

PLANETARY NEBULA NGC 6543



STAR V838 MONOCEROTIS (V838 MON)



SOUTH POLE OF GIANT ASTEROID VESTA



CREATION RESEARCH SOCIETY



QUARTERLY

Volume 49 Summer 2012 Number 1

- LITTLE ICE AGE - PART IV
- A HYDRODYNAMIC INTERPRETATION OF THE
TAPEATS SANDSTONE - PART II"
- ACCELERATED NUCLEAR DECAY AND RADIOMETRIC DATING
- THE APPARENT AGE OF THE TIME-DILATED UNIVERSE - PART I
- THE ANATOMY OF A WORLDVIEW



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Creation Research Society Quarterly

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Haec Credimus

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

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Editorial

There Can Be Only One

The concept of evolution is many different things. To its ardent supporters, it is one of the greatest and most illuminating scientific ideas in history. To many scientists, it is something they accept by default: it is all they have ever been taught, and it is the only idea that is acceptable in scientific circles. To the average person it is an idea they likely take as a matter of “faith” because everyone else does. To many people it is also a perspective; one

they use to construct their worldview, even their culture.

The concept of evolution is also one other thing: It is a mindset. It is a mindset that assumes all biological change equals Darwinian evolution. It is a mindset that assumes all biological transformations equal common descent. It is a mindset that assumes the earth is billions of years old because evolution requires the earth to be billions of years old. It is *The Mindset* that requires that all observations be interpreted through the framework of evolution.

what they are accepting. Those opposed to evolution are regarded as backwards and dangerous, anti-science illiterates (e.g., Coyne, 2010; Dennett, 1995; Lurquin and Stone, 2007; Plimer, 1994) who are as ignorant as Holocaust-deniers (Dawkins, 2009), or are even mentally ill (Smith, 2010). Such declarations are intended to have a significant chilling effect on any and all opposing views. In fact, the idea there could even be such a bizarre phenomenon as “an opposing view” is antithetical to the very core of The Mindset.

The alternative to thinking in evolutionary terms is not to think at all (Carrol, 2006, p. 39).

Even one of my favorite evolutionary writers finds it hard to accept that there could be a viable alternative position. In his book *Origins: A Skeptic's Guide to the Creation of Life*, James Shapiro (1986) provides a very keen and detailed analysis of various “origin of life” scenarios. After concluding that there currently is no viable naturalistic explanation for the origin of life, he confesses,

Some future day may yet arrive when all reasonable chemical experiments ... have failed unequivocally. Further, new geologic evidence may indicate a sudden appearance of life on the earth. Finally, we may have explored the universe and found no trace of life ... In such a case, some

The Mindset cannot imagine there is even anyone actually educated in science, conducting research in science, publishing papers in science, or winning awards in science that would not be totally committed to its version of science (i.e., evolution).

There Can Be No Alternatives

Within this mindset, evolution (i.e., common descent) is a fact that is no longer even a debatable position.

Knowledge of evolutionary biology is therefore no mere academic pursuit, nor is the acceptance of its facts a matter that should be open to ... debate (Carrol, 2006, p. 39).

The Darwinian view of evolution is a scientific fact and not an ideology (Schuster, 2005, p. 12).

Evolution is a fact. Beyond reasonable doubt, beyond serious doubt, beyond sane, informed, intelligent doubt, beyond doubt evolution is a fact (Dawkins, 2009, p. 8).

Proponents have successfully created an atmosphere where evolution is simply taken for granted. It is such a mindset that most people accept it without even any real understanding of

continued on p. 72

The Apparent Age of the Time Dilated Universe I: Gyrochronology, Angular Momentum Loss in Close Solar Type Binaries

Ronald G. Samec, Evan Figg*

Abstract

In creation time-dilation cosmologies (e.g., those proposed by Humphreys, 1994, and Hartnett, 2007), one major question is: What maximum apparent age should be used to characterize the universe? The 14.7-billion-year answer provided by the Big Bang community should not be accepted due to its false assumptions, which are at odds with biblical history. There are many age-bearing processes (astrochronometers) that we can glean from today's astronomy. Astrochronometers include wind-up times of spiral galaxies, rates of decrease rotation and magnetic activity, and spin-down and coalescence times of binary stars (magnetic braking), star cluster ages (isochron age) and nuclear burning ages (stellar aging on the H-R diagram), rates of visual binary orbital circularization, stellar kinematic ages, white dwarf cooling ages, pulsar spin-down ages (due to gravita-

tional radiation), radio isochron ages from stellar spectra, and others.

In this study, we will explore the subject of gyrochronology: the precise derivation of stellar ages from the rotational period of single solar-type stars and the orbital periods of interacting binaries. As stars and binaries age, magnetic braking steadily steals away angular momentum, and magnetic activity decreases. We seek to include original research from our astronomical observations. In this regard, we present a preliminary analysis of an asynchronous, fast-rotating and near solar-type double contact eclipsing binary (Wilson and Twigg, 1980), AC Piscium from a recent observing run. We also include pertinent interferometric results of fast-spinning single stars. Finally, we attempt a first-ever age estimate of short period solar-type binaries apart from evolutionary time constraints.

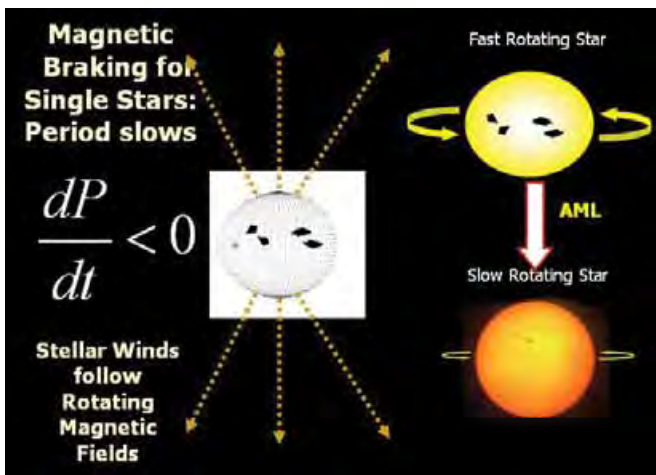


Figure 1. Magnetic braking on single stars. P is the period of rotation. AML is an acronym for Angular Momentum Loss.

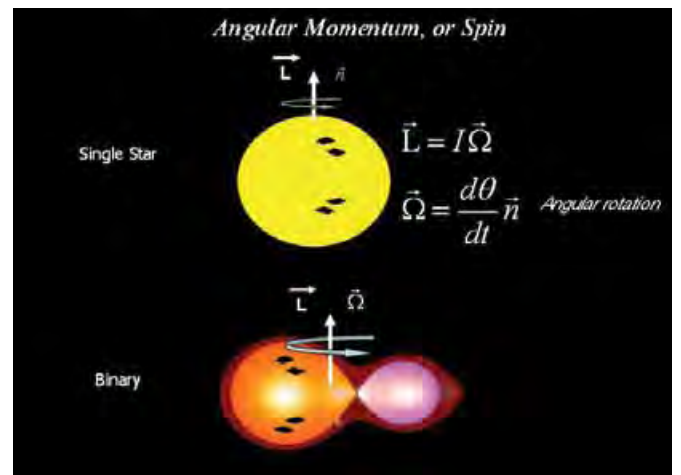


Figure 2. The definitions of angular momentum, L, and angular velocity, Ω .

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Introduction

We will use the term *astrochronologies* to describe most methods of finding the age of an astronomical object or dating such an event. These schemes are usually corrupted by the assumption that the age of the sun and our solar system is 4.57×10^9 years, or 4.57 Gigayears (Gyr), as a necessary input. We shall call this the Solar Age Condition (SAC). This is imposed in the age calculation. This is actually the maximum radioisochron age of “primordial” meteors. Due to this lesser-known calibration, derived ages are truly “astronomical.” In this particular study, we will point to examples of this in the field of *gyrochronology*, the precise derivation of stellar ages from the orbital period of solar-type stars and interacting binaries.

The RATE project (Vardiman et al, 2005) has demonstrated that the billions of years chronology of isochron dating is faulty, and actual geological ages are nearer to the chronology given to us in the early chapters of Genesis. Here the genealogies sum to give the date of creation about 4000–5000 BC. The discrepancy, thousands of years versus billions of years, is due to an accelerated radioisotope decay rate occurring early in earth’s history, whereas standard geology assumes a constant decay rate. This makes the age of the solar system nearer to 7000 years. However, this is the date attributed to earth-bound clocks. In *Starlight and Time* (Humphreys, 1994), general relativity was used for the first time to solve the light-time problem: how can astronomical observations be made of objects billions of light years away in a 7000-year-old universe? Humphreys’s answer to this dilemma is that time dilation occurred in the earth-based observational frame. In his first model, earth-based clocks ran slowly when a collapsing white hole event horizon passed the earth. During those moments, light not only came from the deepest realms of space to earth, but physical processes also accelerated throughout the universe. A mature cosmos with a presumed and possibly apparent age of millions or billions of years was left in its wake. This was followed by the complete evaporation of the white hole responsible for the event. Thus, in the frame of reference at cosmological distances, possibly millions to billions of years passed, while in the earth time frame only a few days of time or less were experienced. The question here is this: What is the apparent age experienced by the universe in its time frame? Also, how large a region can be called the “earth time frame,” and what happened in nearby regions? So we prefer to pose the question as, “What apparent age can we use to characterize the universe?” The 14.7-billion-year answer provided by the Big Bang community should not be accepted due to its false assumptions, which are at odds with biblical history. We will seek to avoid the SAC in our study wherever possible. Thus, we would like to base our timescales on a natural reference clock (NRC) rather than clocks calibrated with the SAC. Such chronometers include Newtonian orbital periods, the speed of light, and situations

where the physical rates, frequencies, velocities, and accelerations are known from observations.

For instance, a recent study was published in *Creation Matters* (Samec, 2011) on the missing intracluster medium (ICM) in globular clusters, which should be created by stellar winds of member stars. We used cluster orbital periods about the Milky Way and the time between orbital passages of the galactic plane as a NRC. We would like to replicate this type of study many times over as we explore age-bearing processes in modern astronomy. One of these, spiral windup times, has been indicated by Humphreys (2001). Others include rotation and magnetic activity and spin-down of solar-type stars and binary star coalescence (magnetic braking), star cluster ages (isochron age) and nuclear burning ages (stellar aging on the H-R diagram), binary star circularization, stellar kinematic ages (stars’ dispersal velocity increase with time due to interactions), white dwarf cooling age, pulsar spin-down age (due to gravitational radiation), radio isochron ages from stellar spectra, and others. In each of these studies, we will seek to scale events with a NRC rather than SAC.

Magnetic Braking

In this study we will explore the area of gyrochronology: the precise derivation of stellar ages from the decay of the orbital period of single solar-type stars and interacting binaries, i.e., magnetic braking. We will explore the magnetic braking of both single stars and close binaries.

Single Stars

By “solar-type stars,” we mean stars that have outer convective zones in the outermost layer. These are called convective *envelopes*. Stars are self-gravitating gaseous spheres that produce energy by continuous nuclear reactions in their cores. The core extends to $0.25 R_{\odot}$, the radius of the Sun. In the Sun, and other A5 to K type stars, the energy is transported outward by electromagnetic radiation through the radiative zone and then onto a convective zone. For the Sun, the radiative zone extends to $0.71 R_{\odot}$. Beyond that, the density and opacity is such that energy is transported by swirling convective currents. These swirling plasmas produce the magnetic phenomena visible on the Sun’s surface, or photosphere, called the *Active Sun*. This includes coronal loops, granulation, sunspots, faculae, prominences, and flares. The magnetic fields on the Sun are largely bipolar—they consist of two poles, north and south. Fields protrude out of the convective regions beyond the photosphere. These bipolar fields restrain the plasmas and produce dark sunspots that occur in pairs called *bipolar magnetic regions*. The magnetic fields extend outward, especially at the poles, and weaken so that plasmas escape along stiff field lines out to a region called the *Alfven* radius, some 50 solar radii. As the winds, consisting of

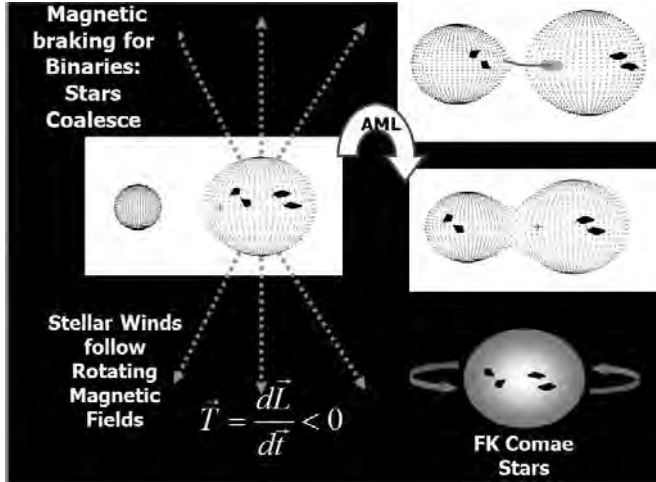


Figure 3. Close Binaries lose angular momentum. Since they are gravitationally locked, they experience spin-orbit coupling. The entire binary loses angular momentum. As this happens the orbits shrink and, by Kepler's law, the period decreases. The stars become contact binaries and finally coalesce into fast-rotating A-type stars to fast-rotating sub-giants, like spotted FK Coma stars.

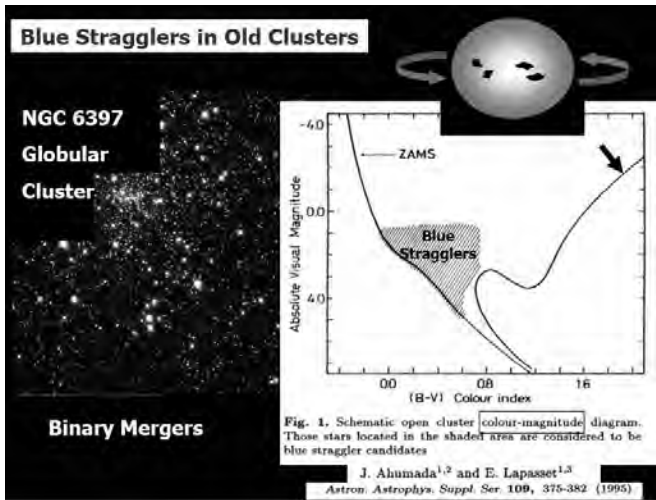


Figure 4. The isochron of an old cluster is pictured on the H-R or color magnitude diagram. Blue stragglers appear above the turnoff along the abandoned blue part of the zero-age main sequence (ZAMS). The picture of NGC 6397 shows the presence of blue stragglers. A drawing of a fast-rotating FK Coma-type star, blue straggler, is shown in the upper corner.

mostly protons, escape, they carry away angular momentum, much the same as a spinning speed skater who spreads her arms. The skater's rotation slows down. In the case of stars, the momentum is lost forever as mass is carried away into space.

