.B. 1994. A biblical geologic model. In Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism* (technical symposium sessions), pp. 581–592. Creation Science Fellowship, Pittsburgh, PA.

7. **Tables.** All tables cited in the text should be individually placed in numerical order following the reference section, and not embedded in the text. Each table should have a header statement that serves as a title for that table (see a current issue of the *Quarterly* for specific examples). Use tabs, rather than multiple spaces, in aligning columns within a table. Tables should be composed with *14-point type* to insure proper appearance in the columns of the *CRSQ*.

8. **Figures.** All figures cited in the text should be individually placed in numerical order, and placed after the tables. Do not embed figures in the text. Each figure should contain a legend that provides sufficient description to enable the reader to understand the basic concepts of the figure without needing to refer to the text. Legends should be on a separate page from the figure. All figures and drawings should be of high quality (hand-drawn illustrations and lettering should be professionally done). Patterns, not shading, should be used to distinguish areas within graphs or other figures. Unacceptable illustrations will result in rejection of the manuscript. Authors are also strongly encouraged to submit an electronic version (.cdr, .cpt, .gif, .jpg, and .tif formats) of all figures in individual files that are separate from the electronic file containing the text and tables.

Special Sections

Letters to the Editor:

Submission of letters regarding topics relevant to the society or creation science is encouraged. Submission of letters commenting upon articles published in the *Quarterly* will be published two issues after the article's original publication date. Authors will be given an opportunity for a concurrent response. No further letters referring to a specific *Quarterly* article will be published. Following this period, individuals who desire to write additional responses/comments (particularly critical comments) regarding a specific *Quarterly* article are encouraged to submit their own articles to the *Quarterly* for review and publication.

Editor's Forum:

Occasionally, the editor will invite individuals to submit differing opinions on specific topics relevant to the *Quarterly*. Each author will have opportunity to present a position paper (1000 words), and one response (500 words) to the differing position paper. In all matters, the editor will have final and complete editorial control. Topics for these forums will be solely at the editor's discretion, but suggestions of topics are welcome.

Book Reviews:

All book reviews should be submitted to the book review editor, who will determine the acceptability of each submitted review. Book reviews should be limited to 1000 words. Following the style of reviews printed in this issue, all book reviews should contain the following information: book title, author, publisher, publication date, number of pages, and retail cost. Reviews should endeavor to present the salient points of the book that are relevant to the issues of creation/evolution. Typically, such points are accompanied by the reviewer's analysis of the book's content, clarity, and relevance to the creation issue.

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Creation Research Society

History—The Creation Research Society was organized in 1963, with Dr. Walter E. Lammerts as first president and editor of a quarterly publication. Initially started as an informal committee of 10 scientists, it has grown rapidly, evidently filling a need for an association devoted to research and publication in the field of scientific creation, with a current membership of over 600 voting members (graduate degrees in science) and about 1000 non-voting members. The Creation Research Society Quarterly has been gradually enlarged and improved and now is recognized as the outstanding publication in the field. In 1996 the *CRSQ* was joined by the newsletter Creation Matters as a source of information of interest to creationists.

Activities—The society is a research and publication society, and also engages in various meetings and promotional activities. There is no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund and research center are maintained to assist in such projects. Contributions to the research fund for these purposes are tax deductible. As part of its vigorous research and field study programs, the Society operates The Van Andel Creation Research Center in Chino Valley, Arizona.

Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the Statement of Belief.

Statement of Belief—Members of the Creation Research Society, which include research scientists representing various fields of scientific inquiry, are committed to full belief in the Biblical record of creation and early history, and thus to a concept of dynamic special creation (as opposed to evolution) both of the universe and the earth with its complexity of living forms. We propose to re-evaluate science from this viewpoint, and since 1964 have published a quarterly of research articles in this field. All members of the Society subscribe to the following statement of belief:

1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.
2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.
3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.
4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.