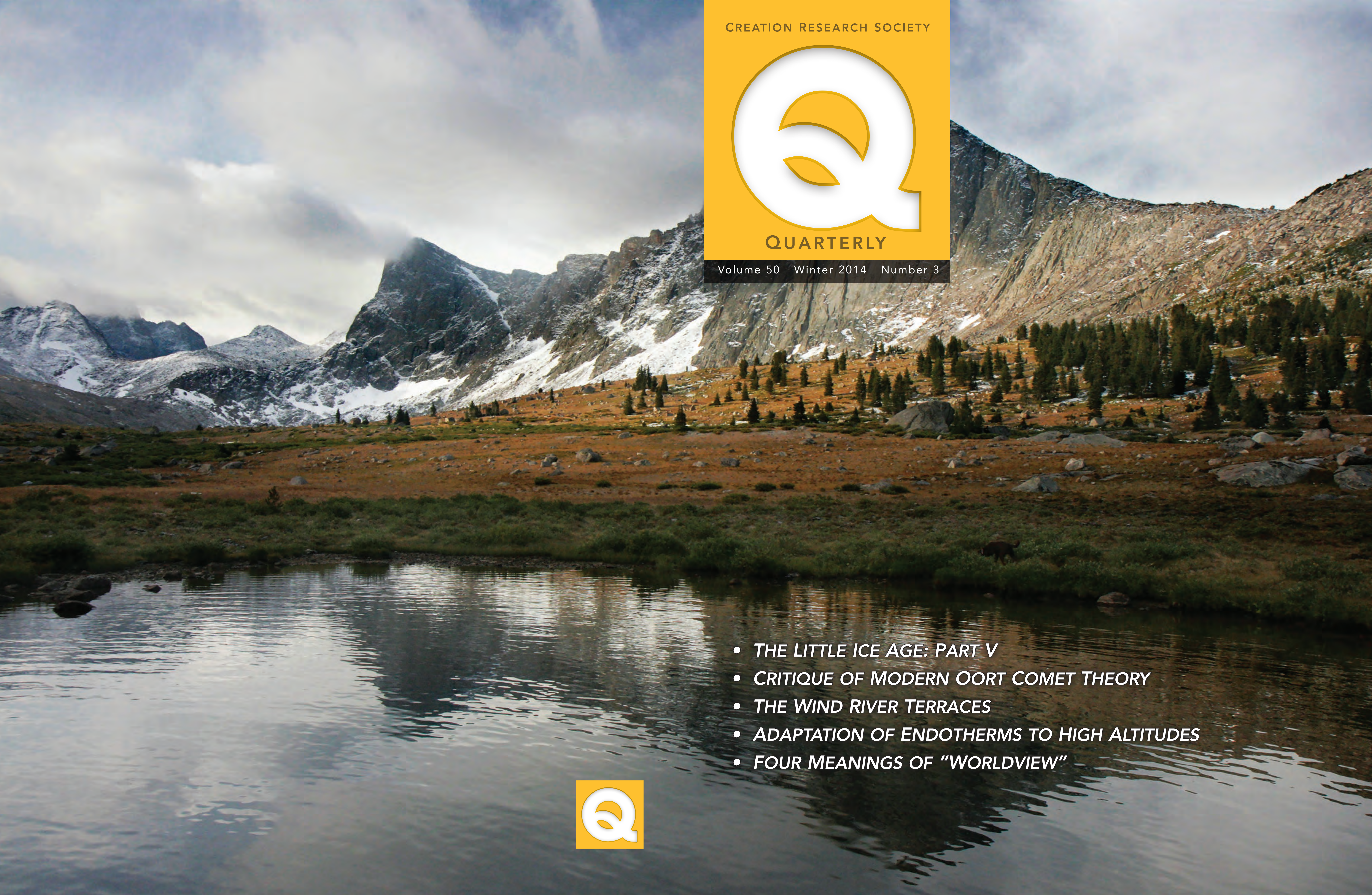

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QUARTERLY

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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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Adaptation of Endotherms to High Altitudes

Jean K. Lightner*

Abstract

God created His creatures to reproduce and fill the earth. As they do so, numerous challenges are faced in different environments, requiring creatures to adapt. High altitudes present serious challenges for endotherms, including a reduced partial pressure of oxygen. Through a variety of mechanisms, many creatures adapt quite successfully to this hytpoxia. Adaptation includes immediate, short-term responses followed by longer-term, more sustainable responses. For mammals and birds that have lived for generations at high altitudes, genetic changes have been identified, reflecting a more permanent response. The neo-Darwinian model does not account for the observed phenotypic and genetic changes. Instead, this adaptation is clear evidence of the care God bestows upon His creatures, even in our current fallen world.

Introduction

The Bible provides an eyewitness account of the origin of life, given to us by the very Author of life Himself. From it we gain valuable information regarding the history of life and its purpose. Animals were created according to their kinds and directed to reproduce and fill the earth (Genesis 1:20–22, 24–25). Disease and death entered the world at the Curse (Genesis 3), and a severe population bottleneck occurred at the Flood (Genesis 6–8). Yet despite these judgments that serve to remind us of the horridness of sin, God still intended for His creatures to fill and inhabit the earth (Genesis 8:15–17; Isaiah 45:18). He provides for them even in this fallen world (Psalm 147:9).

As animals have reproduced and filled the earth, they have had to adapt to different environmental niches. For example, we can see hares in the desert, hares in the arctic, and hares in other environments, each of which poses a unique array of challenges. Similarly, foxes, ducks, and numerous other creatures have a cosmopolitan distribution. Adaptation can seem so commonplace that we fail to consider what is required for this to happen.

One well-studied type of adaption is the adaption to high altitudes. While we have only begun to understand all that is involved, what is already known highlights the incredible robustness of design in God's creatures. They are faced with multiple stresses that are potentially life threatening, yet many are able to adapt and even thrive under these incredibly challenging conditions.

The most obvious high altitude challenges for endothermic vertebrates are

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the reduced partial pressure of oxygen (PO_2) and the generally cooler temperatures. This reduction of atmospheric oxygen (O_2) can result in serious depletion of O_2 in the tissues, impairing metabolism. This not only may jeopardize the maintenance of normal activity, but also may impair the capacity to maintain a constant internal temperature in the face of the cooler ambient temperatures (Storz et al., 2010; Cheviron and Brumfield, 2012).

Another challenge is maintaining adequate hydration. Several responses to high altitude hypoxia (low O_2) also lead to increased water loss. Increased ventilation results in an increased respiratory water loss. Down-regulation of the renin-angiotensin-aldosterone system results in increased urinary output (Yanagisawa et al., 2012). These responses necessitate an increase in water intake to avoid dehydration. This highlights the fact that the many body systems are intricately interconnected. Changes are not made in isolation; instead they often impact many other areas that also must be kept in balance. Maintaining homeostasis is critical to survival and often involves an astounding array of details. Five components of the O_2 pathway where physiologic and/or genetic adaptation may compensate for high altitude stress are described below.

Increasing Oxygen in the Lungs

One of the first physiologic responses to hypoxia is an increase in ventilation (breathing). The carotid bodies, chemoreceptors located in (or near) the neck, sense the drop in PO_2 and stimulate a rapid rise in ventilation within minutes. This increases the PO_2 in the lungs, helping to compensate for the drop in PO_2 in the atmosphere. While this helps significantly, it does not restore lung PO_2 to sea-level values. This means other physiologic changes need to take place for the creature to adapt well to the high altitude (Storz et al., 2010; Ainslie et al., 2013).

Further, increasing ventilation has other significant consequences in addition to increasing water loss as mentioned above. The rise in PO_2 is associated with a drop in the partial pressure of carbon dioxide (PCO_2). This causes a rise in pH and respiratory alkalosis. Ironically, CO_2 and hydrogen ion concentration ($[H^+]$, which declines as pH rises) normally stimulate breathing via central and peripheral chemoreceptors. It is possible that the decrease in CO_2 and $[H^+]$ play a role in reversing the initial spike in ventilation. This reversal occurs within the first 10 to 20 minutes. However, ventilation is still maintained at a significantly higher level than it would be at sea level (Ainslie et al., 2013).

Given that CO_2 and $[H^+]$ are important signals for breathing, and that the concentration is reduced as ventilation is increased, what is the signal to maintain this higher ventilation rate at high altitudes? At this point there is considerable conjecture as to how this occurs. It seems that changes within the central nervous system as well as interactions between central and peripheral chemoreceptors must be involved. Further, interindividual differences have been noted in the specifics of the response. It has been suggested that in individuals with a more dramatic ventilatory response, the drive to breathe is more peripheral, while a blunted response allows for a more acidic pH and the drive to breathe depends more heavily on the central chemoreflex (Ainslie et al., 2013).

Increasing Pulmonary Diffusion

Once O_2 is in the lungs, it must diffuse from the alveoli to the blood. Hypoxia is known to induce pulmonary alveolar and vascular remodeling (Semenza, 2004; Weir and Olschewski, 2006; Ravikurma et al., 2009). In some instances this is adaptive. Animal studies have demonstrated an increase in gas exchange surface area and diffusion capacity in response to (usually simulated) high-altitude exposure. Many of these studies were done on growing animals; at least one study failed to show such changes in adult beagles. So it would seem that significant adaptive changes affecting diffusion are more commonly the result of augmenting normal development. Effective adaptation affecting diffusion is not well documented in adults (Ravikurma et al., 2009).

Increasing Oxygen Delivery by the Blood

There are several strategies that can increase the amount of O_2 carried by the blood. The first is simply to pump more blood per minute. An increase in total cardiac output is observed with exposure to acute hypoxia. This is the result of an increased heart rate. The degree of tachycardia can vary with factors such as rate of ascent. Cardiac output declines to sea-level values within a few days, though generally the heart rate remains high with an accompanying decreased stroke volume (Naeije, 2010).

The increased cardiac output is transient as the body employs other strategies to maintain O_2 delivery to the tissues. Hypoxia results in an increase of hypoxia-inducible factors (HIFs). HIFs are protein heterodimers consisting of one of three α-subunits and a β-subunit also known as aryl hydrocarbon receptor nuclear translocator (ARNT). ARNT and the HIF α-subunits are constitutively expressed, with the 2α-subunit being more tissue specific than the 1α-subunit. These α-subunits are broken down rapidly in an O_2-dependant pathway. A drop in O_2 leads to a proportional increase in HIF levels, allowing for a rapid response to hypoxia. HIFs are transcription factors that regulate a number of genes involved in the response to hypoxia, including

the one encoding erythropoietin (EPO; Semenza 2004; Haase 2013).
Serum EPO levels peak within a day or two of arriving at a high altitude. Among its functions, EPO stimulates erythropoiesis, the production of red blood cells (RBCs). Within a few weeks of arriving at a high elevation, an increased number of RBCs are circulating. The increased hemoglobin (Hb) allows for increased binding of O_2 for transport to the cells. However, this response also needs to be carefully modulated. Excessive polycythemia can increase the viscosity of the blood, lower cardiac output, and result in other adverse outcomes (Gore et al., 2007; Storz et al., 2010; Naeije, 2010; Cheviron and Brumfield, 2012).

In addition to this physiologic response, various genes in the HIF pathway exhibit polymorphisms, presumably from mutations (i.e., changes in the DNA sequence), which are associated with an adaptive phenotype at high altitudes. The egl nine homolog 1 (EGLN1) protein, also known as prolyl-4-hydroxylase domain 2 (PHD2), is a key enzyme in hydroxylation of HIF-α. Endothelial PAS domain protein 1 (EPAS1) is another name for HIF-2α. The peroxisome proliferator-activated receptor-α (PPARA) also affects erythropoiesis. Genetic variants in these three genes are found in Tibetans and are associated with lower Hb levels (compatible with those of lowlanders at sea level) and protection against chronic mountain sickness compared to other humans living at high altitudes (Cheviron and Brumfield, 2012; Haase, 2013).

Another strategy for dealing with the decline in PO_2 is to adjust the affinity of Hb for O_2. Ideally, it is best if Hb binds strongly to O_2 when it picks it up (loading) at the lungs but releases it readily when delivering (unloading) it to the tissues. The binding affinity of Hb to O_2 changes with PO_2, but this change is not linear. The relationship is described by the oxyhemoglobin dissociation curve (ODC; Figure 1, p. 136).

The drop in PO_2 presents several challenges. The first is to maintain adequate delivery of O_2. O_2 delivery is represented on the ODC by the difference in the y-axis values between the points representing arterial and venous blood saturation (A1-V1 and A2-V2 in Figure 1). The decrease in PO_2 under hypoxic conditions (A2-V2) is partially compensated for because O_2 loading and unloading is occurring over a steeper portion of the ODC. Thus, despite a significantly smaller difference in PO_2 between arterial and venous blood, the amount of O_2 delivered is nearly the same as the normoxic example given (A1-V1).

The second challenge is to maintain adequate PO_2 to drive diffusion at the tissue capillaries. Adequately addressing these dual challenges of maintaining adequate O_2 delivery and PO_2 at the tissue capillaries may require a change in the affinity of Hb for O_2, which will result in a change in the shape and position of the ODC. Figure 2 (p. 136) illustrates a decrease in O_2 binding affinity resulting in a right shift in the ODC (red), and an increase in O_2 binding affinity resulting in a left shift in the ODC (green).

A number of factors can shift the ODC, including changes in pH (Bohr effect) and temperature. The body can also change the concentration of allosteric cofactors within the RBC to modulate Hb-O_2 affinity. The most potent example in mammals is 2, 3-diphosphogylcerate (DPG), which decreases Hb-O_2 affinity by binding and stabilizing the deoxygenated conformation. This will shift the ODC to the right and facilitate unloading of O_2 at the tissues. An increase in DPG has been documented to occur in humans within 24 hours of ascent to a very high altitude (Storz et al., 2010; Cheviron and Brumfield, 2012).

A right shift in the ODC is thought to be most adaptive under moderate hypoxia and is readily accomplished through phenotypic plasticity. In severe hypoxia, a left shift can be more beneficial because it allows for oxygen loading and unloading over a steeper portion of the ODC. A chronically left-shifted ODC is seen in various mammals and birds that have genetically adapted to alpine living. The left shift has been correlated with genetic polymorphisms affecting the α- and/or β-globin portions of the Hb molecule, which either directly increase the O_2 affinity of Hb or decrease its sensitivity to allosteric cofactors (Weber 2007; Storz et al., 2010; McCracken et al., 2009).

The α- and β-globin subunits of adult Hb are surprisingly variable, but only a few sites have been demonstrated to make significant contributions to O_2 binding affinity (Weber, 2007). One example of molecular adaptation is found in Andean camelids: llamas and vicuñas. The high O_2 affinity of their Hb is correlated with an amino acid substitution in the second residue of the β-globin polypeptide which decreases binding of DPG. The vicuña, which inhabits the highest elevations (4,000–5,000 meters) and has the highest oxygen affinity, possesses an additional amino acid substitution in the α-globin polypeptide (Storz, 2007).

The most extensive research on genetic adaptation in Hb has been carried out on deer mice, which inhabit elevations from below sea level in Death Valley to 4,300 meters in some mountain ranges within North America. Lowland populations differ from those at high-altitude by 8 amino acid substitutions in the α-chain and 4 in the β-chain subunit. The high Hb-O_2 affinity in alpine populations appears to be from reduced binding affinity with allosteric cofactors (DPG and Cl^- ions) and is associated with a greater maximal rate of O_2 consumption at high altitudes. This allows for greater aerobic activity and thermogenic capacity in these active, non-hibernating rodents. Interestingly, the lowland genotype is correlated with a higher maximal rate of O_2 consumption at low altitudes (Storz, 2007; Cheviron and Brumfield, 2012; Natarajan et al., 2013).

Genetic adaptation is usually believed to require extensive periods of time. However, Andean chickens, which were introduced to that region about 500 years ago, have a higher Hb-O_2 affinity than their lowland counterparts. This putatively genetic characteristic was retained after moving some to a low altitude for a year, and it was passed on to their offspring (Velarde et al., 1991). There was a gradual trend toward a lower Hb-O_2 affinity over the lifetime in both generations. This has not been characteristic of other high-altitude species transferred to long-term residence at low altitude (León-Velarde et al., 1997). Thus, it could be that this is a heritable epigenetic trait. Apparently no investigation to identify Hb polymorhpisms has been published.

Increasing Diffusion to the Tissue Mitochondria

As mentioned, sufficient PO_2 in the blood is necessary to drive the diffusion of O_2 from the blood to the tissue mitochondria, where it is used. Theoretically, O_2 diffusion capacity could be increased to offset some of the decline in PO_2 relative to sea-level values. This could be accomplished by increasing the density and distribution of capillaries in the tissues and/or changing the cellular arrangement of the mitochondria (Storz et al., 2010). While the transcription factor HIF is also known to affect angiogenesis (Gore et al., 2007; Semenza, 2004), it is unclear how much vascular remodeling occurs when adult lowland species become acclimatized to high altitude. Some of the debate over this may be related to differences in interindividual responses, which produce ambiguous results within and between studies. Storz and colleagues (2010) conclude that there appears to be negligible plasticity in the morphological capacity for O_2 diffusion during high-altitude acclimatization.

In contrast, studies have shown that some high-altitude species have adaptations improving diffusion. The bar-headed goose has an increased number of capillaries in the flight muscle and heart in addition to mitochondria that are redistributed closer to these capillaries. These morphologic features appear to be genetic, as previous exposure to high altitude is not required for their appearance. However, not all high-altitude species have this phenotype (Storz et al., 2010). This indicates that there is variation in the genetic responses of different high-altitude populations.

Adjusting Oxygen Utilization to Accommodate the Supply

There is also variability in the response of the tissue as lowland species become acclimatized to high altitudes. Metabolic capacity may decrease in muscle tissue through reductions in cell size and number of mitochondria. A shift in fuel preference may also help decrease O_2 demand (Storz et al., 2010). In athletes training under simulated high-altitude conditions, adaptations were observed that allowed better coupling between energy use and production sites resulting in improved mitochondrial efficiency (Gore et al., 2007). However, in other instances mitochondrial efficiency is merely sustained or even impaired (Storz et al., 2010).

One study in deer mice, which have high thermoregulatory demands, demonstrates that changes in expression levels for genes in the oxidative phosphorylation and fatty acid oxidation pathways contribute to an adaptive enhancement of thermogenic capacity in high-altitude populations. This is intriguing, as fatty acid utilization produces more energy per gram than carbohydrates but requires more O_2. Therefore, the alterations in the oxidative phosphorylation pathway appear necessary to allow for the increased use of lipids as a fuel source. The wild-caught mice from different altitudes were tested after acclimating to a common low-altitude environment (i.e., common garden conditions). It remains to be elucidated as to whether the underlying basis of differential gene expression is from genetic- or epigenetic-based differences (Cheviron et al., 2012).

Failure in the Adjustment Process

The previous sections highlight some of the most elementary components of adaptation to high altitudes. God's creatures were not only designed to be able to make the necessary adjustments, but there is also interindividual variation allowing for a response that meets specific individual needs. This certainly testifies to a wise and caring Creator. However, given the reality of the Curse, failure in the process is expected to occur.

Acute mountain sickness (AMS) can occur when ascending rapidly to a high altitude. Symptoms appear within a day or two and may include headache, gastrointestinal upset (nausea, vomiting, and/or anorexia), fatigue, dizziness, and insomnia. Symptoms tend to be more severe with a more rapid rate of ascent, higher altitude, and more physical exertion. However, for most people they resolve within three days to a week (Beidleman, et al., 2013).

Sometimes AMS will progress to a more severe and potentially fatal syndrome: high-altitude pulmonary edema (HAPE) or high-altitude cerebral edema. In the case of the former, there is an exaggerated pulmonary vasoconstriction response to hypoxia with resulting hypertension and increased leakage of fluid from the vessels as a result of this stress. It is a condition that has claimed the lives of strong, young mountain climbers over the centuries. Though these conditions are serious and potentially fatal, they can be readily reversed if recognized early and treated promptly. Prevention and treatment is based on giving one's

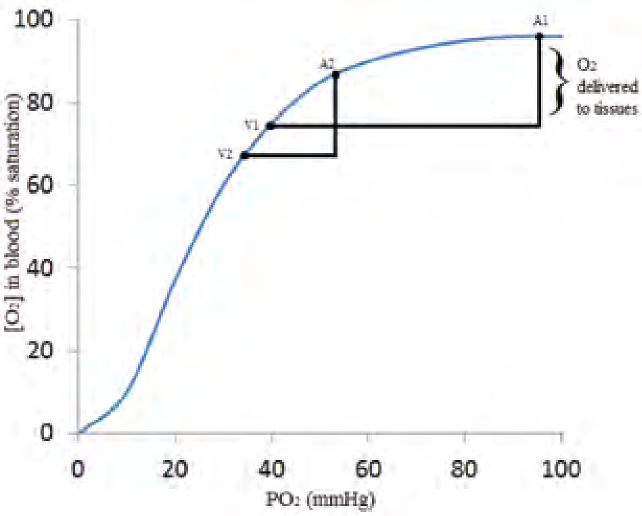

Figure 1. An oxyhemoglobin dissociation curve (ODC) has a sigmoidal shape. A1 and A2 represent theoretical examples of arterial blood under normoxic and hypoxic conditions, respectively. V1 and V2 are the corresponding values for venous blood after oxygen (O_2) unloading at the tissues. The difference between arterial and venous (A1-V1 and A2-V2) values on the x-axis shows the difference in PO_2 between the normoxic and hypoxic conditions. Note that the amount of O_2 delivered to the tissues (the change in value on the y-axis) is almost the same in both cases because O_2 was loaded and unloaded over a steeper portion of the curve in the second case. The shape and position of the ODC will often change under varying conditions, as illustrated in Figure 2.

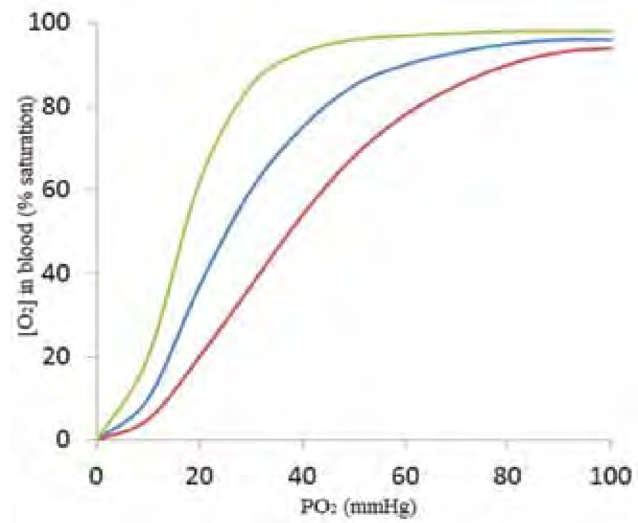

Figure 2. Examples of changes in shape and position that can occur in the oxyhemoglobin dissociation curve (ODC). A right shift (red) can result from a drop in pH or an increase in temperature or allosteric cofactors that decrease O_2-hemoglobin affinity. Under cases of mild hypoxia, a right shift can often be beneficial as it facilitates O_2 unloading at the tissues. A left shift (green) can result from an increase in pH or a decrease in temperature or allosteric cofactors affecting O_2-hemoglobin affinity. The latter is viewed as the most advantageous under extreme hypoxia since it maximizes O_2 loading in the arteries and both loading and unloading occur over a very steep portion of the curve. Adaptive mutations that affect hemoglobin affinity resulting in a left-shifted ODC are found in various endotherms that have lived for generations at high altitude.

body the time to adapt: ascending more slowly, avoiding extremely high altitudes, decreasing physical activity, and adding supplemental oxygen to alleviate symptoms if it becomes necessary. There are also some medications that can be helpful for individuals who are more susceptible (Paralikar, 2012).

Studies suggest that genetic polymorphisms in mitochondrial DNA, genes of the renin-angiotensin-aldosterone system, and genes of several other pathways may affect the risk of HAPE (Luo et al., 2012a; Luo et al., 2012b; Luo et al., 2012c; Srivastava et al., 2012). However, despite the intensity of research on this serious disease, is has been difficult to elucidate the pathogenesis of this condition. This is partially because the disease is rare, making it difficult to obtain a large enough sample size for statistical comparisons. Further, there are numerous biological pathways interacting to maintain homeostasis under hypoxic stress. This explains why a number of different polymorphisms have been implicated as having some effect (Luo et al., 2012a). Finally, the overall health and behavioral choices of the individual greatly impact the development of the disease (Paralikar, 2012).

People living long-term at altitudes over 2500 meters may develop a syndrome known as chronic mountain sickness (CMS). Symptoms vary somewhat, but commonly include breathlessness and/or palpitations, cyanosis, decreased exercise tolerance, headache, impaired mental function, tinnitus, and paraesthesia (tingling or other skin sensations with no obvious physical cause). Underlying features include excessive pulmonary hypertension (which is correlated with maladaptive pulmonary vascular remodeling that increases the diffusion barrier) and/or excessively high hematocrit. These symptoms will normally disappear within a few weeks if the person moves to a low altitude (Hainsworth and Drinkhill, 2007; Naeije and Vanderpool, 2013; Gonzales et al., 2013).

CMS has not been documented among the Ethiopians of the East African high-altitude plateau. It is rare among Tibetans. Andeans are more susceptible to this disease. A recent genome-wide association study identified 11 regions associated with CMS susceptibility in Andeans. Two genes (SENP1, a regulator of erythropoiesis, and ANP32D, an oncogene) from these regions were transcribed at a higher level in response to hypoxia in individuals with CMS compared to those without. Further studies of the orthologs in flies indicate that down-regulation of these genes enhanced survival in flies exposed to hypoxia (Zhou et al., 2013). This again highlights the point that the more we study adaptation to high altitude, the more it is evident that an astounding array of genes needs to be properly controlled for maintenance of homeostasis.

An Obvious Trend

Endotherms exhibit a profoundly complex, well-integrated response to high-altitude hypoxic stress. As a lowland species adapts to a high altitude, there are immediate effects (spike in ventilation and increased cardiac output) that subside as more long-term adjustments are made. Young mammals developing at high altitudes have been shown to adapt even more than adults (e.g., in remodeling alveoli and vasculature to improve diffusion between lungs and the blood). Populations that have lived for generations at high altitudes often carry adaptive genetic changes. Given how effectively adaptation occurs in most endotherms, it would seem that these genetic changes are merely a further coordinated response to the high-altitude environment.

This idea that physiologic adaptation is somehow linked to evolution (i.e., genetic change) actually was suggested by evolutionists over a hundred years ago (reviewed in Kirschner and Gerhart, 2005). It has never been a popular part of evolutionary explanations for several reasons. It fails to account for major anatomical innovations (e.g., eyes or wings). It also requires the preexistence of well-integrated, complex systems that allow for both physiologic and genetic change. These preexisting systems clearly exist, but neo-Darwinian mechanisms cannot account for their origin or the observed adaptive changes within them.

Failure of Neo-Darwinian Mechanisms to Account for Observations

The neo-Darwinian mechanisms of random mutation and natural selection are proffered as a naturalistic explanation for genetic adaptation. It is well known that mutations aren't truly random in that there are hotspots where they occur far more frequently. However, it is assumed that mutations are essentially errors, induced either by environmental insults (e.g., UV radiation) or replication errors that are not properly repaired (Akashi and Yoshikawa, 2013). If mutations are biased to produce beneficial changes, it would be evidence of design, which is rejected *a priori* by evolutionists. Of course, random mutation and natural selection are believed responsible for far more than just the type of adaptation accepted by biblical creationists; they are invoked to explain the origin of all the diverse life-forms today from a putative common ancestor—a natural history at odds with the biblical history of original created kinds.

The field of population genetics, which is highly mathematical, has produced some impressive literature that is largely ignored in popular-level evolutionary explanations. It is well recognized in this field that the frequency of a particular lineage will fluctuate over time; this is termed genetic drift. It is well established in this naturalistic model that *most beneficial mutations that arise would be lost due to genetic drift*! Of those that survive drift, they are unlikely to become prominent or fixed in a population unless they have a large selective advantage, something that would be absent where phenotypic plasticity allows for robust adaptation (Patwa and Wahl, 2008).

Population genetics models did not predict the patterns of change we observe. The idea that many mutations of miniscule effect should be the underlying basis of evolution was reinforced by the work of Ronald A. Fisher, who showed that as the size of the mutational effect increased, the probability that it would be beneficial became vanishingly small. This was largely due to the effects of pleiotropy, where a mutation can affect a number of characters, some in a positive way and others in a negative way. Yet the reality is that we have a number of clear examples where one or a few mutations of sizable effect underlie adaptation (Orr, 2005).

Evolution by natural selection should occur only if each mutation added provides some benefit. Further, only a few steps are predicted to occur in a typical adaptive walk (Orr, 2005). This creates a serious problem when attempting to account for the dozen amino acid substitutions in the two Hb subunits of high-altitude-adapted deer mice. Epistasis was demonstrated among these adaptive mutations (Natarajan, 2013). This epistasis would obstruct the pathway of an adaptive walk.

Although some newer models do allow for mutations of sizable effect, they do so by ignoring the reality of nonlethal harmful mutations (Orr, 2005). Most mutations are near neutral and not significantly affected by natural selection. Realistic numerical simulation shows that deleterious mutations, which would be far more frequent than beneficial ones unless mutations are biased to be beneficial, would become fixed in a population via genetic drift at a rate that vastly exceeds the rate that beneficial ones are fixed. This means postulating more time for beneficial mutations to arise and become fixed will result in a staggering load of deleterious genetic mutations. Rupe and Sanford (2013) term this phenomenon "Haldane's ratchet." Thus, natural selection of randomly generated mutations is not a plausible mechanism for the genetic adaptation that is observed.

Explanatory Value of the Creation Model

If neo-Darwinism cannot account for genetic changes that allow creatures to adapt to new environments, it certainly cannot account for the origin of the complex, well-integrated pathways that allow for adaptation to begin with. In contrast, the biblical creation model accounts elegantly for all these observations. Creatures can adapt to new environments, which present challenges that may not have been encountered by their ancestors. This is attributable to the fact that there is a Creator who designed them with the capability to adapt to new environmental challenges. As a result of the Curse, not everything works perfectly today. There is enough disease and death to make it clear the world is broken; this should lead us to recognize that we need a Savior. Yet when examined in detail, it is clear that adaptation is an amazing process that we have barely begun to understand.

There are a number of genes where mutations have occurred since the Flood (Lightner 2008, 2009). We know this because, regardless of the standing variation at Creation, a maximum of 4 alleles would have been preserved through the Flood for any of the unclean kinds on the ark. The variety added by these mutations can be adaptive. So at the very least, some genes were designed to allow for adaptive mutations. Given the amazing responsiveness of endotherms to environmental challenges, it is reasonable to assume that many mutations may be biased to be at least potentially adaptive. This would account for why most mutations seem to be near neutral; their effect is often difficult to discern without extensive study, and they may be advantageous only in a limited set of circumstances.

It is clear that when adaptive mutations arise, natural selection is not an adequate mechanism to preserve them. The vast majority would be lost to genetic drift. Therefore, God must have designed some way for adaptive mutations to increase in frequency in populations. In some instances individuals with adaptive alleles might be the ones that migrate into a new area. In this case the adaptive alleles would become common in the resulting population due to the founder effect. Yet it appears that more than this is occurring. A coherent creation model predicts that many mutations are biased to be beneficial and that a created mechanism must exist to increase allele frequency of adaptive mutations.

The exciting part is that recent scientific research provides evidence that biased mutations could likely be the case (reviewed in Lightner, 2013). It is well known that homologous recombination, which occurs during meiosis, can change the DNA sequence. This process is initiated by enzyme-induced double-stranded DNA breaks. While crossing over is the best-known outcome, gene conversion may actually be more common. Other break-repair mechanisms incorporate other changes into the DNA sequence. Further, biased gene conversion has been documented to occur in mammals. Biased gene conversion would increase allele frequency. It also violates the assumptions of models using statistical tests to identify selection, meaning that where biased gene conversion is occurring to a significant degree, it is being mistaken for natural selection. So while considerably more research needs to be done to establish the significance of these meiotic mutations, it already appears that the Creation model provides the most robust scientific explanation for genetic adaptation.

Summary

God created His creatures to reproduce and fill the earth, and so they have. Even today He provides for His creatures in amazing ways so they can adapt to some incredible challenges. High-altitude adaptation is one example where numerous changes must be effectively made so that life can inhabit even some surprisingly high regions of the world. In some instances there can be failure in the process, highlighting the fact that we live in a world that has been cursed because of sin. Yet in most cases the process of adaptation proceeds remarkably well. Immediate, short-term responses are followed by longer-term, more sustainable responses. For mammals and birds that have lived for generations at high altitudes, genetic changes have been identified, reflecting a more permanent response. In all these details, it is clear that we have an awesome Creator who provides for the needs of His creatures.

Abbreviations

AMS — acute mountain sickness
Cl^- — chloride
CMS — chronic mountain sickness
CO_2 — carbon dioxide
DPG — 2, 3, diphosphoglycerate; also known as 2, 3 biphosphoglycerate (BPG)
EPO — erythropoietin, a hormone that stimulates erythropoiesis, the production of RBCs

$[H^+]$ — hydrogen ion concentration
Hb — hemoglobin
HAPE — high altitude pulmonary edema
HIF — hypoxia inducible factor
O_2 — oxygen
ODC — oxygen dissociation curve
PCO_2 — partial pressure of carbon dioxide
PO_2 — partial pressure of oxygen
RBC — red blood cell

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References

Ainslie, P.N., S.J.J. Lucas, and K.R. Burgess. 2013. Breathing and sleep at high altitude. *Respiratory Physiology & Neurobiology* 188(3): 233–256. http://dx.doi.org/10.1016/j.resp.2013.05.020

Akashi, M., and H. Yoshikawa. 2013. Relevance of GC content to the conservation of DNA polymerase III/mismatch repair system in Gram-positive bacteria. *Frontiers in Microbiology* 4:266. doi: 10.3389/fmicb.2013.00266

Beidleman, B.A., H. Tighiouart, C.H. Schmid, C.S. Fulco, and S.R. Muza. 2013. Predictive models of acute mountain sickness after rapid ascent to various altitudes. *Medicine & Science in Sports & Exercise* 45(4): 792–800.

Cheviron, Z.A., and R.T. Brumfield. 2012. Genomic insights into adaptation to high-altitude environments. *Heredity* 108:354–361.

Cheviron, Z.A., G.C. Bachman, A.D. Connaty, G.B. McClelland, and J.F. Storz. 2012. Regulatory changes contribute to the adaptive enhancement of thermogenic capacity in high-altitude deer mice. PNAS 109(22): 8635–8640.

Gonzales, G.F., J. Rubio, and M. Gasco. 2013. Chronic mountain sickness score was related with health status score but not with hemoglobin levels at high altitudes. *Respiratory Physiology & Neurobiology* 188:152–160.

Gore, C.J., S.A. Clark, and P.U. Saunders. 2007. Nonhematological mechanisms of improved sea-level performance after hypoxic exposure. *Medicine and Science in Sports and Exercise* 39(9): 1600–1609.

Haase, V.H. 2013. Regulation of erythropoiesis by hypoxia-inducible factors. *Blood Reviews* 27:41–53.

Hainsworth, R., and M.J. Drinkhill. 2007. Cardiovascular adjustments for life at high altitudes. *Respiratory Physiology & Neurobiology* 158:204–211.

Kirschner, M.W., and J.C. Gerhart. 2005. *The Plausibility of Life: Resolving Darwin's Dilemma*. Yale University Press, New Haven, CT.

León-Velarde, F., O. Mejía, J.A. Palacios, and C. Monge. 1997. Changes in whole blood oxygen affinity and eggshell permeability in high altitude chickens translocated to sea level. *Comparative Biochemistry and Physiology. Part B, Biochemistry & Molecular Biology* 118(1): 53–57.

Lightner, J.K. 2008. Genetics of coat color I: the melanocortin 1 receptor (MC1R). *Answers Research Journal* 1:109–116.