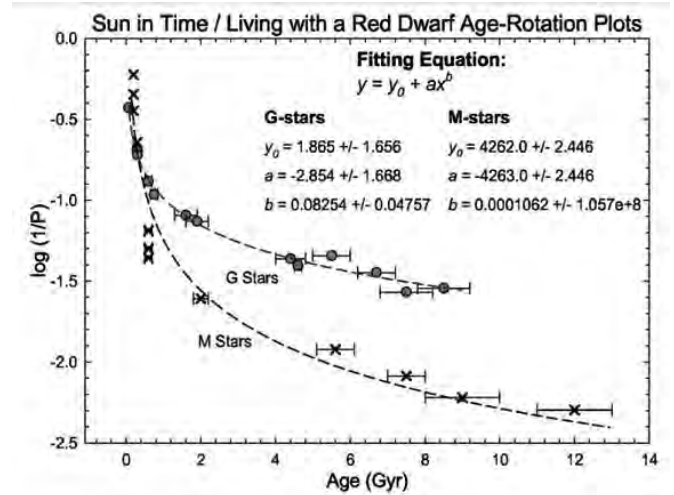


Figure 5. The period-age relation for single solar analogs and M-type stars determined by linking stars to nearby open clusters with known ages, calibrated with CaII emissions of stars with M67 solar-type stars (Solar age), and from U-V-W space motions (kinematic ages), from isochrones of modern stellar evolution codes (from Guinan and Engle, 2008). P is in days.

In this way, over time, a fast-rotating, magnetically active star becomes a slow-rotating, less active star like our present-day Sun with its ~25-day rotational period. This process is called magnetic braking (see Figure 1).

Angular momentum, L, for an object orbiting about a single axis is written as

$$\vec{L} = I\vec{\Omega}$$

$$\vec{\Omega} = \frac{d\theta}{dt} \vec{n}$$

I is the Moment of Inertia, sometimes called the *rotational inertia*, and Ω is the angular velocity. I has to do with the distribution of mass about the axis of rotation, distance r. Vectorally, Ω is the rate of change of angle, θ , in radians per second, times the unit vector directed along the north pole (see Figure 2). I can be written as

$$I = \sum_i m_i r_i^2 = MK_z^2$$

K_z is known as the radius of gyration, and M is the total mass. The torque, $\vec{\tau}$, is the rate of change of angular momentum.

$$\vec{\tau} = \frac{d\vec{L}}{dt}$$

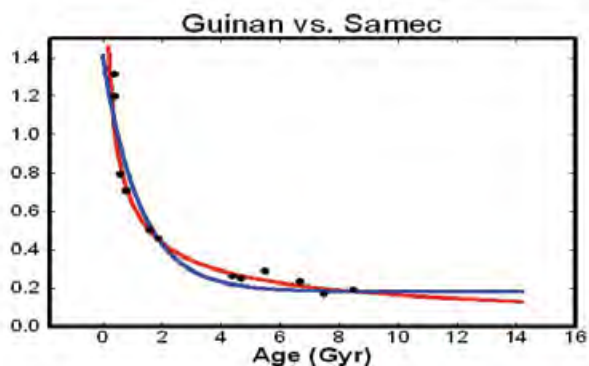


Figure 6. Conversion of Figure 5 to an angular velocity versus age to demonstrate the spin-down due to magnetic braking. The red line is Guinan's power law fit and the blue is the magnetic braking law fit. Both are adequate fits, but the magnetic braking fit follows the theory.

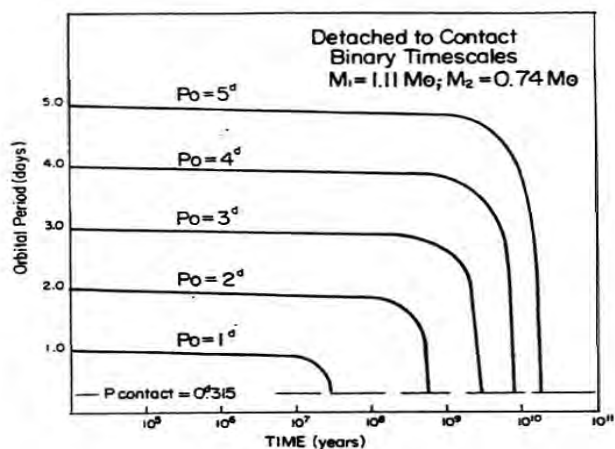


Figure 7. The time needed to brake from a, 1-5 d period binary to a 0.315 period binary with masses of 1.00 to 5.00 (Guinan and Bradstreet, 1988).

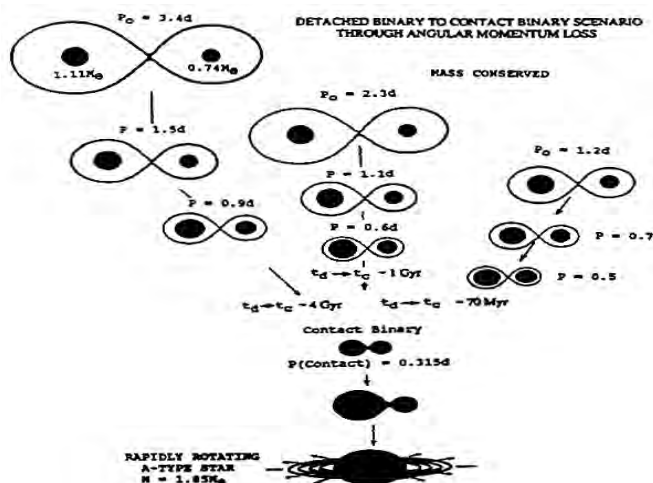


Figure 8. Graphic Depiction of the time evolution of a solar-type binary braking from a, 1-5 d period binary to a 0.315 period binary and on to a coalesced, rapidly rotating single star (Guinan, Bradstreet, and Robinson, 1987).

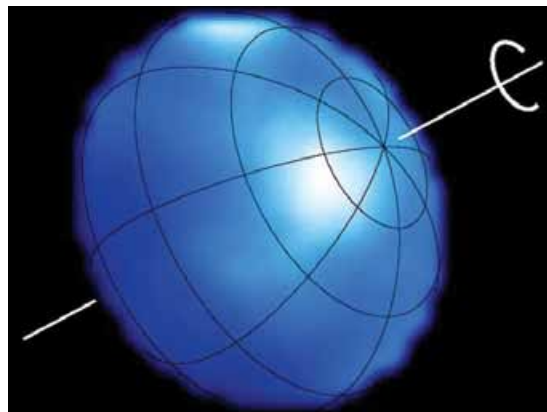


Figure 9. The CHARA-constructed image of Altair. Constructed images of all the tabled stars may be found on the CHARA website: <http://www.chara.gsu.edu/CHARA/Slides/CHARAoverview.pdf>.

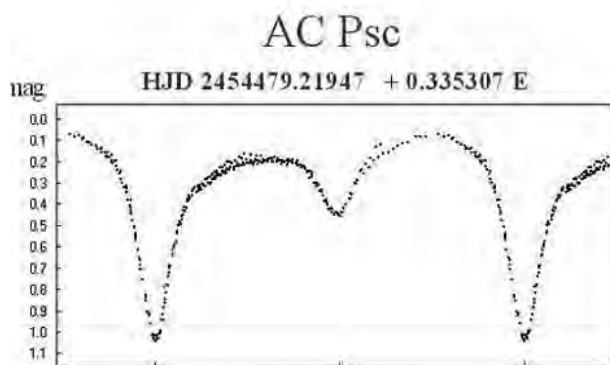


Figure 10. Unfiltered observations by Kryachko et al (2008). Note the hump around phase 0.8 just before the primary eclipse.

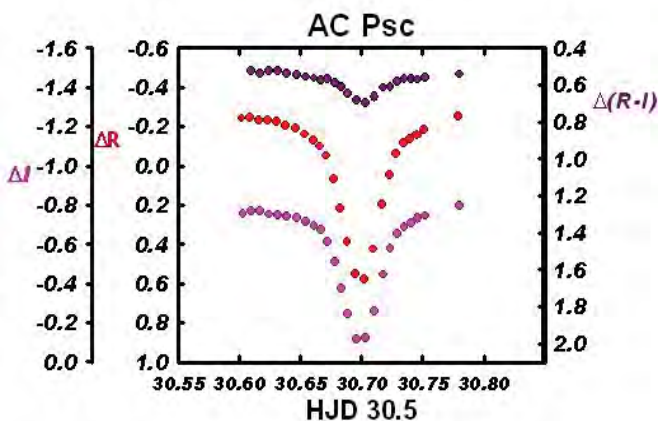


Figure 11. R and I curves, and R-I color index curves taken on HJD 2454730. HJD are "Heliocentric Julian date" observations transformed to the center of the Sun to eliminate light-time effects that would be experienced on the earth due to its orbital motion (when we are closer to the star, the eclipses would take place earlier, etc.).

Binary Stars

Binary stars consist of two stars that orbit about a common center of mass with a common orbital period. When binaries lose angular momentum, their orbits shrink and the period decreases (see Figure 3). With time, the entire binary steadily loses angular momentum. As this happens, the orbit shrinks and, by Kepler's law, the orbital period shortens. When the atmospheres of the stars touch, the stars are called *contact binaries*. The stars continue to coalesce into fast-rotating single stars such as A-type stars or sub giants, like the spotted FK Coma stars. An example of this phenomenon is found in star clusters where the proximity of stars allows more interacting binaries to form. The magnetic braking process described here is thought to be responsible for the existence of so-called *blue stragglers* in these star clusters. As star clusters age, the turnoff point of the giant branch extending to the right of the main sequence on the H-R diagram shifts to lower and lower masses, leaving a gap above it. Stars are not supposed to appear in this "empty" zone (see Figure 4). Surprisingly, some "young" blue stars do appear here, even in old clusters. These "born-again" stars are called blue stragglers and are thought to be due to binary coalescence. So AML causes *single stars* to slow their rotation and *binaries* to coalesce.

Astronomical Timescales, Single Stars

Ed Guinan (Guinan & Engle, 2008), in his multi-decade study of the Sun's evolution through time using solar analogs, has provided us with a typical and thorough study that yields gyrochronological ages. These ages are based on the SAC. We have summarized the repercussions of this work in a previous paper (Samec, 2004).

Figure 5 shows the rotational period of solar analogs and M-type stars (which are fully convective from the core to the surface) versus age. Rotational periods decrease with time, presumably due to magnetic braking. The relation is unmistakable. But the ages are all scaled with the astronomical age of our sun. The rate of change of the period dP/dt found from the decay of the period with time will be tied into the decay of the angular momentum later. Here we will tie the angular velocity, Ω , which is proportional to $1/P$, to this process through the well-known magnetic braking equation, (1), for single stars (Reed, 2011). The term r_A is the Alfvén radius, P is the rotational period, M is the mass at any time, and M_0 is the initial mass. The solution to equation (1) is (2). If we assume that the mass loss is constant (R), the solution is equation (3). Since R is negative, the angular velocity decreases with time.

$$\Omega = \frac{2\pi}{P}$$

$$\frac{d\Omega}{dt} = \Omega \frac{dM}{dt} r_A^2 \quad (1)$$

$$\Rightarrow \Omega = \Omega_0 e^{(M-M_0)r_A^2}, M < M_0 \quad (2)$$

or, allow

$$R = \frac{dM}{dt}$$

$$\Rightarrow \Omega = \Omega_0 e^{Rr_A^2 t}, R < 0 \quad (3)$$

We can easily convert Figure 5 to demonstrate this relation (Figure 6). We include our magnetic braking fitting relation and Guinan's power law (which has no scientific basis). Our braking law (with zero point fitting terms) does fit well (equation 4), demonstrating that the theory produces a good fit.

$$\Omega = 1.64e^{(-0.795t-0.287)} + 0.181 \quad (4)$$

We note that both of these plots give ages in billions of years, following the SAC, which was used.

Astronomical Timescales, Binary Stars

Much of the work in the area of binary stars has been done by Bradstreet and Guinan. In their benchmark paper, "Kinematic Clues to the Origin and Evolution of Low Mass Contact Binaries" (Guinan and Bradstreet, 1988), they produce an example plot of the evolution of a binary to a contact configuration with a 0.315 d period. This is given as Figure 7. Again, the models in this section are all calibrated by the SAC (4.6×10^9 years). The effect of this is seen in the time axis scales of tens of millions to tens of billions of years. Figure 8 shows a graphic depiction of the same process including the final coalescence into an A-type star.

Recent Studies in Optical Interferometry

Recent studies of bright (backyard-type) stars have revealed that many are stars rotating at near the centrifugal limit, that is, they are rotating at near break-up velocity! This interesting work has been done at Mount Wilson with the CHARA array (Center for High Angular Resolution Astronomy). For O to about A4V-type stars, this has not been as surprising, since these stars do not have convective atmospheres, and do not have stiff magnetic dipole fields for winds to travel on to cause magnetic braking. So their fast rotations are preserved from their creation. In fact, the author suggests that the attribute of fast rotation could be an attribute of all stars at their creation and is probably the origin

of disks on young stellar objects. (The high rotations cause the formation of disks, which bleed away the excess angular momentum.) Early disks have the appearance of spiral arms. (It could be that this is the origin of galactic spiral arms, that is, the high spin rate of galaxies and their need to lose excess AML and not the presence of dark matter.)

What is surprising is that a number of convective or partially convective stars have been studied in this interferometric work and found to also have this attribute! The observation distinction of convective stars is that their so-called gravity darkening coefficient, $\beta < 0.25$. For radiative stars, $\beta = 0.25$. β seems to minimize at about 0.08 for deeply convective stars. We summarize the results of this interferometric work in Table I.

These stars are evidently quite young. (Could this be used as evidence for young creation models?) Although it is too early to make any conclusions on stars in general, it appears that the Creator induced fast rotations in many created stars by whatever means, and solar-type stars steadily spin down by magnetic torques induced by out-flowing winds along stiff field lines. If both radiative *and* convective stars retain their high rotations, does this not attest to the youthfulness of these stars?