Lightner, J.K. 2009. Karyotypic and allelic diversity within the canid baramin (Canidae). *Journal of Creation* 23(1): 94–98

Lightner, J.K. 2013. Meiotic recombination—designed for inducing genomic change. *Journal of Creation* 27(1): 7–10.

Luo, Y.J., W.X. Gao, S.Z. Li, X.W. Huang, Y. Chen, F.Y. Liu, Q.Y. Huang, and Y.Q. Gao. 2012a. Mitochondrial haplogroup D4 confers resistance and haplogroup B is a genetic risk factor for high-altitude pulmonary edema among Han Chinese. *Genetics and Molecular Research* 11(4): 3658–3667.

Luo, Y., W. Gao, Y. Chen, F. Liu, and Y. Gao. 2012b. Rare mitochondrial DNA polymorphisms are associated with high altitude pulmonary edema (HAPE) susceptibility in Han Chinese. *Wilderness & Environmental Medicine* 23(2): 128–32.

Luo, Y., Y. Zou, and Y. Gao. 2012c. Gene polymorphisms and high-altitude pulmonary edema susceptibility: a 2011 update. *Respiration* 84(2): 155–162.

McCracken, K.G., C.P. Barger, M. Bulgarella, K.P. Johnson, S.A. Sonsthagen, J. Trucco, T.H. Valqui, R.E. Wilson, K. Winker, and M.D. Sorenson. 2009. Parallel evolution in the major haemoglobin genes of eight species of Andean waterfowl. *Molecular Ecology* 18:3992–4005.

Naeije, R. 2010. Physiological adaptation of the cardiovascular system to high altitude. *Progress in Cardiovascular Disease* 52:456–466.

Naeije, R., and R. Vanderpool. 2013. Pulmonary hypertension and chronic mountain sickness. *High Altitude Medicine & Biology* 14(2): 117–125.

Natarajan, C., N. Inoguchi, R.E. Weber, A. Fago, H. Moriyama, and J.F. Storz. 2013. Epistasis among adaptive mutations in deer mouse hemoglobin. *Science* 340:1324–1327.

Orr, H.A. 2005. The genetic theory of adaptation: a brief history. *Nature Reviews. Genetics* 6:119–127.

Paralikar, S.J. 2012. High altitude pulmonary edema — clinical features, pathophysiology, prevention and treatment. *Indian Journal of Occupational and Environmental Medicine* 16(2): 59–62.

Patwa, Z., and L.M. Wahl. 2008. The fixation probability of beneficial mutations. *Journal of the Royal Society Interface* 5:1279–1289.

Ravikurma, P., D.J. Bellotto, R.L. Johnson Jr., and C.C.W. Hsia. 2009. Permanent alveolar remodeling in canine lung induced by high-altitude residence during maturation. *Journal of Applied Physiology* 107:1911–1917.

Rupe, C.L., and J.C. Sanford. 2013. Using numerical simulation to better understand fixation rates, and establishment of a new principle: Haldane's ratchet. In Horstemeyer, Mark (editor), Proceedings of the Seventh International Conference on Creationism (Digital edition). Creation Science Fellowship, Pittsburgh, PA.

Semenza, G.L. 2004. O_2-regulated gene expression: transcriptional control of cardiorespiratory physiology by HIF-1. *Journal of Applied Physiology* 96:1171–1177.

Srivastava, S., S. Bhagi, B. Kumari, K. Chandra, S. Sarkar, and M.Z. Ashraf. 2012. Association of polymorphisms in angiotensin and aldosterone synthase genes of the renin-angiotensin-aldosterone system with high-altitude pulmonary edema. *Journal of the Renin-Angiotensin-Aldosterone System* 13(1): 155–160.

Storz, J.F. 2007. Hemoglobin function and physiological adaptation to hypoxia in high-altitude mammals. *Journal of Mammalogy* 88(1): 24–31.

Storz, J.F., G.R. Scott, and Z.A. Cheviron. 2010. Phenotypic plasticity and genetic adaptation to high altitude hypoxia in vertebrates. *The Journal of Experimental Biology* 213:4125–4136.

Velarde, F.L., D. Espinoza, C. Monge, and C. de Muizon. 1991. A genetic response to high altitude hypoxia: high hemoglobin-oxygen affinity in chicken (Gallus gallus) from the Peruvian Andes. *Comptes rendus de l'Académie des sciences. Série III, Sciences de la vie* 313(9): 401–406.

Weber, R.E. 2007. High-altitude adaptations in vertebrate hemoglobin. *Respiratory Physiology & Neurobiology* 158:132–142.

Weir, E.K., and A. Olschewski. 2006. Role of ion channels in acute and chronic responses of pulmonary vasculature to hypoxia. *Cardiovascular Research* 71:630–641.

Yanagisawa, K., O. Ito, S. Nagai, and S. Onishi. 2012. Electrolyte-carbohydrate beverage prevents water loss in the early stage of high altitude training. *The Journal of Medical Investigation* 59:102–110. Archived at https://www.jstage.jst.go.jp/article/jmi/59/1%2C2/59_1%2C2_102/_pdf.

Zhou, D., N. Udpa, R. Ronen, T. Stobdan, J. Liang, O. Appenzeller, H.W. Zhao, Y. Yin, Y. Du, L. Guo, R.Cao, Y. Wang, X. Jin, C. Huang, W. Jia, D. Cao, G. Guo, J.L. Gamboa, F. Villafuerte, D. Callacondo, J. Xue, S. Liu, K.A. Frazer, Y. Li, V. Bafna, and G.G. Haddad. 2013. Whole-genome sequencing uncovers the genetic basis of chronic mountain sickness in Andean highlanders. *The American Journal of Human Genetics* 93(3): 452–462.

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Clarifying Four Meanings for "Worldview"

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Abstract

Because the majority of authors and speakers discussing the worldview concept have focused primarily on its effects and not its causes, they have been largely unsuccessful at clearly defining the initial origin and functional operation of the human worldview in certain key ways. Lacking this clarity, the term "worldview" is often used intuitively and even inaccurately. Moreover, different senses of the term are used as if all meanings were equivalent. The result, unfortunately, is that an individual may simultaneously reference distinctly different aspects of the worldview paradigm, thus either causing confusion by his or her statements or perhaps even becoming confused as to what he or she is actually discussing. Hence, four distinct potential meanings for "worldview" are identified and clarified: the *worldview mechanism*, *worldview structure*, *worldview perspective(s)*, and the *social worldview*. It is this last sense, which is a second-order construct of the individual's *worldview perspective*, where one will find collective views such as the creationist worldview and atheistic worldview.

This, I think, I may at least say, that we should have a great many fewer disputes in the world, if words were taken for what they are, the signs of our ideas only; and not for things themselves…. And if men would tell what ideas they make their words stand for, there could not be half that obscurity or wrangling in the search or support of truth that there is.
(John Locke, 1690, III:10.5)

Introduction

It is important to understand the human worldview because it provides the conceptual tool a person uses to understand both himself and the meaning of his existence. Unfortunately, for that very reason it can be tremendously difficult to grasp. Our worldview is such an immediate component of our perceptual mechanism that in evaluating it, it becomes nearly impossible to differentiate reality from perception, potentially making it invisible! Indeed, it can be like trying to remove one's own eye to better understand its limitations and examine its defects.

Complicating this already difficult matter, people often equivocate on different meanings and unknowingly switch between nuanced meanings, applying characteristics to one aspect that belong to another. Chisham (2012) did not specifically label these meanings, but did describe their systematic interaction in perceiving and predicting truth. Consequently, it seems best to clarify these so the various senses of meaning can be utilized properly and interrelated correctly and clearly.

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Potential Meanings for the Term "Worldview"

The first meaning for "worldview" refers to the overall functional system generating one's opinions. We will call this the *worldview mechanism*. Chisham defines this process, pointing out that a worldview is a natural by-product of rationality. Because rationality drives it, people will typically develop their worldview only as far as their rationality demands (Chisham, 2012, p. 70). Consequently, some will think deeply, while others may focus only on areas of personal interest, and still others may seem to care very little about developing their ideas on broader worldview issues. However, even the latter may exhibit a surprising outburst of anger when a moral nerve is touched, indicating they do hold some things to be universally true!

A second meaning for "worldview" mentioned by Chisham (2012, p. 70) comes from the fact that this *worldview mechanism* automatically creates a "file" and thereafter uses it for reference. This functions like a jar where one deposits his answers to the universal worldview question Chisham identifies (i.e. How do I understand myself relative to ultimate truth?), indicating a certain retaining object within the human psyche—the *worldview structure*, if you will.

Third, every individual places his personal *worldview perspective(s)*, or truth values that define his unique system of thought, into this container we labeled *worldview structure*. One's personal *worldview perspective* (singular when referring to the collective whole, plural when referring to certain specific values) is what most people are referring to when they talk about "worldview" (or think they are, anyway).

Fourth, and finally, a *social worldview* is a person's *worldview perspective* within his social context. Usually the *social worldview* is stated as the aggregate opinion of a group. Examples of this might include a Christian or Hindu worldview, a German or Asian worldview, a Republican or Libertarian worldview, and an atheistic or communistic worldview. These essentially express Gaussian distributions of opinion for topical areas of social interest, reflecting societal influences upon collective populations. It should never be forgotten, however, that worldviews are first and foremost personal. Thus, *social worldviews* are merely second-order expressions of views accepted or adopted by individuals.

Discerning These Differences in the Discussion of Worldview

Note carefully that the *worldview mechanism* and the *worldview structure* it creates are objective aspects of human reality, not just "notions." Their existence is not at all optional, imaginary, or subjective. Rather, these two aspects of worldview are quite real, predictable, and, frankly, nonnegotiable. They represent how humans actually think and the mental structures and substructures created as a result. The third item, however—one's personal *worldview perspective*—is subjective and unique for each individual, consisting of various subjective personal notions or observations on life. Because the *social worldview* is a second-order expression of one's *worldview perspective*, it also is subjective; but this is not always clear to the individual because his surrounding community seems to hold a very similar view. It is often only by comparison to other cultures that one can perceive the influence of his or her cultural paradigms.

So, for example, when Summit Ministries founder David Noebel says, "Every individual bases his thoughts, decisions, and actions on a worldview" (Noebel, 1997, p. 1), he is not suggesting everyone holds the same opinions on life! Rather, he is referring to a collection of opinions serving a specific, unified function—a collective truth definition matrix, if you will. He is indicating the *worldview structure* (created by the *worldview mechanism*). He is speaking of a reservoir into which one's *worldview perspectives* are inserted (i.e., the answers to that "final" question: How do I understand myself relative to ultimate truth?).

In our next example, R. C. Sproul's website introduces his "Christian Worldview" teaching series with the claim, "Everyone has a worldview, a framework that helps them to interpret reality and answer life's ultimate questions. Many people, however, are unaware of their presuppositions" (Sproul, 2013). The first sentence refers to a ubiquitous "worldview framework," referring to the *worldview structure*, while the second sentence speaks of "presuppositions," indicating specific *worldview perspectives*. Sproul is clear but moves from a universal to particulars without warning, as if they were the same.

Notice how this division fades with Francis Schaeffer (1990, p. 132): "Let us remember that every person we speak to, whether shop girl or university student, has a set of presuppositions, whether he or she has analyzed them or not." In one sense, he acknowledges a universal "*set* of presuppositions" (i.e., the *worldview structure*), but the presuppositions themselves represent the individual's unique *worldview perspectives*; so in a sense he fails to distinguish the universal from the specific.

This can become increasingly uncertain in the context of a live discussion because at any moment the speaker or author may begin with universal concepts (the *worldview mechanism* or *worldview structure*) and without warning turn to particulars of a *worldview perspective*, as if the principle and the position were one in the same. In the blink of an eye, the discussion may flip between the two, confusing both participants.

This extremely common error confuses the information *in* the jar (*worldview perspectives*) with the jar itself (*worldview framework*). David Naugle demonstrates this problem when he claims,

> Presently I will show how any theory or definition of "worldview" is itself a function of the actual worldview of the theorist or the definer…. What nuances, in other words, does Christian theism as a *Weltanschauung* impart to the notion of *Weltanschauung* itself? ... A worldview is a semiotic system of narrative signs that has a significant influence on the fundamental human activities of reasoning, interpreting, and knowing. I begin here with a look at how any view of "worldview" is itself worldview-dependent. (Naugle, 2002, p. 253)

Interestingly, the title of Naugle's book is *Worldview: The History of a Concept*, indicating there is a *single* concept. He intuitively senses a single, underlying concept toward which he is reaching but fails to precisely identify what that concept is. In this case, he is infusing "*weltanschauung*" with two meanings: (1) the definition *for* the concept (*worldview structure*) and (2) the definitions provided *by* the concept (*worldview perspectives*). Further confusing the matter, in common usage "*Weltanschauung*" typically refers to a *social worldview*. Later in the same chapter, Naugle demonstrates that an entire conference of anthropologists fell into the same error.

> One major goal of this gathering was to discuss and define the term "worldview" itself. The conveners' perspectives were plentiful, their agreements few, their negotiations mostly unsuccessful. There was a simple reason … for their patented lack of progress on this front. As Jones tells the story in his report, as the conferees were *openly discussing* "worldview," they were *tacitly revealing* their own. (Naugle, 2002, p.254)

Noebel's assertion above that "everybody's got a worldview" is so common it seems surprising a comprehensive definition had not already been found. The fact that so many have found this elusive for so long points to a different fact: extracting your own worldview is tremendously difficult when discussing it, whether conceptually, personally, or otherwise. This is because separating your personal definitions from concepts and other people's ideas (while people are freely interchanging terms) simply becomes mentally overwhelming. Little wonder that confusion ensues! Furthermore, as Chisham points out, the common definition everyone seeks is probably best posed as a question, not a statement (Chisham, 2012). If Naugle's anthropologists were hoping everyone could agree on a uniform *worldview perspective*, they were in error, for they would have to share a single mind to have a single perspective, which is clearly physically impossible. The fact they could not demonstrates they could not separate concepts from beliefs. Understanding the four usages discussed here likely have would solved their dilemma.

Contemporary usage of "worldview" typically refers to what we have labeled the *worldview perspective* and/or *worldview structure*. It is extremely rare to find any writers who even attempt discussing the *worldview mechanism* as a functional system. Most people cannot even put the terms "mechanism" and "worldview" in the same sentence, until the principles given in Chisham (2012) describing this global mechanism are explained. Naugle comes close to stumbling upon this when he defines a worldview to be a "semiotic system of narrative signs." He explains that semiotics (the study of the nature and relationships of signs in language)

> is best conceived as a general theory of culture, and all cultural studies can best be explained and understood under the rubric of semiotics. This would include the cultural reality and the fundamental mechanism of *Weltanschauung*. (Naugle, 2002, p. 292)

However, it might be suggested that Naugle is looking at the backside of the tapestry. Certainly, semiotics plays a role in the *worldview mechanism*. (If you think about it, language is nothing more than symbolic sense or sense-derivative information used programmatically to create sentences describing more complex thoughts.) René Descartes made a similar epistemological mistake in thinking his "method of doubt" was the basis of knowledge. Consider the sequence by which humans come to know things (in reverse order): (3) You cannot use symbolism (in the case of Naugle) or doubt (in the case of Descartes), which both involve rationalization, without having already acquired a language. (2) Language, however, is necessarily acquired through first-order sense experience. Thus, (1) analogy-to-self (i.e., via personal sense experience) is the basis upon which language and, subsequently, rationality are built. Consequently, the proper rubric for understanding worldview is simply that people acquire knowledge by way of analogy-to-self. As Chisham explains by way of an analogy to matter,

> In summary, sense experiences provide the particles from which language is formed, and language provides the matter out of which intellectual thoughts are constructed. Lacking initial sense experience, none of this intellectual hierarchy will materialize. If a language does form, some alternative sense proxy was found. Thus, every opinion or understanding is ultimately traceable to individual, not communal perception—at least not in any primary sense. (Chisham, 2012, p. 65)

Consider one final example from Chuck Colson and Nancy Pearcey, coauthors of *How Now Shall We Live?* (1999), who use "Creation, Fall, and Redemption" as a method for understanding worldview. Broad usage of this three-point shorthand for "worldview" can be traced from Reformed teachers such as Kuyper and Dooyeweerd (e.g., Pearcey, 2005, p. 26), through Cornelius Van Til to his student Francis Schaeffer, and through him to Pearcey and Colson. In fact, Schaeffer influenced many modern worldview thinkers such as David Noebel, founder of Summit Ministries, and Del Tackett, host of Focus on the Family's *The Truth Project*. The "Creation, Fall, Redemption" motif answers three common questions, which according to Colson and Pearcey are: (1) Where did we come from? (2) What went wrong? (3) How do we fix it (p. 14)? These can be understood as simply past, present, and future tense (time domain) restatements of the universal worldview question: *How do I understand myself relative to eternal reality?* As such, the Creation, Fall, redemption sequence serves as shorthand Christian answers to the universal worldview question, thus providing the Christian *social worldview*, as we have defined it. In her book *Total Truth*, Pearcey states:

> If the grid of Creation, Fall, and Redemption provides a simple and effective tool for comparing and contrasting worldviews, it also explains why the biblical teaching of Creation is under such relentless attack today. In any worldview, the concept of Creation is foundational: As the first principle, it shapes everything that follows. Critics of Christianity know that it stands or falls with its teaching on ultimate origins. (Pearcey, 2005, p. 150)

She is right about this grid being an effective tool for diagnosing worldview differences—*if* she is addressing a Christian—because she presumes a Christian perspective as her starting point. In fact, her second and third questions presume Christianity (i.e., "What went wrong?" and "How do we fix it?" [cf. Pearcey, 2005, p. 25]), as was also the case in *How Now Shall We Live?* noted above. This presumption would become immediately apparent if these same questions were asked of an atheist, who might take offense to the suggestion something had "gone wrong." Because the points of disagreement are presented up front in the form of loaded questions, they are likely to preclude objective discussion of core principles, which in turn precludes resolution. Pearcey has so thoroughly embedded her own worldview into her definition that she is not able to articulate the concept generically, having intertwined the universal principle with her individual perspective. A better, more neutral restatement of these three time domain questions comes out roughly as: (1) Where did I come from? (2) How did I get (to) here? and (3) Where is my life and the universe headed, particularly after I die? Of course, Pearcey's conclusion is right in any case because the definition of one's origin also logically defines one's destiny and the nature of the universe for everything in between.

Atheism, however, also stands or falls on the question of origins, though Pearcey fails to recognize this in her statement. The unintended consequence of being self-centric when speaking about worldview concepts with those holding a *different* view is that the discussion is not particularly useful in helping the other individuals understand they hold many of the same sorts of presumptions in many of the same areas.

The benefits Pearcey advocates are achievable for all faith positions—if the three questions are stated in a neutral way. And, as any Christian apologist understands, getting an individual to admit his own presumptions and engage in fair and equitable debate is sometimes 90% of the battle. Understanding the fourfold nature of "worldview" can help Christians understand their own hidden assumptions, as well as create an expectation of honest reciprocity in dialog with others.

Thus, understanding of the worldview paradigm's definitions, concepts, and principles can be impeded by those who speak or write about them if they use ambiguous and/or equivocated terms. This causes the worldview concept to appear even more ghostlike than it is—occurring as an object in one case, a personal perspective in another, and a mechanism elsewhere, as if these different meanings were synonymous. However, diligence and precision regarding these four meanings of worldview can provide more careful and accurate diagnosis of what is being discussed. Of course this comes ultimately from understanding the *worldview mechanism* and its principle question: *How do I understand myself relative to eternal reality?*

Conclusion

People have generally defined the term "worldview" by intuition, sensing an underlying principle of interpretation coloring the human perspective without ever really carefully dissecting, analyzing, and systematically understanding the worldview. Unfortunately, this intuitive usage has led to inaccuracy and sometimes even error. Consequently, this discussion was intended to provide additional precision to and structural definition for "worldview" to facilitate onward development of these principles.

If a worldview's purpose is to discover truth and predict true courses of action, it seems incumbent on us to speak about the concept itself and its pieces in precisely true ways. This paper is not intended to be the definitive corrective reference but merely a step toward better dialog in that regard. Thus, four distinct concepts were presented for the term "worldview." The first and most common use refers to the individual's subjective worldview ideas, or *worldview perspective(s)*. Second, while everyone's answers are not the same, rationality causes the common human experience of collecting such answers, forming a mental retaining object or "file" identified herein as the *worldview structure*. Third, as described by Chisham (2012), as well as in this paper, the *worldview* *mechanism* is the tool that rationality uses to assemble the *worldview structure* and *worldview perspective(s)* and governs the concept, as a whole. Finally, a *social worldview* is a second-order consequence of humans rationalizing within social settings.

References

Chisham, S. 2012. Anatomy of a worldview: the eternal self-identity. *CRSQ* 49:63–72.

Colson, C., and N. Pearcey. 1999. *How Now Shall We Live?* Tyndale House Publishers, Carol Stream, IL.

Locke, John. 1690. *Essay Concerning Human Understanding*. http://www2.hn.psu.edu/faculty/jmanis/locke/humanund.pdf (accessed January 23, 2014).

Naugle, D. 2002. *Worldview: The History of a Concept*. Eerdmans Publishing, Grand Rapids, MI.

Noebel, D. 1997. *Understanding the Times*, 8th printing. Harvest House Publishers, Eugene, OR.

Pearcey, Nancy. 2005. *Total Truth: Liberating Christianity from its Cultural Captivity*. Good News Publishers, Wheaton, IL.

Schaeffer, Francis. 1990. *The God Who Is There*. Good News Publishing. Wheaton, IL.

Sproul, R.C. 2013. Christian worldview. Ligonier Ministries, www.ligonier.org/learn/series/christian_worldview (accessed January 1, 2013).

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Critique of Modern Oort Comet Theory

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Abstract

The Oort comet theory proposed in 1950 has been extended and modified by modern research. Creationists have used short-period comets as a young-age indicator and suggested that comets caused impacts on the moon and the earth. The original ideas of Jan Oort from 1950 have been modified by scientists today to deal with difficulties in Oort's original proposals. This paper reviews modern theories on comets, especially regarding the orbital dynamics of the different types of comets. Short-period comets are considered as two separate groups: the Jupiter-family comets and the Halley-type comets. Both groups of short-period comets have a limited "lifetime." Long-period comets and near-parabolic comets also are considered as the original rationale for the Oort theory. A young-age view suggests that long-period and near-parabolic comets may have been created along their current orbits, headed inbound toward the sun. Naturalistic comet theories have experienced difficulties related to explaining how comets could make the necessary transitions from one type of orbit to another. The Oort theory is also believed to apply to extrasolar planetary systems. This implies that it should be possible to observe interstellar extrasolar comets, yet none have been observed. These issues show that though it is widely accepted by astronomers, the Oort comet theory has not been successful.

Introduction

In 1950, the well-known Dutch astronomer Jan Hendrik Oort proposed the existence of what is now called the Oort Cloud, a region thousands of astronomical units from our sun where many comets are believed to reside (Oort, 1950, 1951). Creationists have consistently doubted and rejected the concept (Slusher, 1980; DeYoung, 1989; Faulkner, 1997; Looy, 2006). Yet the concept is widely accepted by the scientific community, though variations on the original proposal have been investigated. Many studies of comet orbits and the Oort cloud have taken place, including many types of computer simulations. After over 60 years of research on the Oort proposal, it is appropriate to evaluate the theory. In fact, a number of persistent problems with the Oort theory have not been adequately explained.

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These include problems related to short-period comets (for Halley-type and Jupiter family comets), the number of long-period comets observed, and what happens to comets in the Oort cloud. Another interesting question arises as an implication of the Oort theory: Why are there not extrasolar interstellar comets entering our system?

It is appropriate to review terminology on comets and orbits before dealing with the Oort theory. Recall that *perihelion* (often designated with lowercase letter q) is the point on an elliptical orbit that is closest to the sun. *Aphelion* is the point that is at the greatest distance from the sun (designated with capital Q). The *semimajor axis* (usually designated with lowercase a) is one-half the longer distance across an elliptical orbit, from the perihelion to the aphelion. Another helpful concept regarding orbits is the concept of *total energy*, which is defined as the kinetic energy plus the gravitational potential energy (usually written as E=T+V). *Gravitational potential energy* (V) can be written as $-GM_s m/r$, where G is the gravitational constant, M_s is the mass of the sun, m the mass of the comet, and r represents the distance from the sun. If the total energy (E) of an object in orbit is positive, it will travel on a hyperbolic orbit and will likely escape the sun's influence. If an object has a negative total energy, it will travel on an elliptical orbit and will be bound to the sun. If an object had a total energy of exactly zero, then it would follow a parabolic trajectory and possess an orbital eccentricity of exactly 1.0. In astronomy, elliptical orbits have eccentricities between 0 and 1.0, and hyperbolic orbits have eccentricities greater than 1.0.

Comets are grouped into certain categories according to the periods of their orbits. *Short-period comets* have long been considered those with orbital periods less than 200 years, and *long-period comets* have been those with orbital periods greater than 200 years. Today there are additional categories of comets. One category is for those with orbital periods between 20 and 200 years. These are often referred to as *Halley-type comets*, or sometimes simply as intermediate-period comets. The Halley-type comets often are in highly inclined and sometimes retrograde orbits. Another class of short-period comets is known as *Jupiter-family comets* (JFCs). JFCs are observed in orbits that lie mostly between Mars and Jupiter. Their orbits are also more frequently modified than other comets, even over timescales less than 100 years. A significant number of JFC objects have been discovered in recent years by various observations. The JFC objects are defined in terms of something known as the *Tisserand parameter*, which essentially measures their tendency to be perturbed by Jupiter (Danby, 1962; Jewitt, 2004).

The Tisserand parameter is a number usually defined in relation to Jupiter. It is used in studying the dynamics of asteroids and comets. The Tisserand parameter, sometimes called the *Tisserand invariant* or the *Tisserand criterion*, is an application of the restricted, three-body problem to comets. It assumes the comet's mass is negligible compared to Jupiter and that the center of mass of the sun and Jupiter as a pair is essentially at the sun. The Tisserand parameter (T_J) is defined below and is a constant of the motion as a small body is perturbed by a planet like Jupiter to a good approximation. In this equation a, e, and i represent the semimajor axis, eccentricity, and inclination of the comet orbit. The semimajor axis of Jupiter's orbit, a_J, is 5.2 A.U.

$$T_J = \frac{a_J}{a} + 2\sqrt{\left[(1-e^2)\frac{a}{a_J}\right]}\cos i$$

If the Tisserand parameter of a comet has a value between 2 and 3, it is usually considered a Jupiter-family comet. Main-belt asteroids generally have $T_J > 3$.

Short-Period Comets

Creationists have used short-period comets as an argument for a young solar system for some time. This argument hinges on the destruction of short-period comets and that proposed mechanisms of replacing the short-period comets are inadequate. It was once generally thought that short-period comets were replaced from the Oort cloud as longer-period comet orbits are modified by the planets into shorter orbits. Today it is generally believed that short-period comets come from either the Kuiper belt (the region from about 30 to 55 A.U.) or from what is called the "scattered disk" beyond the Kuiper belt. Faulkner addressed the Kuiper belt as a comet source (Faulkner, 1997). The Kuiper belt is a plausible source of the Jupiter-family, short-period comets. Short-period comets are still a valid indicator of a young solar system. However, because so much has been learned about the dynamics of the various classes of short-period comets, there is a need to update the subject. Halley-type comets are believed by scientists to have longer lifetimes than the Jupiter-family comets. For example, one estimate of the physical lifetimes of Jupiter-family comets gives a range between 3,000 and 30,000 years, with 12,000 years being a most likely time for the object to be visible (Levison and Duncan, 1997). This applies to JFC objects near the ecliptic, and it supports the view that they come from the Kuiper belt. One recent listing of known observed comets from the University of Central Florida has 479 JFC objects and 70 Halley-type objects (Fernandez, 2013).

The Halley-type comets (HTCs) have presented unique challenges to comet researchers hoping to explain their origin and dynamics. Halley-type comets have Tisserand parameters less than 2, their orbits are generally more inclined than the JFC objects, and a significant number of them orbit retrograde (orbit inclination is greater than 90 degrees). They also tend to have more eccentric orbits and longer periods than the Jupiter-family comets. Since their orbits are more inclined, the Kuiper belt is not a plausible source for many of them. Thus, some scientists argue they originate from the Oort cloud. On the other hand, it has been argued that if they were from the Oort cloud, their orbits would cover a greater range of inclination angles and the retrograde cases would outnumber the prograde cases. However, this is not observed. Therefore, some scientists have argued that the HTC objects come from the region beyond 55 A.U. distance known as the scattered disk. "Transneptunian region" is a broad term that includes both the Kuiper belt and the scattered disk. The distinctions between the Edgeworth-Kuiper belt and the scattered disk are not totally consistent among researchers. Morbidelli and Brown (2004) consider Kuiper belt objects those from about 30 to 50 A.U. distance that are not likely to interact with Neptune. But the scattered disk starts in the same general region near Neptune and then extends out to distances of about 100 to 200 A.U. The scattered disk objects, according to Morbidelli and Brown, are more likely to interact with Neptune. The scattered disk is believed to include objects with a broader range of orbit inclinations. There has been significant debate among researchers regarding how many objects are in the scattered disk. Orbital simulations have generally convinced researchers that the HTC objects are not likely to come from the Kuiper belt or from Jupiter family comets.

Therefore, the scattered disk is becoming the preferred source for replenishing the Halley-type comets. The scattered disk is believed to consist of objects left over from solar system formation. Many of them never were in the Oort cloud, though it is thought that some of their orbits would be modified to put them in the Oort cloud. After the formation of the solar system, their perihelia would initially be in the region of the Kuiper belt. Levison et. al. (2006) study a scenario in which scattered disk objects first have their orbits lengthened by the outer planets to put them in the Oort cloud. They may stay in the Oort cloud for a long period of time, but they eventually have a tendency to come near Neptune. Neptune can then alter the orbit so that the perihelion is pulled in (to about 1 to 4 A.U.), and the orbit tends to have its inclination altered in the process. Thus, Neptune can alter the orbits of scattered-disk objects so that they become Halley-type comets. This scenario works in simulations but often requires times of over a billion years.

Modern observations of objects in the transneptune region have noted a few objects that are considered scattered-disk objects. Extrapolating from these observations, the implication is that there are fewer objects in the scattered-disk region than models estimate and there are fewer observed Halley-type comets than models imply should exist. Levison et al point out, "So there appears to be a discrepancy between the value of N_{SD} (d>10) needed by our model to make enough HTCs and the observations of the scattered disk, and perhaps with models of Jupiter-family comet origins" (Levison et al., 2006, p. 630). The same authors give a value of 69,000 years for what they call the "death rate" of HTC objects. This would be the time for these objects to be destroyed near the sun, become inactive from loss of volatiles, be captured, collide with a planet, or be ejected out of the solar system. Observational evidence does not suggest an adequate source to replenish these objects. Computer simulations do not explain the HTC objects' orbital characteristics in a plausible way, even if they did come from the scattered disk. Also, note that the scattered disk is a largely hypothetical construct. It is not known how many objects are present at that distance since opportunity to observe those objects is very limited. Some conclusions from recent research on short-period comets include the following:

- It is plausible for orbits of Kuiper-belt objects to be modified by influence of the outer planets into centaur or Jupiter-family comet orbits.
- Both Jupiter-family comets and Halley-type comets have a short lifetime that is consistent with a young solar system.
- Models of the Oort cloud and of comet orbital dynamics imply there should be more Halley-type objects than are observed.

Long-period Comets

What observation or observations of comet orbits provided the impetus for the Oort theory? The observation motivating the Oort theory was mainly the properties of the orbits of the long-period comets. The long-period comets suggested to Oort the existence of another, more distant population of source objects, which are often referred to as the near-parabolic comets. Some long-period comets are considered nonperiodic because they have been observed only once near the sun and it is believed they will never be observed again. The term "near-parabolic" is sometimes taken as synonymous with the term "new comets." A "new" comet would be a comet that is approaching its perihelion for the first time, thus it would be on its first trip toward the sun. It is debated by scientists how many of the near-parabolic comets are actually "new" comets. A few near-parabolic comets are observed each year. They are in extremely long, narrow elliptical orbits with eccentricities being a decimal value very close to 1. An issue that is debated today is how to determine if a long-period comet is a new comet or a returning comet; that is, is it on its first trip toward the sun, or has it passed its perihelion before? This distinction turns out to be an important issue in comet studies.

Jan Oort's theory proposed that comets formed along with planetesimals in the region near the outer planets very early in the history of our solar system. They would have been deflected outward away from the sun occasionally by the outer planets into longer orbits that put their aphelia at distances on the order of tens of thousands of A.U. from the sun. Oort (1951) reasoned that the cloud would range in distances from the sun from approximately 30,000 A.U. to 150,000 A.U. Estimates both from Oort and more recent scientists suggest the number of comets in the Oort cloud would be approximately 10^{11}. Oort also considered that if an object reached distances of tens of thousands of A.U. from the sun, perturbations from the planets would be negligible and the perturbations of nearby stars would become significant compared to the gravitational pull of our sun. Thus, as comets would form in the early solar system, they would form in nearly circular orbits originally as other planetesimals and asteroids; then planets such as Jupiter or Saturn could modify orbits of some of these small objects and increase the eccentricity and size of the orbits.

Once an orbit is made more elliptical, it becomes likely for it to cross the orbits of the planets. Thus, some kind of gravitational interaction with a planet would also be more likely. This is believed to lead to comet orbits being altered into very long eccentric orbits that would put their farthest point (the aphelion) possibly at tens of thousands of A.U. distance. At the aphelia, comets would be moving very slowly, and thus they would be easily perturbed by forces from outside our solar system, such as nearby stars. If there were many other comet objects in the same region, the objects essentially could be "caught" by the cloud while they moved slowly near the aphelion of their orbit. The comets then could be stable in the comet cloud for millions of years. Oort suggested that nearby passing stars could sometimes perturb comets out of the comet cloud so they would head inward toward the sun and possibly become observable (Oort, 1950, 1951).

Modern Modifications to the Theory

Modern theory attempts to explain comets by thinking of them as if moving up and down a ladder. Some of the steps in the ladder were not envisioned by Jan Oort. The comets with the longest orbits are those referred to as the near-parabolic comets, whose aphelia are in the farthest regions of the Oort cloud. These represent the "top" of the ladder. Then there are long-period comets with orbital periods ranging from hundreds of thousands to millions of years. Within those orbits are the comets of the inner Oort region (aphelia distances from roughly 3,000 to 20,000 A.U.); then, moving inward, we find the short-period comets. To explain all the comets, modern scientists attempt to argue that comets can move both up and down this "ladder" of distance scales, thus explaining our observations on the one hand and sustaining the Oort cloud on the other hand. But there have always been difficulties explaining the various orbital transitions required for objects to move up and down the distance ladder. The scattered disk, which lies outside the Kuiper belt, and the inner Oort cloud can be thought of as the "middle" of the distance ladder. They constitute transition regions from which comets are evolving both inward and outward in the theory.

In recent years scientists have modified the original Oort proposal. First, it has been found through many computer simulations that passing stars are not very efficient at perturbing comets inward toward the sun (Fernandez, 1994; Dones, et al., 2004). This mechanism was the only one seriously considered by Oort, but it is generally accepted today that by itself this mechanism would not provide enough comets to explain observations through history. Today it is generally accepted that the forces that perturb comets out of the Oort cloud are three. In order of their importance, they are (1) galactic tidal forces, (2) passing stars, and (3) occasional nearby giant molecular clouds. The galactic forces from the plane of the Milky Way galaxy are believed to be the most effective of these forces in nudging comets out of the Oort cloud and sending them inward toward the sun so that they may be observed.

A second change from Oort's original concept regards short-period comets. It was thought that short-period comets could have come from the Oort cloud, as could long-period comets. But today it is generally understood that short-period comets could not come from the Oort cloud (though for HTC objects this is still debated). Where the short-period comets come from is still a mystery debated by astronomers, but the Edgeworth-Kuiper belt is considered the best candidate source. After a comet has been perturbed out of the Oort cloud, it will require hundreds of thousands or even millions of years for it to make its way near to the planets so that it might be observed. The outer planets, especially Jupiter and Saturn, tend to modify incoming comet orbits. An incoming long-period comet is about equally likely to get accelerated such that it is ejected out of the solar system or have its orbit modified so it is a smaller, less elliptical orbit (Dones et al., 2004).

These long-period comets may have their orbits further modified as they make more frequent passes near the outer planets. Jupiter tends to capture or deflect comets relatively frequently. So the comets that are thought to come in from the Oort cloud will face one of several fates, according to theoretical studies. They may pass near enough to Jupiter (or Saturn) that they get accelerated into a hyperbolic path that causes them to escape the sun's gravity and continue indefinitely into space. Or they may collide with a planet or other object in the solar system. They could fall into the sun or be broken up near the sun. Or they could be deflected by Jupiter or Saturn back out toward the Oort cloud again. Of comets that are deflected outward into long orbits, some of these could get "caught" in the Oort cloud once again (about 5% return to the Oort cloud by one estimate in Dones et al., 2004). Even some of the objects in the Oort cloud may also get perturbed out into space and escape the sun's gravity after being in the Oort cloud for a long period. Oort seemed to underestimate the tendency of objects in the Oort cloud to be lost into space, escaping the sun's gravity.

Because of the issue of how often objects in the Oort cloud could escape into space, as well as move inward toward the sun, astronomers have modified the dimensions of the Oort cloud. Oort believed the cloud would continue possibly somewhat beyond 150,000 A.U., but today scientists argue it would not continue farther than about 100,000 A.U. Today it is generally understood that the outer part of the Oort cloud has a tendency to lose objects into outer space. This has been shown in computer simulations studying stellar perturbations. Nearby stars are just as likely to make a comet in the Oort cloud escape into space as come inward toward the sun. Thus, it is believed tidal forces from the galactic plane are more effective at perturbing comets inward. In addition, there have been no observations of comet objects on trajectories suggesting they could have come from outside our sun's influence.

Considering the relative speed of our sun compared to the local standard of rest in our galaxy, objects coming from other stars and passing into our solar system should be travelling at very high-speeds (such as tens of km/sec at the outer Oort cloud). Thus any extrasolar interstellar comets would be on hyperbolic orbits very different from any other objects in our solar system and would have eccentricities much more than 1.0. In other words, even if a comet were "at rest" in space relative to the galaxy, it would still approach our sun at a significant speed if coming from another star. Since no extrasolar comets have been observed approaching our system, there is no prospect of the Oort cloud being refilled from outside our solar system. Thus, it is not just short-period comets that must be replenished over long periods of time. The Oort cloud itself must be replenished to last for billions of years.

Astronomers have proposed that there is an inner Oort cloud, sometimes referred to as the inner core of the Oort cloud. The inner Oort region ranges from about 3,000 A.U. out to about 20,000 A.U. It is believed that Jupiter and Saturn could occasionally "pump up" the orbital energy of comets in the inner Oort region to replenish comets in the outer Oort region. Thus, the outer planets, particularly Jupiter and Saturn, are believed to have a crucial role in explaining both inbound comets that we can observe and outbound comets that are thought to replenish the Oort cloud over billions of years.

Jan Oort did not believe that objects would be stable in the region now called the inner Oort cloud. Significant research has been done on perturbations to comets that could reside in the Kuiper belt region and the inner Oort region. It is believed some objects from this region could be modified to become Jupiter-family comets or centaur objects (if their orbits are shortened). Other inner Oort comets could be modified into longer orbits that move them farther out into the Oort cloud. Thus, the inner core region in essence is treated as an important transition zone. Orbital periods of inner core comets would range from several thousand to a few million years. Note that in an old-age perspective, some long-period comets have been able to orbit the sun multiple times and return again. But a young-age alternative may be to understand almost all the inbound, long-period comets as being on their first orbit.

Difficulties with Modern Comet Theories

It is important to test comet models against observations and ask how successful the models have been in their explanatory power. One obvious issue with the Oort theory, even with modern observational techniques, is that development of the theory depends greatly on supposing populations of objects that cannot be observed, such as most of the scattered disk, all of the inner Oort cloud, and all of the main Oort cloud. There are valid insights from the many orbital evolution simulations of comets. But these studies do not actually establish the existence of a spherical comet cloud. The orbital studies do show that there are objects (the long-period comets) that tend to have aphelia on the order of 10,000 to 50,000 A.U. But this does not establish the existence of the Oort cloud; it merely establishes that these objects are in extremely long elliptical orbits.

The near-parabolic comet orbits possess the longest and most eccentric orbits known of all objects gravitationally bound to our sun. The existence of these comets may be one of the best arguments in favor of the Oort theory. These objects seem to move as if they were started almost at rest and allowed to fall toward the sun. This is essentially what the Oort theory says. It has these objects existing for a long period at great distance from the sun, where they drift in quasi-stable orbits until some effect imparts a small acceleration to them—enough to make them begin falling toward the sun. Then after a few million years, they come nearer to the planetary region, where they can be observed in the highly elliptical near-parabolic orbits. This may be consistent with the Oort theory, but a creation perspective could allow for them being created or forming at a lesser distance along their current orbits. It is not necessary to assume that comets have traversed their entire orbits or even half of their orbits since creation. The period of a comet orbit does not tell us the age of the universe, the galaxy, or the solar system.

A significant difficulty with today's comet theories is that the number of observed, returning long-period comets are less than that predicted by the models. For example, Jewitt states "The dynamical part of Oort's model predicts a ratio of returning comets relative to first-appearing comets that is larger than is observed" (Jewitt, 2004, p. 660). Generally, researchers assume that comets with aphelia greater than 10,000 A.U. are new; they have never reached their perihelion before. However, researchers admit this is a crude assumption. Hughes stated, "We are not able to divide the long-period comets sensibly into different 'age' groups" (Hughes, 2001, p. 523). Here "age groups" assumes there will be identifiable orbital characteristics that indicate something about how many orbits comets have made. This is a very questionable assumption for the long-period comets. It is true that a comet will be brighter at its first perihelion passage than it will be at later perihelions. However, brightness variations do not seem to give much insight into long-period comets that have not yet been observed near perihelion. It is also possible to calculate backward and determine the prior position of a comet, within limits. Dybczynski (2001) proposed a different definition of new comets, saying they must have a previous perihelion of at least 15 A.U. Dybczynski's approach attempts to account for planetary perturbations on observed comets to determine their previous perihelion. By this definition only 44 comets would qualify as new. It has proved difficult to identify orbital characteristics that would be related to the number of orbits a comet has completed. Thus, comet orbit studies suggest it is questionable that researchers can make a reliable determination of whether a particular observed comet is "new" or not. We may know about how many orbits an observed comet has made, but comet researchers attempt to use statistical analyses of comet orbits to infer whether comets not observed near the sun are new or not. This effort has not been successful in my opinion.

Hughes (2001) also summarized his results modeling comet visual magnitudes (represented by H) and distance and compared them to observations by another study. He says, "In passing, equation (10) predicts that 15 long-period comets per year pass the Sun having q < 1 A.U. and H < 10.5, in comparison with the 3 yr^{-1} quoted by Fernandez (1999)" (Hughes, 2001, p. 523). A number of studies of the statistics of comet magnitudes and aphelia distance have noted that the number of long-period comets seems to "fade" or drop off with decreasing distance more than would be expected. Jan Oort referred to this in his 1950 paper, and it is still noted by researchers today. On the other hand, some have applied special analysis methods that give somewhat better agreement with observations (Francis, 2005). But various methods of comparing models to observations give widely varying results. Francis (2005) shows discrepancies in how the LINEAR mission observations of comets compare with his own and two other comet models, especially regarding the number of comets as a function of perihelion distance. Here LINEAR represents the Lincoln Near Earth Asteroid Research project conducted by MIT. In studying near-earth objects, LINEAR has discovered 279 comets. Astronomers have not arrived at a consensus on an explanation for this "cometary fading" effect. This fading effect is not related to a comet being less bright after passing near the sun. This is assumed to be some effect occurring before the comet exhibits a coma—before it reaches the inner solar system that makes these comets hard to observe. This could be an indication long-period comets do not transition into the planetary region as often as suspected. Long-period comets are not generally believed to be modified into short-period comets directly. But once a long-period comet comes near the outer planets, the outer planets tend to further modify the orbit, often by reducing the semimajor axis and reducing the eccentricity. Without adequate numbers of transitioning long-period comets, this leads to difficulties with explaining the short-period comets, as well as the frequency of comets being deflected outward to replenish the Oort cloud.

Planetary science has in recent times been propelled by an enhanced motivation from the discoveries regarding extrasolar planets. The evidence for the existence of extrasolar planets is good, and many examples now exist (Spencer, 2011). It is generally accepted among scientists that solar systems outside our own generally form in a manner similar to how our system is believed to have formed. A solar disk contracted and condensed into our sun and planets. Comets are believed to have formed in the regions of our system near the forming outer planets, where ices and volatile compounds could condense into small bodies. Therefore, if the processes that formed many comets in our solar system also occurred in other solar systems, this has an interesting implication. Models have estimated that of all the comets that could form near the outer planets early in the history of our solar system, only a small percentage would traverse to the Oort cloud and be stable there. Some comets that would form among the newly forming planets may collide with a planet or fall into the sun. Others stay in orbit relatively near the sun and never make it to the Oort cloud. In our solar system, Jupiter and Saturn are able to accelerate comets to escape velocity in a number of cases, leading to objects that are observed to follow hyperbolic trajectories out of the solar system. So the only objects that would make it to the Oort cloud in the beginning would be those that happened to pass by one of the planets so that it was deflected outward away from the sun; then of those that were deflected outward, a few might get captured into the Oort cloud. This is how the Oort cloud is believed to have formed. Valtonen and Innanen estimated that "at least one out of 1000 original comets would remain in the solar system in the Oort cloud" (Valtonen and Innanen, 1982, p. 307). This implies that many more escape from the Oort cloud into interstellar space. Thus, if this were happening for most nearby stars, there should be many comets in the interstellar medium. We should then be able to observe some of these extrasolar interstellar comets.

Since 1982 other estimates that consider more modern observational techniques have led to discussions of the issue of "missing interstellar comets." Sen and Rana (1993, p. 298) refer to estimates saying that for every comet "trapped in the Oort cloud, there should be 30–100 comets lost into the interstellar medium." A more recent study by Francis (2005) uses a lower estimate for the number of long-period comets and arrives at the conclusion that with modern methods a 5-year observational study could detect one or two interstellar comets if the work could detect objects of 24th magnitude. So even with the most conservative assumptions regarding the number of comets, it should be possible to observe interstellar comets. As two researchers said, "This lack of detections of extrasolar comets is becoming an embarrassment to the theories of solar system and cometary formation" (McGlynn and Chapman, 1989, p. L105). These comets would have a very distinctive hyperbolic trajectory and would travel at velocities at least several kilometers per second faster than any other observed comets. Such a finding would be a newsworthy event. But comet researchers seem to always agree that no one has ever observed an object like this.

It might be objected that these interstellar comets would be so faint that they would be impossible to observe. If you assume traditional observation techniques with one person using a telescope, it may be impossible to observe such objects. But today there are multiple projects that do totally automated searches of the sky in which multiple CCD cameras collect large amounts of data. Some of these projects can detect very faint objects. Thus, astronomers are more hopeful now than in the past that interstellar comets could be observed. There are only a few projects active today that can observe objects of 24th magnitude. Others are planned. There is at least one new telescope that is especially well suited to detecting faint interstellar comets. It is called the Pan-STARRS telescope at the University of Hawaii. The Pan-STARRS results website shows that since its mission began in 2010, 14 long-period comets have been discovered, but no interstellar comets have been reported (Hsieh, 2013). There are a number of efforts to do automated data collection and automated software searches of image data to find faint objects in our solar system. The near-earth asteroid search is one of the drivers of this effort; the search for extrasolar planets is another. There is also interest in mapping objects in the Kuiper belt. It is these automated searches with wide-field cameras specifically made for finding faint objects and doing sensitive photometric measurements that would be most likely to find interstellar comets.

Why is it no interstellar comets have been observed? First, it may be that they aren't there in the numbers predicted by the Oort theory. Also, if both the galaxy and our solar system are young, we would not expect to see such objects. Such extrasolar comets, if they exist, would not have had time to cross space from nearby stars in a time frame of 6,000 years. Long-period comets would traverse only a small part of their orbit in several thousand years. Observations of comets tell us about comet orbits, but they do not really confirm the Oort theory. It would be appropriate for creation scientists to examine the research on comet orbits. The shortage of observed Halley-type comets, the shortage of observed returning long-period comets, the young physical lifetime of short-period comets, and the lack of any observed extrasolar interstellar comets all imply the Oort theory has not been successful. A young-age creation perspective does not dictate how many comets should be observed or how long their orbits should be. We should question the assumption that all comets can be explained by their orbits transitioning up and down a great "distance ladder." Orbital simulation studies of comets give insight into the dynamics, but they do not tell us the actual history of long-period comets or the near-parabolic comets.

This review has not addressed issues regarding the composition of comets. This is an area where much has been learned in recent years as well. Young-age creationists should explore alternatives to the Oort theory that begin with supernatural biblical creation and yet deal with the scientific evidence realistically. Comets also could have relevance to explaining cratering in the solar system and some of the effects of Noah's Flood.

References

Danby, J.M.A. 1962. *Fundamentals of Celestial Mechanics*. The Macmillan Company, NY.

DeYoung, Donald B. 1989. *Astronomy and the Bible: Questions and Answers*. Baker Book House, Grand Rapids, Michigan.

Dones, L., and P.R. Weissman, H.F. Levison, and M.J. Duncan. 2004. Oort cloud formation and dynamics. In Festou, M.C., H.U. Keller, and H.A. Weaver (editors), *Comets II*, pp. 153–174. University of Arizona Press, Tucson, AZ.

Dybczynski, P.A. 2001. Dynamical history of the observed long-period comets. *Astronomy and Astrophysics* 375:643–650.

Faulkner, Danny R. 1997. Comets and the age of the solar system. *Creation Ex Nihilo Technical Journal* (Now *Journal of Creation*) 11(3):264–273.

Faulkner, Danny R. 2001. More problems for the 'Oort comet cloud.' *TJ* (Now *Journal of Creation*). 15(2):11.

Fernandez, Julio A. 1994. Dynamics of comets: recent developments and new challenges. In Milani, A., M. Di Martino, and A. Cellino (editors), *Asteroids, Comets, Meteors 1993*, pp. 223–240. International Astronomical Union, Belgirate, Italy.

Fernandez, Yan. 2013. List of Jupiter-family and Halley-family comets. University of Central Florida Physics website. http://www.physics.ucf.edu/~yfernandez/cometlist.html (accessed November 16, 2013).

Francis, Paul. 2005. The demographics of long-period comets. *Astrophysical Journal* 635:1348–1361.

Hsieh, Henry H. 2013. Pan-STARRS solar system results. Institute of Astronomy, University of Hawaii. http://www.ifa.hawaii.edu/~hsieh/panstarrs.shtml (accessed November 20, 2013).

Hughes, David W. 2001. The magnitude distribution, perihelion distribution and flux of long-period comets. *Monthly Notices of the Royal Astronomical Society* 326:515–523.

Jewitt, David C. 2004. From cradle to grave: the rise and demise of the comets. In Festou, M.C., H.U. Keller, and H.A. Weaver (editors), *Comets II*, pp. 659–676. University of Arizona Press, Tucson, AZ.

Levison, Harold F., and Martin J. Duncan. 1997. From the Kuiper Belt to Jupiter-family comets: the spatial distribution of ecliptic comets. *Icarus* 127:13–32.

Levison, Harold F., Martin J. Duncan, Luke Dones, and Brett J. Gladman. 2006. The scattered disk as a source of Halley-type comets. *Icarus* 184:619–633.

Looy, Mark. 2006. The tale of a comet. Answers in Genesis, http://www.answersingenesis.org/articles/2006/05/06/tale-of-a-comet (accessed October 29, 2013).

McGlynn, Thomas A. and Robert D. Chapman. 1989. On the nondetection of extrasolar comets. *The Astrophysical Journal* 346:L105–L108.

Morbidelli, A., and M.E. Brown. 2004. Kuiper Belt and the primordial evolution of the solar system. In Festou, M.C., H.U. Keller, and H.A. Weaver (editors), *Comets II*, pp. 175–191. University of Arizona Press, Tucson, AZ.

Oort, J.H. 1950. The structure of the cloud of comets surrounding the solar system, and a hypothesis concerning its origin. *Bulletin of the Astronomical Institutes of the Netherlands* 11(408):91–110.

Oort, J.H. 1951. Origin and development of comets. *The Observatory* 71(863):129–144.

Sen, A.K. and N.C. Rana. 1993. On the missing interstellar comets. *Astronomy and Astrophysics* 275:298–300.

Valtonen, M.J., and K.A. Innanen. 1982. The capture of interstellar comets. *Astrophysical Journal* 255:307–315.

Slusher, Harold S. 1980. *Age of the Cosmos*. Institute for Creation Research, San Diego, CA.

Spencer, Wayne R. 2011. Retrograde exoplanets challenge theories. Answers in Genesis, http://www.answersingenesis.org/articles/aid/v6/n1/retrograde-exoplanets-challenge-theories (accessed November 21, 2013).

Were the Wind River Terraces Caused by Multiple Glaciations?

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Abstract

Geologists believe that fifteen terraces in the upper Wind River Basin of northwest Wyoming are correlated to multiple ice ages. However, field examination reveals only four significant terraces: WR1, WR3, WR7, and WR9. The bottom two, WR1 and WR3, were connected to glacial outwash from an ice cap over the Wind River Mountains but were likely formed during the same glaciation, not from two distinct ice ages, called the Pinedale and Bull Lake glaciations in the uniformitarian scheme. Although terrace WR7 is claimed to be linked to the Sacagawea glaciation, the moraine in the type area for this glaciation is not physically connected to terrace WR7. This moraine has similar geomorphology to the "Bull Lake" and "Pinedale" moraines, suggesting just one glaciation for all these moraines. Terrace WR7 also has contradictory dates ranging up to about 660 kyr, based on dates from the Lava Creek B ash in WR7. This date indicates three missing glaciations. The few terraces above WR7 are not associated with any glacial feature, despite geologists' claims. Due to uncertain dating of WR7, the dates of higher terraces are equally uncertain. Terraces above WR3 are best understood as pediments and planation surfaces formed during channelized Flood erosion and runoff in currents moving toward the southeast through the Upper Wind River Basin.

Introduction

Multiple, elongated terraces flank the sides of river valleys all over the world. These terraces lie parallel to and above the river and its immediate floodplain. There are two main types: depositional and erosional. Depositional, or gravel, terraces are composed of gravel, cobbles, and boulders, collectively called coarse gravel, laid down on a floodplain during flooding. When the river returns to normal stage and erodes its bed, it leaves flat terraces of gravel with a steep embankment along the valley sides. This can happen more than once, resulting in a flight of gravel terraces (Figure 1). Some valleys can have a dozen terraces. Terraces are especially common and large if the valley was a drainage conduit for glacial meltwater from an ice sheet,

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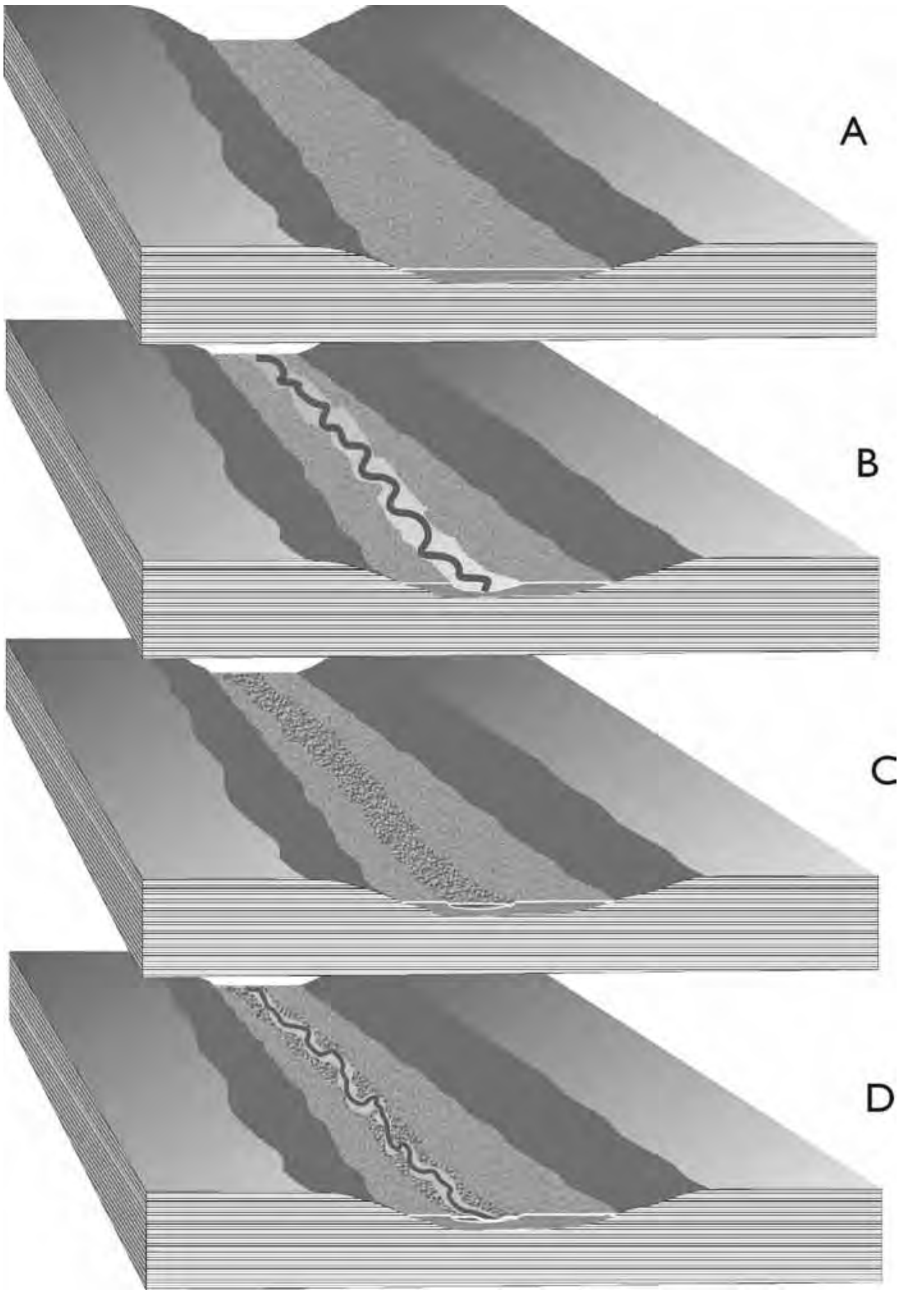


Figure 1. The formation of two gravel terraces in a river valley. (A) The river valley is first carpeted with a layer of coarse gravel. (B) The river erodes this gravel, leaving gravel terraces on either side of the valley. (C) A second depositional event partially fills the eroded valley with coarse gravel. (D) The river erodes the second layer resulting in new gravel terraces. (Drawn by Peter Klevberg)

ice cap, or mountain glacier at the end of the Ice Age. For example, two large terraces formed along the upper Snake River Valley of Jackson Hole Valley, Wyoming (Figure 2) during the melting of the Yellowstone ice cap.

The second type of terrace is erosional on hard rock and is called a *strath* terrace. Strath terraces are elongated planation surfaces cut in bedrock along valley slopes and covered with a thin layer of coarse gravel. Uniformitarian scientists believe strath terraces are remnants of a broad, flat bedrock floor, called a strath that extended across the *whole* valley from an earlier age in which the river eroded *laterally* and not downward. Upon subsequent downward cutting of the bedrock, the strath is left hanging on the sides of the valley with a thin veneer of coarse gravel on top (Neuendorf et al., 2005, p. 632). Just like with depositional terraces, multiple strath terraces can form in a single valley (Figure 3).

Both types of terraces occur in the upper Wind River Valley, northwest Wyoming. They are predominantly strath terraces, and are attributed to multiple uniformitarian ice ages associated with the classical location for mountain glaciers in the Wind River Mountains. Geologists have identified 15 depositional and strath terraces, which they correlate to different ice ages, although each ice age did not form a distinct terrace that remains. This is based on a possible date of 1.7 Ma (million years ago) for the top terrace (Chadwick et al., 1997). This date is based on the astronomical theory of the ice ages in which ice ages occur every 100 kyr (thousand years) for the last 900 kyr and cycle every 40 kyr older than 900 kyr.

General Geology of the Upper Wind River Area

The upper Wind River broad valley lies between the Absaroka and Owl Creek Mountains on the north and the Wind River Mountains on the south. Yellowstone National Park lies to the northwest and Teton National Park to the west (Figure 4). The rocks in most of these mountains are quite different. Those in the Teton, Beartooth, and Wind River

Figure 2. Two large, coarse gravel terraces along the Snake River at Snake River Overlook, Jackson Hole, caused by outwash from the melting Yellowstone ice cap.

Mountains are composed mostly of Precambrian granite and gneiss, while the Owl Creek Mountains are composed of an east-west uplifted Precambrian granite core covered by sedimentary rocks (the geological column and ages are used for discussion purposes only).

The Wind River Mountains are capped by an extensive planation surface (Figure 5), while other flat surfaces along their flanks are likely pediments (Figures 6 and 7). This mountaintop planation surface is eroded into granite and gneiss, as well as some of the steeply dipping sedimentary rocks, such as at Gypsum Mountain. Because the planation surface is cut on both Precambrian granite and gneiss and Phanerozoic dipping sedimentary rocks, some geologists believe the planation surface formed during the Laramide orogeny of the Late Cretaceous to early Eocene with the final uplift during the Oligocene (Steidtmann et al., 1989). Blackwelder earlier deduced:

> The age of the Wind River summit peneplain [planation surface] is debatable, but, by a process of finessing, it may be worked out with some degree of assurance. It will be admitted by all that, since it trunkates [sic] the structures produced by the folding at the close of the Cretaceous, it must be of Cenozoic age. (Blackwelder, 1915, p. 202)

However, it is also possible that the planation surface cutting into the granite could be exhumed—part of the Great Unconformity overlying Precambrian igneous and metamorphic rocks over much of the western and central U.S. The same, or a similar, unconformity is seen in Grand Canyon, separating Paleozoic sedimentary rocks from underlying Precambrian sedimentary rocks and igneous and metamorphic basement (Figure 8). Arguments in favor of the one on the Wind River Mountains being an exhumed planation surface are (1) the faulted planation surface, on top of what is probably the same granite and gneiss on the Beartooth Mountains, has a 480-meter thick, early Paleozoic erosional remnant on top of the granite and gneiss, and (2) the flat top of Mount Moran in the Teton Mountains, the same Precambrian granite and gneiss, has a

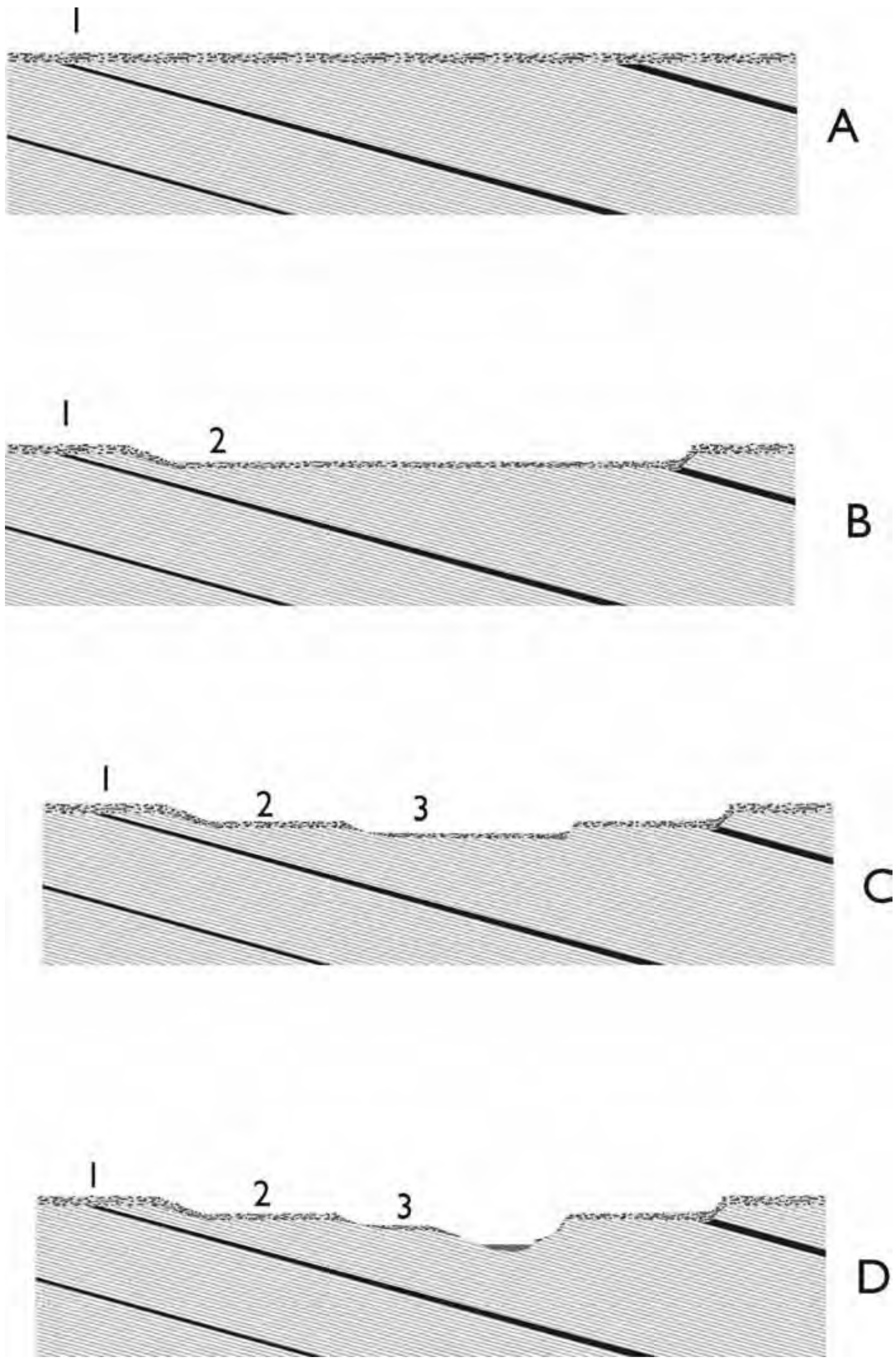


Figure 3. The formation of three strath terraces in a river valley. (A) The river first erodes a nearly flat planation surface, or "strath," on hard rock and deposits a thin veneer of coarse gravel across the entire valley. (B) The river erodes some of the bedrock, leaving strath terraces on either side of the valley. (C) A second erosional event creates a second set of strath terraces. (D) A third episode forms a third set of strath terraces. (Drawn by Peter Klevberg)

15-meter thick patch of Cambrian Flathead Sandstone on top. The evidence is well explained by a combination of early Flood erosion of basement rocks and late Flood erosion caused by Flood runoff during differential vertical tectonics.

The uplift of the Wind River Mountains was caused by a thrust fault. Motion was to the southwest, inclined about 30° from the horizontal with a vertical throw of about 14 kilometers and a horizontal displacement of 26 kilometers. It uplifted basement granite relative to the sedimentary fill of the Green River Basin.

The Absaroka Mountains are composed of the Absaroka Volcanics (Figures 9 and 10), which were formed by multiple debris flows of volcanic material that accumulated over an area of 23,000 km^2 and reached a thickness of 1,830 m (Hergenrather et al., 2012; Sundell, 1993). This is the material in which the so-called fossil forests of Yellowstone National Park are located (Figure 11). The Absaroka Volcanics are dated as Eocene by uniformitarian geologists. The top has been planed flat, and the planation surface is still visible in the southern Absaroka Mountains (Love et al., 2007). Afterward, the mountains were deeply dissected by valleys up to about 1,200 m deep. This sequence of events fits well with the late-Flood, two-stage erosion—sheet erosion followed by channelized dissection—during the retreating stage of the Flood (Oard, 2008; Walker, 1994).

In addition to the Absaroka Volcanics in the northern and eastern park, volcanic rocks of Yellowstone National Park consist of almost all types of lava from basalt to rhyolite. It represents the largest supervolcano in the world and is believed to be composed of three major Pleistocene super eruptions: (1) Huckleberry Ridge dated at 2.1 Ma, (2) Mesa Falls dated at 1.3 Ma, and (3) Lava Creek dated at 0.65 Ma (Love et al., 2007). Ash from these eruptions spread over most of the western and central United States, and westward into the

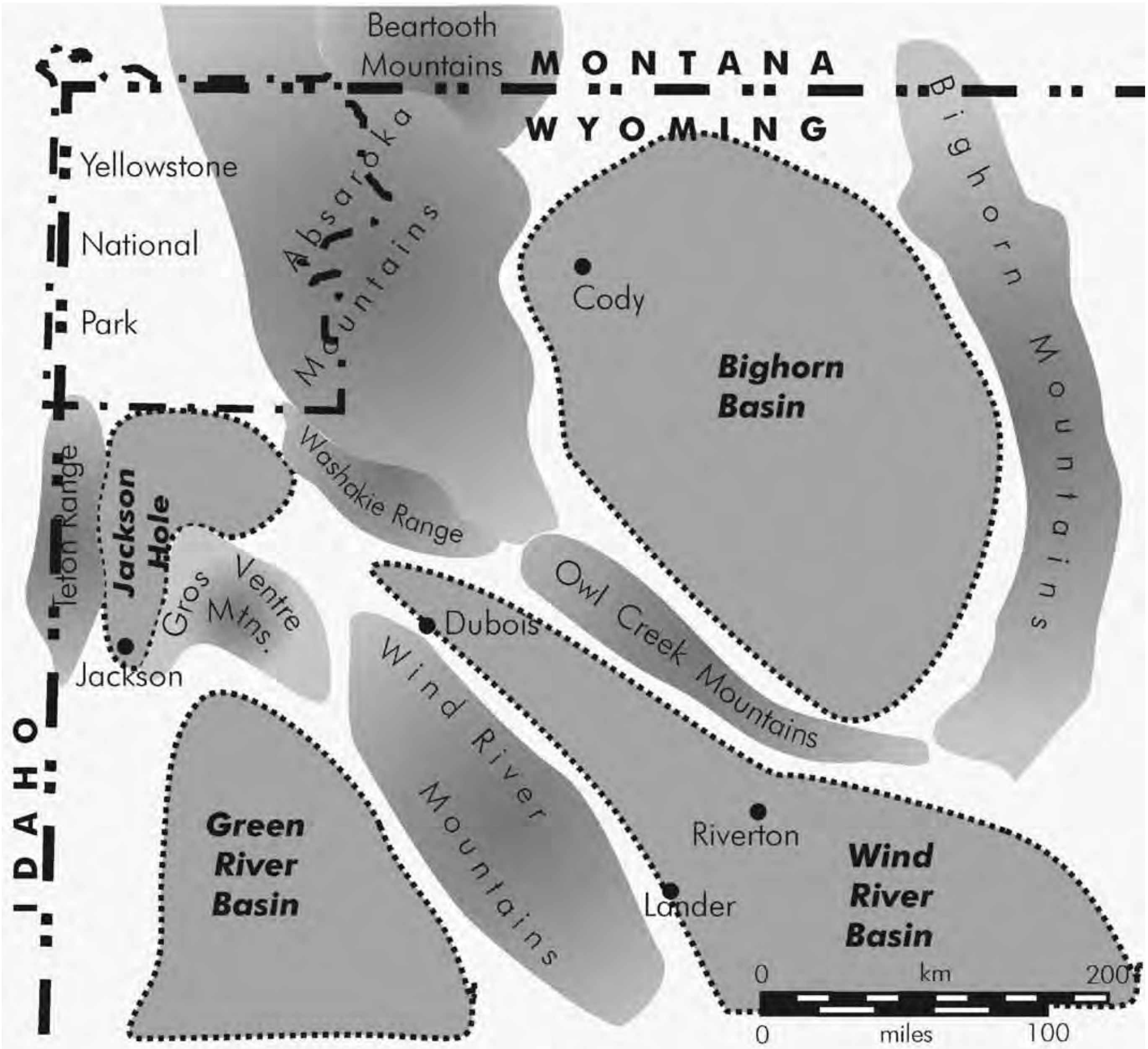


Figure 4. Map of northwest Wyoming showing the study area of the upper Wind River Basin between Dubois and Riverton. (Drawn by Peter Klevberg)

Pacific Ocean, well off the West Coast, where it is believed to have been found in deep-sea drill cores (Sarna-Wojcicki et al., 1987).