AC Piscium, Short Period Asynchronous Rotating Eclipsing Binary

This study of gyrochronology all began when the analysis of a binary revealed two components of a short period binary that have periods of rotation faster than the orbital period. This suggested further work on this phenomena and its affect on the age of the cosmos. Here we give an abbreviated analysis of this binary largely conducted by a senior physics major at Bob Jones University in the 2010–2011 academic year and completed in the summer. Short period systems of this type

are nearly always synchronously rotating, so this is evidently an interesting system related to the subject at hand.

1. AC Piscium: History and Observations

AC Psc has various identifications, including NSVS14605916, GSC 0584 1274, 2MASS J23213576+0635568, SV* GR 263 (Pinto and Romano, 1973). The position of the variable star (V) is $\alpha(2000) = 23^{\text{h}} 21^{\text{m}} 35.776^{\text{s}}$, $\delta(2000) = +06^{\circ} 35' 57.58''$ (Guide8). It was recently reclassified by ROTSE (<http://www.rotse.net/>) as an Algol-type binary (IBVS #5699) with the following ephemeris (fitted time of minimum light + orbital period):

$$\text{HJD } T_{\text{min I}} = 2451458.768 + 0.3353 \text{ d} \times E \quad (5)$$

and an R-magnitude range of 13.6 – 14.6 (primary eclipse). Its secondary eclipse had an R-mag of 14.1. It has a difference of depths of eclipse of 0.5 mags. This suggests that it is not a contact binary. It was recently observed by Kryachko et al (2008) with a small scope using no filters. The observations cover 11 nights from October 5, 2001, to July 31, 2003. They determined the improved ephemeris:

$$\text{HJD } T_{\text{min I}} = 2454479.21947 + 0.335307 \text{ d} \times E \quad (6)$$

(Indeed, amateur creationist astronomers could purchase GO TO scopes and CCD cameras to help us in this work.) Here it is said to be a possible EB (like Beta Lyra), RS CVn system due to the hump following the secondary eclipse. In RS CVn binaries, such spot-induced asymmetries move through the light curve due to differential rotation of various latitudes of the star where the spot happens to occur. Also, it is believed to be the X-ray source 1RXS J232128.6+063633. X-rays arise due to coronal activity in convective stars. Figure 10 shows the light curve they observed.

Table I. Attributes of Interferometrically Observed Convective Stars.

STAR	Spectra	Equatorial Temperature	Rotational Velocity	Ref
Altair	A7V	6860K	90%–92% of brake up	1
α Cephei	A9V	6700K	93%–94% of brake up	2
α Ophiuchus	A5V	7460K	88.5% of brake up	3
β Cassiopeiae	F5V	6200K	93% of brake up	4
Vega	A5V	7900K	91% of brake up	5

1 Monnier et al, 2007

2 van Belle et al 2006; Zhao et al 2009

3 Zhao et al 2009

4 Che et al 2011

5 Aufdenberg et al, 2006. Note that T(pole) is 10,15 K0 so Vega is only partially convective.

AC Psc was officially named in the 62nd Name List (1977). Photometric color indices were determined from 2-MASS observations. This gives a $J-H = 0.653$, $H-K = 0.012$, or spectral types of K7V and K5V, respectively. We note that these are consistent with each other and are similar to those found from our own photometric measurements.

Four color, B, V, R_c, I_c filtered light curves were taken on September, 17–20, 2008, at Lowell Observatory with the 0.81-m reflector with NURO time. Multiband observations enable surface temperature related phenomena to be delineated in simultaneous light curve solutions. For instance, in many cases, we have noted that mass ratios are determined to within 10%, even before radial velocity curves are taken. Our observations were taken with the cryogenically cooled 2KX2K CCD. Some 112 observations of AC Psc were taken in the B-filter, 142 in V, 132 in R and 129 in the R filter.

In Figure 11 is a representative R, I and R-I curve taken on HJD (Heliocentric Julian date) 2454730.

2. AC Psc: Period Study

Six times of minimum light (or eclipse timings) calculated from our observations mostly using parabola fits of four primary eclipses, HJD I = 2454730.7000 (± 0.0007)d, 24554729.6941 (± 0.0006)d, *2454728.6882 (± 0.0005)d, 2454727.6821 (± 0.0040)d, and 2 secondary eclipses, HJD II = 2454727.8503 (± 0.0006)d, 2454728.8564 (± 0.0004)d. The starred eclipse was determined by the Wilson code-fitting algorithm. The following improved linear ephemeris as calculated from all data is shown in Figure 12 along with the plotted residuals.

By removing the first point (perhaps an outlier), we were able to determine a reasonable quadratic fit. The residuals and ephemeris are shown in Figure 13. Since the period change is so quick as compared to AML (perhaps 10 X faster), a period increase is taking place, opposite to what would be expected, a $dp/dt < 0$. The components are apparently separating for a brief time due to the transfer of angular momentum from the primary star to orbital angular momentum of the system. The primary star is evidently not yet coupled (synchronously rotating).

3. Finding Charts, Positions, and Standard Magnitudes

The positions of the comparison (C) and check (K) are given in Figure 14 for the sake of future observers. Observations in the differential photometry performed here is in the sense of $\Delta mag = V-C$. C-K is used to determine if the comparison star is not varying.

The C-K values were constant throughout the observing interval. C was identified as GSC 0584 0247. Its position is $\alpha(2000) = 23^h 21^m 35.576s$ and $\delta(2000) = +06^\circ 39' 10.54''$. K is GSC 0584 0776. Its position is $\alpha(2000) = 23^h 21^m 50.484s$, and $\delta(2000) = +06^\circ 40' 04.12''$, $B-V = 0.332$.

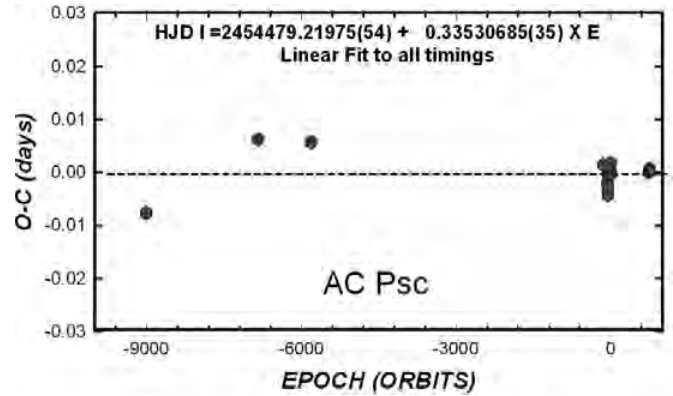


Figure 12. Improved linear ephemeris was calculated from all available data of AC Psc.

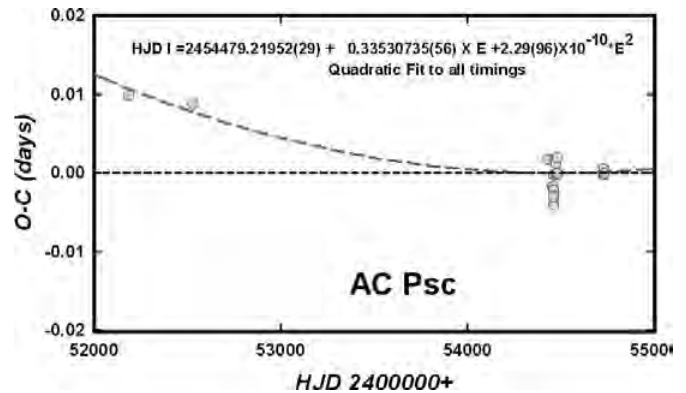


Figure 13. Quadratic ephemeris showing possible increasing period.

Landolt standard stars were observed on all four nights with good results, and the magnitudes of the V, C, and K stars were transformed to the standard Johnson-Cousins system using normal techniques. These confirmed that the primary had a temperature of about 4000K as was used in our light-curve solution (photometric spectral type K7.5). The C and K stars were both early G type stars. Average values are shown in Table II.

4. Phased Light Curves

We phased the light curves with the linear ephemeris given in Figure 15; mag versus phase is given. The BVRI light curves are EA/EB type (EA-Algol type) with their large difference in eclipse amplitudes when comparing the primary to the secondary eclipse. This may indicate a semidetached configuration (one star filling its critical surface and the other under filling). The light curves also show unsymmetrical effects (about the

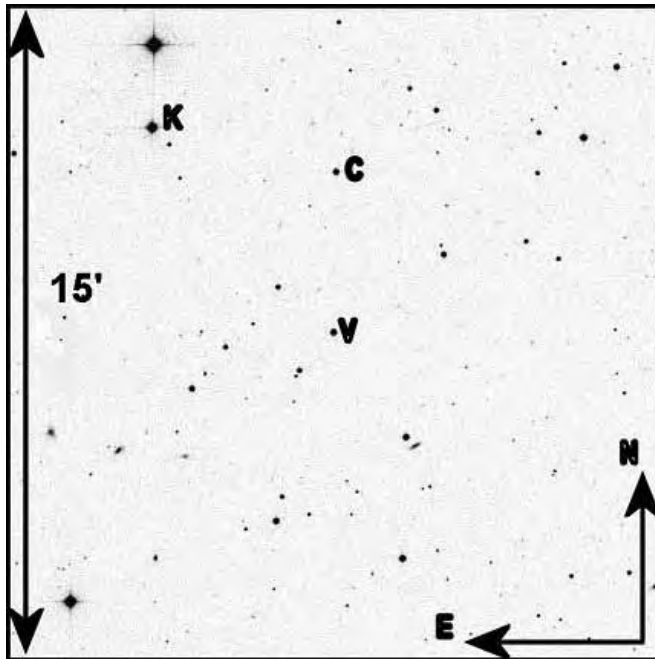


Figure 14. Finding Chart for the variable (V), comparison (C) and the Check star (K).

center of eclipses) due to spots and unknown phenomena. We note that the “hump” observed in the Figure 10 curve is now depressed, possibly due to variable stream spot.

5. Synthetic Light Curve Solution

The phased light curves, B, V, R, and I, were firsthand modeled with Binary Maker 3.0 (Bradstreet and Steelman, 2002). We sought to produce nearly consistent fits. The parameters from these fits were averaged and entered along with the light curves into the 2004 Wilson Code (Wilson and Devinney, 1971; Wilson, 1990, 1994; Van Hamme and Wilson, 2003). We followed this by attempting a simultaneous 4-color synthetic light curve solution. We tried mode 4 and 5 (semidetached with a either component as M_1 , the component at superior conjunction at primary eclipse), third light, and spots with poor results. Next, we tried to vary the “F” parameter (nonsynchronous rotation, and double contact mode 6). This immediately led to solutions, albeit poor ones. Due to the confusion as to the actual mode of the binary, we ran our solutions in mode zero, which allows unconstrained models. With this, we allowed the F parameters to continue to iterate. We also began solutions at various fixed mass ratios or q values to determine the lowest residual solution. This q-search resulted in the diagram in Figure 16.

The mass ratio minimized at near $q=0.45$. Next, we allowed the q-value to adjust, and the Wilson code converged on our final solution. Our best BVRI solution is found to be a near double contact with a primary just under filling its rotating lobe, 97%, and spinning at 1.36 times the orbital Ω . It is probably releasing a gas stream, producing a weak hot spot on the secondary. This is also confirmed since the location of the hot spot (caused by a gas stream) obeys the Coriolis force, and it is placed at near 90° latitude. In addition, the secondary is spun

Table II. Standard Magnitudes C, V (at quadratures), K.

	V	B-V	V-R	R-I	V-I	Sp. type
K	11.34	0.62	0.32	0.33	0.68	G1.0(1.5)
$\pm$	0.06	0.03	0.01	0.03	0.03	
V phase						
0.00	14.83	1.31	0.82	0.93	1.75	K7.5(2.0)
$\pm$	0.20	0.02	0.02	0.02	0.03	
0.25	14.30	1.45	0.70	0.80	1.74	K6.5(0.3)
$\pm$	0.10	0.02	0.03	0.22	0.11	
0.50	14.30	1.16	0.69	0.79	1.57	K7.5(1.0)
$\pm$	0.07	0.02	0.02	0.02	0.03	
0.75	14.25	1.23	0.71	0.83	1.64	K7(1)
$\pm$	0.01	0.04	0.02	0.01	0.04	
C	14.08	0.57	0.49	0.35	0.69	G2.0(1.5)
$\pm$	0.05	0.02	0.02	0.01	0.01	

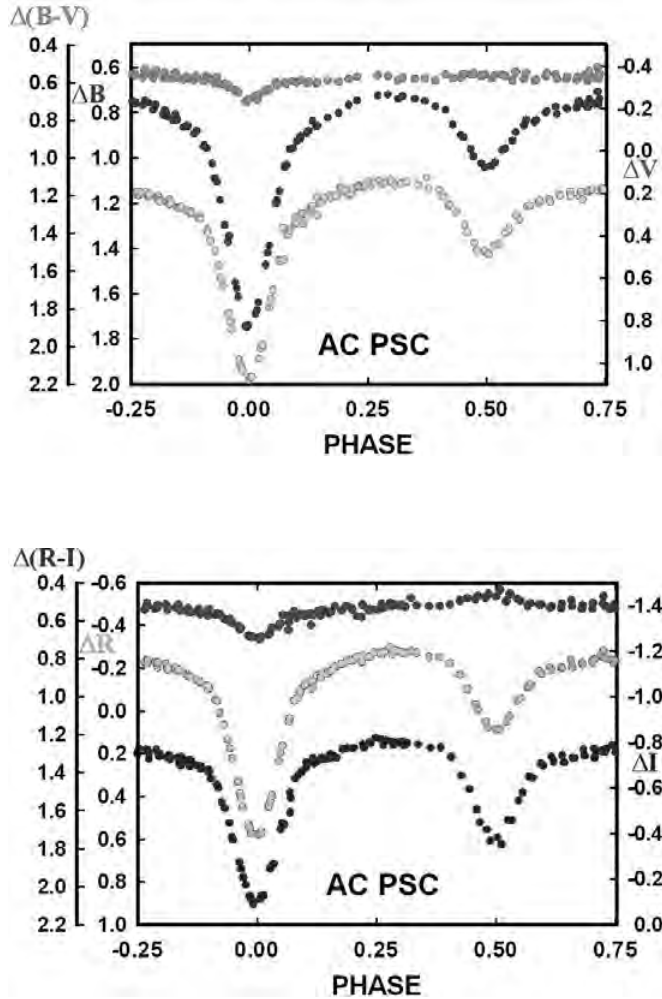


Figure 15a, b. AC Psc, B,V,R,I Delta Mag light curves phased with equation in Figure 13.

up, at 1.42 times the orbital Ω . Some solution parameters are given in Table III.