As the mountain ranges uplifted, the Wind River Basin and other basins sank and were infilled by thick sediments that now reach over 8,500 m in thickness in the Wind River Basin (Love, 1960; Thornbury, 1965). But the top of this valley fill has been eroded by as much as 850 m, based on erosional remnants in the Wind River Basin (McMillan et al., 2006). Crowheart Butte (Figure 12) is a remnant about 300 m high in the center of the upper Wind River Basin that represents the minimum erosion in the northwest part of the greater Wind River

Figure 5. Planation surface on the top of Wind River Mountains.

Figure 6. Pediment or planation surface remnant along the southeast Wind River Mountains.

Figure 7. Large pediment along the northeast Wind River Mountains.

Figure 8. The Great Unconformity (solid line) on eastward tilted Precambrian sedimentary rocks in the eastern Grand Canyon. The Greatest Unconformity (dashed line) is between the Precambrian rocks and the igneous and metamorphic rocks below.

Figure 9. Absaroka Volcanics (view northwest from Brooks Lake, Wyoming, at about 2,900 m msl).

Basin. Erosional remnants north of the Wind River in the northwest Wind River Basin show about 700 m of erosion (Fan et al., 2011). So, during the formation to the Wind River Terraces, deep valley erosion was occurring.

The Wind River Terraces

The upper Wind River is believed to possess a classical series of terraces. It is claimed that there are fifteen fluvial, mostly strath, terraces in the upper Wind River Basin above Riverton, labeled WR1 to WR15, from the lowest to the highest (Hancock et al., 1999). However, only WR1, WR3, WR7, and WR9 are of any significant size (Figure 13). WR1 is just above the modern floodplain in the upper reaches but merges with the cur-

Figure 10. Close up of Absaroka Volcanics at Brooks Lake.

Figure 11. Multiple levels of petrified trees in the Absaroka Volcanics at Specimen Creek, northwest Yellowstone National Park.

rent floodplain downriver toward Riverton. WR3 is about 40 meters higher and is composed of around 25 m of gravel near Dubois, thinning to a few meters downstream near Riverton. Although shown as continuous on Figure 13, WR7 consists of isolated remnants and is about 140 meters above the river. WR9 is located around Riverton and is about 190 m above the river. WR15 consists of only one small fragment south of Bull Lake and is 300 meters above the river (Hancock et al., 1999). The coarse gravel on the strath terraces includes granite or gneiss from the Wind River Mountains, volcanics from the Absaroka Mountains, and exotic, well-rounded quartzite rocks from central Idaho (Oard, 2008).

Most of the other terraces are not distinct or significant; some are just disconnected buttes and mesas (Chadwick et al., 1997). As a result of few distinct terraces, a considerable difference exists in mapped terraces between various investigators (Hall and Jaworowski, 1999). Blackwelder (1915) could identify only three terraces in the area, which are now called WR1, WR3, and WR15.

Terraces Correlated with Multiple Glacial/Interglacial Oscillations

The terraces are assumed to have been caused by glacial/interglacial oscillations from classical mountain glacial episodes in the Wind River Mountains (Hancock et al., 1999). Scientists claim there have been many such episodes every 100 kyr for the past 900 kyr and every 40 kyr older than 900 kyr, based on Milankovitch astronomical cycles. However, moraines for only three ice ages are claimed in the field; evidence for older ice ages cannot be found (Hall and Jaworowski, 1999). These ice ages are: (1) the Pinedale glaciation (WR1), (2) the Bull Lake glaciation (WR3), and (3) the Sacagawea Ridge glaciation (WR7). WR1 and WR3 are both strath and gravel terraces in different locations. All the others are considered strath terraces.

The youngest episode is the Pinedale glaciation, identified from moraines around Pinedale, Wyoming, along the southwest edge of the Wind River Mountains. Its glacial maximum is dated by cosmogenic beryllium-10 to about 21,700 years (Gosse et al., 1995). The classical ice age moraines from the next-youngest ice age, the Bull Lake glaciation, are from the northeast Wind River Range north of Bull Lake, which also has Pinedale moraines.

Figure 12. Crowheart Butte.

Problems with the Pinedale and Bull Lake Glaciations

It is difficult to link the Pinedale and Bull Lake terminal moraines to separate glacial episodes. The moraines may show a slight difference in weathering, but they appear similar. The Bull Lake terminal moraines (Figure 14) are composed of 15 nested moraines, some of which are supposedly from the Pinedale ice age (Chadwick et al., 1997). However, there is much confusion on the dating of these classical moraines.

> Thus, stratigraphic names, such as Bull Lake, are not tied to a clear understanding of glacial chronology in the type localities…. In the Wind River Basin, it has not been clear which, if any of the Bull Lake deposits represent late Illinoian advances [from the second to the last or Bull Lake ice age]. (Chadwick et al., 1997, p. 1,443)

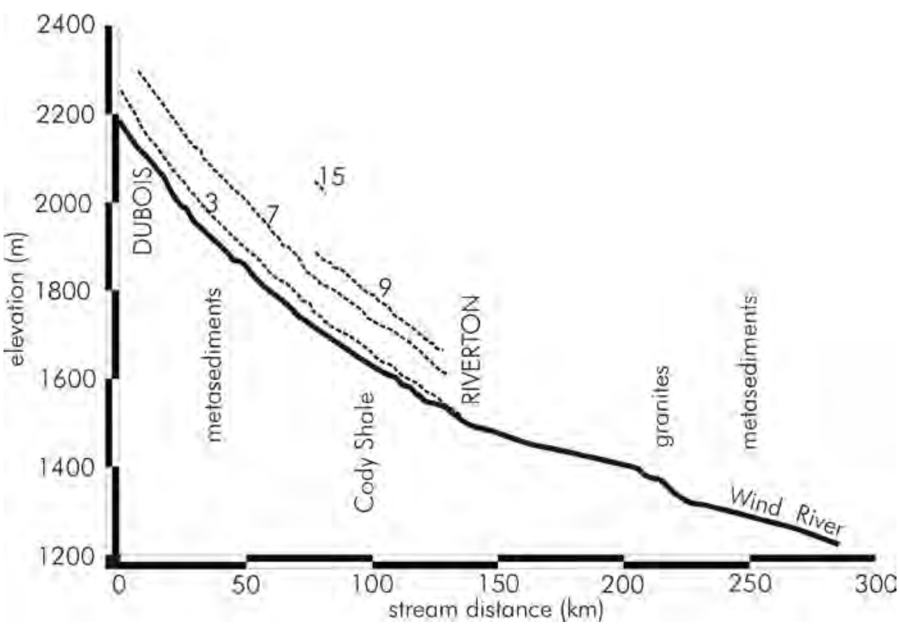


Figure 13. A plot of the terraces in relation to the Wind River (redrawn from figure 3 of Hancock et al., 1999 by Peter Klevberg). In reality WR7 is patchy.

Regardless, these researchers simply correlate the Bull Lake ice age to marine isotope stage 6, which is the second to the last ice age, based on their belief in astronomical cycles. But they do admit there could be younger or older ice ages represented in the Bull Lake terminal moraines. Although the chronology of Rocky Mountain glaciation has been under almost constant revision, researchers simply correlate supposed ice ages to the marine isotopic record, which is based on deep-sea cores (Chadwick et al., 1997; Hall, 1999).

The Bull Lake terminal moraines are simply farther out along the edges of tributary valleys in the Wind River Mountains than the Pinedale terminal moraines. The sequence of terminal moraines look like nested terminal moraines from *one* ice age. The weathering differences of the "Bull Lake glaciation" are likely due to longer exposure to acid

Figure 14. One of the terminal moraines at Bull Lake.

Figure 15. Edge of either a Pinedale or Bull Lake lateral moraine northeast of Dinwoody Lakes.

Figure 16. Outwash and WR3 from moraine in Figure 15.

Figure 17. Coarse gravel of WR3 as seen from WR1.

Figure 18. The Sacagawea Ridge lateral moraine east of Dinwoody Lakes.

Figure 19. Bull Lake lateral moraine east of Dinwoody Lakes.

Figure 20. The top of a Pinedale lateral moraine east of Dinwoody Lakes.

Figure 21. Small outwash fan from Sacagawea Ridge moraine shown in Figure 18.

rain caused by Ice Age volcanism (Oard, 2004a).

Outwash fans from the Pinedale and Bull Lake terminal moraines blend into the two lower terraces, especially WR3, which is very extensive (Figures 15 to 17). WR1 and WR3 could simply be two terraces from distinct erosional events during the same ice age, like the two large terraces in Jackson Hole that both formed during the melting of the Yellowstone ice cap (Figure 2). This confusion in relative timing may explain why uniformitarian scientists have so many problems dating WR3 (Sharp et al., 2003).

Sacagawea Ridge Glaciation Illusory and Not Connected to WR7

The next oldest glaciation after the Bull Lake glaciation is the Sacagawea Ridge glaciation. Its type area is just east of Dinwoody Lakes, and it is supposedly represented by terrace WR7 (Lindsey et al., 2007). However, the lateral moraine representing the Sacagawea episode is still sharp-crested (Figure 18) and indistinguishable from the adjacent Bull Lake (Figure 19) and Pinedale (Figure 20) lateral moraines, suggesting that these are simply nested moraines from one ice age.

Moreover, the Sacagawea Ridge moraine has a small outwash fan to the east (Figure 21); although it is east of Dinwoody Lakes, it is *not* connected to terrace WR7 west of Dinwoody Lakes (Figure 22). The correlation of WR7 with the Sacagawea Ridge moraine is based only on their *similar* altitude: "Outwash adjacent to the younger of two Sacagawea Ridge moraines has been correlated with this river terrace [WR7] on the basis of very similar elevations" (Hall and Jaworowski, 1999, p. 1,248). I verified this in the field—there is no physical connection. This is probably why Hancock et al (1999, pp. 47, 56) qualified that the Sacagawea Ridge outwash *may be* or *appears to be* correlated to WR7. It is also the likely reason that Blackwelder (1915) never included WR7 as one of his glacial terraces in the area.

The supposed Sacagawea glaciation is fraught with problems. Based on the location of its lateral moraine just outside the Bull Lake lateral moraine east of Dinwoody Lakes, one might expect it to be the third most recent glacial episode. But there are three missing glaciations between the Bull Lake and Sacagawea glaciations, based on the Milankovitch 100 kyr cycle and the "solid" date of 660 kyr for terrace WR7. This date for WR7 is based on the date of the Lava Creek B ash from the last Yellowstone eruption found just above bedrock at several locations on WR7, including the terrace west of Dinwoody Lake (Chadwick et al., 1997, p. 1,447). Therefore, the Sacagawea event would have been the *seventh* most recent glaciation with three leaving no evidence at all. Figures 23 and 24 show one of the ash outcrops on WR7 west of Dinwoody Lake. The ash is dated by tephrochronology (Dethier, 2001; Hancock et al., 1999).

However, terrace WR7 has also been dated by cosmogenic radionuclides (CRNs), radioactive nuclides formed by the cosmic ray bombardment of Earth's surface. The subsequent decay of the isotopes supposedly gives a time for the exposure at or near the surface. CRN dating of WR7 yielded an age of only about 300 kyr (Hancock et al., 1999). Others think WR7 could be as young as 250 kyr (Phillips et al., 1997). Sharp et al (2003) came up with dates ranging from 140 to 315 kyr. Such dating discrepancies are explained away by supposed eolian erosion:

> A possible explanation for these discrepancies is that eolian deflation [erosion] reduces the thickness of loess mantling Wind River terraces through time leading to overestima-

Figure 22. The top of WR7, a pediment erosional remnant along the Wind River Mountains, west of Dinwoody Lakes.

Figure 23. Lava Creek B ash layer from the last Yellowstone Park super eruption on top of bedrock in WR7 (Hans and Lisa Reinhardt for scale).

> tion of cosmogenic-nuclide production in the underlying gravel and too young cosmogenic ages. (Sharp et al., 2003, p. 148)

Hancock et al (1999) earlier suggested this explanation, and they also admit the difficulty of dating by cosmogenic radionuclides:

> Our work on the older terraces illustrates the continuing difficulty of precisely dating depositional surfaces older than a few 100 ka [thousand years] with CRN, because of the uncertainties in the geologic history of the surfaces and the large errors arising from calibrations of the rate of production which are inherent in dating surfaces with CRNs. (Hancock et al., 1999, p. 57)

On the other hand, if the CRN dates are considered correct, an explanation must be found for the older date of the Lava Creek B Ash. The standard "reworking" explanation appears to be the current favorite, having been "reworked" from older terraces (Hancock et al., 1999, p. 57), which, unfortunately, do not exist. Also, it is unclear how reworking from higher terraces would result in patches of nearly pure ash, like those found on terrace WR7 (Figures 23 and 24).

Problems with Terraces Higher than WR7

Terraces higher than WR7 are not associated with moraines or any other glacial indicator (Chadwick et al., 1997, p. 1,450; Hall and Jaworowski, 1999, p. 1,247). WR9 is a large, flat terrace northwest of Riverton on which the airport was built (Figure 25). The ages of these higher terraces are based on simple extrapolation of the linear incision rate of the upper Wind River from WR7 down to the river (Hancock et al., 1999), which makes the dating of WR7 especially crucial. If the date of 660 kyr is accepted, the extrapolated date for WR15, the highest terrace, is 1.7 Ma (Chadwick et al., 1997). That would imply that the very small WR15 is a remnant of approximately the 30th most recent glaciation, based on the Milankovitch cycle theory, which posits one every 100 kyr back to 900 kyr and one every 40 kyr from 900 kyr back through the 2.6 million years of the Pleistocene (Walker and Lowe, 2007). There are now supposed to be around 50 regularly repeating ice ages during the Pleistocene. But if the younger dates on WR7 are real, then WR15 is only 431 to 511 kyr (Hancock et al., 1999), which is much younger.

Higher Terraces Carved during Channelized Flood Runoff

If the glaciation explanation is unreliable for all but WR1 and WR3, then how do we explain the other terraces and terrace remnants? First, we must accept the results from the field, not the hypothetical inferences of Milankovitch cycles. Second, we must look for alternate explanations. One such theory is that they were created by late Flood-channelized runoff. Do the predictions of that theory explain the field data better than the uniformitarian glaciation theory?

WR7 really is the remnant of a pediment (Figure 22), a planation surface at the foot of mountains. Pediments in valleys would also be considered strath terraces. Pediments are not forming today but being destroyed by local erosion. Pediments appear to have formed by strong channelized flow down a given valley, cutting its sides to form planation surfaces (Oard, 2004b).

WR9 is a planation surface capped by coarse gravel (Figure 25), a small percentage of which is well-rounded quartzite rocks with percussion marks (Figure 26). WR9 formed in the center of the valley around Riverton. The closest source of the quartzite is central Idaho (Oard, 2008). Exotic rocks transported long distances and covering planation surfaces is not unusual; they have been explained by the late Flood runoff mechanism (Oard, 2008).

Other terraces observed in the Wind River region can be explained by this mechanism. If cut into the edges of mountains, they would be "pediments," and if cut across valley fill, they would be planation surfaces. Both occur at multiple levels in the upper Wind River Basin (Figure 27). Geologists claim that both pediments and planation surfaces in the Wind River Basin are strath terraces because both are cut into hard rock.

Adjacent basins, like the Bighorn Basin to the northeast, have similar features. That basin was eroded an average of 470 m (McMillan et al., 2006), leaving pediments along its edge and remnants of two planation surfaces in the central and northern parts of the basin. Similarly, in the channelized flow of the Flood, the top of a thick valley fill was eroded during uplift of the area. During erosion, planation surfaces were carved by fast currents leaving behind a lag of coarse gravel as the currents slowed. The erosion of the valley fill at the edge of the valley produced pediments with a coarse gravel cap. Increasing and decreasing

Figure 24. Close up of Lava Creek B ash.

Figure 25. WR9 northwest of Riverton upon which the airport is built.

Figure 26. A quartzite cobble with percussion marks from the gravel capping WR9.

Figure 27. Multiple planation surfaces or pediments in the upper Wind River Basin.

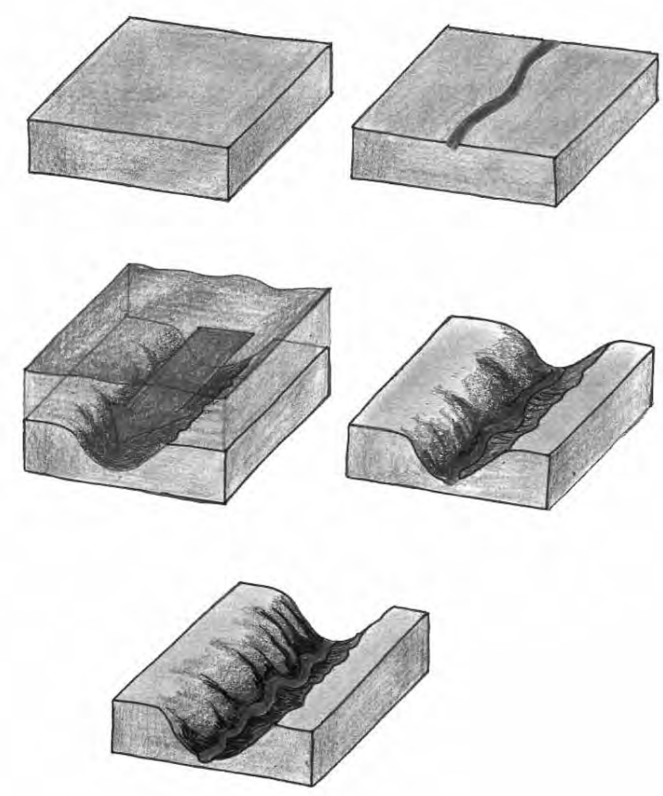
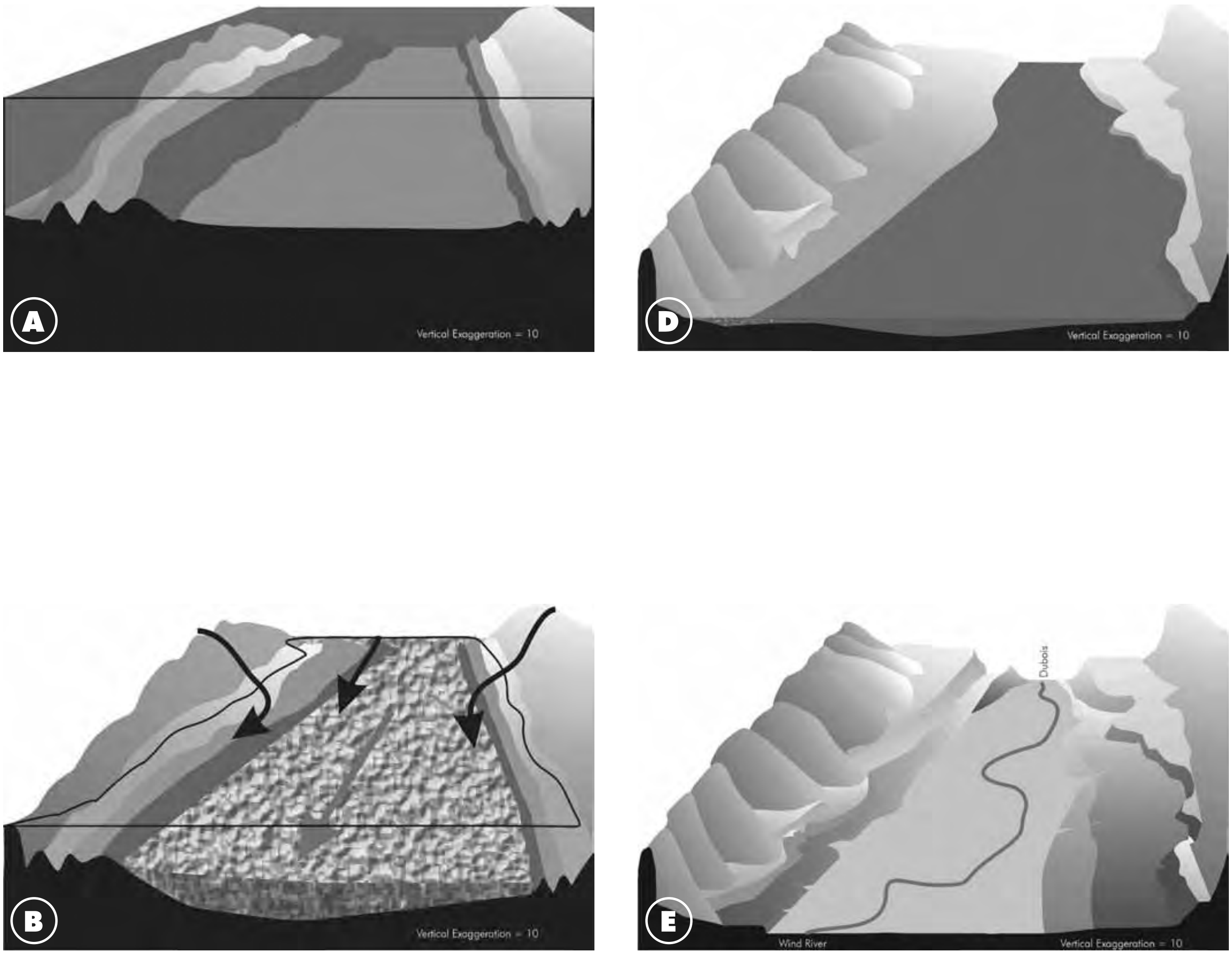


Figure 28. Comparison of the two highly disputed hypotheses for the origin of valleys around the year 1800 (drawn by Mrs. Melanie Richard). One group believed the valley came first through catastrophic erosion (left), while others believed the valley was eroded slowly over millions of years (right).

flow during channelized Flood runoff would result in multiple erosion events with planation surfaces and pediments at different altitudes, as observed in the upper Wind River Valley. The last erosion event produced the narrow river valley that exists today, which was modified by post-Flood glaciation with the forming of gravel-outwash terraces.

In summary, the "strath terraces" higher than WR3 are pediment and planation surface remnants formed during late Flood-channelized runoff and erosion moving southeast down the valley. The lower two, WR1 and WR3, were subsequently formed after the Flood by glacial outwash erosion and deposition during the post-Flood rapid Ice Age. Figure 28 presents a schematic on the origin of valleys, contrasting the uniformitarian and diluvial theories. Figure 29 is a schematic showing how Flood runoff could have formed pediments and planation surfaces in the upper Wind River Valley. Table 1 compares the uniformitarian explanation with the Flood runoff mechanism for the four significant upper Wind River terraces. The other terraces are small and insignificant, and terraces older than WR7 are not related to glaciation, the evidence of which supports only one ice age.



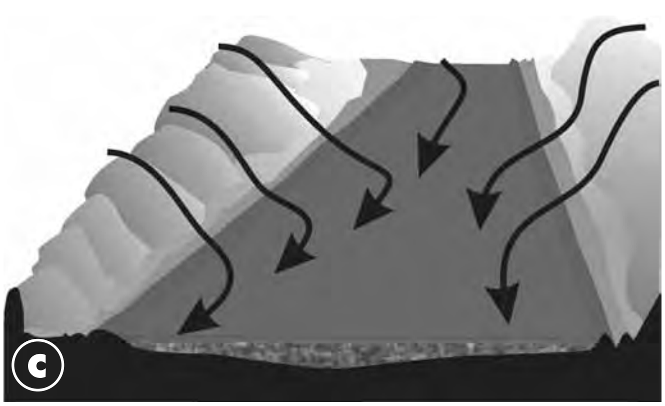


Figure 29. Schematic of valley erosion from Dubois to Bull Lake during the channelized-flow phase of the Genesis Flood (drawn by Peter Klevberg). (A) Thick sediments deposited in the Upper Wind River Basin. (B) As Floodwater continues to go down, sediments continue to accumulate (gray area in the valley represents the total Flood erosion). (C) As Floodwater channelizes, erosion develops. (D) Continued draining of the Floodwater with erosion and the formation of pediments and planation surfaces. (E) The Floodwater drained leaving behind multiple pediments and planation surfaces before glaciation develops.

Table 1. Comparison between the uniformitarian and Flood erosion/runoff explanations for the significant terraces in the upper Wind River valley of northwest Wyoming. The claimed Sacagawea moraine is similar to the Pinedale and Bull Lake moraines with three missing moraines earlier than the Sacagawea moraine. There is no evidence for glaciation for any terrace higher than WR7.

Terrace	Uniformitarian explanation	Flood explanation
WR1	Pinedale glacial outwash terrace	Lowest Ice Age terrace
WR3	Bull Lake glacial outwash terrace	Highest Ice Age terrace
WR7	Sacagawea glacial outwash terrace	Pediment remnant from Flood runoff
WR9	Glacial strath terrace remnant	Planation surface from Flood runoff

Strath Terraces Common Worldwide

Strath terraces are common in valleys all over the world. There are numerous strath terraces in the western United States (Hancock and Anderson, 2002; Merritts et al., 1994). Nearly all the terraces along rivers and streams draining the western Oregon coast range are strath terraces (Personius, 1995). As in the upper Wind River Basin, uniformitarian scientists propose formation by glacial deposition and erosion in the valleys over dozens of ice ages:

> The well-preserved strath-terrace sequences found in many river systems of western North America record discontinuous incision into bedrock throughout the late Quaternary. (Hancock and Anderson, 2002, p. 1,132)

Strath terraces are also common in the valleys that have dissected the Appalachian Plateau Province west of the Valley and Ridge Province of the Appalachians. The most prominent is called the Parker strath terrace and lies about 100 m above the bottom of the valleys (Oard, 2011). Figure 30 shows the Parker Strath terrace along the edge of the Cumberland Plateau of the southern Appalachian Plateau.

Strath terraces are also reported in Alaska, eastern Tibet, and eastern Bolivia (Montgomery, 2004); Taiwan (Shyu et al., 2006; Yanites et al., 2010); the Tien Shan Mountains (Molnar et al., 1994); along the Somme River of France (Merritts et al., 1994); and along the valleys of the western Andes of South America (Hall et al., 2008). These are just a small sample from the literature. Strath terraces likely are present by the thousands in valleys all over the world.

Strath Terraces Can Form after the Flood

Although the strath terraces higher than WR3 in the upper Wind River Basin are simply pediment and valley planation surface remnants of the Flood (Figure 29), this research shows that "strath terraces" also formed during Ice Age runoff. That is consistent with the literature. Since post-Flood valley erosion has been slight since the Flood, post-Flood strath terraces would be expected to be of limited extent and close to the altitude of the river.

Like the lower two terraces in the upper Wind River Basin, which vary between being strath terraces and gravel terraces, strath terraces can form in glaciated areas from the action of extensive meltwater. These would be near the valley bottom, as seen in the Upper Wind River Basin. In addition, strath terraces could have been cut during heavy, early-Ice Age rainfall. The above conditions may be responsible for some of the lower strath terraces west of the Oregon coast range (Personius, 1995) and in the western Olympic Mountains of Washington (Wegmann and Pazzaglia, 2002).

Small strath terraces could have formed after the Flood by two processes: (1) weathering of bedrock banks between the low and high water line (Montgomery, 2004; Stock et al., 2005), and (2) flood erosion along the banks (Crickmay, 1974).

Origin of Most Strath Terraces Unknown

Since the straths are remnants of flat, wide valleys carved in bedrock, their formation appears to represent a period of valley widening with little or no deepening. I believe the uniformitarian interpretation is close, but many strath terraces are remnants of valleys tens of kilometers wide! In the uniformitarian model, this would require a river similar to those of today to meander back and forth over a wide area, planing the bedrock to a flat surface *with little or no downward dissection* (Hancock et al., 1999, p. 42). This is mechanically inconsistent; meandering rivers typically are found in areas of low gradient and

Figure 30. The rolling Parker strath terrace (left arrow) west of the planation surface of the Cumberland Plateau (right arrow).

deposit sediment in a floodplain. Rivers in areas of higher gradient, which erode into bedrock, typically do not meander and tend to incise in deeper channels. The uniformitarian model simply assumes what they need, as indirectly admitted by Hancock and Anderson (2002, p. 1,134):

> Investigation of the valley-widening processes in rock-floored channels and of the controls on widening rates is sorely needed. However, lateral planation that far exceeds vertical incision over time is a key field observation that must be reproduced in this model.

The formation of a valley-wide planation surface seems difficult, if not impossible, by river erosion, since rivers normally cut downward and will cut laterally only during flooding and can leave strath terraces along the edge of the river over only small areas (Crickmay, 1974). To achieve large-scale terraces and valley-scale planation by this process would require much larger currents.

Although some strath terraces appear linked to river floods, especially during Ice Age runoff, most strath terraces are difficult to explain, especially when the area never underwent glaciation: "Despite the widespread use of strath terraces in fluvial and tectonic geomorphology, the conditions surrounding planation of a strath surface are not well understood" (Fuller et al., 2009, p. 467). This is especially the case for the relatively high strath terraces. Hancock and Anderson (2002, p. 1,132) write:

> The timing, duration, and mechanisms of strath terrace formation are difficult to infer solely from field observations because terrace sequences represent incomplete records, are difficult to date, and formed during fluvial conditions that differ from the present.

Note that they admit a violation of the principle of actualism. Some scientists believe the valley-wide bedrock was beveled during a time of increased sediment supply when the valley was at a higher level (Fuller et al., 2009). Others think strath terraces were formed by meander migration and cutoff (Finnegan and Dietrich, 2011). Still others state that they are caused by an as-yet-unknown factor that caused an accelerated incision rate (Hancock and Anderson, 2002). Accelerated uplift is suggested by others (Merritts et al., 1994).

Summary and Discussion

The two lower gravel-and-strath terraces in the upper Wind River Basin appear to be a result of deglaciation, and field evidence suggests both were cut during the same glacial episode. But that does not necessarily imply that the higher terraces were also a result of glaciation. Unfortunately, uniformitarians assume that to be the case, based on the circular reasoning application of Milankovitch cycles, which would include up to 50 episodes during the Pleistocene. This circularity again appears when geologists use the occurrence of strath terraces in other river valleys and basins to infer Pleistocene glaciation. An alternative explanation, supported by the higher terraces in the Wind River Basin, is planation and pediment formation during channelized runoff during the last stage of the Flood (Oard, 2004b, 2008). Those terraces higher than WR3 are pediments and planation surfaces that formed during high velocity, down-valley Flood erosion and runoff during differential vertical tectonics (Figure 29).

Since strath terraces are common worldwide, it is likely that the mid- to high-level, rock-floored terraces are pediments or planation surfaces also caused by Flood runoff. If so, these Pleistocene-aged terraces are best explained by the Flood. This implies that the post-Flood boundary is in the mid-Pleistocene, in some places, based on strath terrace remnants. This is the same location proposed by the late Roy Holt (1996) after extensive field research.

A mid-Pleistocene post-Flood boundary in the upper Wind River Basin is also suggested by the existence of the Lava Creek B ash between the bedrock and the coarse gravel cap on pediment remnants of WR7 (Figure 23 and 24). This ash is dated as mid-Pleistocene, 660 kyr in the uniformitarian timescale. Since it is from the last major eruption of the Yellowstone supervolcano, it demonstrates that the large Yellowstone eruptions occurred late in the Flood, not afterward. Since Yellowstone ashes are found across the western and central United States and are used to date fossils, this Flood date would have radical implications for the death of these fauna, if the identification of Lava Creek B ash at these distal locations is correct. The occurrence of Lava Creek B ash above fossils would suggest those organisms died in the Flood, while those found above the ash would likely have died after the Flood. Clearly, more information from other locales is needed, along with an in-depth analysis of tephrochronology.

Acknowledgments

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References

CRSQ: Creation Research Society Quarterly

JOC: Journal of Creation, Technical Journal, or Creation Ex Nihilo Technical Journal

Blackwelder, E. 1915. Cenozoic history of the mountains of central Wyoming. *Journal of Geology* 23:97–117, 193–217, 307–340.

Chadwick, O.A., R.D. Hall, and F.M. Phillips. 1997. Chronology of Pleistocene glacial advances in the central Rocky Mountains. *GSA Bulletin* 109:1,443–1,452.

Crickmay, C.H. 1974. *The Work of the River: A Critical Study of the Central Aspects of Geomorphology*. American Elsevier Publishing Co., New York, NY.

Dethier, D.P. 2001. Pleistocene incision rates in the western United States calibrated using Lava Creek B tephra. *Geology* 29:783–786.

Fan, M., P.G. DeCelles, G.E. Gehrels, D.L. Dettman, J. Quade, and S.L. Peyton. 2011. Sedimentology, detrital zircon geochronology, and stable isotope geochemistry of the lower Eocene strata in the Wind River Basin, central Wyoming. *GSA Bulletin* 123:979–996.

Finnegan, N.J., and W.E. Dietrich. 2011. Episodic bedrock strath terrace formation due to meander migration and cutoff. *Geology* 39(2): 143–146.

Fuller, R.K., L.A. Perg, J.K.Willenbring, and K. Lepper. 2009. Field evidence for climate-driven changes in sediment supply leading to strath terrace formation. *Geology* 37(5): 467–470.

Gosse, J.C., J. Klein, E.B. Evenson, B. Lawn, and R. Middleton. 1995. Beryllium-10 dating of the duration and retreat of the last Pinedale glacial sequence. *Science* 268:1,329—1,333.

Hall, R.D. 1999. Effects of climate change on soils in glacial deposits, Wind River Basin, Wyoming. *Quaternary Research* 51:248–261.

Hall, R.D., and C. Jaworowski. 1999. Reinterpretation of the Cedar Ridge section, Wind River Range, Wyoming: implications for the glacial chronology of the Rocky Mountains. *GSA Bulletin* 111:1,233–1,249.

Hall, S.R., D.L. Farber, L. Audin, R.C. Finkel, A.-S. Mériauz. 2008. Geochronology of pediment surfaces in southern Peru: implications for Quaternary deformation of the Andean forearc. *Tectonophysics* 459:200.

Hancock, G.S., and R.S. Anderson, 2002. Numerical modeling of fluvial strath-terrace formation in response to oscillating climate. *GSA Bulletin* 114(9): 1,131—1,142.

Hancock, G.S., R.S. Anderson, A.A. Chadwick, and R.C. Finkel. 1999. Dating fluvial terraces with ^{10}Be and ^{26}Al profiles: application to the Wind River, Wyoming. *Geomorphology* 27:41–60.

Hergenrather, J., T. Vail, M. Oard, and D. Bokovoy. 2012. *Your Guide to Yellowstone and Grand Teton National Parks: A Different Perspective*. Master Books, Green Forest, AR.

Holt, R.D. 1996. Evidence for a Late Cainozoic Flood/post-Flood boundary. *JOC* 10(1): 128–167.

Lindsey, D.A., W.H. Langer, and B.S. Van Gosen. 2007. Using pebble lithology and roundness to interpret gravel provenance in piedmont fluvial systems of the Rocky Mountains, USA. *Sedimentary Geology* 199:223–232.

Love, J.D. 1960. Cenozoic sedimentation and crustal movement in Wyoming. *American Journal of Science* 258-A:204–214.

Love, D., J.C. Reed Jr., and K. Pierce. 2007. *Creation of the Teton Landscape: A Geological Chronicle of Jackson Hole & the Teton Range*. Grand Teton Association, Moose, WY.

McMillan, M.E., P.L. Heller, and S.L. Wing. 2006. History and causes of post-Laramide relief in the Rocky Mountain orogenic plateau. *GSA Bulletin* 118:393–405.

Merritts, D.J., K.R. Vincent, and E.E. Wohl 1994. Long river profiles, tectonism, and eustasy: a guide to interpreting fluvial terraces. *Journal of Geophysical Research* 99(B7):14,031–14,050.

Molnar, P. et al 1994. Quaternary climate change and the formation of river terraces across growing anticlines on the north flank of the Tien Shan, China. *The Journal of Geology* 102:583–602.

Montgomery, D.R. 2004. Observations on the role of lithology in strath terrace formation and bedrock channel width. *American Journal of Science* 304:454–476.

Neuendorf, K.K.E., J.P. Mehl Jr., and J.A. Jackson. 2005. *Glossary of Geology*, Fifth Edition. American Geological Institute, Alexandria, VA.

Oard, M.J. 2004a. *Frozen in Time: The Woolly Mammoth, the Ice Age, and the Biblical Key to Their Secrets*. Master Books, Green Forest, AR.

Oard, M.J. 2004b. Pediments formed by the Flood: evidence for the Flood/post-Flood boundary in the Late Cenozoic. *JOC* 18(2):15–27.

Oard, M.J. 2008. *Flood by Design: Receding Water Shapes the Earth's Surface*. Master Books, Green Forest, AR.

Oard, M.J. 2011. Origin of Appalachian geomorphology, part II: formation of surficial erosion surfaces. *CRSQ* 48:111–113.

Personius, S.F. 1995. Late Quaternary stream incision and uplift in the forearc of the Cascadia subduction zone, western Oregon. *Journal of Geophysical Research* 100:20,193–20,210.

Phillips, F.M., M.G. Zreda, J.C. Gosse, J. Klein, E.B. Evenson, R.D. Hall, O.A. Chadwick, and P. Sharma. 1997. Cosmogenic ^{36}Cl and ^{10}Be ages of Quaternary glacial and fluvial deposits of the Wind River Range, Wyoming. *GSA Bulletin* 109:1,453–1,463.

Sarna-Wojcicki, A.M., S.D. Morrison, C.E. Meyer, and J.W. Hillhouse. 1987. Correlation of upper Cenozoic tephra layers between sediments of the western United States and eastern pacific Ocean and comparison with biostratigraphic and magnetostratigraphic age data. *GSA Bulletin* 98:207–223.

Sharp, W.D., K.R. Ludwig, O.A. Chadwick, R. Amundson, and L.L. Glaser. 2003. Dating fluvial terraces by ^{230Th}/U on pedogenic carbonate, Wind River Basin, Wyoming. *Quaternary Research* 59:139–150.

Shyu, J.B.H., K. Sieh, J.-P. Avouac, W.-S. Chen, and Y.-G. Chen. 2006. Millennial slip rate of the Longitudinal Valley fault from river terraces: implications for convergence across the active suture of eastern Taiwan. *Journal of Geophysical Research* 111 (B08403):1–22.

Steidtmann, J.R., L.T. Middleton, and M.W. Shuster. 1989. Post-Laramide (Oligocene) uplift in the Wind River Range, Wyoming. *Geology* 17:38–41.

Stock, J.D., D.R. Montgomery, B.D. Collins, W.E. Dietrich, and L. Sklar. 2005. Field measurements of incision rates following bedrock exposure: implications for process controls on the long profiles of valleys cut by rivers and debris flows. *GSA Bulletin* 117:174–194.

Sundell, K.A. 1993. A geologic overview of the Absaroka volcanic province. In Snoke, A.W., A.W. Steidtmann, and S.M. Roberts (editors), *Geology of Wyoming*, Geological Survey of Wyoming Memoir No. 5., pp. 480–506. University of Wyoming, Laramie, WY.

Thornbury, W.D. 1965. *Regional Geomorphology of the United States*. John Wiley & Sons, New York, NY.

Walker, M., and J. Lowe. 2007. Quaternary science 2007: a 50-year retrospective. *Journal of the Geological Society, London* 164:1,073–1,092.

Walker, T. 1994. A biblical geological 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.

Wegmann, K.W., and F.J. Pazzaglia. 2002. Holocene strath terrace, climate change, and active tectonics: the Clearwater River basin, Olympic Peninsula, Washington State. *GSA Bulletin* 114(6):731–744.

Yanites, B.J., G.E. Tucker, K.J. Mueller, and Y.-G. Chen. 2010. How rivers react to large earthquakes: evidence from central Taiwan. *Geology* 38(3):639–642.

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The Little Ice Age in the North Atlantic Region

Part V: Greenland

Peter Klevberg, Michael J. Oard*

Abstract

The first paper in this series introduced methods of studying past climate change. Subsequent papers addressed the historicity of the Medieval Warm Period and Little Ice Age, the importance of the Little Ice Age in understanding climate change and constraining climatic models, and an account of effects of the Little Ice Age in Iceland and Norway. This paper presents a summary of the climate change record in Greenland, especially for the Little Ice Age.

The Uniqueness of Greenland

Greenland is the focus of much attention in the climate change debate. It is referred to as a "subcontinent" because the island verges on the size of landmasses we refer to as continents. Its high latitude and place between the North Atlantic and Arctic Oceans make it of particular value to this study. Nearly the entire island is covered by ice (Figures 1 and 2), approximately two miles (three km) thick in the central region. This is the world's second largest ice sheet. If it were to melt, it would result in a rise in sea level of more than six meters (about three fathom). The Antarctic ice sheet is more than an order of magnitude larger than Greenland's ice sheet, while Vatnajökull in Iceland, the third largest, is 0.1 percent the size of the Greenland ice sheet and typically referred to as an "ice cap." Evaluation of data from the Greenland ice sheet has been provided elsewhere (Oard, 2005); this paper focuses on the features and history of Greenland as they relate to the Little Ice Age.

Greenland shares our North Atlantic study area with Iceland and Norway (Figure 2) but is much larger. Iceland is relatively small and surrounded by ocean (with some sea ice); Greenland is large and surrounded by sea ice (and some open ocean). The combination of ocean island, continental peninsula, and subcontinent makes it possible to distinguish regional from hemispheric or global climatic effects in the study area.

Greenland lacks a good historical record. The few written accounts come mostly from Iceland, as very few written records have survived from Greenland from the time of the Little Ice Age. Proxy data therefore have greater importance for Greenland than for Iceland or Norway. Proxy data, including foraminifera, pollen, insects, and oxygen isotope ratios, therefore have greater importance for Greenland than for Iceland or Norway. As described in part I of this series, proxy data are useful but greatly inferior to historical records.

Greenland and World Climate Change

Greenland has a prominent place in current world climate research. Figure 3 shows locations of important ice core projects. Data from ice cores, particularly oxygen isotope ratios, are used to infer the climatic history (i.e., paleoclimate) of Greenland and by extension the world. While methodological problems

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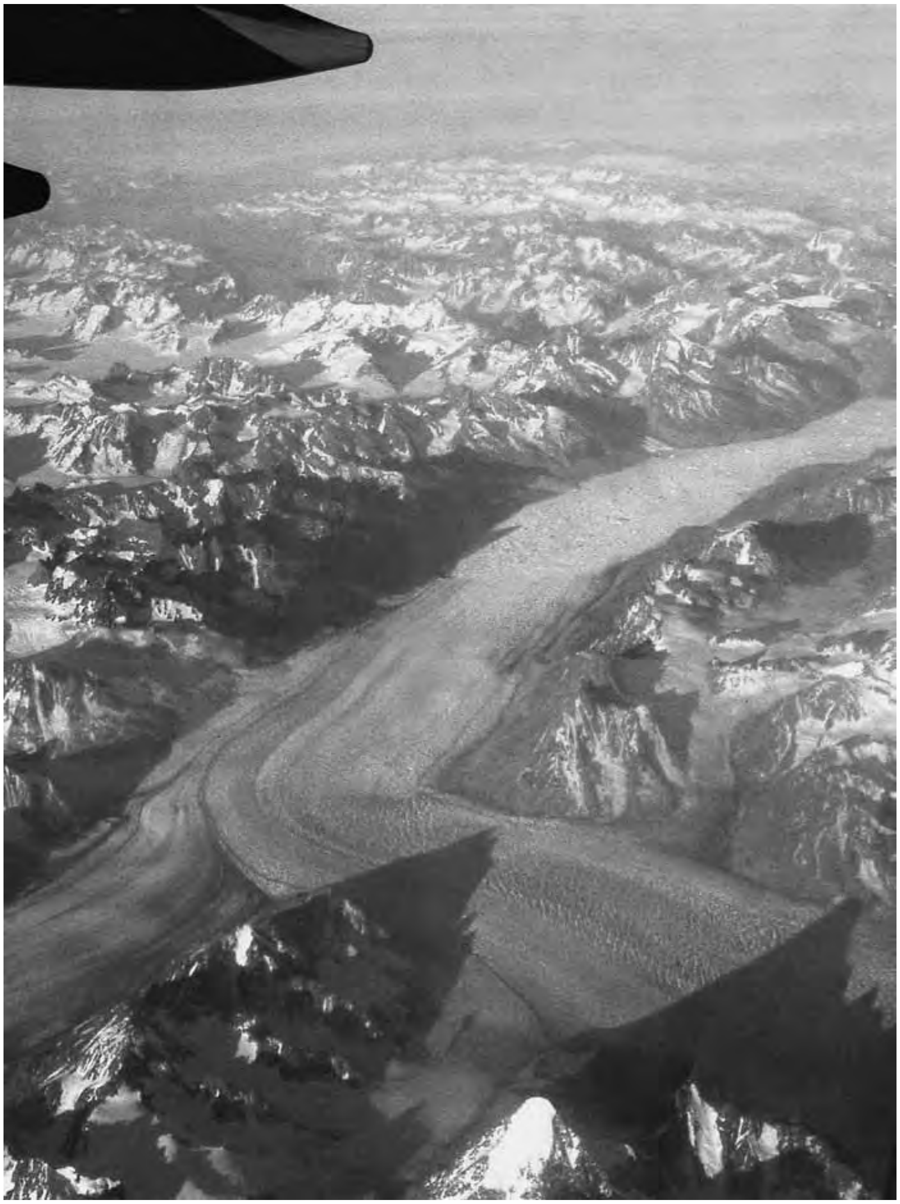

Figure 1. Southern Greenland from 35,000 feet (10,000 m). The river of ice is an outlet glacier draining the Greenland Inland Ice (ice sheet).

are not insignificant (Vardiman, 1997), and results become virtually unusable at significant depth (Oard, 2005), we believe the top few centuries' worth of ice provide reasonably reliable paleoclimatic data. These centuries include the Little Ice Age.

This paper summarizes the history of Greenland, a history that is far shorter than evolutionists realize, and a history marked by significant climate change.

History of Habitation

At least three peoples have settled Greenland in its history: at least two Hamitic peoples from the west, and one Japhethetic people from the east (Genesis 11). It is possible that seven or more cultures have existed on the main island and the smaller islands that make up the country of Greenland (Table I and Figure 4): Independence I and II, Saqqaq, Dorset I and II, Norse, and Thule (Andreasen, 2003; Gabriel et al., 2002; Høegh-Knudsen et al., 2003; Jensen, 2002; Jensen et al., 2008; Raahauge et al., 2003, 2005; Sørensen and Pedersen, 2004). It is also possible that some or all of the first three, for which we have only archaeological evidence, may not have been separate cultures (Andreasen, 2003).

Postdiluvial Settlement of Greenland

It is reasonable to infer that the early postdiluvial climate of Greenland was very hospitable, more supportive of plant, animal, and human life than at any time thereafter (Oard, 1990). Whether people actually reached Greenland during that time is unknown; if they did, evidence of occupation would have a low probability of surviving the Great Ice Age that likely followed. Thus, evidence for human habitation is likely to be from after the Great Ice Age—a position shared by both evolutionists and creationists.

Norse *Landnám*

We know a good deal about Eirík Rauða (Erik the Red). His life and the founding of Norse Greenland are recounted in *Eiríks soga Rauðu* (Saga of Erik the Red) and *Grönlendingesaga* (Saga of the Greenlanders), which are available sources (Ingstad and Ingstad, 1996). He and his father were banished from Jæren in Norway for killing a man, so Eirik settled in Iceland. Later, a feud arose when Eirik retaliated against a neighbor over the death of one of his servants. Banished from Iceland, he sailed westward in search of land that had been sighted by other Icelanders, the nearest part of which was known as Gunnbjørnsskjær (Figure 5). Eirik was gone from AD 983 to 985. During that

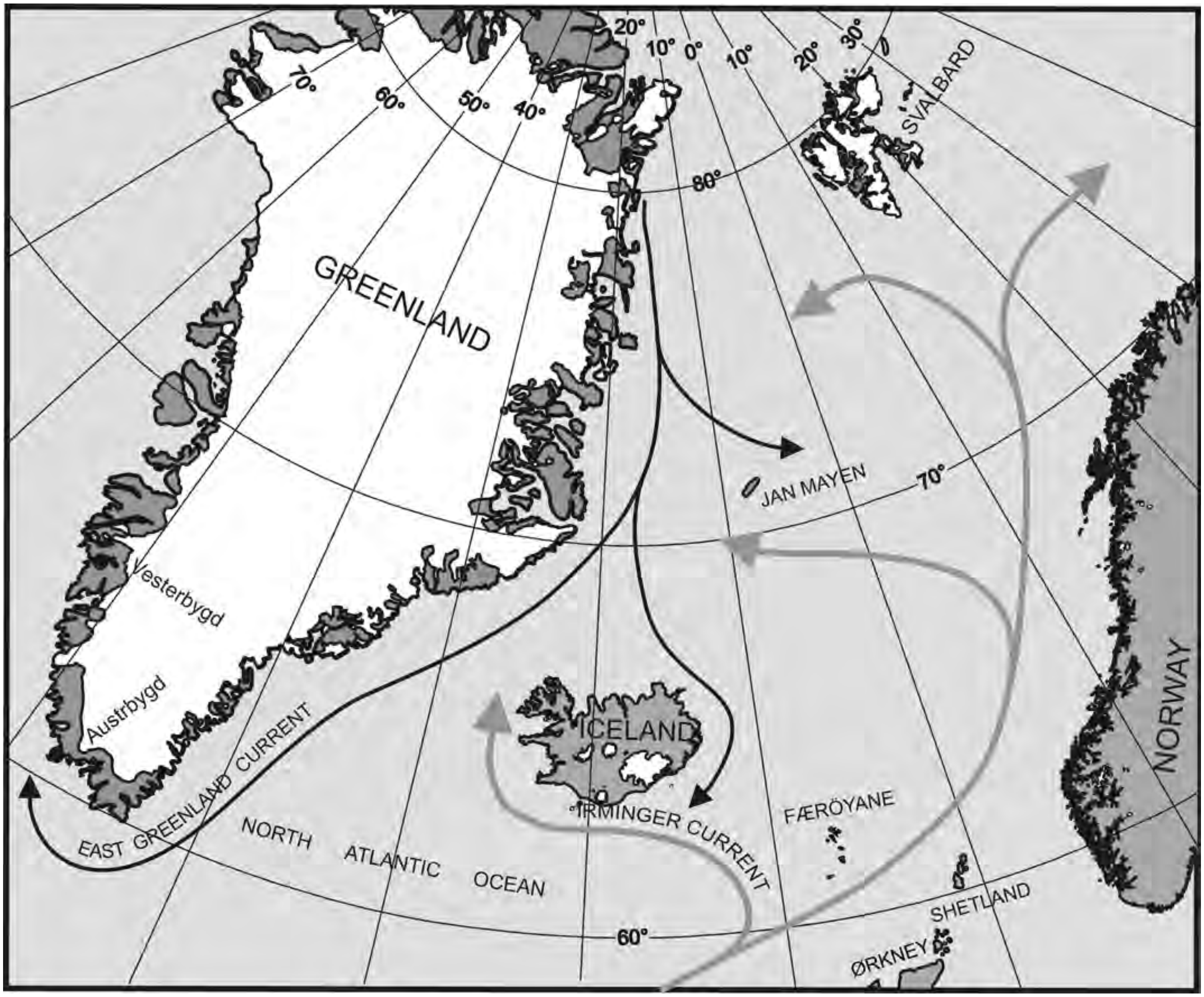

Figure 2. Map of North Atlantic Region. Austrbygd and Vesterbygd were the medieval Norse settlements in Greenland. Warm currents are shown by gray arrows and cold currents by black.

time, he explored the entire west coast as far as Disko Island (Norðrsetr, modern Qeqertarsuaq—see Table II). He then returned to Iceland and recruited a sizeable number of his former neighbors to immigrate to Greenland.

The Norse settlement of Greenland was a true *landnám*, i.e., settlement of a previously uninhabited country. When Eirík explored Greenland, he found the country devoid of people, but he found evidence of earlier human habitation. In today's terminology, these artifacts would be described as Independence I, Saqqaq, or Dorset I (Figure 4). While it is possible that Dorset people were in northernmost Greenland at the time, no one was in the more habitable south. Did they leave during the Medieval Warm Period to continue their cold weather ways? No one knows. Greenland's climate would never have been what one would call balmy, even during the Medieval Warm Period, and the sources say Eirik called the country "Greenland" to make it attractive to settlers, but it also seems that it really was greener than it is now. Dwarf birch (*Betula pubescens*), which is bigger than a bush but small for a tree, grew much more widely, and trees were

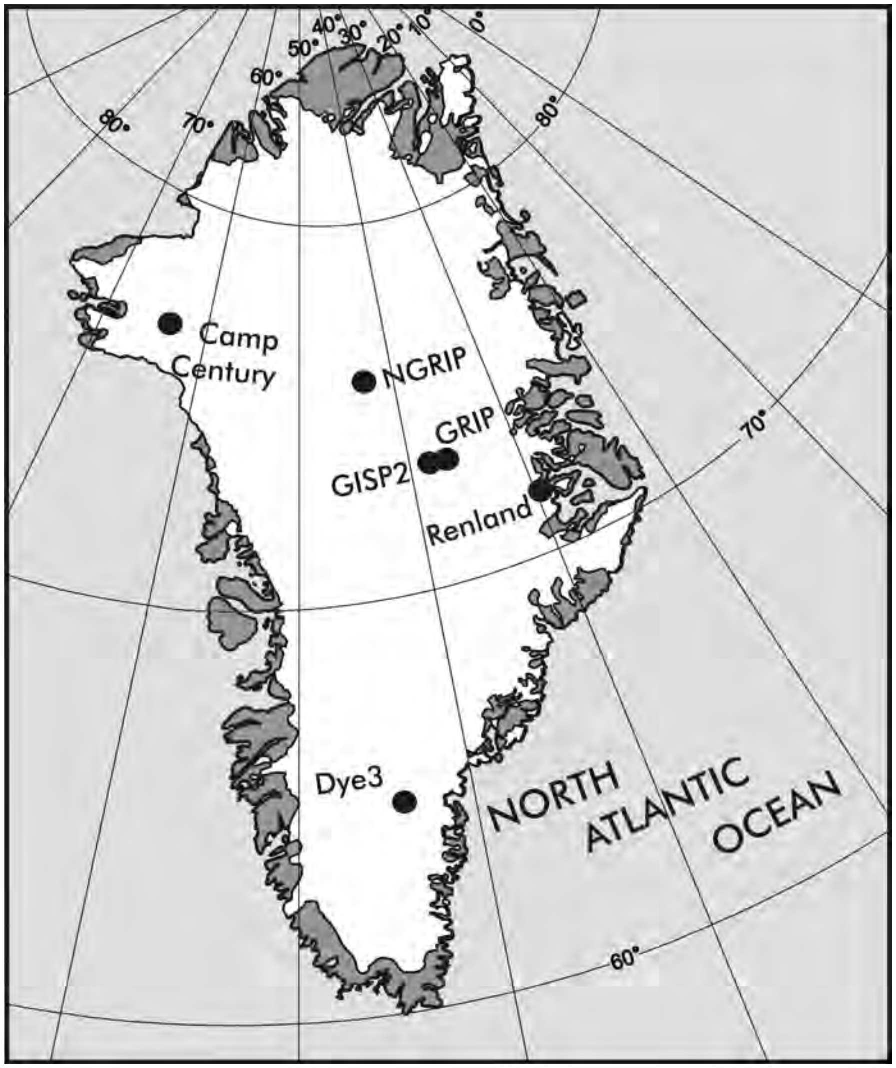

Figure 3. Ice core drilling locations on Greenland.

larger than later (Ingstad, 1959). Even today, the areas settled by the Norse respond well to the short summers and are capable of supporting large flocks of livestock (Ingstad, 1959). For the Norse, the most important crop was grass. The chieftains or clan leaders (hövðingar) chose the best farm sites, with those from the lower social strata settling in the less desirable areas (Arneborg, 2002). As the leader of the immigration, Eirik became the recognized leader of the tiny new nation (Figure 6).

Medieval Greenland

The sagas indicate a stable, hierarchical society. Archaeological research confirms this (Arneborg, 2002; Ingstad and Ingstad, 1996; Møller and Madsen, 2006). Like contemporary European society, the Greenlanders had to struggle to survive. Eirik's saga provides insight that life was often difficult, with bad years when many hunters failed to return, and food could be scarce.

The Greenlanders ranged widely, and it was not long after the settlement of Greenland that Leifur Eiríksson (aka Leif Erikson or "Leif the Lucky") bought a ship and explored the coasts of Helluland, Markland, and Vinland, known today as Baffin Island, Labrador, and Newfoundland. In the 1960s, the Ingstads excavated what is probably Leif's Vinland settlement at L'Anse Aux Meadows and established the veracity of the history provided by sagas, history long discounted by academics and even denied long after excavation was finished (Ingstad and Ingstad, 1996)! L'Anse Aux Meadows was forested in AD 1000 when the Norse settled there, but the climate later became too cold to support woodland. Pollen analyses indicate that while it was measurably warmer in 1000 than later—and possibly than today—it was not dramatically warmer than now (Ingstad and Ingstad, 1996).

Norwegian traders sailed to both Austrbygd and Vestrbygd (Figure 2), though the journey from Iceland to Greenland

Table I. Peoples of Greenland

Estimated Dates	Culture
2000–800 B.C.	Independence I
2000–800 B.C.	Saqqaq
ca. 800–1 B.C.	Independence II
700 B.C.–200 A.D.	Dorset I
800 A.D.–1300 A.D.	Dorset II
986–ca. 1540 A.D.	Norse
1150–2010 A.D.	Thule

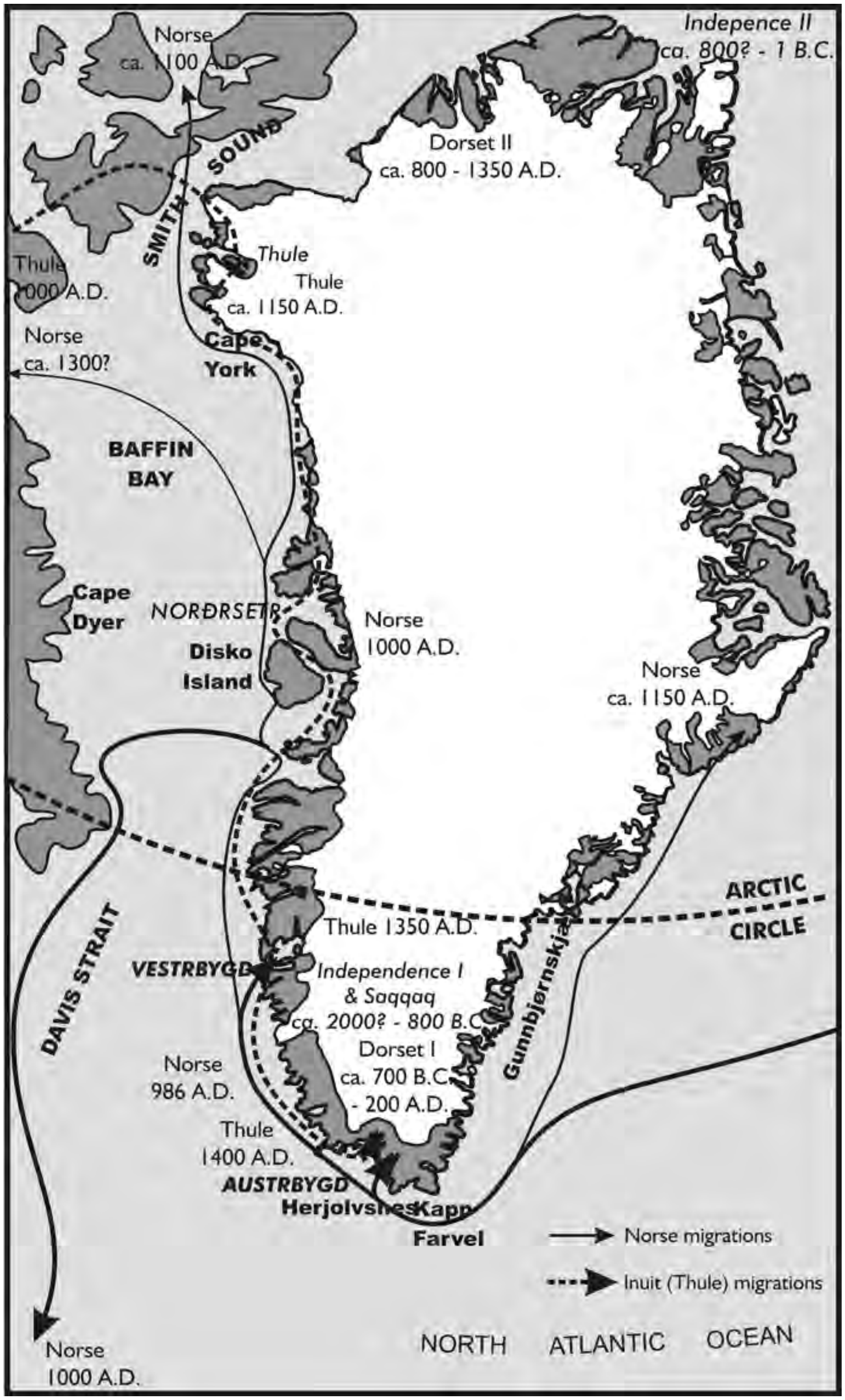

Figure 4. Map of Greenlandic cultural history. In southern Greenland, Eirik discovered earlier human settlements described as Independence I, Saqqaq, or Dorset I.

was replete with dangers. While sailing as far up the coast as Vestrbygd was clearly feasible, ice sometimes blocked the mouth of the fjords on Greenland's southwest coast, as noted in *Einar's þåttur*, an account from the early 1100s. Trade was at first quite regular between the trading center of Bergen in Norway and Greenland. Over time, at least four factors worked against this trade: increasing sea ice, the Black Death, Scandinavian politics, and German hegemony in trade (Bjørvik, 1994; Fagan, 2000; Helle, 1994; Heyerdahl and Lilliesträm, 1999; Ingstad, 1959). Sea ice forced the route south, made the voyage more dangerous, and shortened the trading season. The Black Death was imported to Norway from England via Bergen and decimated the population. Scandinavian politics resulted in Greenland being "forgotten," and the German Hanseatic League took power over virtually all trade through Bergen. A Norwegian ship did arrive from Greenland in 1410, but it had been blown off course on its way to Iceland (Ingstad, 1959). Another is recorded from 1484—the crew was said to have been murdered by the German merchants for breaching their monopoly, but Ingstad (1959) finds this story doubtful. The value of walrus ivory and furs, the most valuable trading wares of the Greenlanders, also sank steadily through medieval times (Bjørvik, 1994). Climate appears to have been an important factor but far from the only one in the decline in trade.

Clergy in medieval times were generally the only people who were literate, but runic inscriptions from Greenland indicate that some of the laity also were literate. Whereas church records are an important historical source for European history, those from Greenland are rare; the most famous is the wedding record from the Hvalsey church in 1408 (Ingstad and Ingstad, 1996). The main churches in Greenland were all destroyed by fire (Arneborg, 2001; Heyerdahl and Lilliesträm, 1999). *Einar's* *þáttur* (*Einars þáttr sokkasonar*) records the Greenlanders' decision to request that the king of Norway assign a bishop to Greenland. At this time (1123), Vestrbygd was an important community with leading men, a fact confirmed by the nature of archaeological discoveries at Sandnes (Arneborg, 2001). The first Roman Catholic bishop to visit Greenland was likely Erik Gnupson, who apparently established his see in Sandnes in Vestrbygd; he went to Vinland in 1121 and never returned (Ingstad and Ingstad, 1996). The last ecclesiastical head to live at the see in Garðar is believed to have been Alf (bishop 1367–1377), though Bishop Anders may have been there in 1406 (Ingstad, 1959). Records indicate that ecclesiastical levies for building Saint Peter's Cathedral in Rome and for paying for crusades were collected by Bishop Arne (bishop 1314–1343). Others were named bishop of Garðar clear up to 1537, but none apparently went there after 1400. "An old priest" was said to have officiated in Hvalsey in 1408, the time of the last surviving document.

Climate apparently contributed to the demise of the see of Garðar. A Vatican letter from 1492 expressed belief that no ship had ventured to Greenland in eighty years (Fagan, 2000). That must refer to trading ships or ships that Catholic officials could use to reach Greenland, as a papal record from 1448 speaks of "foreign ships that raided Austrbygd and destroyed the holy buildings"(Ingstad and Ingstad, 1996, p. 100).

Grove (1988, p. 1) believes grain was grown in Greenland, though others dispute this (Ingstad, 1959; Seaver, 2010). The *Konungsjugsá*, a literary source composed ca. 1250, mentions efforts by *hövðingar* at growing grain in Greenland, apparently without success (Ingstad, 1959). Grain was an import ware, and Greenlanders were not accustomed to eating it; they subsisted on a diet largely of meat, fish, sour butter or cheese, and various native plants (Ingstad, 1959). Diet varied with social status, and common people would not have eaten grain. If grain was a marginal crop at *landnám*, it is likely the interior fjord areas of Austrbygd at that time had a climate similar to the south coast of Iceland today, i.e., milder than the present climate. There is no doubt that after 1350 at the latest, grain cultivation would have been impossible.

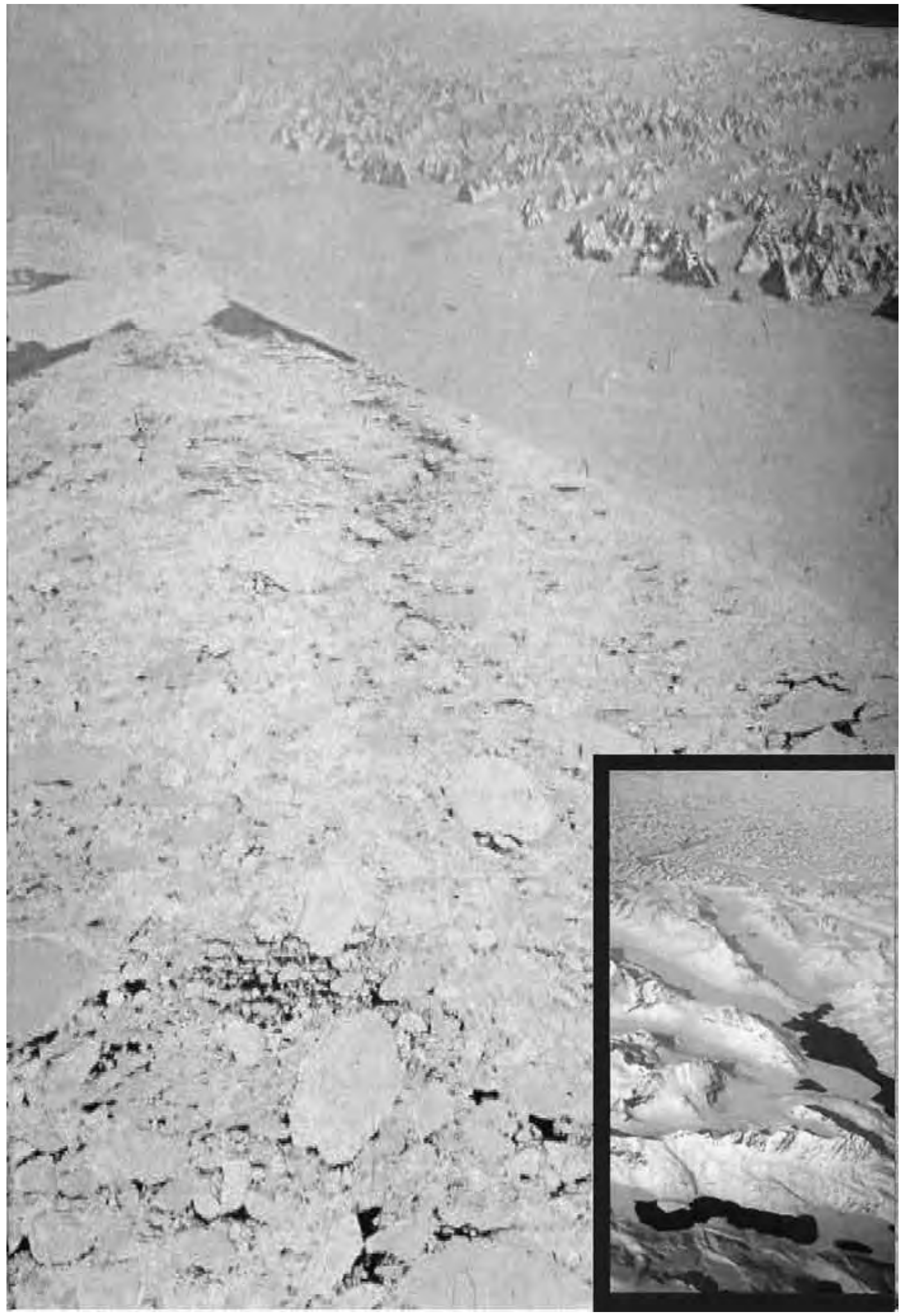

Figure 5. Photographs from the air of southeastern coast of Greenland (Gunnbjørnsskjær?). Need one wonder why this region has never been the site of significant human habitation?

Table II. Equivalent Place Names

Norse	Inuit	Danish
Anavík	Ujarassuit	Anavik
Austrbygd	Nanortalik, Qaqortoq, and Narsaq	Østerbygd
Bjarney	Qeqertarsuaq	Disko øer
Brattahlið	Qassiarsuk	Brattahlid
Einarsfjörðr	Igalikup Kangerlua	Einarsfjorden
Eiríksfjörðr	Tunuglliarfik	Eriksfjord
Eysunes	Nfgssuaq	Ildnæs
Garðar	Igaliko	Gardar
Herjolfsnes	Ikigaat	Herjolfsnæs
Hvatnahverfi		Vatnahverfi
Karlsbuðir	Arfersiorfik	Nordre Strømfjord
Kvalseyfjörðr	Qaqortukulooq	Hvalseyfjord
Langey	Tugtutôq	
Lysufjörðir	Kangerlussuaq	Søndre Strømfjord
Midtfjörðir	Sermilik	
Norðrsetr		Nordresæter
Nyland, Duneyar	Ittoqqortoormiit	Scoresbysund
Sandnes	Kilaarsarfik	Sandnæs
Straumfjörðr	Niaqungunaq	Fiskefjorden
Vestrbygd	Nuussuaq	Vesterbygd
	Qaanaaq	Thule
	Paamiut	Frederikshåb
	Narsarsuaq	"Bluey One"
	Nuuk	Godthåb
	Nanortalik	Lichtenaufjord

Arguments have been made that Norse diet changed to an increasingly marine one with time (Arneborg et al., 1999). These studies are hamstrung by attempting to compare human remains from different locations, times, and social strata, without mentioning dependence on radiocarbon dating. However, if true, this dietary change would provide circumstantial evidence for climatic deterioration.