In Figure 17, we show the light-curve solutions overlaying the data. The surface models are given in Figure 18.

AC Psc is a detached system composed of nonsynchronously spinning components. The secondary component is presently spun up by a stream from the primary at 1.42 X the synchronous rate. Notably, the primary is still slightly spun up at 1.36 X the synchronous rate, which means that it was spinning at a faster rate at its creation like many other single stars. This is unusual. The usual near-contact binary is synchronously rotating due to gravitational drag. However, the asynchronous rotations should slowly die out over time and the system will come into contact as a normal “over contact” binary. The driving mechanism for this assumed process is the

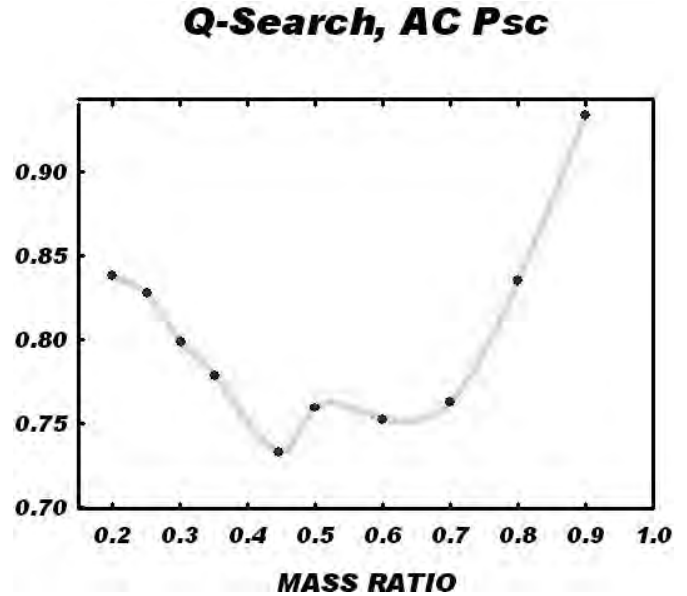


Figure 16. Mass ratio (Q) search of models to determine the best fit mass. The mass ratio minimizes at about 0.45.

torque supplied by out-flowing winds along “stiff” magnetic field lines originating from the solar-type stars.

Age Determination

We now embark on the climax of the paper, the determination of the age of close eclipsing binaries undergoing AML. During the past 25 years, we have been observing binaries undergoing AML with negatively measured dP/dt 's, especially from those of solar type. From these we can obtain an average AML loss. A listed tabulation is given in Table IV. These results are *independent* of the usual SAC calibration. Here our results are dependent only on NRC's, orbital periods. In Figure 19, we show a typical O-C residual plot from eclipse timings. This type of calculation gives the rate of period decrease of $T = -Q^*E^2 + Px E + T_0$, the standard form of quadratic ephemerides, i.e., the new eclipse happens at time T after so many epochs, or orbits, E , added to the initial eclipse, with a quadratic, E^2 , “deceleration term.” This acts the same way as a Newtonian kinematical calculation with a deceleration, $y = -1/2 at^2 + bt + c$, like the motion of a car with its brakes on. In this case the period or the angular momentum is decelerating.

In this calculation we will use AML equations from the analysis of Guinan and Bradstreet (1988). But we use only those free of the SAC. Equation (6) gives the orbital angular momentum of a gravitationally coupled binary star.

$$L_{orb} = 1.242 \times 10^{52} q(1+q)^2 (M)^{5/3} P_{orb}^{1/3} \text{ cm}^2 \text{ gm} / \text{s} \quad (6)$$

Table III. Some Parameters of the BVRI simultaneous solution of AC Psc.

Inclination = $79.7 \pm 0.1^\circ$	Star 1: Less Massive Component
$T_1 = 2899 \pm 18$ K, $T_2 = 4040$ K	Star 2: More Massive Component
gravity coefficient 1,2 = 0.32, 0.32, reflection 1,2 = 0.50	Omega Potentials 1: 3.073 ± 0.005
Near Double Contact, nonsynchronous rotation,	Omega Potentials 2: 3.144 ± 0.059
$F_1 = 1.362 \pm 0.019$ (x orbital rate)	Mass Ratio: $M_1/M_2 = 0.4458 \pm 0.0016$
$F_2 = 1.415 \pm 0.011$	Fill-out: Fill-out Star 1 = 0.967,
Spot Parameters:	Fill-out Star 2 = 0.945
Colatitude: $81 \pm 1^\circ$, Longitude: $48 \pm 5^\circ$	HJD0 = $2454728.68770 \pm 0.00011$
Normalized Flux Ratios: $L_1/(L_1+L_2)$ -I,R,V,B:	Period = $0.335331d \pm 0.000029$
0.610 ± 0.004 , 0.524 ± 0.005 ,	Radius: $10.2 \pm 0.3^\circ$, T-Factor: 1.16 ± 0.01
	0.510 ± 0.003 , 0.461 ± 0.004

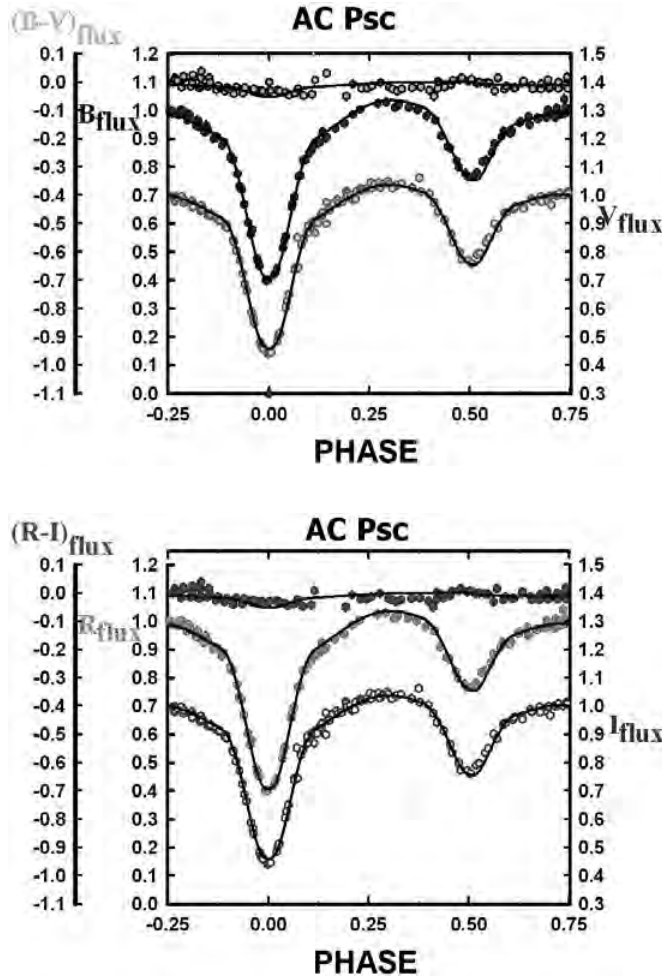


Figure 17a, b. AC Psc, B,V normalized fluxes overlaid (upper). R,I normalized fluxes also overlaid. B,V,R,I are simultaneous solutions. The first figure has a drawing of the gas stream included for illustration.

Taking the derivative, assuming no mass transfer and an insignificant mass loss, the torque, $\mathfrak{T}$, becomes:

$$\mathfrak{T} = \frac{dL}{dt} = 4.1 \times 10^{51} q(1+q)^{-2} M^{\frac{5}{3}} P_{orb}^{-2/3} \frac{dP_{orb}}{dt} \text{ cm}^2 \text{ gm} / \text{ s}^2 \quad (7)$$

where, M is in solar masses, P in days, dP/dt in days/year. Ages, Δt , are calculated from this simple relation:

$$\Delta t = \frac{\Delta L}{\mathfrak{T}}$$

In Tables IV, V, and VI we give the numerical results of our studies.

Conclusion

We find that the actual determination of the rate of angular momentum loss has a much greater effect on the ages of short period binaries than supposed by the binary star community. Given average values of AML and assuming that we can neglect the small changes in mass over the lifetime of the short-period binaries (Maceroni and Rucinski, 2000), and that these binaries begin their lifetime with periods of 10 days or less (Maceroni and Rucinski, 2000; Guinan and Bradstreet, 1988; Kroupa and Burkert, 2001), their apparent ages *average* from about 300,000 to 700,000 years, whose range actually includes ages as low as hundreds of years. (We could use starting periods much larger than this and still arrive at ages much smaller than that of Bradstreet and others.) The ages are seen to be far less than

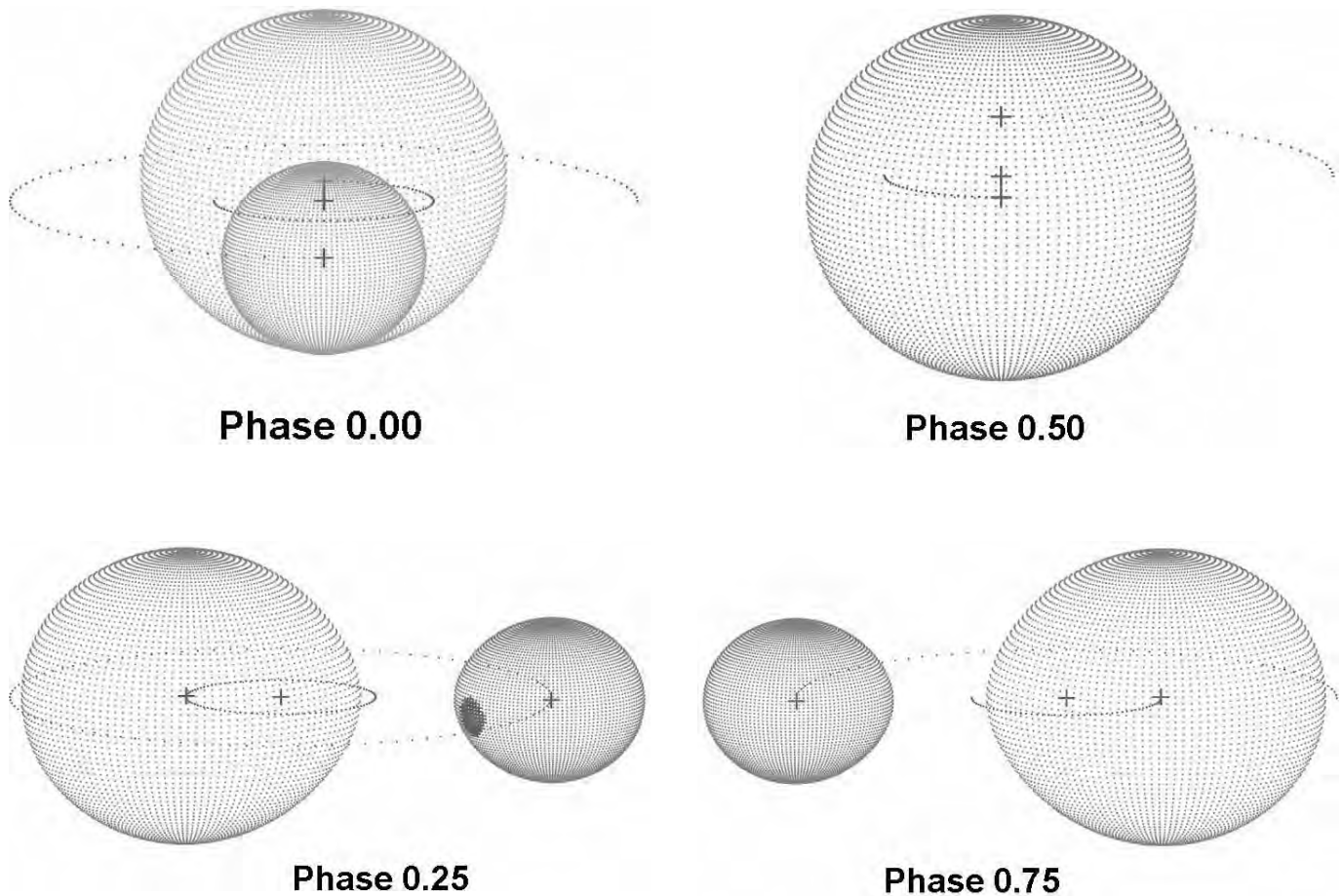


Figure 18. Surface models of the best BVR solution at quadratures. On the 0.25 phase model, a stream has been added for illustration.

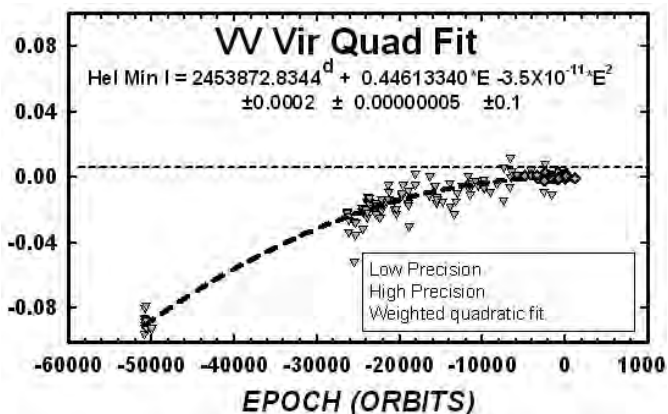


Figure 19. Our observation and calculation from previous eclipse timings shows that the orbit of VV Vir is decaying. Since this system is of solar type, we conclude that the period decrease and the angular momentum loss is negative. We included this binary in our calculation of the age of such binaries.

the multibillion-year scenarios painted by binary star researchers (less than a thousandth!). In fact, the range easily includes the biblical age of the solar system, 7000 years, depending on the initial created orbital periods. We observe that all of these objects are local (all within ~ 1000 parsecs or ~ 3000 ly) and *not cosmological, deep-space objects*. This may validate the notion that all nearby objects partook in the same dilation effects as the earth during Creation Week and that they all have ages measured in earth time on the order of 10,000 years, nearly the same as we find for solar system objects such as that of Jupiter and interplanetary dust. In the *Publications of the Astronomical Society of Japan* (2009), Tian et al. noted that the rate of decay is “1–2 orders of magnitude faster” than equations by Guinan and Bradstreet predict. Although this should be 3–4 orders, it confirms the thesis of this paper.