Seaver (2010) tells of some Icelanders who in 1540 happened across the body of a man in Austrbygd who had recently died. The description of his clothing matches that of many bodies disinterred from Norse graveyards, and the description of the poor state of his knife matches what could be expected in fuel-starved Greenland. She disputes details of the story but accords it a basis in fact. If true, it is at present the last record of contact with Norse Greenland—such as it was. Seaver (2010, p. 99) also argues that a "large festal hall" at Herjolfsnes near the southern tip of the subcontinent could not have been built before the middle 1400s, and evidence appears to support a functioning Norse community at Herjolfsnes into the 1500s (Ingstad, 1959), but a German expedition in 1542 found Greenland uninhabited (Ingstad, 1959). The Arctic explorer Frobisher apparently did not encounter Norse during his 1576–1578 expedition, nor did the Danish Dannels expedition in 1652–1654.

In 1721, Hans Egede Saabye obtained royal permission to go to Greenland as a missionary to the Greenlanders. When he arrived, he found no Norse. So he mastered the Inuit language, translated the Bible into Inuit, and spent the rest of his life ministering to them. His son Paul recorded accounts of the Inuit (Ingstad, 1959). Some of the Inuit believed the Norse were still in Greenland just as Hans Egede had expected. They told of peaceful coexistence but also of ships that sailed into Austrbygd and attacked the farmers. A Dano-Norwegian expedition in 1481 had written of encountering "pirates," though it is difficult to interpret their descriptions, which could easily have been skin boats. The Inuit were neither well-armed nor practiced in war and would make unlikely "pirates." Evidence points to peaceful coexistence between Norse and other peoples (Ingstad, 1959; Seaver, 2010).

Modern Greenland

Most of today's Greenlanders are Inuit. They are descendants of the Thule people who reached Greenland from the Canadian Arctic in medieval times

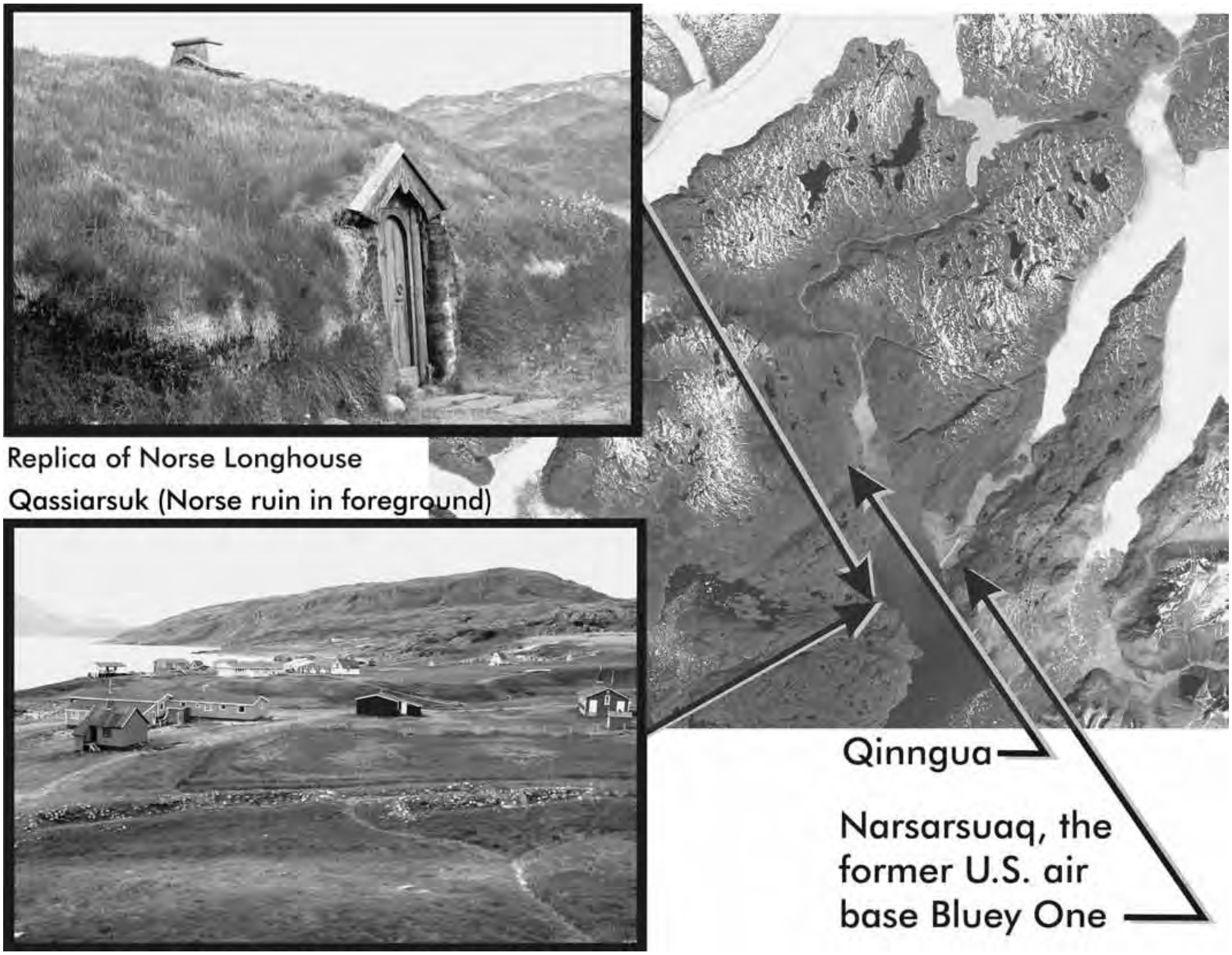

Figure 6. The most famous Norse Greenlandic farm was Eirík the Red's Brattahlið on Eiríksfjörðr (Eriks Fjord). Note on the satellite photograph that a lake traps calving ice so that this fjord is free of icebergs at its head and with the best climate for agriculture in the region. Qassiarsuk is the traditional site for Brattahlið, but another possibility is nearby Qinngua. Aerial from NASA Earth Observatory, other photographs from Can Stock Photo.

and continued expanding their range southward along the west coast until they were living side by side with the Norse (Fagan, 2000; Raahauge et al., 2002). When the Norse disappeared (see Appendix A), the Inuit continued their traditional existence.

As a Danish protectorate, Greenland has long had significant Danish influence and a sizable Danish minority. Most archaeological investigations and investigations of Greenlandic cultures have been conducted by the Danish National Museum. Work has also progressed on measuring glacial fluctuations and investigating the ice sheet. Widespread extension of glaciers from late medieval times, with minor recession during the twentieth century, is evident and matches observations from elsewhere in the world (Grove, 1988). Although the media frequently report stories of receding glaciers in Greenland, recent decades have actually been cooler than "normal" in both air and sea temperatures (Fagan, 2000). "The past 40 years' cooling trend in Southern Greenland shows that climate change is far from a simple, even process" (Hansen and Cappelen, 2003, p. 1).

Greenland's history provides important data for climate change research. Interpretation of these data is not without difficulty and controversy, but in general it agrees with Grove's (1988) interpretation that the Little Ice Age was a global phenomenon.

Proxy Data

Oxygen isotope dating of tooth enamel and benthic foraminifera have been used as proxies for the temperature history of Greenland (Grove, 2001), but the primary data come from ice cores. These proxies are limited but seem to reinforce the Little Ice Age timing seen elsewhere in the study area (Johnsen et al., 2001). Data from GISP-2 (Figure 3) are interpreted to show a particularly cold period in the mid 1300s (Fagan, 2000). Diatom evidence from cores in Austrbygd (Figure 2) indicates an overall cooling from the Medieval Warm Period to the Little Ice Age and significant cooling after 1350 (Jensen et al., 2004). The Little Ice Age peaked (as defined by ice extent) around 1750, but a second peak in Greenland occurred around 1880 (Grove, 1988). This was true for both the inland ice margin and outlet glaciers, east coast and west.

The Little Ice Age

Evidence for the Little Ice Age in Greenland corresponds with climatic change elsewhere in our study area. "But the climate continued to be mild from about 1000 until the middle of the 1100's, during the time the country was settled, and later it vacillated between milder and colder periods until the middle of the 1440's, when it became significantly colder"(Krag, 1994, pp. 42–43).

Permafrost at Hvalsnes

Bodies disinterred from the cemetery at Herjolfsnes indicate the ground was permanently frozen after 1350 (Grove, 1988). This may indicate a markedly colder climate, though some dispute this (Ingstad, 1959) and believe the climate became only slightly cooler.

Changes in Fishing and Sea Routes

While sea ice fluctuates from year to year, Barðarsson's account that the trade route had to be moved farther and farther south indicates a decadal to centennial scale for this change. Disappearance of cod and their return in recent decades is a clear sea temperature signal (Fagan, 2000).

Advancing Ice

Eyewitness accounts from the 1700s tell of rapid expansion of Greenland outlet glaciers. Fast advances were also observed in the late 1800s, both in inland ice and outlet glaciers, with temperature as the main control (Grove, 1988). We are not aware of any eyewitness account of farms actually being overrun by glaciers, and they are usually destructive of archaeological material. An exception is Gården under Sandet in Vesterbygd, which was preserved under glaciofluvial sediments. Ingstad (1959) presents evidence that the caribou/reindeer herd of northeastern Greenland died out because their habitat was covered by snow and ice during the Little Ice Age.

Disappearance of Norse Greenlanders

The disappearance of the Norse Greenlanders remains a mystery. Many of the theories are climate related, but it is impossible to prove their disappearance was caused by climate change (Appendix A). Migration of the Inuit (Thule people) south during the Little Ice Age may have been due to population growth, depletion of game, reduction in game due to climatic deterioration, or a combination of these factors. In any case, they came to live in the same areas as the Norse and competed with them for seal, caribou, and other resources. Unfortunately, it was then that cooling climate increased the need for resources. The Inuit survived and have remained in Austrbygd to this day, but there is much evidence for starvation and deprivation (Ingstad, 1959).

Glacial Studies

Melting glaciers is a popular theme in the media. Scientific studies attempt to quantify changes through mass balance comparisons, studying the accumulation of snow on the inland ice and the ice lost at outlet glaciers. Accurate results are hampered by the form of Greenland's coast (Figure 2). The feet of glaciers are easier to observe and have been studied for the past couple of centuries, though with greater scientific rigor in recent decades. Studies show that Greenland's glaciers advanced contemporary with Little Ice Age advances in Europe, but unlike Europe Greenland's glaciers have been slow to retreat or even advanced through the 1970s (Gordon, 1981). Mass balance studies for the ice sheet indicate slightly negative to slightly positive overall mass balance, but with significant differences between regions (Dietrich et al., 2005; Simpson et al., 2011; Tarasov and Peltier, 2002).

Much study has been directed to ice cores and their proxies over the past few decades to reconstruct paleoclimates. A summary of the problems with the assumptions and methods behind these reconstructions was presented by Oard (2005). Recent studies emphasize computer modeling to infer ice cover changes for Greenland and other regions, much of which is based on ice core interpretations (Tarasov and Peltier, 2002). These are now focused on recent centuries to interpret data from isostasy with greater temporal precision, as will be described later in this paper.

Altered Currents?

The countries in our study area are dependent on the transport of heat via ocean currents to moderate their high-latitude climates. As shown in Figure 2, the Irminger Current moderates the climate of Iceland, while the East Greenland Current causes the arctic landscape of Figure 5 at the same latitude that barley and fruit trees grow in Norway. Thor Heyerdahl posited that Gunnbjørnskjær was not the frigid coast shown in Figure 5 but rather an island (*skjær* can be translated as bank, reef, skerry, or island). He hypothesized that this was a volcanic island reported to have erupted in 1332 and "burned up completely" in 1456 (Heyerdahl and Lilliesträm, 1999, p. 350). The last eruption, he said, was in 1783. Without the impediment of the island, sea ice moved more freely and abundantly south with the East Greenland Current. To our knowledge, no research has been pursued to confirm or deny Heyerdahl's hypothesis.

Isostasy

Dramatic isostatic changes in Greenland may have contributed to the disappearance of Norse society. The beach at Brattahlið in Austrbygd (Figures 2 and 6) is now 3–4 m (10–13 ft.) below sea level (Sparrenbom et al., 2006), and the prominent church at Sandnes in Vestrbygd has seen a rise in sea level or drop in land elevation of 6 m (19 ft.) in the several centuries since it was built (Weidick, 1996). Recently, global positioning system (GPS) and satellite data have been tapped to determine rates of vertical motion. These data have been combined with data from radiocarbon-dated elevated shorelines to refine glacial models. While many of the assumptions made by researchers are questionable and the models are sensitive to assumptions of earth structure (Bennike et al., 2002; Fleming and Lambeck, 2004; Tarasov and Peltier, 2002), an increase in the Greenland Ice Sheet during the Little Ice Age is clearly indicated (Bennike, 2002; Weidick, 1996; Weidick et al., 2004). Many believe the present ice margin represents an advance of 25 to 80 km (15 to 48 miles) beyond the minimal margin preceding the Medieval Warm Period (Bennike, 2002; Dietrich et al., 2005; Simpson et al., 2011; Sparrenbom et al., 2006; Wahr et al., 2001). Greenland shows an isostatic pattern opposite to that of Scandinavia: it appears to have risen most at the coasts and actually subsided near the ice margin, indicating a thickening ice sheet and rebounding coasts (Wahr et al., 2001; Weidick, 1972; Weidick et al., 1990). Isostatic adjustments have significant implications, as summarized in Appendix B.

Regional or Global?

The North Atlantic Oscillation (NAO) is a major meteorologic phenomenon in the North Atlantic region and can explain many observed weather patterns. Typical winter lows over Iceland and highs over the Azores channel westerly winds to Europe. Reversing this pattern weakens the winter storm track. Figure 7 illustrates the "Greenland above effect," with high barometric pressure over Greenland. This results in warmer winter temperatures in Greenland and colder temperatures in Norway and usually most of the rest of Europe. The "Greenland below effect" is the opposite situation.

The NAO can explain asynchronicity in winter temperatures between Greenland and Europe; it cannot explain growth of ice in Greenland contemporary with growth of ice masses elsewhere. The NAO is, however, linked with weather patterns in the North Pacific (Van Loon and Rogers, 1978; Rogers and Van Loon, 1979). The Little Ice Age appears to have been at least hemispheric based on Greenland evidence, which is part of the motivation for ice core research. Proxy data indicate declining temperatures in later medieval times, and advances in inland ice and coastal glaciers in Greenland coincided with the growth of glaciers in Iceland and Norway (Grove, 1988; Klevberg and Oard, 2012a, 2012b).

The NAO or oscillatory weather patterns do not explain growth of the ice sheet inferred from isostatic data or the advance of the ice margin during recent centuries. Retreat of glacial fronts during recent decades has not equalled the advance of the Greenland ice margin during the Little Ice Age, nor has that margin melted back to its Medieval Warm Period position. As pointed out in previous papers of this series (Klevberg and Oard, 2011b, 2012a, 2012b), temperature is but one climatic variable, and Weidick (1972) attributes much of the observed change in the Greenland Ice Sheet to changes in precipitation and storm tracks. This fits well with contemporary observations for the Little Ice Age in Iceland and Norway (Klevberg and Oard, 2012a, 2012b).

Summary

The Greenland Ice Sheet is the world's second largest, forming a huge heat sink that modulates climate on a global scale. Both historical and proxy data indicate that Greenland in AD 1000 was warmer than at present, and that it cooled significantly during the Little Ice Age. Recent warming has been uneven, with a general cooling trend in southwestern Greenland over the past few decades. The Little Ice Age cooling cannot be attributed to the NAO; only decadal differences between Europe and Greenland can be explained by the NAO. In general, the timing of glacial advance coincides with Iceland and Norway, though recession has been later and to a lesser scale in Greenland. It is difficult to quantify climatic changes in Greenland from changes in equilibrium line altitude (ELA), since data are

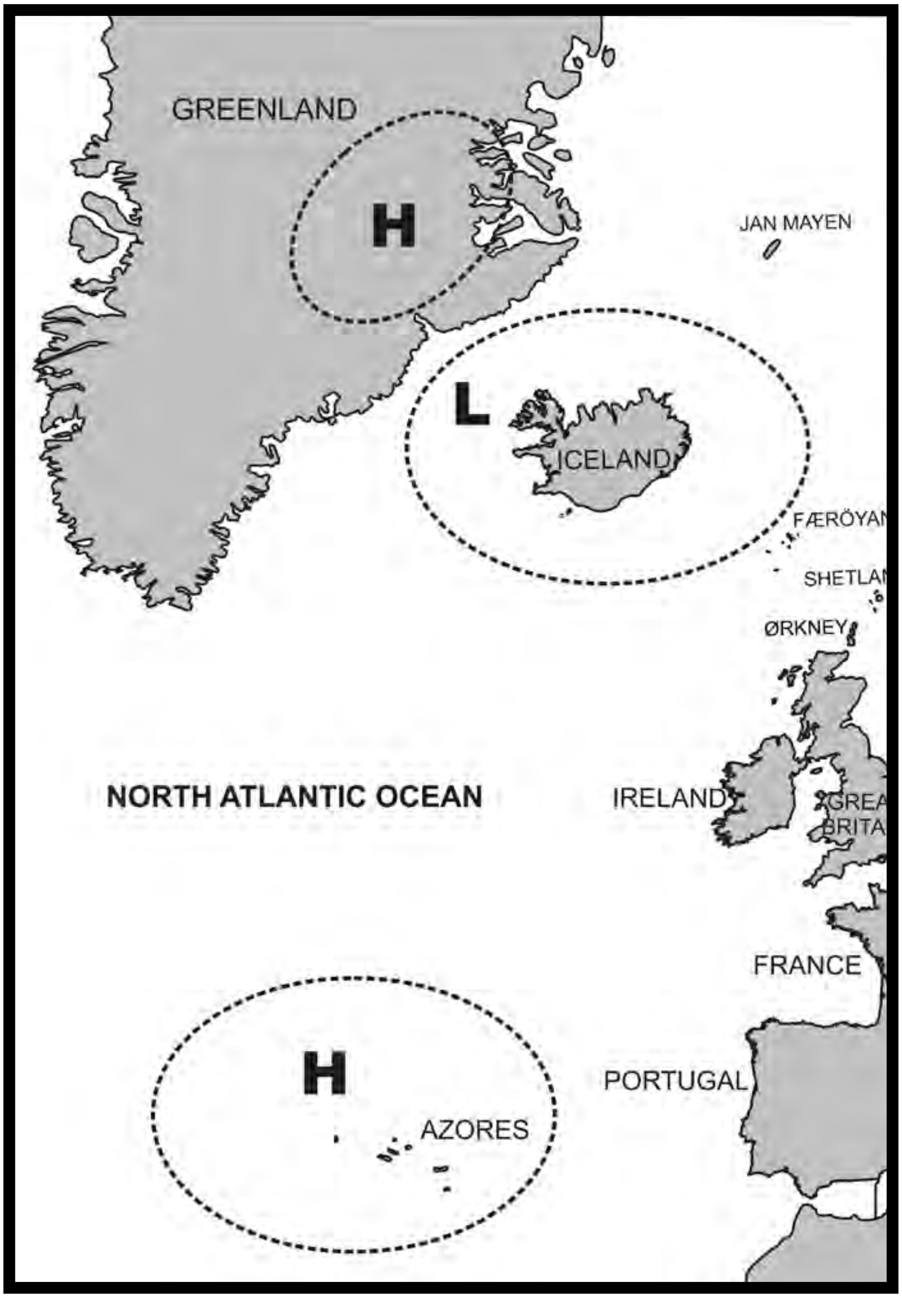

Figure 7. The North Atlantic Oscillation. The N.A.O. is shown in "positive" or normal mode; a "negative" N.A.O. index would have high barometric pressure over Iceland and low over the Azores. The "Greenland above" effect is illustrated, with high pressure over Greenland and warmer-than-average temperatures in Greenland coinciding with lower-than-average temperatures in Scandinavia. The "Greenland below" effect is the opposite.

often imprecise and the ELA is low to begin with. More reliance on somewhat problematic proxy data, particularly ice cores, is therefore necessary in studying paleoclimatology in Greenland. However, recent work on isostasy indicates that the Little Ice Age had a profound impact on Greenland.

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Glossary

Hanseatic League (Hansa) – A trading monopoly based in northern German cities that controlled much of northern European trade and exerted great political influence during medieval times.

hövðingar – Norse aristocracy, consisting mostly of local chieftains, feudal lords, or clan leaders, though *hövðingar*, especially of higher rank, typically ruled over people unrelated to them, in addition to slaves and servants.

isostasy – gravitational equilibrium between lighter continents and denser oceanic crust and mantle; loading of the surface by ice causes depression of the earth's surface, and unloading causes the surface to rebound and rise (isostatic adjustment).

landnám – Norse word for settling a country that was previously uninhabited.

References

CRSQ: Creation Research Society Quarterly

Andreasen, C. 2003. Paleoeskimo dwellings in Greenland: a survey. *Etúdes Inuit* 27:283–306.

Arneborg, J. 2001. Kirke, kristendom og storbønder i Grønland–et nyt forskningsprosjekt [in Danish]. In Bisgaard, L., and R.S. Christensen (editors), *Kristningen av norden–et 1000-års jubilæum.* pp. 8–25.

Center for Middelalderstudier, Syddansk Universitet, Odense, Denmark.

Arneborg, J. 2008. Resources, mobility, and cultural identity in Norse Greenland AD 980 - 1450. Annual Report to the Comission for Scientific Research in Greenland. National Museum of Denmark, Copenhagen, Denmark.

Arneborg, J., J.T. Hansen, and C. Paulsen. 2002. Kirkearkæologiske undersøgelser: ruingruppe 60V2-IV-620/Ø48 - Igaliku, Narsaq, ruingruppe 61V3-III-522/Ø33 - Qorlortoq, Narsaq, ruingruppe 61V1-III-529/Ø35 - Qorlortup Itinnera, Narsaq [in Danish]. Feltrapport 5, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Arneborg, J., J. Heinemeier, N. Lynnerup, H.L. Nielsen, N. Rud, and Á.E. Sveinbjörnsdóttir. 1999. Change of diet of the Greenland Vikings determined from stable carbon isotope analysis and ^{14}C dating of their bones. *Radiocarbon* 41:157–168.

Bégin, Y., D. Bérubé, and M. Grégoire. 1993. Downward migration of coastal conifers as a response to recent land emergence in eastern Hudson Bay, Québec. *Quaternary Research* 40:81–88.

Bennike, O. 2002. Late Quaternary history of Washington Land, North Greenland. *Boreas* 31:260–272.

Bennike, O., S. Björck, and K. Lambeck. 2002. Estimates of South Greenland late-glacial ice limits from a new relative sea level curve. *Earth and Planetary Science Letters* 197:171–186.

Bjørvik, H. 1994. *Folketap og sammenbrudd 1350–1520*. (Volume 4 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Brasen, T. 2001. The farm under the sand. *Folio* 38(16), http://www.folio.ualberta.ca/38/16/03.html (accessed January 27, 2014).

Christensen, D.V. 2002. Handel og kommunikation i Nordatlanten: rapport om prøveundersøgelser på den formodede atlanthavn, Sandhavn ved Maakkarneq, Nanortalik Kommune. Feltrapport 3, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Diamond, J. 2005. *Collapse: How Societies Choose to Fail or Succeed*. Viking, New York, NY.

Dietrich, R., A. Rülke, and M. Scheinert. 2005. Present-day vertical crustal deformation in West Greenland from repeated GPS observations. *Geophysical Journal International* 163:865–874.

Einars þáttr sokkasonar [*Einar's þáttur*, in Old Norse]. Downloaded from www.heimskringla.no/original/islendingesagaene/graenlendingathattr.php (accessed December 31, 2008).

Fagan, B. 2000. *The Little Ice Age: How Climate Made History 1300–1850*. Basic Books, New York, NY.

Fell, M. 1999. *And Some Fell into Good Soil: A History of Christianity in Iceland*. Peter Lang, New York, NY.

Fleming, K., and K. Lambeck. 2004. Constraints on the Greenland Ice Sheet since the last glacial maximum from sea-level observations and glacial rebound models. *Quaternary Science Reviews* 23:1053–1077.

Gabriel, M., B. Grønnow, U. Odgaard, C. Pasda, and K. Pasda. 2002. Bosættelsesmønstre i det centrale Vestgrønland: rapport om undersøgelserne i Angujârtorfiup Nunâ, Manitsoq Kommune, sommeren 2001 [mostly in Danish]. Feltrapport 4, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Gordon, J.E. 1981. Glacier margin fluctuations during the 19th and 20th centuries in the Íkamiut Kangerdluarssuat area, West Greenland. *Arctic and Alpine Research* 13:47–62.

Grove, J.M. 1988. *The Little Ice Age*. Methuen, New York, NY.

Grove, J.M. 2001. The initiation of the "Little Ice Age" in regions round the North Atlantic. In Ogilvie, A.E.J., and T. Jónsson (editors), *The Iceberg in the Mist: Northern Research in Pursuit of a "Little Ice Age"* pp. 53–82. Kluwer Academic Publishers, Boston, MA.

Hansen, N., and J. Cappelen. 2003. Avkøling I det sydlige Grønland [in Danish]. Danish Meteorological Institute, http://www.dmi.dk/dmi/afkoeling_i_det_sydlige_groenland (accessed November 27, 2010).

Hebsgaard, M.B., M.T.P. Gilbert, J. Arnebord, P. Heyn, M.E. Allentoft, M. Bunce, K. Munch, C. Schweger, and E. Willerslev. 2009. "The farm beneath the sand"–an archaeological case study on ancient "dirt" DNA. *Antiquity* 83:430–444.

Helle, K. 1994. *Under kirke og kongemakt 1130–1350*. (Volume 3 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Heyerdahl, T. 2000. *Jakten på Odin* [in Norwegian]. J.M. Stenersens Forlag, Oslo, Norway.

Heyerdahl, T., and P. Lillieström. 1999. *Ingen Grenser* [in Norwegian]. J.M. Stenersens Forlag, Oslo, Norway.

Høegh-Knudsen, P., C. Krause, and N.A. Møller. 2003. Palæoeskimoer i Sydgrønland: rapport om undersøgelserne på Illussat (60V2-II-26) Nanortalik Kommune, sommeren 2002 [in Danish]. Feltrapport 10, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Ingstad, H. 1959. *Landet under leidarstjernen*. Gyldendal, Oslo, Norway.

Ingstad, H., and A.S. Ingstad. 1996. *Oppdagelsen av det nye land* [in Norwegian]. J.M. Stenersens Forlag, Oslo, Norway.

Jensen, E.L. 2002. Uunup Saqqaa–kontakter mellem Øst- og Vestgrønland: rapport over forundersøgelse og arkivsøgning, oktober 2001 - marts 2002 [in Danish]. Feltrapport 7, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Jensen, J.F., B. Grønnow, A.B. Gotfredsen, B.H. Jakobsen, A. Kroon, M. Meldgaard, and M. Sørensen. 2008. GeoArk 2005 og 2007: rapport over rekognosceringer i Nordøstgrønland [in Danish]. Feltrapport 27, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Jensen, K.G., A. Kuijpers, N. Koç, and J. Heinemeier. 2004. Diatom evidence of hydrographic changes and ice conditions in Igaliku Fjord, South Greenland, during the past 1500 years. *The Holocene* 14:152–164.

Johnsen, S.J., D. Dahl-Jensen, N. Gundestrup, J.P. Steffensen, H.B. Clausen, H. Miller, V. Masson-Delmotte, A.E. Sveinbjörnsdottir, and J. White. 2001. Oxygen isotope and paleotemperature records from six Greenland ice-core stations: Camp Century, Dye-3, GRIP, GISP2, Renland and NorthGRIP. *Journal of Quaternary Science* 16:299–307.

Klevberg, P., and M.J. Oard. 2011a. The Little Ice Age in the North Atlantic region–part I: introduction to paleoclimatology. *CRSQ* 47:213–227.

Klevberg, P., and M.J. Oard. 2011b. The Little Ice Age in the North Atlantic region–part II: magnitude, extent, and importance of the Little Ice Age. *CRSQ* 48:49–58.

Klevberg, P., and M.J. Oard. 2012a. The Little Ice Age in the North Atlantic region–part III: Iceland. *CRSQ* 48:224–238.

Klevberg, P., and M.J. Oard. 2012b. The Little Ice Age in the North Atlantic region, part IV: Norway. *CRSQ* 49:43–55.

Krag, C. 1994. *Vikingtid og rikssamling 800 - 1130*. (Volume 2 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

McGovern, T.H. 1991. Climate, correlation, and causation in Norse Greenland. *Arctic Anthropology* 28:77–100.

Mikkelsen, N., A. Kuijpers, and J. Arneborg. 2008. The Norse in Greenland and late Holocene sea-level change. *Polar Record* 44:45–50.

Motyka, R.J., 2003. Little Ice Age subsidence and post Little Ice Age uplift at Juneau, Alaska, inferred from dendrochronology and geomorphology. *Quaternary Research* 59:300–309.

Møller, N.A., and C.K. Madsen. 2006. Nordboerne i Vatnahverfi: rapport om rekognoscering og opmåling af nordboruiner i Vatnahverfi, sommeren 2005 [in Danish]. Feltrapport 24. Sila-Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Møller, N.A., L. Lund Johansen, C.K. Madsen, L. Felding, P. Baltzer Heide, and K. Smiarowski. 2007. Udgravninger i norrøne kirkegårde og møddinger: rapport om opmålinger og utgravninger i Vatnahverfi, sommeren 2007 [in Danish]. Feltrapport 26, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Oard, M.J. 1990. *An Ice Age Caused by the Genesis Flood*. Institute for Creation Research, Dallas, TX.

Oard, M.J. 2005. *The Frozen Record: Examining the Ice Core History of the Greenland and Antarctic Ice Sheets*. Institute for Creation Research, Dallas, TX.

Panagiotakopulu, E., P. Skidmore, and P. Buckland. 2007. Fossil insect evidence for the end of the Western Settlement in Norse Greenland. *Naturwissenschaften* 94:300–306.

Raahauge, K., M. Appelt, H.C. Gulløv, H. Kapel, C. Krause, and N.A. Møller. 2002. Tidlig Thulekultur i Sydgrønland: rapport om undersøgelserne i Nanortalik Kommune, sommeren 2001 [in Danish]. Feltrapport 1, SILA: Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Raahauge, K., P. Høegh-Knudsen, H.C. Gulløv, J. Møhl, C. Krause, and N.A. Møller. 2003. Tidlig Thulekultur i Sydgrønland: rapport om undersøgelserne i Nanortalik Kommune, sommeren 2002 [in Danish]. Feltrapport 9, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Raahauge, K., E.L. Jensen, B. Grønnow, and H.C. Gulløv. 2005. Bopladser langs konebådsruten mellem Vest- og Østgrønland, rapport om besigtigelser fra Pamialuk til Aluk, sommeren 2004 [in Danish]. Feltrapport 19, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Rian, Ø. 1994. *Den nye begynnelsen 1520–1660*. (Volume 5 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Rieck, F., J. Dencker, H. Kapel, and K. Raahauge. 2002. Skib, naust og maritime aktiviteter i det norrøne Grønland: rapport om prøveundersøgelser af et formodet skibsnaust og en smedje ved Ikigaat/Herjolfsnæs, Nortalik Kommune, sommeren 2001 [in Danish]. Feltrapport 2, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Rogers, J.C., and H. Van Loon. 1979. The seesaw in winter temperatures between Greenland and Northern Europe. Part II: some oceanic and atmospheric effects in middle and high latitudes. *Monthly Weather Review* 107:509–519.

Ross, J.M. 1997. Paleoethnobotanical investigation of Garden Under Sandet, a waterlogged Norse farm site, Western Settlement, Greenland (Kaiaallit Nunaata). M.A. thesis, University of Alberta, Edmonton, AB.

Sandgren, P., and B. Fredskild. 1991. Magnetic measurements recording late Holocene man-induced erosion in S. Greenland. *Boreas* 20:315–331.

Seaver, K.A. 2010. *The Last Vikings*. I.B. Taurus, New York, NY.

Simpson, M.J.R., L. Wake, G.A. Milne, and P. Huybrechts. 2011. The influence of decadal- to millenial-scale ice mass changes on present-day vertical land motion in Greenland: implications for the interpretation of GPS observations. *Journal of Geophysical Research* 116:B02406 (doi: 10.1029/2010JB007776).

Sparrenbom, C.J., O. Bennike, S. Björck, and K. Lambeck. 2006. Holocene relative sea-level changes in the Qaqortoq area, Southern Greenland. *Boreas* 35:171–187.

Sørensen, M., and K.B. Pedersen. 2004. Killiaq kilder og palæo-eskimoer: arkæologisk rekognoscering af nordkysten af Nuussuaq, fra Serfat til Qaarsut, Uummannaq Kommune [in Danish]. Feltrapport 17, Sila - Nationalmuseets Center for Grønlandsforskning, Copenhagen, Denmark.

Tarasov, L., and W.R. Peltier. 2002. Greenland glacial history and local geodynamic consequences. *Geophysical Journal International* 150:198–229.

Thomson, A.M., I.A. Simpson, and J.L.

Brown. 2005. Sustainable rangeland and grazing in Norse Faroe. *Human Ecology* 33:737–761.

Van Loon, H., and J.C. Rogers. 1978. The seesaw in winter temperatures between Greenland and Northern Europe. Part I: general description. *Monthly Weather Review* 106:296–310.

Vardiman, L. 1997. Rapid changes in oxygen isotope content of ice cores caused by fractionation and trajectory dispersion near the edge of an ice shelf. *Creation Ex Nihilo Technical Journal* (now *Journal of Creation*) 11(1): 52–61.

Vebæk, C.L. 1991. Hunting on land and at sea and fishing in medieval Norse Greenland. *Acta Borealis* 8:5–14.

Wahr, J., T. Van Dam, K. Larson, and O. Francis. 2001. Geodetic measurements in Greenland and their implications. *Journal of Geophysical Research* 106:16,567–16,581.

Weidick, A. 1972. Holocene shore-lines and glaciated stages in Greenland–an attempt at correlation. Grønlands Gbeolgiske Undersøgelse *Rapport Nr. 41*.

Weidick, A., H. Oerter, N. Reeh, H.H. Thomsen, and L. Thorning. 1990. The recession of the inland ice margin during the Holocene climatic optimum in the Jakobshavn Isfjord area of West Greenland. *Paleogeography, Paleoclimatology, Paleoecology* 82:389–399.

Weidick, A. 1996. Late holocene and historical changes of glacier cover and related relative sea level in Greenland. *Zeitschrift für Gletscherkunde und Glazialgeologie* 32:217–224.

Weidick, A., M. Kelly, and O. Bennike. 2004. Late Quaternary development of the southern sector of the Greenland Ice Sheet, with particular reference to the Qassimiut lobe. *Boreas* 33:284–299.

Appendix A: The Mystery of the Disappearance of the Greenlanders

For centuries, a few thousand Norse Greenlanders occupied hundreds of remote farms and hunting camps in southwestern Greenland and traded with European voyagers at Herjolfnes and other locations. The population of Vestrbygd vanished about 1350, but the larger Austrbygd community was still populous in the early 1400s, and still in existence to at least 1540. It, too, was gone without a trace by 1721, when Hans Egede Saabye came to bring the gospel of Jesus Christ to them. Finding Inuit rather than the Norse he had expected, he learned their language and ministered to them. Why the Norse Greenlanders disappeared remains a mystery. As shown in Table III, more than a dozen theories have been devised to explain this disappearance, either alone or in combination.

Was the Little Ice Age the Cause?

No clear evidence exists that the Little Ice Age affected Greenland strongly enough to bury most Norse farms and put an end to their civilization. Alternative ideas include some that involve climate change and some that do not. The likelihood or unlikelihood of these theories helps to provide some degree of insight into the effects of the Little Ice Age on Greenland.

Theories for the Disappearance of the Norse Greenlanders

Of the theories shown in Table III, only two are blatantly climatic. Eight are primarily political or cultural, and four could be called "natural" without necessarily being directly climate related.

Annihilation by Inuit

Ivar Barðarsson, who led the expedition from Austrbygd in the 1300s to rescue Vestrbygd, believed the Norse there had been attacked by Inuit. Ingstad (1959) provides evidence that the possibility of this is remote. While there were accounts of Inuit attacks on Norse, these were very rare, and relations appeared to have been nearly always friendly. Inuit were known to form friendships with Norse and even to have rescued some in time of calamity.

Assimilation by Inuit

Fridtjof Nansen, the famous explorer who skied across Greenland, was a "uniformitarian" who disputed the existence of the Little Ice Age prior to its end. He thus did not adhere to a climate-related theory but instead believed the Norse had simply assimilated into Inuit culture. However, evidence indicates that the genetic contribution of Europeans to the present Greenlandic people stems from the much smaller group of Danes and Norwegians who settled in Greenland after 1750 and married Inuit women.

Overrun by Ice

Advancing ice did threaten, if not destroy, Norse farms (Grove, 1988) and probably overran many of the more inland sites (Weidick, 1972, 1996). That the ice continued to advance into the eighteenth century and beyond is attested to by records of interviews with Inuit hunters (Grove, 1988). As noted above, the inland ice appears to have advanced up to 80 km (48 miles) from its post-Great-Ice-Age minimum. However, many sites did not suffer from glacial advance, and the growth of glaciers could not have constituted a sufficient condition for the disappearance of the Norse Greenlanders, though it may have contributed to the demise of their society. Advancing ice, increasing permafrost, and glacial erosion would all have challenged the Norse Greenlanders. Ice advance is certainly a climatically governed factor.

Table III. Summary of Theories for Demise of Norse Greenlanders

Theory	Notable Promoters	Climate Related?	Likelihood	Contributing Factor?
Annhilation by Inuit	Barxarsson	No	Remote	No
Assimilated by Inuit	Nansen	Possibly	Low	No
Overrun by Ice	Weidick	Yes	Localized	Probably
Insect Plague	Ingstad*	No	Low	Possibly
Isostatic Depression	Ingstad*	Probably	High	Possibly
Soil Erosion & Deforestation	Popular**	Possibly	Low	Possibly
Colder water, shorter growing season, lack of driftwood	Fagan*	Yes	High	Probably
Loss of Trade	Fagan*	No	High	Very likely
Pride and Starvation	Popular**	Yes	Remote	Probably not
Disease		Possibly	Low	Probably not
Inbreeding & Lack of Vitality	Norlund	Possibly	Low	Probably not
Ecclesiastical Greed	Ingstad*	No	High	Probably
Pirates	Ingstad*, Heyerdahl	No	High	Probably
Outmigration	Ingstad*, Heyerdahl	Probably	High	Very likely

*Provided as suggested contributing factor but not adequate explanation in itself.
**Most popular Establishment explanations, so promoters are common (e.g. McGovern, 1991; Diamond, 2005).

Insect Plague

It may seem strange that an insect plague could erupt in the chilly climate of Greenland, but infestations of caterpillars have been observed in recent decades that resulted in denudation of large areas of vegetation (Ingstad, 1959). Such has been suggested for the reason Vestrbygd was abandoned, as one winter without hay would mean death for man and beast, whether cold weather or insects were responsible. However, this does not explain why livestock were roaming free when Ivar Barðarsson and company arrived from Austrbygd, nor does it explain the disappearance of the considerably larger Austrbygd community a couple of centuries later.

Isostatic Depression

Ingstad (1959) provides considerable documentation of the drop in land relative to sea level. This has amounted to 5–6 m (15–20 ft) since the settlement of Greenland and appears to be isostatic depression, since sea-level rise was apparently not more than 40–50 cm (16–20 in) during the Little Ice Age (Fagan, 2000), and Norway continued to rise out of the sea during this same period. While isostatic depression would not have been catastrophic nor adequate cause for abandoning their homes, the Norse would have lost considerable real estate, some of their best land, and probably some hard-earned buildings to the sea (Mikkelsen et al., 2008). Isostatic depression would therefore have been a contributing factor, not a sufficient condition, for the demise of Norse Greenland. Isostatic depression could be the result of significant ice build-up during the Little Ice Age or dramatic crustal cooling; no other cause is evident. As noted above, a significant amount of the relative sea-level rise (i.e., isostatic depression) appears related to the Little Ice Age and actually appears to be overprinted on isostatic rebound from ice melting after the Great Ice Age.

Soil Erosion and Deforestation

As mentioned in part III of this series, Iceland experienced damaging soil erosion during the Little Ice Age, the effects of which are still visible. Demand for fuel increased at the same time the growing seasons were shortened, and deforestation and soil erosion went hand in hand. Starving people tend to think little of the long-term effects of overgrazing and deforestation. This has been suggested as a major factor in the demise of Norse Greenland (Fagan, 2000; Sandgren and Fredskild, 1991), though many data appear to indicate that climatic deterioration at least played a role in erosion (Arneborg, 2008) and that Greenlandic farmers, like many other Norse, were actually good and skilled stewards of their land (Ingstad, 1959; Møller and Madsen, 2006; Thomson et al., 2005; Ross, 1997). Harsher climatic conditions and advance of ice during the Little Ice Age would have contributed to soil erosion, however, and less availability of driftwood would have increased the pressure on the limited dwarf birch woodland. Thus, while probably not a major factor, to the extent that soil erosion and deforestation increased pressure on the Norse community, they would have served to contribute to its demise.

Colder Water, Shorter Growing Season, Lack of Driftwood

Fagan (2000) notes that only a slightly colder seawater temperature than at present would have driven cod from Greenland's southwest coast. While some claim the early medieval Norse Greenlanders had an aversion to fish (Diamond, 2005), this assertion indicates ignorance of Norse practices with fish byproducts and flies in the face of historic evidence that fish always formed a fundamental part of the Greenlanders diet (Ingstad, 1959). In 1770, E. Þórhallesen discovered a fish-drying place that remained from the Norse community (Ingstad, 1959). Loss of this resource would have hit the community hard. Climatic deterioration would have made life more difficult for livestock, another fundamental source of sustenance for the Norse. Demand for driftwood for fuel and lumber exceeded replenishment. As the Little Ice Age commenced, this demand would have increased at the same time that Greenlanders would have had to go farther and farther in search of it. This also made smelting of iron difficult and expensive. Coal was even imported to Vestrbygd from present-day Rhode Island (based on chemical and mineralogical analysis), apparently for this purpose (Ingstad, 1959). A shorter growing season would have affected caribou (reindeer) just as it did domestic livestock, with less game meat for the larder. Loss of driftwood meant less fuel to heat with during increasing long and cold winters, and while blubber could substitute for some of that, lack of good driftwood for boat building or constructing houses could have been devastating. On the other hand, right up to the time of its disappearance, the Vestrbygd community obtained wood from Labrador (Ingstad and Ingstad, 1996). Their boats were smaller and grossly inferior to the famous oak Viking ships of Norway in which the first settlers arrived, and these later Greenlandic boats were held together by wooden pegs and sinews as fuel for smelting iron became scarce (Ingstad, 1959). Yet one of these 18-man boats was blown off course from Markland (Labrador) and ended up in Iceland in 1347, right about the time the Vestrbygd community probably disappeared. So while these climate-induced factors would have complicated life, they would not have been sufficient conditions for the end of the Norse settlements.

Loss of Trade

Trade meant much to support a population of thousands in such a challenging landscape. Trade helped lift their standard of living and brought them valuable items such as sewing needles and iron for tool making (Christensen, 2002; Rieck et al., 2002). The loss of trade would not in itself make life impossible, but it would have made it more difficult. Loss of trade was not solely the result of climatic deterioration, but climate did play a role.

Pride and Starvation

Today, the most popular theory for the demise of Norse Greenland is that they were cultural holdovers who insisted on being European and refused to adopt Inuit lifestyles (Diamond, 2005; McGovern, 1991). They looked down on the natives, calling them *skrælingar* ("wimps") and starved to death rather than stoop to the *skræling* way of life. This cultural suicide may have been speeded along through bad farming practices and other unsustainable resource development or perhaps by deteriorating climate, though some dispute the role of climate at all (McGovern, 1991). Target species and hunting equipment of the Inuit, which some think could have saved Norse society, do not seem to have been adopted by the Norse Greenlanders (McGovern, 1991; Vebæk, 1991). Fagan (2000) provides a detailed description of archaeological evidence for this position based on Nipaatsoq, a small farm near Sandnes in Vestrbygd, which shows evidence of squalor and starvation.

Fagan's description notwithstanding, this argument carries little if any weight. Not only were livestock roaming about Vestrbygd when Barðarsson and his men arrived, they slaughtered and hauled back as many as they could. Arguments similar to Fagan's continue to be made, but evidence from the nearby Gården Under Sandet (GUS), which was excavated in recent years, appears more typical of Vestrbygd and differs significantly from Nipaatsoq (Brasen, 2001; Ross, 1997). Refined methods utilized at GUS are providing a fuller and perhaps more complicated picture (Hebsgaard et al., 2009; Panagiotakopulu et al., 2007). A single farm in Vestrbygd such as Nipaatsoq could also have been inhabited by an *utlægr* (banished outlaw) and may not be indicative of the community as a whole. Much remains shrouded in mystery, and the prevailing view is simplistic at best.

It is true that the Norse called the natives they encountered in Vinland *skrælingar* and provoked some confrontations with them. However, they had remarkably peaceful relations with the Thule people (Ingstad, 1959). The Thule people had their own *skræling*-like word, and true to their traditions, made up tall tales of how they chased

Figure 8. Fishing on Storfjord, Sunnmøre, Norway. Klevberg's farmer friend Harald Haugen sets nets from a boat built from timber harvested from his small dairy farm at Viset. Farms too small to be otherwise viable have been the norm in Norway for centuries; fishing and hunting have always been combined with farming. This kind of multifacted economy prevailed in Norse Greenland. The *naust* (a type of boathouse built above high-tide line) in the middle right photograph is a typical Norwegian wooden structure; in medieval Greenland, a *naust* would have been built of turf and stone with minimal wood. Greenlandic boats were built with spruce from Labrador fastened with sinews (Ingstad, 1959). Winter fishing and fish preservation methods practiced for millenia in Norway were taken with the Norse to Greenland and provided vital nutritional support for the Norse Greenlanders. The large fish shown here (middle left photograph) is a cod, the staple Nordic fish. The Little Ice Age resulted in disappearance of cod from Greenlandic waters (Fagan, 2000). Most of photographs by Harald Haugen.

out "giants" when they came to Greenland. This lends credence to belief that Dorset II culture was present in northern Greenland in medieval times, as the Dorset were noticeably larger than the diminutive Thule people yet ran away when confronted (Ingstad, 1959).

The "pride and starvation" argument reveals considerable academic ignorance, if not revisionist arrogance. As pointed out long ago (Ingstad, 1959), Norse culture involved making use of virtually all of the same resources that the Inuit did, with hunting a major source of food and materials from the very beginning. In addition, the Norse had livestock; they had a more diverse and secure base than did the Inuit. To this day, a combination of fishing, hunting, and farming is traditional in Norway (Figure 8). The Greenlanders dug pits in the permafrost to act as freezers for meat and other foodstuffs (Ingstad, 1959). Yet toward the end of Norse Greenlandic society, they were described as barbarians who wore furs and ate raw meat, with a standard of living that differed little from the Inuit (Heyerdahl and Lillieström, 1999; Ingstad, 1959). It is ironic that in the early 1900s, the Inuit had so decimated the wild game population that they had to adopt sheep raising to avoid starvation (Ingstad, 1959).

Disease

An intuitive idea for the disappearance of the Norse in Greenland is the bubonic plague. It killed at least two-thirds of Norway's population and about that in Iceland. Might it not have done the same in Greenland? The Black Death harried Norway at the same time Vestrbygd was abandoned, so it cannot be the cause of that community's disappearance, since it could not have spread there by that time. The Black Death hit Iceland hardest about 1400, so it could have spread to Austrbygd from Iceland thereafter. However, evidence of mass deaths has not been uncovered in either

Figure 9. The church ruin on Hvalsey, southwestern Greenland (Austrbygd), is the best preserved church ruin in the country (Can Stock Photo).

Vestrbygd or Austrbygd (cf. the various archaeological reports in the bibliography of this paper). Some researchers speculate that depopulation of Europe by the Black Death tempted Greenlanders to emigrate (Ingstad, 1959).

Inbreeding and Lack of Vitality

The early archaeologist Nørlund popularized the idea that inbreeding and lack of vitality led to the slow death of the Norse civilization in Greenland. The evidence he proffered from Herjolfsnes has since been refuted (Ingstad, 1959). The Norse population of 3,000 to 9,000 (probably 4,000 to 5,000) was adequate to avoid any significant inbreeding issues (Ingstad, 1959); also, the church's teaching prohibiting marriage between relatives was strict (Rian, 1994).

Ecclesiastical Greed

A century before the Reformation, the Roman Catholic Church owned up to two-thirds of Austrbygd, and it was the best land (Ingstad, 1959) with the best buildings (Arneborg, 2001; Fagan, 2000; Møller et al., 2007—cf. Figure 9). The bishop held the hunting rights for the best caribou (reindeer) hunting sites and regulated the harvest. Could loss of land ownership and increasingly onerous taxes have contributed to the abandonment of Austrbygd? This would have been particularly difficult during a time of climatic deterioration.

Pirates

Pirates in the ice-infested waters off Greenland? You have got to be kidding! That was the lead author's reaction when first coming across this theory. Heyerdahl (Heyerdahl and Lillieström, 1999) had become too radical this time, and the academics were justified in dismissing him. But not so: we have documentation that Algerian pirates raided Torshavn in the Færoes and Heimaey in Iceland, and English pirates burned the homes of impoverished farmers in Iceland in the early 1400s (Fell, 1999; Ingstad, 1959). Basque and English fishermen had ventured to Greenland and Newfoundland and even stopped to trade with the Norse (Ingstad, 1959; Seaver, 2010). Inuit preserved stories of pirates who attacked Austrbygd, were repulsed with difficulty, but returned the next year to burn Austrbygd (Ingstad, 1959), at least the churches (Arneborg, 2001). Many of Austrbygd's inhabitants were taken as slaves, but some eventually made their way back home (Heyerdahl and Lillieström, 1999). Whether enough of them escaped or returned to recreate a functioning society is another question. One Inuit account tells of Inuit rescuing a Norse woman and children. They returned months later to find the area destroyed and uninhabited, so those rescued were adopted by the Inuit (Ingstad, 1959). It seems that pirate raids had little to do with climate change, except that the ice must not have increased enough to block access to the southwestern fjords.

Outmigration

As is widely known, the Norse built a settlement in Newfoundland in AD 1000. Their explorations and settlement over wide portions of eastern Canada have been confirmed by Canadian archaeologists and others (Ingstad and Ingstad, 1996). Why, then, is there such opposition to this evidence among academics (Seaver, 2010)? Why does the Establishment seek to limit the Norse presence to L'Anse Aux Meadows and the briefest period possible? Why are they so opposed to evidence for widespread communication between peoples in ancient times elsewhere in the world (Heyerdahl, 2000; Heyerdahl and Lillieström, 1999)?

The scope of this paper does not allow a thorough evaluation of Establishment bias or the evidence for the Norse presence in North America. Most creationists are probably aware of this bias, whether it be against design in nature or for biblical history rather than the gradual "cultural evolution" of isolated groups of "primitive" people. One's view of history—natural or cultural—has a great deal of relevance to many scientific debates, including the topic of climate change.

The first Norse to settle in North America got themselves into trouble with the natives through their "shoot first, ask questions later" policy. The American Indian cultures were not the same as the Nordic cultures they were used to. To what extent the different peoples were able to later understand each other, we do not know. We have little historiography to work from in evaluating medieval Norse immigration to North America. Yet it is clear that in the 1100s and the 1300s, Norse were in North America, and as conditions worsened in Greenland, it would have been only reasonable to consider moving to the other side of the Davis Strait.

The Greenlanders' 18-man boats would not have been large enough to transport much for the dangerous, three-day voyage over the Davis Strait, so if the inhabitants of Vestrbygd moved en masse to North America, they would have had to leave the majority of their livestock behind. There would have been no reason to harm the animals, and they would have been left roaming loose, just as Ivar Barðarsson found them. This seems the most likely explanation for the disappearance of the Vestrbygd community.

Austrbygd continued another two hundred years after the disappearance of Vestrbygd. While the inhabitants of Vestrbygd seem to have vanished, Austrbygd seems to have withered away. There is, however, evidence not only of people kidnapped from Austrbygd but also of some who willingly left for England (Ingstad, 1959) and what is now the New England states (Heyerdahl and Lillieström, 1999). Various means of outmigration were available to the final Norse Greenlanders (Seaver, 2010).

Significance of Norse Mystery to Little Ice Age

Vestrbygd, the northern community, may have been prompted to leave due to climate change. If a year or two without fodder occurred, a major crisis would have resulted. This does not appear to have been the case for Austrbygd. If life became difficult due to a combination of factors—loss of private ownership of land, increasing taxes, worsening climate, attacks by pirates—then people would be inclined to leave a family or two at a time. This may have been the case. We will probably never know with certainty why this society disappeared, but the most likely theories are linked to the Little Ice Age. Thus, while there is no unequivocal evidence for climate as "the cause" for the disappearance of the Norse Greenlanders, it very likely played an important role.

Appendix B: Implications of Isostasy

The remarkable rate of isostatic rebound in some regions (Klevberg and Oard, 2012b) and isostatic depression in others (as described in this paper) has wide-ranging implications for earth science research, implications far beyond the scope of this series of papers. While various glacial models have been referenced in this paper, we caution readers to be aware of the following pitfalls in these models.

- Glacial models are natural history scenarios, not scientific fact. They incorporate into them assumptions about Earth history, including "deep time," which are refuted by biblical chronology and often by more recent historical accounts.
- Glacial models are commonly based on standard interpretations of ice core data, interpretations that are seriously flawed (Oard, 2005).
- Unique solutions are not possible with glacial models, as these models are dependent on input assumptions regarding the structure of the earth. This is one of the areas of greatest ignorance hampering models (Fleming and Lambeck, 2004).
- Relative sea-level curves are derived from limited deposits that are accessible and amenable to dating. Problems with radiocarbon dating have been extensively covered by creationists (e.g., Klevberg and Oard, 2011a). Even with correction for the marine reservoir effect (Weidick, 1972) and variations over time (Fleming and Lambeck, 2004), errors are certainly introduced into the modeling process, especially the farther back in time dates are inferred.

As speculation of future climate change has encouraged efforts to refine models and test them against historical data, considerable improvement in modeling has occurred. One of the results has been downward revision of some of the assumed values for viscosity of the mantle based on rapid isostatic adjustment from the ice growth and recession over the course of the Little Ice Age, not only in Greenland, but also in Hudson Bay and Alaska (Bégin et al., 1993; Motyka, 2003), as well as the rest of the North Atlantic area that is the focus of this series. The time required for isostatic adjustment may thus be less than previously thought, and the Great Ice Age could have occurred much more recently than is commonly believed. Results of these recent isostasy studies could challenge many presently held beliefs among both creationists and evolutionists, and those researchers interested in glaciation and deglaciation, plate tectonics, and the structure of the earth may find these recent results the basis of very fruitful research.

Minutes of the 2013 Creation Research Society Board of Directors Meeting

The fiftieth annual Creation Research Society (CRS) Board of Directors meeting was held 13–15 June 2013, at the Doubletree Inn and ICR facilities in Dallas, Texas. The following board members were present: Mark Armitage, Gene Chaffin, Don DeYoung, Danny Faulkner, Robert Hill, Russ Humphreys, Jean Lightner, Gary Locklair, Michael Oard, Ron Samec, and Glen Wolfrom. John Reed was unable to attend due to health issues.

President Don DeYoung called the first session of the general board meeting to order at 19:00 on Thursday, 13 June 2013, and noted a milestone in the history of the CRS: our fiftieth regular board meeting.

Dr. Henry Morris III, CEO of the Institute for Creation Research (ICR), graciously provided conference facilities for the board meeting and welcomed the board to Dallas. Dr. Morris invited board members to his home for dinner on Friday. At that time he introduced us to members of AMS who are producing a series of videos for ICR.

President DeYoung overviewed the logistics of our meeting. The first part of the general board meeting was Thursday evening. Friday was dedicated to committee meetings. The second half of the general board meeting was on Saturday. Don shared several letters to the board from George Howe and Annette Miller, among others. After a number of historical documents were reviewed, board members expressed their thanks for both current and past members of the CRS. We are especially grateful to the founders of the Creation Research Society for their vision and perseverance.

Recording secretary Gary Locklair asked for corrections or additions to the 2012 meeting minutes as published in the Winter 2013 *CRSQ*. The minutes stood approved as printed. Gary reported the results of the 2013 board elections. With 195 ballots received, the following were elected to three-year terms: Don DeYoung, D. Russell Humphreys, Gary Locklair, and Ron Samec. A list of future candidates suggested by the membership was presented. The recording secretary was asked if any member has suggested electronic voting or expressed concern over the use of postcards; the answer was no.

Financial secretary Mark Armitage reported that our income is up slightly and we will end the year spending less than our expense budget. He reported that investment income showed a modest increase. Mark reported that we used $10,000 of our endowment for expenses. He encouraged the board to reduce the expense budget for next year by 5%. Issues related to finances were discussed by the entire board.

The International Conference on Creationism will be held in August, and CRS will have a reception room for attendees. Danny Faulkner reported that the next local CRS conference is scheduled for the second weekend in August 2014 at Answers in Genesis (AIG).

Don DeYoung shared information from the lab committee meeting earlier in the afternoon. The Chino Valley campus is in good shape, and the driveway was resurfaced recently. The iDino project is under the direction of the lab committee. Kevin Anderson, lab director, continues work on a part-time basis.

Kansas City was selected as the site of the 2014 board of directors meeting.

Don DeYoung was recognized for his years of service to the CRS, and especially his leadership as CRS president.

The first session of the full board meeting adjourned at 20:50.

Friday, 14 June 2013, was devoted to committee meetings. The Internet, membership, periodicals, publication, constitution, finance, lab, and research committees all met and conducted business.

Mark Armitage presented information on the iDino project during lunch. The triceratops horn that was uncovered contains long sheets of soft tissue. Within the soft tissue are osteocytes—amazing cells that build and maintain bones. This unexpected finding provides evidence that dinosaurs are not millions of years old.

Friday evening Dr. Morris hosted board members, along with ICR staff and members of AMS, at a dinner in his home.

The second part of the general board meeting was called to order at 08:30 on 15 June 2013 by President DeYoung. He reviewed the agenda for the morning.

Vice president Gene Chaffin led the devotion based on the God Particle. The laws of nature must have existed before time began in order to have a beginning. There is no power in the laws of nature; they need to be carried out by God. He spoke and the universe came into existence. Natural laws are not bigger than God; the laws are how God normally operates. However, God is not constrained by natural law. Gene provided an original poem in closing.

Internet committee chairman Gary Locklair reported on matters relating to the CRS website, CRSnet, and the CRS Facebook page. The fine work of its volunteer webmaster, Fred Williams, and his assistant, Tony Massey, was noted. The CRS online presence continued its steady growth.

Gene Chaffin, periodicals committee chairman, announced that Danny Faulkner has agreed to serve as *CRSQ* editor, subject to approval by Danny's employer. Outgoing editor Kevin Anderson was thanked for his 10 years of fine service. The editor will be allocated $1,000 per year to pay for invited papers on select topics. The board approved a measure to make all *CRSQ* publications older than 3 years available on our website. Glen Wolfrom, along with assistants Bob Hill and Jean Lightner, were thanked for their work on *Creation Matters*.

Publication committee chairman Mike Oard reported that book sales continue to generate a profit. A concern is the cost of postage, especially the dramatic increase in international postage rates. Two eBooks were recently published, thanks to the efforts of Glen Wolfrom and Gary Locklair. Mike is looking for a publisher for our "coffee table" book (*Creation Illustrated—Scientists Speak*). The publication operation remains robust.

Glen Wolfrom, membership committee chairman, overviewed membership trends for the past 10 years. The first 5 years of review showed growth, while the last 5 years have shown a decline in membership. The CRS currently supports 1551 members and subscribers. Two special membership offers will be provided this summer, one at the CUS Society of Creation conference in July and the other at ICC in August. The board discussed a number of issues related to membership including a member survey and contacting those who did not renew.

Gene Chaffin, Gary Locklair, and Glen Wolfrom were recognized for their anniversary years of service to the CRS.

CRS Board of Directors. Members shown (l–r) Kevin Anderson (Director, VACRC), Diane Anderson (Administrative Assistant), Jean Lightner, Don DeYoung, Danny Faulkner, Mark Armitage, Mike Oard, Glen Wolfrom, Robert Hill, Ron Samec, Eugene Chaffin, Russell Humphreys, Gary Locklair.

Gene Chaffin, research committee chairman, reviewed the list of active research projects, including proposals dealing with helium escape, carbon-14, microscopic botany, pyranoids, Flood geology, and astrochronology. The committee is investigating ways to encourage students to become involved in creationary research.

Constitution committee chairman Gary Locklair reported on ideas for long-range planning and various issues related to the bylaws.

Treasurer Danny Faulkner presented information about fiscal year 2012–2013. Danny provided estimates of $214,700 for net income (down $13,000 from last year) versus $218,500 of expenses for the fiscal year. Our expenses will be far less than the approved expense budget of $269,550 for fiscal year 2012–2013.

Kevin Anderson reported we are in the process of moving our incorporation from Michigan to Arizona.

Financial secretary Mark Armitage reported on the Society's financial holdings. Mark listed the current value of CRS investments (endowments), which had gained $26,000 during the past year.

Treasurer Faulkner and Financial Secretary Armitage led the discussion regarding the 2013–2014 budget. The following committee budget requests were approved: VACRC (lab) – $133,385; Executive/Treasurer – $14,250; Membership – $12,500; Publications – $25,000; Periodicals – $40,000; Research – $19,000; Internet – $500; Constitution – $0; Finance – $0.

An expense budget of $244,635 was approved for fiscal 2013–2014. It was moved and approved to authorize Diane to make a withdrawal from the endowment funds of up to $10K in order to cover expenses.

The constitution requires 12–18 board members for the CRS. The board submitted the names of Danny Faulkner, D. Russell Humphreys, Mike Oard, and Rob Carter as candidates for the 2014 board of directors election. There are four openings to be filled. If all are elected, our board would stand at 13 members. The board discussed several other candidates to be submitted for consideration next year.

Election of board officers was held. Don DeYoung was elected president, Gene Chaffin was elected vice-president, and Gary Locklair was elected recording secretary. The following were confirmed for the second year of their three-year term: Glen Wolfrom as membership secretary, Mark Armitage as financial secretary, and Danny Faulkner as treasurer.

The meeting was adjourned at 11:55.

Respectfully submitted,
Gary Locklair
CRS Recording Secretary

Pine Needles, Limes, and Other Simple Solutions

If a problem is serious—even drastic—might there be a simple solution? Sometimes the answer is yes. Medical history documents a horrible disease cured by a solution *so simple* that the cure was dismissed for many generations. That dreaded disease was scurvy, once the greatest threat (and killer) of the British navy, during generations when "the sun never set on the British Empire." Yet the cure for this malignant malady was oh-so-simple: Vitamin C—just eat food that contains vitamin C.

But how could such a deadly disease be solved by such a simple solution? This question's answer, as noted below, matches a similar "problem" in creation apologetics.

Sometimes the answer is so simple that it is doubted and disbelieved.

The Scourge of Scurvy

During the 1530s a French explorer named Jacques Cartier confronted a crisis: more than 100 of his sailors were afflicted with the death-threatening disease of scurvy. Was there any cure for this slow-motion death sentence?

> The word scurvy means "scaly skin." This disease causes its victims to lose weight and grow weak. Gums bleed and teeth loosen. Sores do not heal. Connective fibers weaken that [should] hold the body together. Victims of scurvy die as if they have come apart. (Tiner, 2006, p. 108)

Sounds horrible. It was.

Vitamin C (i.e., ascorbic acid) is needed for manufacturing collagen, a group of proteins that are the dominant connective tissue in vertebrates, comprising about one-fourth to one-third of the proteins in the human body. Miserably, bodies break down if collagen production is ruined.

Thankfully, Cartier's crew received a simple, life-saving solution.

> Jacques Cartier's men did not die. The natives offered a homemade remedy: drink a tea of pine needles soaked in water. *Despite the simple nature of the solution, the sailors tried it.* The Indian's [vitamin C-rich] tea brought them back to good health! (Tiner, 2006, p. 108)

Tragically, this medical breakthrough was ignored by most of Cartier's non-French contemporaries. So the widespread widow-maker, scurvy, raged on, despite its easy curability.

During the 1700s, some 200 years after the French began drinking pine-needle tea, more British navy men died of scurvy than died in combat on the high seas. In fact, the mortality total for British sailors was even higher for scurvy than it was for combat, shipwrecks, and other diseases combined (Tiner, 2006, p. 109)!

A Scottish physician, Dr. James Lind, decided to defeat the death-dealing disease. At an Edinburgh hospital, Dr. Lind used controlled experiments[1] to discern whether scurvy could be stopped by applying medicines or adjusting diets. The etiology (causation process) of scurvy was traced to the availability and habitual consumption of fresh fruits and vegetables, foods not typically available to British sailors assigned to long-term sea duty. (Sailors routinely ate lots of salt pork and hardtack biscuits.) Because refrigeration was unavailable then, food aboard British navy ships was preserved from spoiling by smoking, salting, and/or air drying; but these preservation methods destroyed whatever vitamin C may have originally been inside those food items.

One of Dr. Lind's experiments included providing two scurvy patients with two oranges and one lemon, daily. Both quickly recovered! Captain James Cook, a Royal Navy navigator known for many global accomplishments, learned of Lind's successes. Captain Cook consulted with Dr. Lind about the value of citric fruit as preventive medicine against scurvy. They designed a problem-solving hygiene and nutrition plan. The plan's components of fresh drinking water, fresh air ventilation, and citric fruit (lemons, limes, and oranges) became a multi-year experiment for Captain Cook's next

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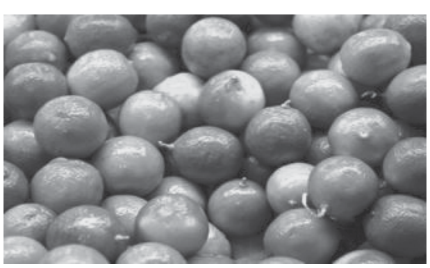
[1] Controlled experiments involve observing (and recording) comparative test results for a "control" group and an "experimental" group, similar to the approach used in Daniel chapter 1. See James William Treece, "Daniel and the Classic Experimental Design," *Acts & Facts* 1990 19 (3), http://www.icr.org/article/daniel-classic-experimental-design/ .

Pacific Ocean expedition. And, as simple as that, scurvy was prevented during Captain Cook's long-term voyages at sea (Tiner, 2006, pp. 110–112).

But could such a huge problem be solved so simply, as an orange a day (or a lemon or lime) keeping the scurvy away? The British bureaucracy remained dubious of the dietary quick fix. A decade of more scurvy aboard other Royal Navy ships dragged on.

Providentially, Dr. Lind's successes led to his eventual promotion to King George II's personal physician. Finally, in 1795, Dr. Lind's citric fruit remedy was officially recognized (and implemented) as the simple solution for the Royal Navy's worst widow maker. British ships were supplied with limes, and British sailors were ordered to drink lime juice. (Limes have a longer shelf life than other citric fruits, such as oranges, tangerines, lemons, and grapefruits.) This new marine diet policy produced a nickname for British sailors, *limeys* (Tiner, 2006, p. 112). Problem solved.

In solving the scurvy scourge centuries ago, Dr. Lind illustrated how—at least in some cases—drastic problems can be remedied by a simple solution. In fact, the same applies to the purported "credibility problem" that many moderns claim when it comes to trusting the authoritative truth and relevance of Genesis.



Simple Solution to Genesis Apologetics "Problems"

Here is a major problem in Genesis apologetics: Why have so many otherwise Bible-respecting Christians (and others) jumped onto the bandwagon of distrusting Genesis history, i.e., exchanging the literal-history meaning of Genesis for some kind of nonliteral (deconstructed) interpretation of the Mosaic account of earth's origins?

What stimulated the bandwagon rush during the late 1700s and early 1800s for "old-earth" interpretations of the Genesis record? When leaders in Christian education circles began, *before Darwin*, to fly the flags of uniformitarian "geologic time"—"day-age" creation, the "gap theory," the "local flood" theory, and uniformitarian "tranquil flood" theory—what motivation drove the etiology of this theological upheaval (in how to read the book of Genesis)?

Long before Darwin published in 1859, many Christian leaders had already begun what became a veritable "stampede" toward the perceived gold mines of "old-earth" interpretations of earth's origins. Why? There is a simple, one-word answer: accommodation.

Christian education leaders wanted to accommodate the supposedly "authoritative science" theories of the closed-Bible deists, such as the uniformitarian interpretation of earth history promoted by influential deists like James Hutton and Charles Lyell.

> Evolution obviously required aeons of geologic time and the scientific community, including the great Isaac Newton himself, was committed to the [Bishop James] Ussher chronology, with its recent special creation and worldwide Flood. Therefore, it was necessary, first of all, that the Flood be displaced as the framework of geologic interpretation, so that earth history could … be expanded into great reaches and cycles of time over endless ages…. Pockets of scientific resistance in the religious community were quickly neutralized by key clerical endorsements of the "day-age theory," which seemingly permitted Christians to hang on to Genesis while at the same time riding the popular [tidal] wave of long ages and evolutionary progress. For those fundamentalists who insisted that the creation week required a literal interpretation, the "gap theory" ostensibly permitted them to do so merely by inserting the [deists'] geologic ages in an imaginary gap between Genesis 1:1 and 1:2, thus ignoring their evolutionary implications. (Morris, 1980, pp. 148–149)[2]

So what was the real problem with the Genesis text? Was it some kind of complicated geoscience or theological conundrum? No. The simple problem was *accommodation*—accommodating the deists' popular "science falsely so-called" (1 Timothy 6:20). Like scurvy, sometimes the cause of Bible misinformation is so simple that the answer is doubted and disbelieved. But the history provided in Genesis really is true and relevant, whether anyone chooses to believe it or not.

References

Tiner, J.H. 2006. *Exploring the History of Medicine: From the Ancient Physicians of Pharaoh to Genetic Engineering*. Master Books, Green Forest, AR.

Morris, Henry M. 1980. *The King of Creation*. CLP Publishers, San Diego, CA.

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[2] See also, in general, Terry Mortenson, *The Great Turning Point: The Church's Catastrophic Mistake before Darwin* (Green Forest, AR: Master Books, 2004).

Letters to the Editor

The policy of the editorial staff of CRSQ *is to allow letters to the editor to express a variety of views. As such, the content of all letters is solely the opinion of the author, and does not necessarily reflect the opinion of the* CRSQ *editorial staff or the Creation Research Society.*

The Fate of the Universe and Psalm 148

I would like to commend Danny Faulkner and Robert Hill for their article "Creation and the Fate of the Universe" (*Creation Research Society Quarterly* 50:32–35). I agree with their view that the universe is not intended to be eternal but will "pass away" and will be replaced with a new heaven and earth. Psalm 148:6 is important to deal with regarding the question of the fate of the universe, since on first reading, it would seem to imply something contrary to the above view. In the NIV, Psalm 148:5–6 states,

> Let them praise the name of the LORD, for he commanded and they were created. He set them in place for ever and ever; he gave a decree that will never pass away.

I would view verse 6 as similar to a number of other passages that emphasize that no one can undo what God does in His creation. Example passages would include Psalm 119:89–91 and Jeremiah 33:25. If God created it, there is no being that can uncreate it. So I think the way to understand this is that God created the heavens and earth to remain indefinitely, until He changes them. No created being can undo or destroy what God created to last. But God can issue a new decree that makes the universe pass away and make a new universe to put in its place.