We believe that this paper gives physical confirmation of the youthful age of at least the nearby universe. “*For in six days*

Table IVa. Results of 25 Years of Observing Solar Type Binaries AML

	dp/dE (d/E)	dP/dt (d/yr)	period (d)	Est.Spec. Type	M ₁ (M _Y)	M ₂	M
AK CMi	-5.000000E-11	-7.746700E-14	0.56589640	A3	2.40	1.56	3.96
AT Aqr	-3.900000E-11	-4.036458E-14	0.37802984	G5	0.92	0.33	1.25
BE Cep	-1.600000E-11	-1.859084E-14	0.42439404	K1	0.77	0.52	1.29
BM UMa	-5.400000E-08	-4.009828E-11	0.27122032	K3	0.73	0.37	1.10
BX Peg	-1.060000E-10	-8.138137E-14	0.28042024	G8	0.84	0.31	1.15
CN And	-9.800000E-11	-1.241709E-13	0.46279007	F6	1.30	0.50	1.80
EH Hydra	-1.600000E-11	-1.211822E-14	0.27663622	G6	0.91	0.29	1.20
EK Com	-2.050000E-11	-1.496802E-14	0.26668637	K1	0.77	0.24	1.01
GSC 2537 -0520	-1.610000E-10	-1.635512E-13	0.37103770	G5	0.92	0.15	1.07
HM Mon	-1.800000E-11	-2.008706E-14	0.40760000	G2	1.00	0.59	1.59
V1128 Tau	-3.400000E-11	-2.842621E-14	0.30537273	G3	1.00	0.51	1.51
V361 Lyr	-3.600000E-11	-3.051634E-14	0.30961373	F8	1.26	0.87	2.13
V524 Mon	-1.100000E-11	-8.541482E-15	0.28361604	G8	0.88	0.42	1.30
V803 Aql	-9.000000E-11	-6.490916E-14	0.26342299	K3	0.73	0.73	1.46
V965 Cyg	-6.500000E-11	-1.139955E-13	0.64056706	A3	2.45	1.59	4.04
VV CVn	-3.139000E-09	-4.579993E-12	0.53292205	F2	2.60	1.30	3.90
VV Vir	-3.500000E-11	-4.275063E-14	0.44613340	G0	1.05	0.45	1.50
XZ CMi	-3.500000E-11	-5.546414E-14	0.57880796	F3	1.50	1.25	2.75
Average	-3.220528E-09	-2.531976E-12	0.39250929		1.22	0.67	1.89

the LORD made heaven and earth, the sea, and all that in them is, and rested the seventh day: wherefore the LORD blessed the sabbath day, and hallowed it" (Exodus 20:11).

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Table IVb. Results, Continued

	L_2 (today)	$q=M_2/M_1$	dL/dt	L_1 , 5 d (initial)	L_1 , 8d (initial)	L_1 , 10d (initial)
	1.825E+51	0.65	-8.017E+40	1.613E+52	2.580E+52	3.226E+52
	1.450E+50	0.36	-1.228E+38	1.918E+51	3.068E+51	3.835E+51
	2.146E+50	0.68	-9.506E+37	2.528E+51	4.046E+51	5.057E+51
	9.582E+49	0.50	-1.666E+41	1.766E+51	2.826E+51	3.533E+51
	9.548E+49	0.37	-3.093E+38	1.702E+51	2.724E+51	3.405E+51
	3.406E+50	0.39	-1.713E+39	3.680E+51	5.888E+51	7.360E+51
	9.262E+49	0.31	-4.932E+37	1.674E+51	2.678E+51	3.348E+51
	6.600E+49	0.31	-2.693E+37	1.237E+51	1.980E+51	2.475E+51
	7.050E+49	0.17	-1.210E+38	9.500E+50	1.520E+51	1.900E+51
	2.816E+50	0.59	-2.760E+38	3.454E+51	5.527E+51	6.908E+51
	1.868E+50	0.51	-4.824E+38	3.059E+51	4.894E+51	6.118E+51
	3.605E+50	0.69	-3.596E+39	5.822E+51	9.315E+51	1.164E+52
	1.302E+50	0.47	-7.180E+37	2.296E+51	3.673E+51	4.591E+51
	1.691E+50	1.00	-2.189E+39	3.210E+51	5.136E+51	6.420E+51
	2.144E+51	0.65	-7.332E+40	1.674E+52	2.678E+52	3.347E+52
	1.564E+51	0.50	-2.825E+42	1.467E+52	2.348E+52	2.935E+52
	2.521E+50	0.43	-2.771E+38	2.825E+51	4.521E+51	5.651E+51
	1.055E+51	0.83	-7.782E+39	9.114E+51	1.458E+52	1.823E+52
Average	5.050E+50	0.52	-1.757E+41	5.154E+51	5.154E+51	1.031E+52

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Table V. Time (years) to change from 10-, 8-, and 5-day periods to present orbital periods.

	Age (years) 5d	Age (years) 8d	Age (years) 10d
	5.65E+03	9.48E+03	1.20E+04
	4.58E+05	7.55E+05	9.52E+05
	7.71E+05	1.28E+06	1.61E+06
	3.18E+02	5.19E+02	6.54E+02
	1.65E+05	2.69E+05	3.39E+05
	6.18E+04	1.03E+05	1.30E+05
	1.02E+06	1.66E+06	2.09E+06
	1.38E+06	2.25E+06	2.83E+06
	2.30E+05	3.80E+05	4.79E+05
	3.64E+05	6.02E+05	7.61E+05
	1.89E+05	3.09E+05	3.90E+05
	4.81E+04	7.89E+04	9.94E+04
	9.56E+05	1.56E+06	1.97E+06
	4.40E+04	7.19E+04	9.05E+04
	6.31E+03	1.06E+04	1.35E+04
	1.47E+02	2.46E+02	3.12E+02
	2.94E+05	4.88E+05	6.17E+05
	3.28E+04	5.51E+04	6.99E+04
Average	3.34E+05	5.49E+05	6.92E+05

Table VI. Average, Maximum and Minimum Results

	Age (years)		
	5d Initial Period	8d Initial Period	10d Initial Period
Average	330,000	550,000	690,000
Maximum	1,380,000	2,250,000	2,830,000
Minimum	100	200	300

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A Hydrodynamic Interpretation of the Tapeats Sandstone

Part II: Middle and Upper Tapeats

W.R. Barnhart*

Abstract

Bedforms and grain-size distributions in the middle and upper Tapeats Sandstone were analyzed to determine depositional conditions, including flow velocity, direction, and depth. I found that cut-and-fill structures were formed by high-density turbulent flow. Alternating compound cross-beds and high-velocity flat beds are the products of changes in depth and competency, possibly caused by cycles of one large storm wave followed by a secondary wave train. Foreset azimuth readings from cross beds indicate a large, unidirectional depositional current, moving northeast to southwest, and composed of many parallel tongues of deposition. Its vast extent and lateral consistency are seen in the ubiquity of tangential toe contacts on both large and small internal cross beds of the compound cross bedding throughout the formation. *Diplocraterium* ichnofossils in these tangential toe contacts shows an unexpected association of trace fossils with high-energy environments. Flow velocities were determined from grain size corrected to show the total preserved load, recognizing that deposited sediments represent mixed and bed loads *after* removal of much of the suspended load. Calculated velocities of over 4 m/s show that the entire Tapeats was rapidly deposited. A rhythmic pattern of bedforms supports that depositional rate. Conditions during Tapeats deposition are better understood by this hydrodynamic approach rather than through the use of facies models.

Introduction

As the bottommost member of the Cambrian Tonto Group in the Grand

Canyon, the Tapeats Sandstone has long been viewed as the first part of “a classic transgressive sequence of sandstone,

mudstone, and limestone that accumulated on the slowly subsiding Cordilleran miogeocline and adjacent craton” (Middleton and Elliot, 2003, p. 90). Deposited on the Great Unconformity overlying either Precambrian crystalline basement or tilted nonfossiliferous sedimentary sequences, the erosional

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contact below the basal Tapeats is characterized by Rose (2006, p. 228, brackets added) as a “peneplain with only local relief in excess of a few meters per 100 m [328 ft] laterally.” The “local relief” typically refers to monadnocks found at eastern Grand Canyon and as far south as the Chino Valley in central Arizona (Figure 1, locations of monadnocks in Barnhart, 2012a, Figure 2). These Precambrian high are viewed as erosional remnants of the edges of tilted Precambrian sedimentary sequences. The classic studies of McKee (1945), Hereford (1977), and Rose (2006) all emphasized these features and interpreted the Tapeats as subtidal deposits sourced from the northeast. McKee (1945) saw evidence of reworking by tidal action in depths of less than 15.2–18.3 m (50–60 ft) of water. Hereford (1977, p. 209, brackets added) agreed that the sands were “deposited primarily on sandy intertidal flats...governed by the diminishing energy of tidal currents flowing shoreward across the gently-sloping tidal flats” under a flow depth of “between 5 and 10 m [16.4 and 32.8 ft].” Rose (2006, p. 234) viewed the Tapeats as a collection of “loose substrates of chemically inert sands and chemically reactive nonmarine paleosols” that moved and reacted “as tidal channels meandered and temporarily pooled and flowed, carrying and recombining various reactive clays, organics, and salts” in a unique pre-vegetated epicratonic estuary.

All of these authors saw the Tapeats as beach or nearshore sands (either above or below wave base) slowly developing on the flat peneplain broken occasionally by the eroded remnants of former marginal highlands. While aspects of their interpretations may be valid, careful analysis of the data does not always support them. The designation of the Great Unconformity as a “peneplain” and the varied composition of the monadnocks are a case in point. Neuendorf et al., (2005, p. 217) defined a peneplain as “a low nearly featureless, gently un-

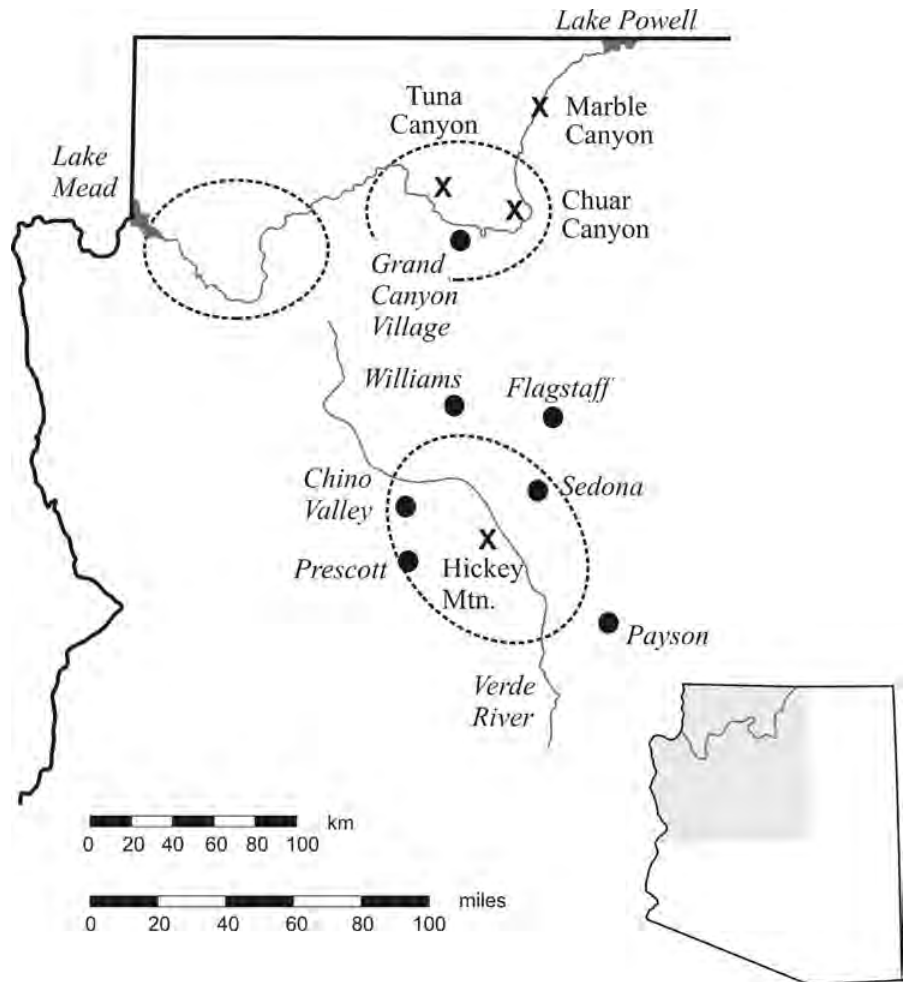


Figure 1. Location map of study area. X's mark locations discussed in text.

dulating land surface of considerable area.” Though the Great Unconformity is relatively flat, its apparent mechanism of origin does not fit the uniformitarian model. Oard (2011, p. 113, emphasis in original) contrasts plains and planation surfaces, with the latter observed to be eroded “independent of rock hardness on the regional scale.” Barnhart (2012a, 2012b) noted that the monadnocks are composed of rocks as soft as shale or as hard as quartzite, yet all are equally eroded and the highs are not restricted to the harder substrates. Therefore, the Great Unconformity is more likely an exhumed planation surface rather

than a peneplain. As Oard (2011, p. 117) observed, the continuous flatness of “planation surfaces are...formed... by some huge watery agency.” The relatively slow and selective erosional process envisioned by secular geologists cannot explain the broad, flat surface over such a large area. Furthermore, the monadnocks are not erosional remnants of marginal highlands, but remnants of a massive planation event, perhaps reflecting patterns of less energy in an otherwise highly erosive regional-scale current.

Barnhart (2012a) showed evidence that the lowermost Tapeats beds were

hyperconcentrated laminar bedforms deposited by high-velocity hyperconcentrated currents that were interrupted by cascades of loose breccia off the monadnocks that generated brief, high-density, turbulent flows depositing sandy debris flows. These events would have occurred simultaneously and during an event of higher energy and magnitude than any modern analog. The erosion and deposition under plastic flow conditions reflect elevated energy and preclude the common concept of low-energy processes on a passive continental margin. In short, the Tapeats is not a beach sandstone in the sense we understand it today.

This paper will look at bedforms in the middle and upper Tapeats. Those bedforms reflect a lower concentration of solids in the current and deposition under fluidal, not plastic, flow. If the Great Unconformity was eroded by high-energy, large-scale currents and the basal Tapeats was deposited plastically in high-velocity currents, then is it likely that the rest of the Tapeats reflects low-energy beach deposition on a slowly subsiding craton? It seems more likely that the rest of the Tapeats strata were also deposited in high-energy conditions. Bedforms and other sedimentary features in these beds will demonstrate that interpretation.

Hereford (1977, p. 199) described bedforms in the middle and upper Tapeats as:

large-scale cross bedding...that is characterized by compound cross-stratification, numerous reactivation surfaces, and herringbone pattern is typical of facies A and generally typical of finer-grained, thinner-bedded facies B. [These constitute] more than 95 percent of the bedding in the Tapeats Sandstone.