I would argue this is the same way to view passages such as Psalm 93:1, which in the King James Bible says, "The world also is stablished, that it cannot be moved." The point of the verse is that neither men nor angels can uncreate or change what God created. God's sovereign purpose cannot be thwarted. Thus, the NIV has translated Psalm 93:1, "The world is firmly established; it cannot be moved." Why is the world, the earth, firm and secure? Because God created it to be inhabited, as Isaiah 45:18 says, and God makes it secure. When Psalm 148:6 says "never pass away," the "never" applies more to human beings and to angels. It's an assurance that created beings will never destroy the earth because it must fulfill God's purpose for it. So "never" in this context does not mean "never" to God.

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Google-based Fossil Tool Proposal

The Creation Research Society, including its iDINO project, made a significant impact at the Seventh International Conference on Creationism. Thank you for the hard work from Mark Armitage, other CRS board members, and Kevin Anderson and Diane Anderson. The conference also provided a networking opportunity to share my vision of developing an Internet tool to educate the public and to help creationists discover new evidence that undermines old-earth claims.

Dr. Mark Horstemeyer, one of the ICC hosts and founder of the Association of Christian Graduate Researchers, expressed interest in seeing this tool developed. Dr. Horstemeyer wrote that he was "very impresse" (Horstemeyer, 2013, personal communication), and he encouraged me to present this idea to the CRS as a letter to the *Quarterly* as perhaps the next best step toward generating comment and gauging interest.

The CRS webmaster, Fred Williams, is my c-host at Real Science Radio. We have discussed using Google Maps and Google Earth to create presentations of the young-earth evidence in fossils and formations. What is the extent, in length and breadth, of some particular layers of strata that contain young-earth fossils or features (such as polystrates, a flat gap, or a highly purified deposition)? Being able to show how far and wide such strata extend can help drive home the strength of such evidence.

Examples: A polystrate tree is a great teaching tool, but the lesson gets more powerful when we can show the extent of the strata that embed that single fossil across a geographic region. In Wisconsin, a fossilized school of jellyfish (e.g., rsr.org/list#jellyfish) taken as a unit forms a polystrate fossil. Realizing that this school of jellyfish was buried as a unit can compress the possible period of deposition of the strata that encases it from a million years down to minutes. Nautiloids, entirely missing "era" from Grand Canyon layers, and many other examples, also dramatically compress the alleged supe slow deposition rates.

Working Name: GEE, for Genesis Earth Explorer, is a play on the Greek word for Earth, gē(transliterated *ge*, as in geology, thougs pronounced *gha*.).

Structure: GEE would consist of a database populated with fossil and formation data. This information could be explored by manipulating the mapping interface, or it could be accessed by topic with the results mapped visually onto a Google-supported display. The database includes two classes of information:

1) data elements
2) geologic infrastructure.

The data elements are fossils and primarily no-strata features. The geologic infrastructure, for the most part, is the environmental framework (transcontinental rock layers, region wide coal seams, etc.) within which the data elements may be found. Over time that infrastructure could be updated to include the greater context of the entire continental and oceanic crust, the trenches, and eventually deeper geologic features, including the Mohorovicic discontinuity, the mantel, and the inner and outer core. (This proposed web-based tool of course could be simplified, and this preliminary description presents only one possible way of structuring the data.)

Data Elements: GEE would be populated with data elements like fossils, pseudotachylytes (PSTs), etc., with optional data fields for each element. These data elements will not include conceptual or theoretical possibilitie, but empirically documented, observable terrestrial features, preferably already described in the literature. Additionally, a settings switch could activate a feature that also presents interpretive comments. GEE will display its data elements over a map in what Google refers to as an Info Window (see below). Data element fields could include:

- a brief description
- photos/video
- latitude/longitude
- depth/elevation
- notes
- reference links to journal papers, creation articles, etc.
- interpretive comments
- identification of its depositional environment, e.g., Morrison, Dakota, Redwall.

For this last field, if a data element is encased within, or forms, part of a strata layer already defined in the database, then filling in this field could be done by a simple cross-link to the relevant portion of GE"s geologic infrastructure (see below).

Data Entry: The developer or development team, including perhaps select volunteers, would do the initial data entry. After launch, authorized users comprised of creation scientists and perhaps enthusiasts could perform data entry with GE"s manager having editorial veto.

Geological Infrastructure: Google provides the framework and the baseline user interface. GEE will overlay crustal features like major sedimentary strata and overthrusts, along with those data elements just described, onto Google Maps, Google Earth, or both (see below). In the initial launch, the database likely would include only a small percentage of the Eart"s geologic infrastructure, possibly describing features of the greatest magnitude, such as those that extend over large regional, continental, and intercontinental areas. The initial version also should include showcase examples (classic polystrates, flat boundaries, mixture of marine and land fossils, missing alleged eras, etc.) visually demonstrating, as researched from the literature, the extent of their encasing strata.

Infrastructure Use: The end user may specifically select and view this infrastructure, including all or any of its constituent layers and features. Fossils and other data elements will populate various locations on this infrastructure. Infrastructure layer(s) can be toggled on or off. Toggled on while viewing a data element, the user will see the extent of the time compression implied by a given polystrate fossil, “missin” stratum, nautiloid mass kill (rememberthenautiloids.com), etc. That extent (shown in the initial launch version in only two dimensions) could be referred to as the *domain*, or the *sphere of influence* (or even the *jurisdiction*), of any particular data element. For example, by the testimony of the Wisconsin jellyfish, for all the layers containing that polystrate school of fossils, for their entire extent, their total time of deposition is compressed from one million years down to the duration of a single, swift depositional event. Also, authorized users whose accounts enable them to enter data elements (fossils, ancient “reefs,” 14c-rich coal seam, etc.) could be permitted to enter infrastructure details such as smaller regional and local flows, sedimentary layers, etc.

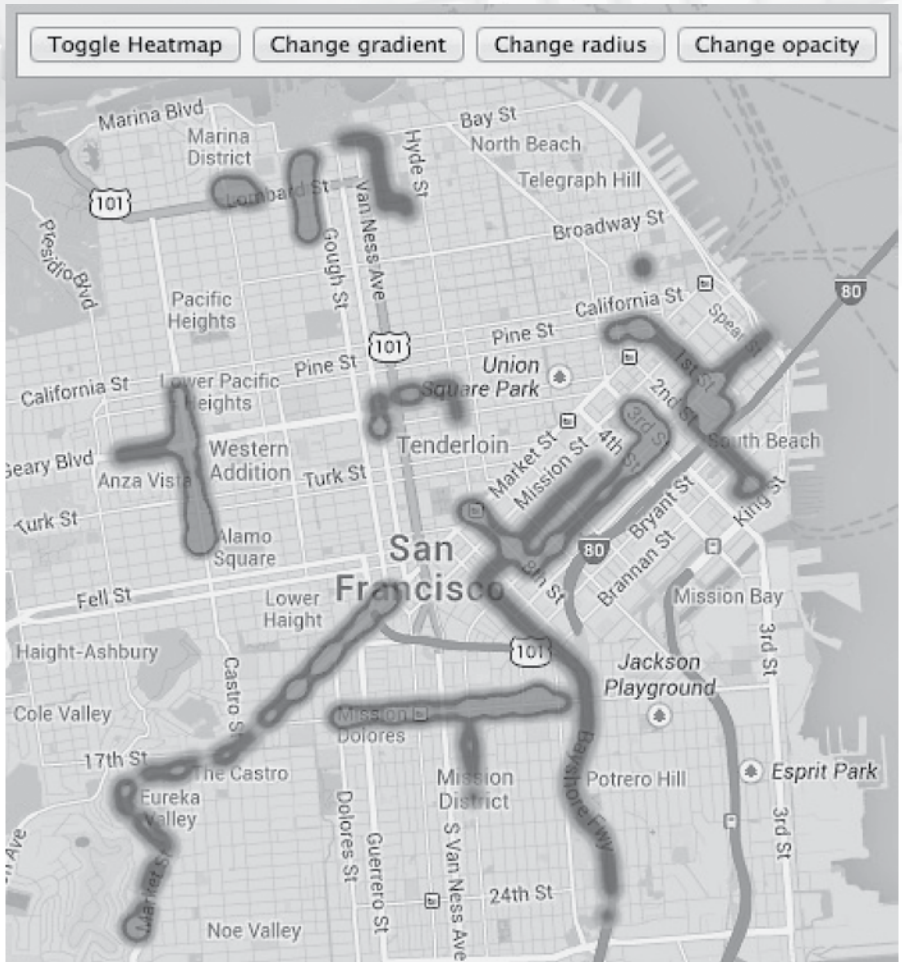

Figure 1. Sample customized map using the Google Maps API (application programming interface)

Query, Menu, and Map Interface: The end user could enter a search term to find information, navigate via the map interface, or use a menu system. Examples of search terms include: petrified trees / nautiloids / Joggins. Menus would offer view: by region, such a: Grand Canyon / Hell Creek Formation / Himalayan Plateau; by fossil, such as jellyfish, dinosaur soft tissue; by “era,” “period,” or “epoc;” and by formation or megasequence.

Google APIs: This application could be developed for Google Maps, Google Earth, or both. In 2013 Google released a new version of Google Maps that partially integrates Google Earth. Our Real Science Radio webmaster (rsr.org), Nathan Rambeck, positively reviewed this proposal. (Separately, Mr. Rambeck has just finished the functional design for a mapping application using Google Maps for mass transit projects that includes images, video, links, etc., for each database element, to allow the creation of custom maps to show aspects of a transportation project over a geographical area.) Interested programmers may view the Google Maps develope”s guide, demo gallery, and APIs (application programming interfaces, at tiny.cc/API). See there the JavaScript to Add an Overlay, for Info Windows, Show/Hide Overlays, Custom Controls, Layers, Heatmaps, Panoramio, MapTypes, Image Overlay, and Street View Service. Googl”s tutorials, such as “Annotate Google Eart” (at tiny.cc/AnnoGE), specifically invite no-profit groups (like CRS or Dr. Horstemeye”s ACGR), to create custom map presentations and (at tiny.cc/NarrGET, to create “Narrated Google Earth Tours.”

Interlaced Strata: GEE could increase both the awareness of time-constraining artefacts in the geologic colum, and their persuasive impact. As an analogy, consider that biblical genealogies argue against insertion of thousands of years, especially where a progenitor interacts with a descendant, including, for example, by the naming of that descendant. GEE could lead to discovery of currently unknown examples of interlaced, time-compressed strata. A data element such as a polystrate fossil constrains the deposition time for a discrete series, or unit, of layers. That series may interlace strongly, or even only at its periphery, with an adjacent series of layers. Such interlacing suggests a constraint also for the period of deposition for those neighboring strata. That compression of neighboring strata also might continue to further neighbors. GEE also could help identify examples of especially powerful time constraints where multiple data elements have overlapping spheres of influence.

Promotion: Google has long enabled special-interest groups to create customized tours. GE"s authorized user accounts, whether of creation scientists, authors, organizations, or select enthusiasts, could enable them to create their own customized tours through the data, highlighting elements and infrastructure of particular interest to their work. Such tours could promote or supplement creationist DVDs, books, models, museums, theories, etc. While various creation and flood models aggressively compete for support, as long as the standard for entering the geological infrastructure and data elements is based on empirical observation and documentation, this web tool might receive broad support and provide benefit throughout the creation movement.

Ownership: At Real Science Radio, we have allocated our own resources elsewhere. Thus, regarding this tool, we merely advocate for its development. We make no claim to any ownership whatsoever. If ever developed, whether by Dr. Horstemeye"s ACGR or any of the creation groups (CMI, AIG, ICR, CRS), the team that develops this resource should maintain control over it, enabling its use for the benefit of all young-earth creationists. GEE might display links to the leading creation ministries as Fred Williams and I currently do on every page of youngearth.com. If interest, and most importantly, financial support, were generated for this project, then at Real Science Radio, we would commit ourselves to participate, if that would be helpful, perhaps by reviewing the functional specification, with data entry, and in promotion.

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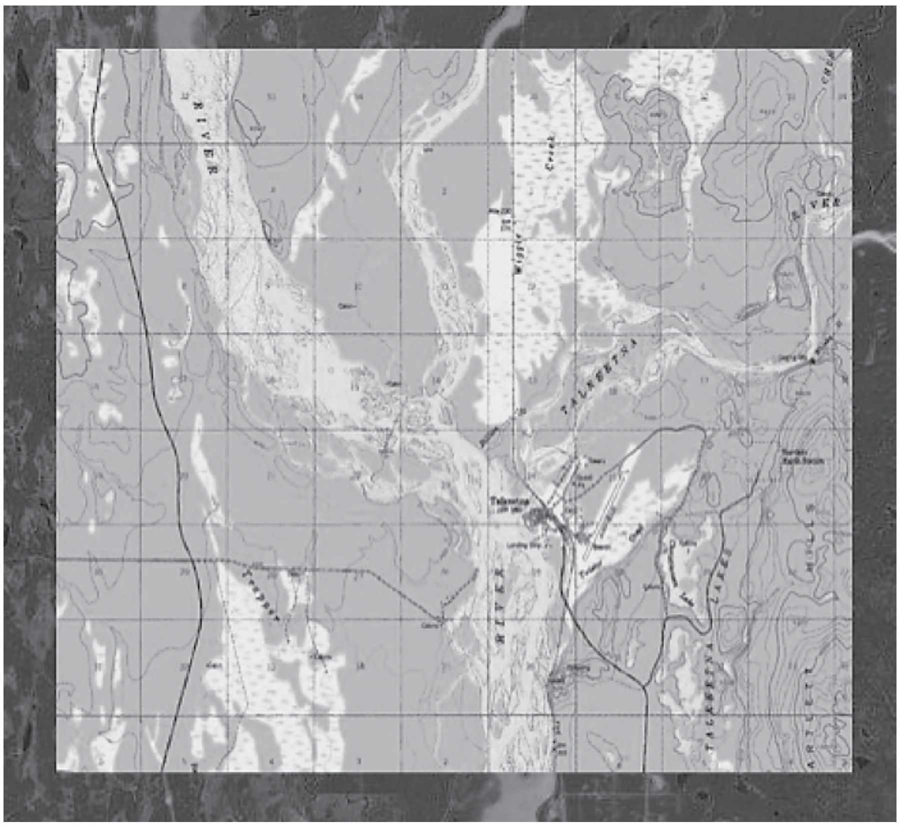


Figure 2. USGS map as a sample "Custom overlay"

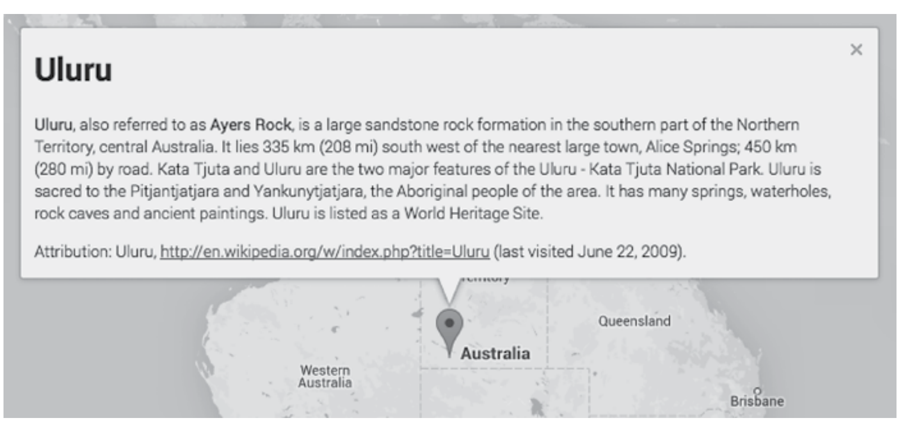
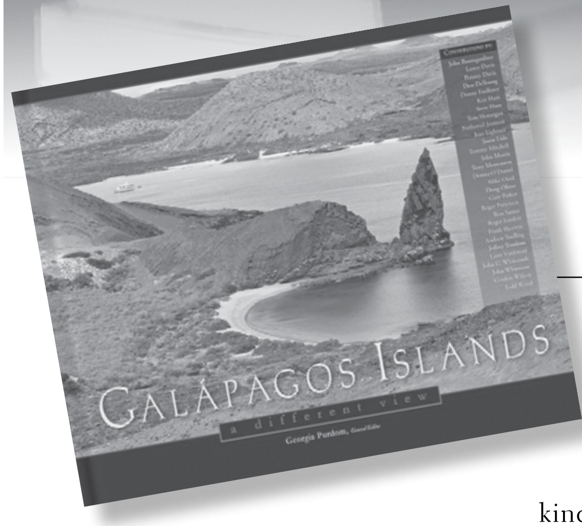


Figure 3. A customizable "Info window" on Google Map

Media Reviews



Galápagos Islands: *A Different View*

by Georgia Purdom, General Editor

Master Books, Green Forest, AR, 2013, 104 pages, $18.99

This book joins the Master Books series, which began with *Grand Canyon: A Different View* (Vail, 2003). *Galápagos Islands* was encouraged by a group tour in which author Purdom participated. A visit to the Galápagos is a life goal for many biologists, whether they hold creationist or evolutionist worldviews.

Georgia Purdom invited article contributions from 29 fellow creation scientists and friends. Five of the writers are current board members of the Creation Research Society. Included topics cover the origin of the islands, geology, astronomy, climate, flora, and fauna. The book is filled with clear, colorful photos, many taken by the author.

Charles Darwin was greatly influenced by his visit to the Galápagos Islands in 1835. His previous experience with wildlife was limited to examples in England. In contrast, the South Pacific islands overwhelmed him with the variety of unfamiliar creatures and plants, and also the species variation between islands. His observations included finches, tortoises, marine iguanas, and cacti. This experience, plus an unwarranted extrapolation into deep time, led Darwin to assume the reality of macroscopic evolution.

The book includes helpful creationist thinking on the meaning of biblical kinds (Gen. 1). This category is suggested to be above species and on the rank of family. On another interesting topic, many Galapagos animals are described as having little fear of people (pp. 5, 86). This phenomenon is well known for sea creatures but unusual for land dwellers. The topic suggests further study in view of the isolation of the Galapagos, concentrated stewardship efforts, and the post-Flood description of animal fear toward mankind (Gen. 9:2).

Environmental stewardship concerns are emphasized throughout the book. This is appropriate since the Galápagos currently hosts 150,000 visitors each year, nearly ten times the islands' population. Rain-shadow effects support wide diversity of ecosystems; seven zones are described (p. 34) along with pictures. The health of these zones are sensitive to visitors, whether tourists or invasive species.

A further book topic of special interest is called mediated design (pp. 65, 71). This is the suggestion that some plants and animals were created with the potential for adaptations to new environments. One possible example is the marine iguana, which dives 50 feet deep in search of food. This swimmer has efficient salt glands for expelling excess salt ingested from the seawater. Perhaps "the original iguana kind was created with the genetic information (in the DNA) for salt glands. This information was more robustly expressed at a later time in an appropriate (salty) environment" (p. 71).

The book includes short testimonies from several Galápagos visitors (pp. 86-91). Georgia Purdom also includes a clear gospel presentation. *Galápagos Islands* does not discuss the region's social history or related political tensions since the emphasis is natural history. Short biographies are given for each contributing author; however, a subject index is lacking. Two concluding pages list related creationist books, articles, and websites. The listed website for the Creation Research Society is incorrect in the first printing and should be creationresearch.org.

This attractive book provides a refreshing alternative to the vast majority of Galápagos studies that promote evolutionary interpretations of data. Thanks to author Georgia Purdom for coordinating the writing project.

Reference

Vail, Tom. 2003. *Grand Canyon: A Different View.* Master Books, Green Forest, AR.

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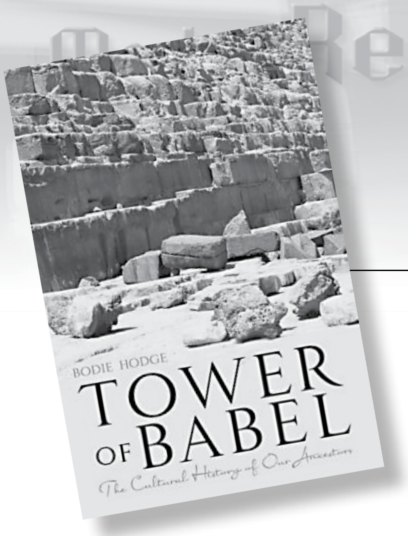

The Tower of Babel: The Cultural History of Our Ancestors

by Bodie Hodge

Master Books, Green Forest, AR, 2012, 272 pages, $14.00.

This book is a very "reader-friendly" treatment of the importance of the confusion of languages at the Tower of Babel event and the Table of Nations (Genesis 10). The first 16 chapters deal with various questions and possible textual problems concerning the Tower of Babel and possible contradictions between Genesis 10 and 11. Also discussed is the meaning of division during the days of Peleg, Nimrod's possible involvement with Babel, the decrease in ages of the post-Flood patriarchs, ancestry worship, the origin of writing, and the original language.

Perhaps the most interesting parts of this book are chapters 17 and 18. Chapter 17, "Where Did All the People Go Initially?" deals with the dispersion of the various people groups after the confusion of languages. Hodge leans almost entirely on secondary sources (the exception being the Genesis account itself) and counsels the reader to use these sources only as a guide. This is the heart of the book, where Hodge has done extensive research concerning the travels and settlements of the descendants of the sons of Noah: Japheth, Shem, and Ham. Many commentators have used the Table of Nations to identify the various tribes and nations of the Middle East around the Mediterranean Sea, extending east to Persia, south to present-day Sudan, west to contemporary Spain, and north to southern Russia.

Japheth's descendants tended to go north and west into Russia and Europe. Ham's offspring settled in Egypt, North Africa, and Arabia. Shem's progeny mostly stayed in the greater Middle East (the Assyrians were Semites, as were the Chaldeans and Syrians/Aram). Hodge uses place names and nation-group name similarities to aid in his research. For example, Cush, a descendent of Ham, is not only the name for Ethiopia but also can refer to Hindu Kush in northeast India. Sineus (a son of Canaan) was the ancestor of the Sinites, some of whom may have left their Sinai homeland and resettled in modern China. Hodge points out that there was much mixing of different people groups. The Maio group in China are the offspring of Japheth, and there are hints of other Hamitic and Semitic groups in Southeast Asia. The book includes many helpful maps and charts of people groups showing possible dispersal routes of the various people groups in post-Flood times.

Chapter 18 deals more in depth with "What About Asia, the Americas and Australia?" Hodge confesses the difficulty of researching these far-flung geographical locations (from the Tower of Babel in present-day Iraq) because of the lack of written history. Legends and oral traditions of ancestors developed later than Babel, and many of these people groups either lost or forgot about their ancestors. Despite these problems, Hodge uses geographic names of people group names of Old World origin that are similar to various American Indian tribes. He mentions some language similarities between Navajo, Chinese, and Tibetan language families. While Hodge makes only sparing use of genetic DNA research, he mentions a genetic link between Dravidians (India) and Australian aborigines.

One of the exciting innovations of this book's Kindle edition are the numerous hot links in the extensive endnotes sections to Internet resources that can facilitate further investigation. Hodge does take some potential controversial positions such as the date for the book of Job. Many commentaries place Job during the time of Abraham or before, but Hodge leans toward a date nearer the period of the Judges and gives detailed arguments for this view.

Hodge concludes his book by connecting the account of the Tower of Babel and Table of Nations to biblical reliability and authority in the struggle with atheistic humanism and calling for a personal commitment to Christ by the reader.

Hodge's volume is one of the more detailed, yet easy-to-read, books on biblical ethnology. He answers many questions and is realistic enough to admit there is much more research to do on these important topics, which may challenge some of his readers to take part in furthering that research.

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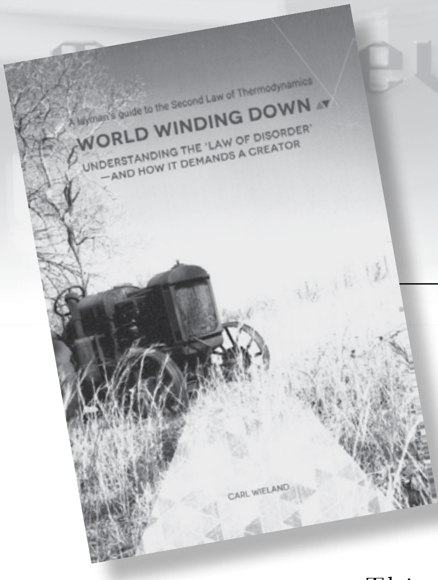

World Winding Down

by Carl Wieland

Creation Book Publishers, Powder Springs, GA, 96 pages, $10.00.

This book is a popular-level summary of the second law of thermodynamics and its interface with the biblical worldview. Author Carl Wieland is a medical doctor and managing director of Creation Ministries International (CMI, Creation.com). He has the ability to explain technical topics clearly and accurately.

The first law of thermodynamics states that total energy is conserved or constant at all times. In our present world, not a single calorie of energy can be created or destroyed. The second law also involves energy and describes unavoidable losses of available energy that occur in all transfer processes, whether driving a car or digesting food. The two thermodynamic laws are the most fundamental and basic rules in all of science; both laws also have theological implications. The first law likely was established at the conclusion of the Creation Week, when God ceased inputting energy into the universe from His infinite supply. The second law, although not equated precisely with the Curse, or Fall of mankind, is related to that event.

This book illustrates the second law in several ways, including the author's near-fatal highway accident in 1986. Included pictures show the mangled vehicle and an x-ray of Carl's fractured skull. His recovery is a story in itself (Wieland, 2011). Along with a universal trend toward disorder, the second law is also expressed by the arrow of time (p. 19), the thermodynamics of heat loss (p. 34), an increase in entropy, or disorder (p. 53), loss of information (p. 85), deterioration of the human genome, and Psalm 102 (p. 72).

The book reminds me of the Henry Morris classic *Twilight of Evolution* from five decades ago, which covers the same topic (Morris, 1963). References in the Wieland book are largely limited to CMI works, and there is no subject index. Page 64 expresses parts of the well-known, anonymous expression of the second law in terms of gambling: First, you cannot win. Second, you also cannot break even. Third, you cannot quit the game.

The book emphasizes that macroscopic evolution does not necessarily violate the second law. As a building project or growing garden shows, increased order and complexity do occur, albeit at the expense of greater losses of order and energy elsewhere. Still, where evolution fails completely is in the spontaneous origin of life and matter and also in the need for an ordering mechanism or programmed machinery to utilize raw energy in a constructive manner (pp. 76, 80). Such mechanisms are available in DNA instructions, chemical bonding rules, laws of nature, etc. However, these intricate, intelligently planned instructional blueprints are not explained by a self-generated universe.

A second major emphasis of the book is that parts of the second law are essential in both the pre-Fall world and in the future state. Solar energy, friction in walking, and the metabolism of food all involve second-law energy processes. Dr. Wieland suggests that negative parts of the second law became dominant, unrestrained, or uncompensated under the Curse (p. 91).

A short history of the second law is included, along with the algebraic formulations of such pioneers as physicist Ludwig Boltzmann (1844–1906). Boltzmann took his own life during an episode of depression, an ultimate expression of the second law itself. By his request, Boltzmann's entropy equation appears on his tombstone in Austria: $S = k \cdot \log W$.

The book ends on a high note. The positive, biblical view of the future is contrasted with naturalism, which ends in a cold, dark, lifeless universe. The final pages of the book present a clear gospel testimony. Thanks are due to Dr. Carl Wieland for placing the second law of thermodynamics on the "bottom shelf" for our understanding.

References

Morris, Henry M. 1963. *Twilight of Evolution*. Baker Book House, Grand Rapids, MI.

Wieland, Carl. 2011. *Beyond the Shadows: Making Sense of Personal Tragedy*. Creation Book Publishers, Powder Springs, GA.

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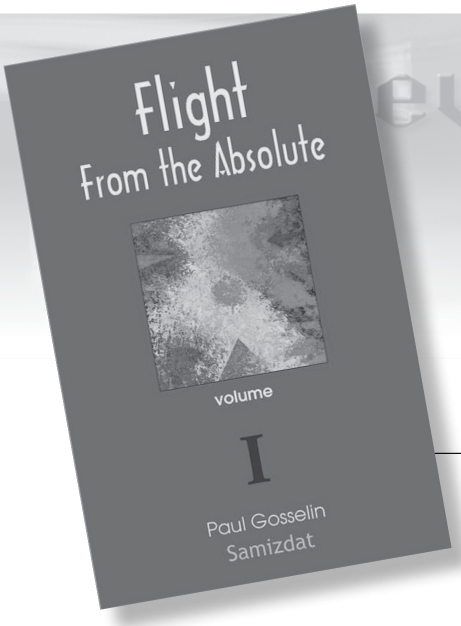

Flight From the Absolute

by Paul Gosselin

Samizdat Press, Golden, CO, 2012, 411 pages, $34.00.

Author Paul Gosselin opens the door to a better understanding of postmodernism in this book. He starts with the Christian West from the Reformation to the Enlightenment, during which substantial scientific advances and discoveries were achieved by Bacon, Copernicus, Galileo, Mendel, Pascal, Pasteur, and others, all of whom assumed the universe was under the providential care of God.

Gosselin traces the path from the Enlightenment's God-fearing scientists (those above) to the deconstruction of the Creation worldview through Charles Darwin's theory of evolution. Evolution then became the dogmatic view of many scientists. Some of these scientiest gave some acknowledgement to the Creator, but even these residues of theistic and deistic religion became unacceptable to many twentieth-century evolutionary biologists. The practical atheistic view permeated the science class as modernism, which was confident that science was the path to truth and objective truth at that. Atheist Richard Dawkins is an example of an old-school philosopher who believes that science is the path to truth.

Postmodernists today operate under the assumption that truth is relative, particularly regarding matters unrelated to science, and is more a psychological crutch. However, postmodernists unhesitatingly believe that evolution is absolutely true and a reliable guide for how to live our lives. They have very dogmatic ideas about what our laws should be and what freedoms humans and animals should have. As a result, postmodernists support or have supported eugenics, euthanasia, abortion, various degrees of extreme animal rights, and the prohibition of Christian expression in the public square.

Gosselin notes that for many in the Western world (North America and Europe) the culture is a religion. Films, pop musicians, the entertainment industry, and high-capacity spectator sports events have taken the place of weekly worship service attendance for the majority of those who were once Christian. The individual is the last absolute, so whatever turns one on is proper.

The book references and examples are voluminous. In a lengthy section of notes on the text (about 80 pages), Gosselin covers the extremist nature of the postmodern, twenty-first century with its artificial intelligence, posthumanism, and animal rights. Doing so, he provides Christians and other theists with alternative answers. Gosselin is a skilled writer and has provided a valuable resource.

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Instructions to Authors

Submission

Electronic submissions of all manuscripts and graphics are preferred and should be sent to the editor of the *Creation Research Society Quarterly* in Word, WordPerfect, or Star-Office/Open Office (see the inside front cover for address). Printed copies also are accepted. If submitting a printed copy, an original plus two copies of each manuscript should be sent to the editor. The manuscript and copies will not be returned to authors unless a stamped, self-addressed envelope accompanies submission. If submitting a manuscript electronically, a printed copy is not necessary unless specifically requested by the *Quarterly* editor. Manuscripts containing more than 35 pages (double-spaced and including references, tables, and figure legends) are discouraged. An author who determines that the topic cannot be adequately covered within this number of pages is encouraged to submit separate papers that can be serialized.

All submitted manuscripts will be reviewed by two or more technical referees. However, each section editor of the *Quarterly* has final authority regarding the acceptance of a manuscript for publication. While some manuscripts may be accepted with little or no modification, typically editors will seek specific revisions of the manuscript before acceptance. Authors will then be asked to submit revisions based upon comments made by the referees. In these instances, authors are encouraged to submit a detailed letter explaining changes made in the revision, and, if necessary, give reasons for not incorporating specific changes suggested by the editor or reviewer. If an author believes the rejection of a manuscript was not justified, an appeal may be made to the *Quarterly* editor (details of appeal process at the Society's web site, www.creationresearch.org).

Authors who are unsure of proper English usage should have their manuscripts checked by someone proficient in the English language. Also, authors should endeavor to make certain the manuscript (particularly the references) conforms to the style and format of the *Quarterly*. Manuscripts may be rejected on the basis of poor English or lack of conformity to the proper format.

The *Quarterly* is a journal of original writings, and only under unusual circumstances will previously published material be reprinted. Questions regarding this should be submitted to the Editor (CRSQeditor@creationresearch.org) prior to submitting any previously published material. In addition, manuscripts submitted to the *Quarterly* should not be concurrently submitted to another journal. Violation of this will result in immediate rejection of the submitted manuscript. Also, if an author uses copyrighted photographs or other material, a release from the copyright holder should be submitted.

Appearance

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 Star-Office/Open Office), 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 100 and 250 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 gel 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:

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

Margulis, L. 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, NY.

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). Images are to be a minimum resolution of 300 dpi at 100% size. 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 (2000 words), and one response (1000 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* is a peer-reviewed technical journal. It has been gradually enlarged and modified, and is currently recognized as one of the outstanding publications 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.

iDINO

Investigation of Dinosaur Intact Natural Osteo-tissue

A CRS Research Initiative

Scientists of the Creation Research Society are conducting a project to investigate the presence of intact tissue in dinosaur bones.

In the past several years, different studies have reported evidence of non-fossilized tissue (e.g., compact bone cells) and intact protein remaining inside fossilized dinosaur bones. Since these fossils traditionally have been dated at ages greater than 65 million years, the presence of this non-fossilized tissue is a direct challenge to the entire evolutionary "millions of years" time frame.

As part of the iDINO project, supraorbital horn of a Triceratops has been obtained and analyzed. This analysis revealed intact osteo-tissue containing osteocyte-like structures with detailed filipodial-like interconnections and secondary branching. The intricate detail of these observed cells offers a strong challenge to claims that the tissue is bacterial biofilm or microscopic artifacts. Instead, these results give powerful evidence that dinosaur fossils are really only a few thousand years old.

The Society is seeking funding from interested groups, churches, and individuals. This funding for the iDINO project will enable a more extensive examination of this supraorbital horn as well as other dinosaur specimens.

For more information contact us at (928) 636-1153 or crsvarc@crsvarc.com.

Also visit www.creationresearch.org for project updates and details.

Figure 1. CRS excavation team at a site in Hell Creek Formation, MT. Dinosaur specimens were obtained that have revealed the presence of intact tissue.

Figure 2. CRS team members excavated a large Triceratops horn at a the Montana site. Analysis of this horn indicates the presence of intact compact bone cells that have not yet fossilized.

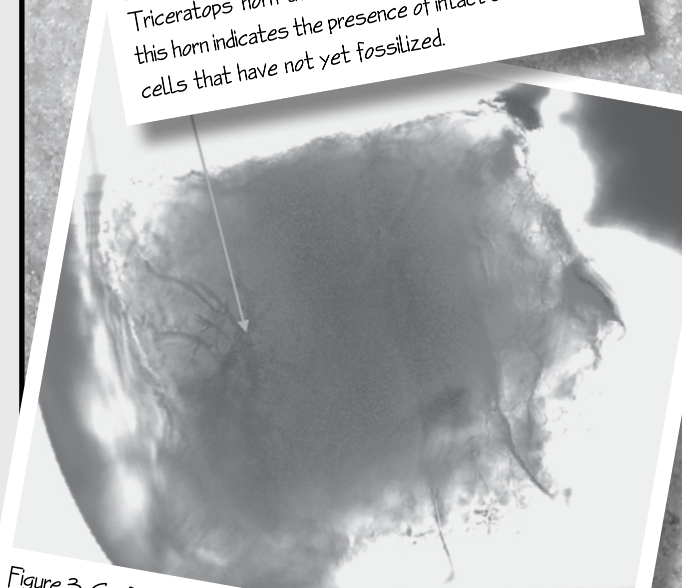

Figure 3. Confocal microscope picture of a thin section of material from Triceratops horn. The arrow points to what appears to be an intact osteocyte cell (a common cell in mature bone). The fluorescence of the cell indicates that it has not yet fossilized.