Rose (2006, p. 228) viewed these layers a little differently:

[They are] dominated by amalgamated channels of tangentially cross-bedded arkosic to subarkosic coarse to very coarse to gravelly sandstone. High-angle tangential cross-beds

(15°–60° foreset dips) can be traced along crude bedding planes a few to a few tens of meters into nested channels. Commonly only the gravelly bases of channels are preserved.

It is amazing that the quantity of work on these strata have yielded only generalized speculations about their origin. This emphasizes the fundamental failure of the facies model approach. In its place, I recommend an analysis of the hydrodynamic conditions of deposition that can be derived from sedimentary features such as bedforms and grains. That analysis will provide the basis for understanding the Tapeats in its entirety as a result of high-energy flooding across the planation surface of the Great Unconformity. These sedimentary features will now be examined in more detail.

Cut-and-Fill Bedforms

McKee (1945, pp. 126, 128, brackets added) described the bedding in the middle Tapeats.

Most of the modifications [from the common cross-lamination] are due to scour-and-fill development. Long narrow channels cut into normal [cross-laminated] beds and later filled with sediments dipping in and forward from both sides are characteristic of deposits near the flanks of monadnocks, although not confined to such localities. Scours that are similar in depth, but considerably wider and therefore proportionally shallower, are common at short distances from the monadnocks and near their bases, beyond the areas affected by initial dip.... The narrow channel-fill deposits ... may possibly have formed by rip currents.

While McKee (1945) fails to distinguish here between “scour-and-fill,” “channel-fill” and the “debris-flow deposits” of Barnhart (2012a), he is definitely describing what I will call “cut-and-fill deposits.” He associated these cut-and-fill deposits with monadnocks and their

associated debris-flow deposits, although the cut-and-fill deposits are not unique to the monadnocks.

Hereford (1977, p. 205, brackets added) described his facies D (in central Arizona) as:

a coarse-grained sandstone to granule conglomerate characterized by small-scale trough cross-stratification filling erosional scours and numerous thin lenticular sandy shale and coarse siltstone partings. ... Thin layers of granule conglomerate line the base of many of the erosional scours. The tops of the sandstone beds are densely covered with *Corophioides* [an ichnofossil] burrows...reversals in foreset azimuths are common.

He agreed with McKee that the “small-scale trough cross-stratification” were cut-and-fill deposits. However, the evidence suggests that they instead are the products of debris flows (Barnhart, 2011).

Rose (2006, p. 228) described bedding in the middle Tapeats.

High-angle tangential cross-beds (15°–60° foreset dips) can be traced along crude bedding planes a few to a few tens of meters into nested channels. Commonly only the gravelly bases of channels are preserved.

In contrast, I identify the “nested channels” and “gravelly bases of channels” as cut-and-fill deposits (Figure 2).

While McKee (1945) took a practical view towards the cut-and-fill structures in light of his interpretive model, attributing them to “rip currents,” it is important to understand that channels are cut by *any* high-energy current not in balance.

Any current carrying sediment is constantly in an energy balance. The work scale is a continuum from high-energy erosion and a sediment load at one end, through sediment transport in the middle equilibrium range, to lower energy conditions with sediment deposition. Most currents shift between these ranges. If the slope is steep, the

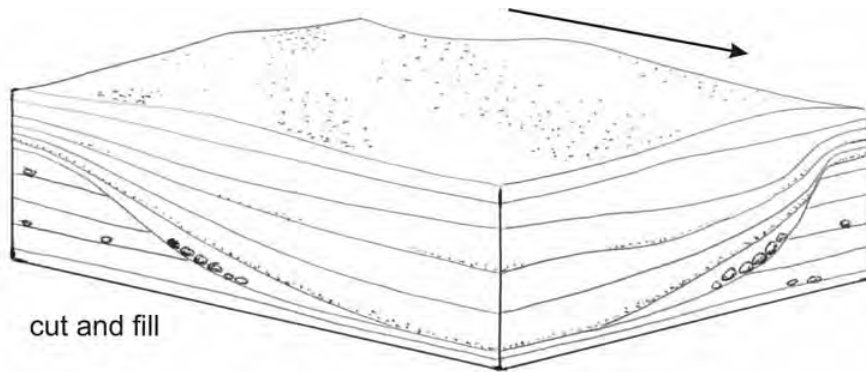


Figure 2. Cut-and-fill block diagram.

sediment load is small, and the substrate is unconsolidated, the current will erode into the substrate to create a flatter slope, trying to reach an equilibrium between energy and sediment load. But if the sediment load is too great, it will exceed carrying capacity and initiate deposition (Schumm and Khan, 1972). The resulting bedform will be a product of the sediment load affected by the rhythmical flexing of drag and release exerted by the buildup and release of shear stress in the boundary layer (Barnhart, 2012a). This makes the bedform a function of flow velocity, not available energy, although unique energy fluctuations may be expressed in unique variations, such as seen in the compound cross beds of the Tapeats.

The traction layer, occurring as the bottommost layer of a debris flow (Barnhart, 2011, figures 5 and 6), is composed of a fine sand fraction but only forms in a debris flow above an unconsolidated substrate. The sequence of bedforms in a debris flow can be confusing. As the basal layer, the traction layer must form first in a high-density turbulent flow. Since fine sand is the fraction most likely to be in suspension, a traction layer of fine sand could be unexpected. But the resuspension of the fine sand fraction from the substrate layer occurs as the highly turbulent head of the flow forces water down into the viscous sublayer.

Not only is this a good example of the significant interaction between the head of a high-density turbidity flow, but it is also a strong indication of extra energy being expended. If there is enough excess energy in the head, a debris flow can erode flute marks into the substrate as deep as 2.4–3.0 m (8–10 ft) (Sohn et al, 2002, their figure 6C).

There is a fine balance between energy and sediment. Too little sediment allows turbulency vectors to erode the substrate. Too much sediment results in deposition, as the current cannot maintain it in suspension. In that continuum, at a slightly higher energy level than needed to produce a traction layer, but less than needed to cause flute erosion, the current is strong enough at its head to create the “cut” of a cut-and-fill sequence, while the flat beds of the fill are produced by the lower energy level of the body and tail of the current. These are not low-energy features; the fill includes both high-velocity flat beds and even horizontal compound cross bedding. There are no internal collapsed bedforms expected in low-velocity flat beds. Laminae show separation by a developed parting lineation, indicating deposition from a current carrying lower concentration of solids than the hyperconcentrated laminar flow that deposited the basal Tapeats (Barnhart, 2012a, figure 13).

If these cut-and-fill channels formed by tidal rip currents (McKee, 1945) or sandbar drainage channels (Klein, 1970), then they should show a series of tangential adjustments along their edges, reflecting repetitive flow back and forth through the same channel, such as repeated cycles of ebb and flood tides. Klein (1970, p. 1098) describes such channels formed on sandbars and mudflats of Minas Basin, Bay of Fundy, Nova Scotia as “semipermanent meandering and straight channels” which serve to drain not only tidal currents but also facilitate the “dewatering of the [surrounding] bar sediments.” This ongoing pattern leaves its marks in small patterns of tapered wedge-shaped deposits along multiple edges. Even if the cut channel had not gone through multiple tidal cycles, the dewatering of surrounding sediment alone would have blurred and deformed the edges of the cut.

By contrast, cut-and-fill features in the Tapeats were shown by McKee (1945, p. 44, his figure 5g) as a clean cut into cross bedding, followed by thin, flat laminae that reflect the flatness of the water surface, not the irregular shape of the bottom. The flat beds typically match the internal bedforms of the cross bedding (Hereford, 1977, p. 208, his figure 9). These bedforms, as shown in the next section, can be produced *only* under high-velocity flow. The lack of reworking along the edges requires deposition of a continuous influx of sediment, strongly suggesting a continuous unidirectional current (Barnhart, 2011, 2012a).

The ubiquitous repetition of relatively narrow channels suggests an incredibly broad current that split along its leading edge into localized tongues of increased turbulence. The following current must have been relatively shallow to produce the thin flat beds filling the channels. The restriction of the first layers to the cut channels show that the cut-and-fill was deposited by one event. The narrow tongues are seen to be part

of a much larger current because at the tops of the channels, the bedding spreads out laterally without interruption, without eroding the channel edge into a rounded form.

Compound Cross Bedding

Flat beds are ubiquitous in the rock record. Flume and field data have verified that simple flat beds form in three instances of fluidal rheology: (1) low-velocity flat beds, (2) antidunes, and (3) high-velocity flat beds. Barnhart (2011, 2012a) determined that they can also be the result of various plastic flows, but the middle and upper Tapeats beds were not deposited under plastic rheology.

Low-velocity flat beds occur when low-velocity ripples form in coarse sand and the ripples collapse due to the large grain size. Antidunes are a high-velocity bedform, forming flat beds when the surface inline waves collapse, sending shock waves through the vertical fluid column that collapse the antidune bedforms. Flat beds produced by the collapse of low-velocity ripples and high-velocity antidunes both show the distorted internal lamination (Barwis and Hayes, 1985, p. 910, their figure 7).

The formation of high-velocity flat beds was investigated at Colorado State University, Fort Collins, Colorado in a 0.15 m x 0.15 m x 2.4 m (0.49 x 0.49 x 7.9 ft) flume (Julien et al., 1994). Figure 3 demonstrates how an apparent flat bed is built up from a prograding slope front. The length of the cross beds is determined by the thickness of the flat beds. Internal cross beds develop until a positive slope of the flume increases “up to the limit of the angle of repose (30° to 40° for sands), the lamination [top surface] of sediment is parallel to the slope” (Berthault, 2002, p. 445, brackets added). These tilted flat beds would likely be classified in the field as cross beds, and if internal depositional cross bedding can be discerned, the resulting bedform is called *compound cross bedding*.

Barnhart (2011) noted that the association of cross bedding with recurring flat beds indicates a change in competency, not flow velocity. Competency is the ratio of flow velocity and flow depth resulting from a sudden increase in flow volume. If flat and cross beds are produced by identical rheological conditions and an increase in flow depth that allows the layer to grow thicker as compound cross bedding, then both

cross bedding and flat beds should be considered as occurring under similar conditions. Compound cross beds (Figure 4) are high-velocity flat beds deposited on an incline and showing internal cross bedding formed during deposition. When sloping compound cross bedding is interbedded with horizontal flat beds, both were likely deposited under the same conditions except for intermittent changes in competency.

Additionally, because the internal cross bedding is a high-velocity bedform, any interruption of the flow would result in the formation of smaller, superimposed, low-velocity ripples or the washed-out, low-velocity flat beds they produce as velocity drops. In their study of bedforms in San Francisco Bay, California, Rubin and McCulloch (1980, p. 224, 225, brackets added) point out:

Small bedforms [low or high velocity] superimposed on larger ones are not merely a curiosity. They appear to be the rule rather than the exception.... Large bedforms generate boundary layers in which smaller bedforms can exist.... At shear velocities that are higher in the sand-wave range, upper flat beds formed at sand-wave crests and ripples [low velocity] were restricted to lower shear-velocity flow in the troughs.

Smaller superimposed bedforms will develop at the boundary layer of larger bedforms with velocity change; either lower or upper flow regime superimposed bedforms will develop if any depositional parameters are changed. The absence of superimposed low-velocity bedforms or their remnants suggests that each of the thick compound cross beds was deposited by a single uninterrupted unidirectional current (Barnhart, 2011). Since the compound cross beds and the horizontal flat beds above and below are genetically related, the absence of small, superimposed low-velocity bedforms indicates that the horizontal beds were deposited sequentially with the diagonal

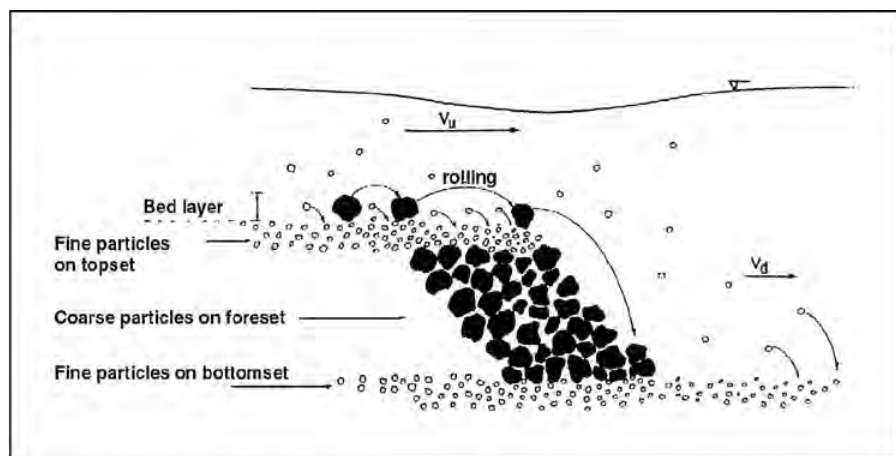


Figure 3. Sequence of deposition in high-velocity flat beds as determined by flume experiments (Berthault, 2002, his figure 3). Cross bedding may not be visible but is obviously present.

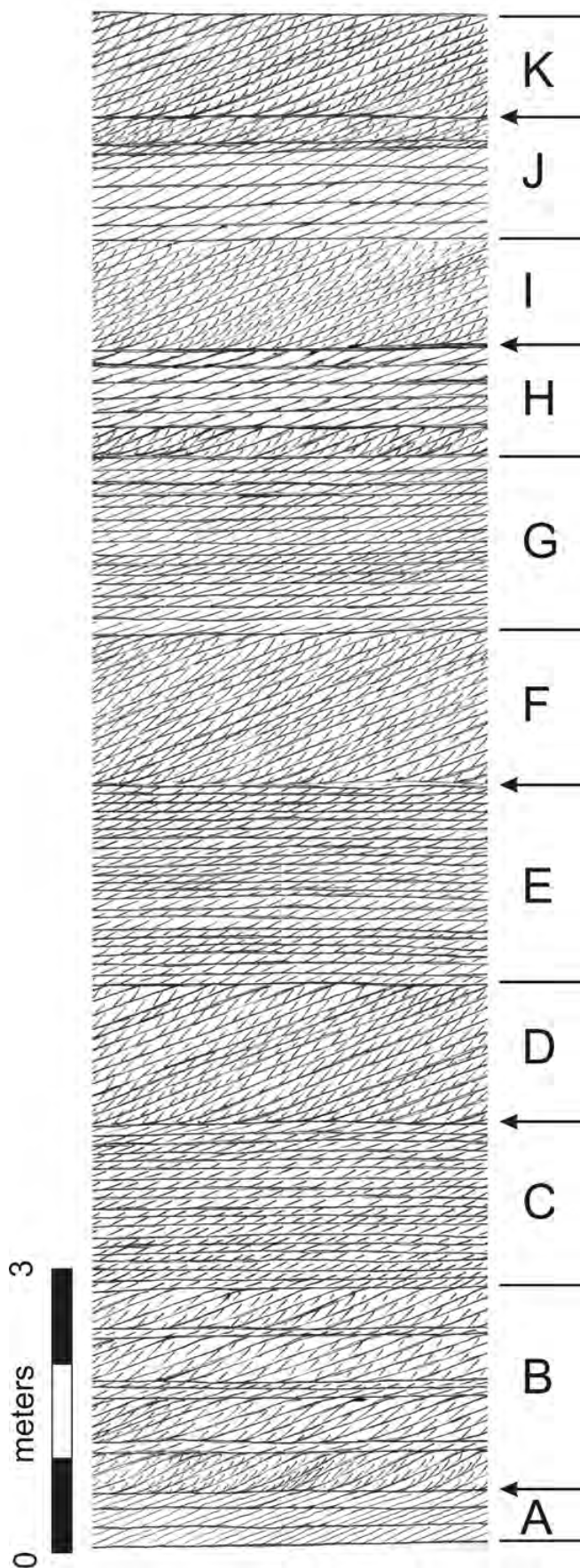


Figure 4. Compound cross bedding of middle Tapeats in Marble Canyon, eastern Grand Canyon at Colorado River. Repetition sequences begin at arrows; see text for discussion.

layers in a continuous unidirectional current.

In the Tapeats, compound cross bedding is seen at Marble Canyon (Figure 4), in the eastern end of Grand Canyon (Figure 1). In the middle to upper Tapeats, strata are deposited in both distinct forms. Horizontal flat beds are seen in layers C, E, H, and J of Figure 4, and cross beds in layers D, F, and I. The angle of the layers in D and F as measured from a photograph are 24° – 26° , and the angle of the smaller compound cross beds are also 24° – 26° , as measured at multiple locations in the photo. The two measures combine to give an angle of 48° – 52° for the smallest cross beds—an angle much greater than any expected angle of repose. All parting surfaces give an appearance of tangential toe contacts (Nichols, 1999, p. 48) on every cross bed, as confirmed by Rose (2006).

Hereford (1977, p. 201) documents similar compound cross bedding (his figures 3 and 4) in the Chino Valley area (Figure 1). He states:

Beds with compound cross-stratification are the thickest found in the Tapeats; thicknesses between 1 and 3 m are not uncommon, with the foresets as thick as 10 cm.

He identifies the angle of dip as 24° on the sloping flat beds; the smaller cross bedding in his photograph exhibits dips of 24° – 26° .

Both the Marble Canyon and the Chino Valley outcrops of the middle Tapeats align with the axis of deposition, northeast to southwest, and it “constitutes more than 95 percent of the bedding in the Tapeats Sandstone” (Hereford, 1977, p. 199). This suggests that the Tapeats was a continuous depositional body, remarkably similar across more than 200 km (124 miles). This sand body was over 300 km (186 miles) wide and 120 m (393.7) thick at the Bass Trail (Middleton and Elliott, 2003). Obviously this would require consistent depositional conditions over

a large area; in the case of the Tapeats, a large unidirectional current.

The photograph from which Figure 4 is taken shows a 0.5 to 1 km (0.3–0.6 mile) stretch of the Tapeats in Marble Canyon. Major stratal features are clearly visible and continue uninterrupted. By contrast, in Chino Valley, Hereford (1977, p. 201) noted that “thick sets of cross-stratification are commonly cut diagonally ... by two or as many as ten planar or curved surfaces” (Figure 5.1). These terminal edges may be unique to the central Arizona region and may well indicate the termination of the depositional tongues of the larger current. Hereford (1977) identified these curved diagonal surfaces as *reactivation surfaces*, where erosion beveled the edges of the original deposit. Similar features were noted on a smaller scale around the depositional perimeter of splay deposits formed during the levee breaches during Hurricane Katrina (Barnhart, 2011). Though found around all edges of the deposit, they are not erosional surfaces formed in a later event.

Nelson and Leclair (2006) identified the distal edges of the splay as < 0.3 m (0.98 ft). They did not taper to zero in a tangential manner, as would be expected from erosion. This is consistent with the edges in Figure 5.1. As Barnhart (2011) determined, the entire thickness and extent of the deposit, including the nature of the distal edges, was formed by a single continuous unidirectional current. Therefore, the three bedding divisions shown in Figure 5.1 are the terminal ends of sediment deposited by three individual waves with no intervening erosional events. Furthermore, the absence of smaller superimposed bedforms suggests that the three episodes of deposition were nearly simultaneous; probably they represent tongues of deposition from the same overall current.

The terminus of deposition definitely is not the same geographically as the extent of the current. The Katrina splay deposits had a distal edge of only about

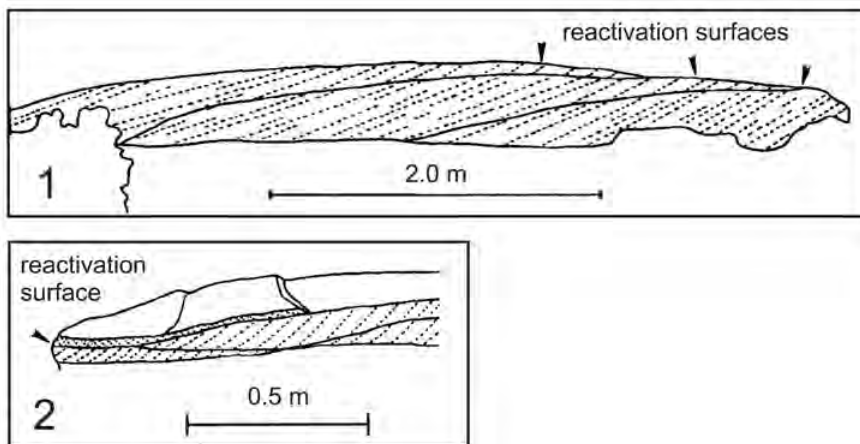


Figure 5. Occurrences of compound cross bedding in central Arizona near South Butte, showing orientation of internal cross bedding. 5.1: Reactivation surfaces are uneroded edges of lobate flow. 5.2: Occurrence of reverse cross bedding produced by antidunes. Modified from Hereford (1977, his figures 3A and 3B).

400 m (1,312 ft) from the canal breach, but the water flowed an additional 6–10 km (3.7–6.2 miles) to fill the entire basin of New Orleans to the level of Lake Pontchartrain. It is crucial to note that sediment thickness and extent were not controlled by the extent of the flow but by its *competency*. The two most significant factors for competency are (1) solids concentration and (2) flow depth. The distal edges of the Hurricane Katrina splay formed under a very rapid flow of up to 2.73 m/s at relatively high solids concentration of 20%–30% (Barnhart, 2011).

Herringbone Pattern of Reverse Cross Bedding

Herringbone pattern cross bedding (Figure 5.2) was found by Hereford (1977, p. 201, 203) in central Arizona, where he noted in his facies A and B “fairly common occurrence of herringbone pattern.” He attributes those bedforms to intertidal sandbars based on Klein’s (1970) study, or transverse bars in braided streams studied by Smith (1972).

Klein (1970) did find herringbone patterns in tidal environments, specifically in Minas Basin, Bay of Fundy,

Nova Scotia. There he documented it in several compound bedforms (Figures 6 and 7). In these figures, the layer of reverse cross bedding measures about 30 cm (0.98 ft) and 10–20 cm (0.32–0.66 ft) respectively. The illustrations show alteration of flood and ebb tidal currents over multiple cycles and two cycles, respectively. Figure 7.1 shows that reworked sand is predominantly oriented by the flood (incoming) tide, and Klein (1970) attributes the reverse cross bedding lower in the section to stronger currents during spring tides. In Figure 7.2, where reversed cross bedding was formed by one day’s normal tidal reworking, the thickness of ebb tide reverse cross beds is the same as that of the flood tidal deposits, except for dune surfaces that were not reworked.

Transverse bar deposits consist of two distinct types of layers (Figure 8), the larger cross-bedded layer (B) that forms at the leading edge of the migrating bar, and the small low- and high-velocity bedforms (A, C) deposited by the shallow, slower flow prior to the bar’s arrival and then by the boundary layer of the elevated surface of the larger cross beds. It is the migration of these small, superimposed bedforms (C) as they “walk

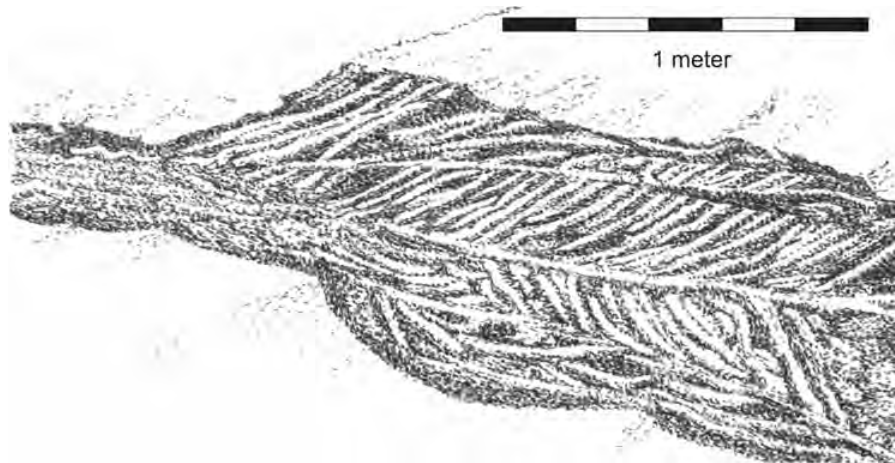


Figure 6. Bidirectional deposit between second and third layers separated by thin layer of decreased flow small bedforms (mostly low-velocity plane beds) in sand bar or sand wave. Trenched cross section with real reactivation surfaces. Ebb current to left, flood current to right. West Bar, Minas Basin, Bay of Fundy, Nova Scotia, Canada (Klein, 1970, p. 1116, his figure 27D).

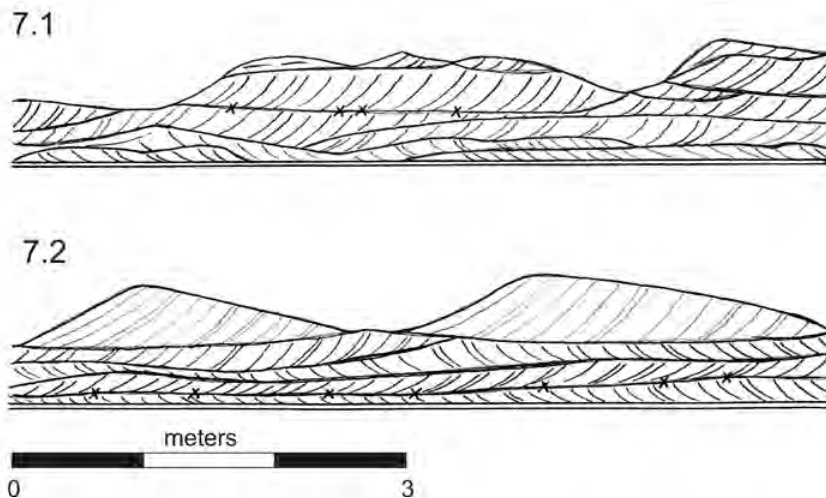


Figure 7. Herringbone cross bedding, evidence of bidirectional flow under tidal conditions. Sandbar at Economy Point, Minas Basin, Bay of Fundy. 7.1: Midtide reworking, August 1, 1968. 7.2: Maximum tide reworking, August 9, 1968. The "x" marks depth of reworking after two tidal cycles (24 hrs.) during maximum spring tides. Modified from Klein (1970, his figures 32A and 32B).

off" the front edge of the bar (Figure 9) that provides the primary source of sediment for the migrating bar. Smith (1972) described reverse cross bedding in both layers of the transverse bars of the

Platte River, Nebraska. He interpreted the larger ones as forming near the bar margin, where merging currents and eddies reversed the orientation of the bar margin, swinging it almost completely

contrary to downstream flow. He interpreted the small reverse cross bedding as secondary, small-scale antidunes that formed superimposed on top of the bar when the ratio of flow velocity to depth on top of the bar was higher due to a decrease in depth. Smith's (1972) reverse azimuth readings constituted about 2–5% of total measurements.

Barwis and Hayes (1985) also documented the formation of small antidunes of 0.5–2.0 cm (0.2–0.8 in) atop a wash-over fan on top of a seaward berm bordering Seabrook Island, South Carolina. The berm crest, about 1.54 m (5 ft) above mean sea level, acted as a weir for breaking waves, causing them to experience a hydraulic jump to supercritical flow as they overtopped the berm. While Smith (1972) did not give a hydrodynamic explanation for the origin of the small-scale antidunes he observed, the genesis would likely be very similar—a continuous unidirectional current running across either berm or bar at increased velocity as the depth decreased. Neither example conforms to Klein's (1970) example of tidal deposition. Thus, these bedforms can be deposited in environments other than tidal.

Two distinct varieties of reverse cross bedding in the Tapeats were documented by Hereford (1977). In Figure 10, the reverse cross beds are of nearly equal height as the normal cross beds above and below (Layers 9, 13, 16, and 18). These are likely not tidal facies, since all are genetically related; they were deposited at approximately the same time. That interpretation relies on the absence of reworking or separate walking dune structures as shown by Klein (Figure 8).

Figure 6 shows three layers in a trench on a sandbar, including those of reversed azimuth. Note the three layers are of roughly equal height, each separated by a distinct layer of smaller bedforms. These flat laminae did not form by the simple settling of the fine fractions (Figure 3) because they pos-

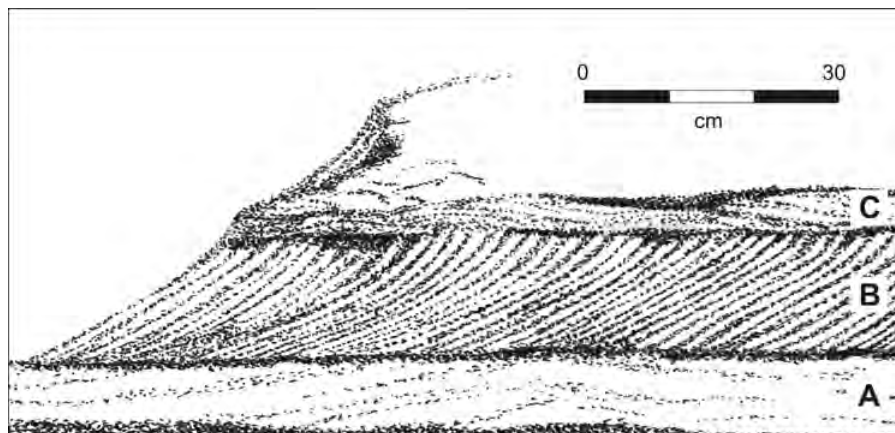


Figure 8. Trenched cross section of transverse bar from Platte River, Nebraska, showing alternating layers of (A) low-velocity flat beds underlayment, (B) alternating cross-bedding of fine and coarse grains, and (C) bed of small low-velocity bedforms left on top surface. Modified from Smith (1972, his figure 3).

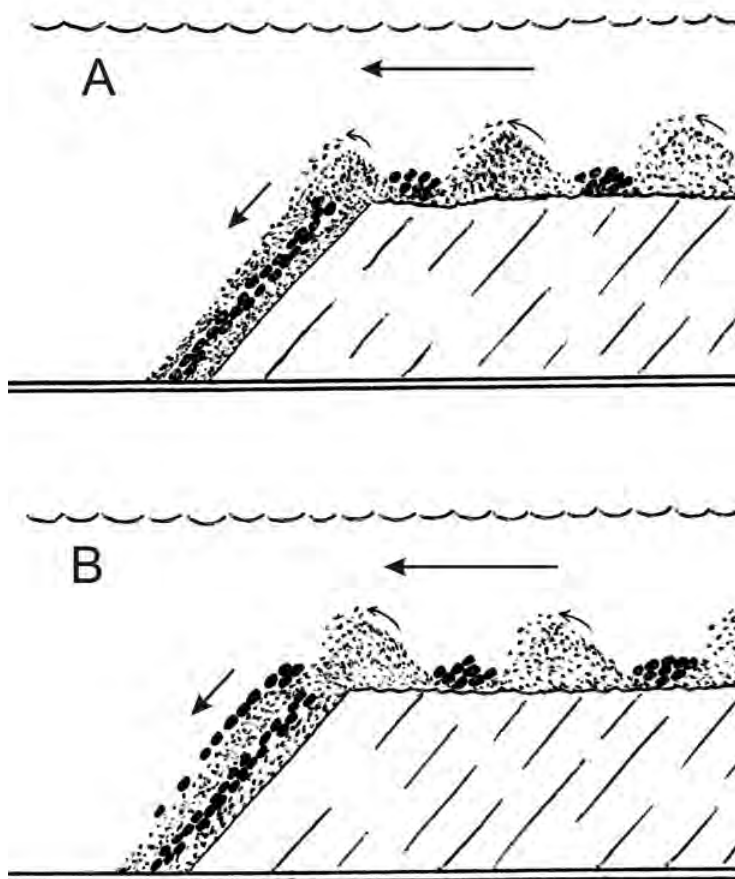


Figure 9. Laminae of cross bedding in Figure 8 showing method of deposition by cascading small low-velocity bedforms walking down current to bar surface. Modified from Smith (1972, his figure 4).

sess the distinct wavy appearance of washed-out ripples and are probably low-velocity flat beds. This is the transition that would be expected as current velocity slows to turn direction of the prominent flow from ebb to flood and back to ebb tides.

In the middle Tapeats, the cross bedding is obvious (Figure 10), but nowhere in the Tapeats has this author seen the stoss slope of a dune. Some should exist, but if the depositional environment was similar to that of the Katrina splay deposits, they would be rare because elevated flow velocity would produce longer wave length, and thus fewer dunes and fewer stoss slopes. Instead, dunes would appear as rapidly progressing transverse bars, prograding not by the migration of small bedforms across their surface, but by direct sedimentation of sloping flat beds down the lee slope. The deposit's height would then be limited only by the depth, with no time to generate small, superimposed bedforms on top.

Another possibility is that higher concentrations of solids would result in no stoss slopes (Barnhart, 2011, 2012a; McKee et al., 1967). Again, the sloping, prograding flat beds would continuously keep the bedform moving with the current as a transverse bar. Figure 10 in layers 13–27 shows overlapping tongues of sediment, each with limited lateral spread but showing evidence of the edges interacting with different current vectors, such as eddies, as documented by Smith (1972).

The second variety of Hereford's (1977) herringbone pattern bedding is shown in Figure 7.2, where the thin laminae of reverse cross bedding, about 2 cm (0.78 in) thick, overlie a bed 4–10 cm (1.6–3.9 in) of normal cross bedding. These proportions suggest that antidunes formed secondary bedforms superimposed on a ridge of previously deposited sediments, as documented by Smith (1972) and Barwis and Hayes (1985).

Both occurrences of reverse cross bedding in the middle Tapeats can

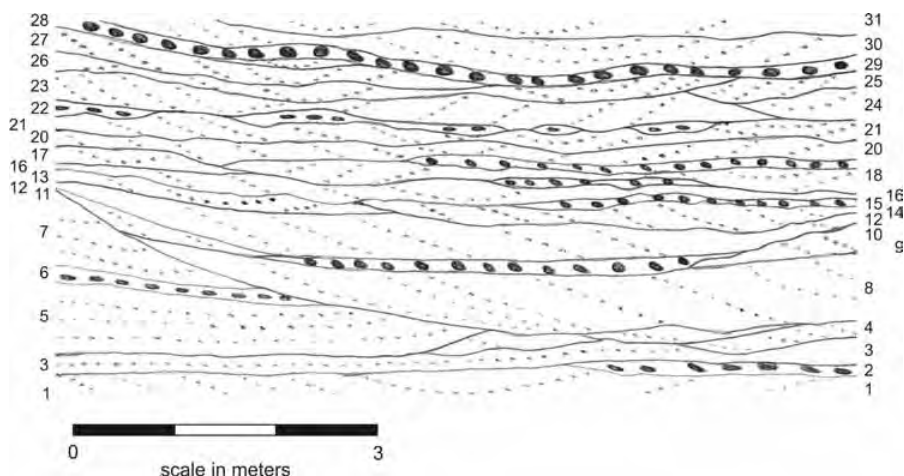


Figure 10. Vertical exposure of middle Tapeats north of East Verde River showing diverse orientations of foresets within individual numbered layers at a single location. Modified from Hereford (1977, his figure 9; note Hereford's image was upside down).

be better explained by deposition, as tongues of sediment persisted in a unidirectional current, rather than as tidal deposits. With little indication of reworking beyond the cut-and-fill structures, it is evident that the flow carried sufficient solids for continuous deposition along the advancing current's front and also in pulses representing wavelength intervals superimposed on that current.

Tangential Toe Contacts and Ichnofossils

Rose (2006, p. 228) describes tangential toe contacts in the middle and upper Tapeats, calling them "tangentially cross-bedded arkosic" layers, adding,

U-shaped burrows (*Arenicolites*) are sparsely present in planar horizons throughout much of the Tapeats Sandstone but are common in the upper parts of typical Tapeats sections, where they occur on steep tangential foresets.... Tangential foresets are not obviously bundled wherever they occur ... nor do they occur en echelon ... and therefore do not contribute to the interpretation of tidal origin.

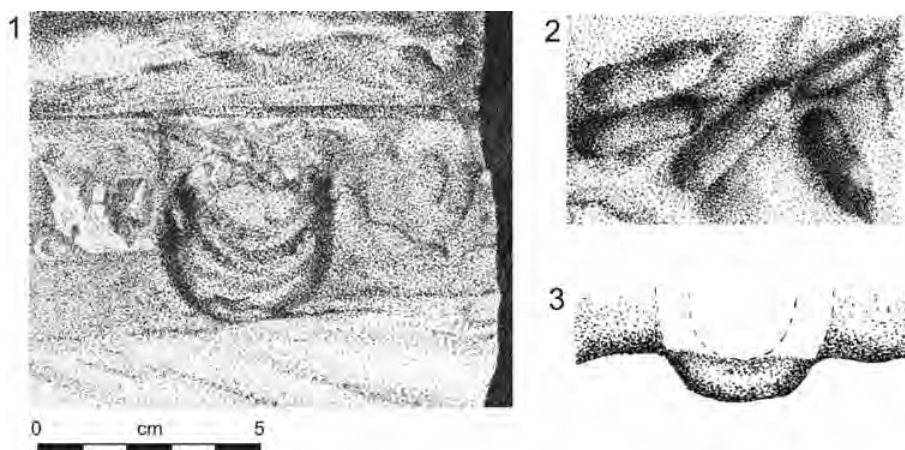


Figure 12.1. Ichnofossil traces of *Diplocraterium* showing spreite within U-shape and upper and lower boundaries of differential cementation. 12.2. Traces of *Diplocraterium* showing torpedo shape of lower bend of tube as it projects on many under surfaces (Hereford, 1977, his figures 8A and 8B). 12.3. Side view of traces.

This is in line with Barnhart (2011), who showed that Katrina splay deposits exhibited tangential toes on cross bedding as a result of high-velocity flow. These contacts manifest the strength and velocity of the vortex that prevents cascading of gains down the lee slope of the dune. Therefore, the stronger the vortex, the more pronounced the



Figure 11. Ichnofossil traces in tangential toe contact of upper Tapeats at Tuna Canyon (Rose, 2006, his figure 3C). Note boundary at top and bottom of ichnofossils created by differences in cementation. Bar is about 5 cm. Top is presumed to be a bedding surface of foreset about 10 cm thick, based on thickness of next layer between arrows.

tangential contacts, and the faster the current.

Thus, ichnofossils in a tangential toe contact require deposition under high-velocity conditions, not the low-energy environment of lengthy bioturbation on top of the sand. Both of these are conditions generally not expected for ichnofossils (Coward and Froede, 1994)

and represent even more rapid intrusions of substrate than the fastest rates determined for modern marine filter feeders (Froede, 2009). The burrows are labeled *Arenicolites* by Rose (2006) and *Corophioides* by Hereford (1977). Figure 11 is from Rose (2006) and shows well-developed burrows on a tangential toe contact in Tuna Canyon (Figure 1). Although the photo's size and weathered surface on the fossil do not allow for visualization of spreite on the interior of the U-shaped burrows, it does clearly show their occurrence within the tangential portion of the deposit. Spreite were clearly visible on all U-shaped burrows observed by the author in the upper Tapeats and are well illustrated in the *Corophioides* shown by Hereford (1977) in Figure 12, near Hickey Mountain. Mason and Christie (1986, p. 249) showed that *Corophioides* "are assigned to ichnogenus *Diplocraterium*" and will be referred to as *Diplocraterium* subsequently in this paper.

Mason and Christie (1986) equated the presence of *Diplocraterium* with marine deposition, positing a marine basin in the northeastern Karoo Supergroup in South Africa, primarily because of the local presence of the ichnofossils. Likewise, Hereford (1977) equates *Diplocraterium* (*Corophioides*) with marine conditions. Sandstone beds where *Diplocraterium* occur in very dense colonies are never more than one burrow deep in a single depositional layer, and none are obscured by bioturbation. Therefore they likely developed simultaneously in a short period of time. Hereford (1977) attributed these deposits to a tidal channel.

Figures 12.2 and 12.3 show the base of the lowest curve of the burrows, commonly seen on partings of overturned rocks. Large clasts containing these features are scattered along the edge of the Tonto Platform in the upper Tapeats. Curiously, the rocks' cement often changes abruptly at both the upper and lower surface of the *Diplocraterium* burrow. Although little or no evidence of

organic residue is found in the burrows, the change in cement composition may indicate the influence of the decomposing organic remains of the trace makers.

The presence of spreite within the U of the burrow (Figure 12.1) is thought to indicate that the organism burrowed down into the substrate by distending first one part and then another of a segmented body. The burrows always appear on the surface of the substrate as a small groove terminating at each end in a hole and are sometimes called "staple marks." But no rubble from the hole was moved up to the surface, nor is any lifting of the substrate visible around the holes. This is unusual since burrowing filter feeders invariably leave a pile of substrate sediment beside or around their burrows (Froede, 2009, his figure 1). Thus, the burrow was excavated into the sand prior to compression and compaction when the sand's surface was formed, suggesting that the organism had to arrive in the same current with the sand. If the sand was transported at a high current velocity, then the same is true of the organisms responsible for the *Diplocraterium* burrows.

Diplocraterium on tangential toe contacts shows that the organisms arrived in great numbers in high-velocity currents. Their demise would have altered the chemistry of pore fluids, which resulted in rapid cementation. Thus, *Diplocraterium* appear to be escape burrows, not feeding structures. Other ichnofossils are thought to be a result of travel or feeding trails. Since most of these are very short in length, a few cm to a few tens of cm, they may have been formed between pulses of deposition. Their increasing abundance in the upper Tapeats may indicate an increased interval between waves as sand deposition waned and ceased. Longer "foraging" ichnofossils may have formed shortly after deposition but before compaction and cementation. Many of these "feeding" or "foraging" trails may actually represent escape structures by

the organisms and the conditions under which they had to function.

Paleocurrents and Cross-Bedding Azimuths

Hereford (1977) measured 727 azimuth readings of cross-bed foreset inclinations at 13 locations in the middle and upper Tapeats in central Arizona. Given the large area, the number and distribution of these measurements, these should be seen as a random sample. However there are several interesting trends that can be seen in these measurements. His rose diagrams (Figure 13) with arrows show the general deviation and vector-averaged direction for each location. He divided these locations into three groups (Group I = 1–4, Group II = 5–8, and Group III = 9–13), and these groups show a decrease in azimuth variation toward the east. Hereford (1977, p. 203) noted: "Groups I and II could be expected to develop on intertidal sandbars by deflection of tidal currents around irregularities on the depositional surface (Klein, 1970) ... [and] are similar to distribution shown. ... from a modern braided river."

But Schumm and Khan (1972, p. 1755) determined that "streams or currents will only braid on slopes > 0.016 ." Calculations (Barnhart, 2012a) show that water flowing down that great a slope would have been too shallow to deposit the thickness of layers seen in the basal Tapeats. Needless to say, this would be even more improbable in the thicker strata of the middle and upper Tapeats.

Klein (1970, p. 1109) showed foreset inclinations of diverse azimuth do occur on intertidal sandbars: "The conclusion is therefore inescapable that this elliptical pattern of sand transport though both flood- and ebb-dominated portions of tidal sand bar is a characteristic transport pattern for intertidal and subtidal sand bodies." His figure 18 shows rose diagrams roughly symmetrical over 60° – 180° spreads with the greatest number of readings in the central range.

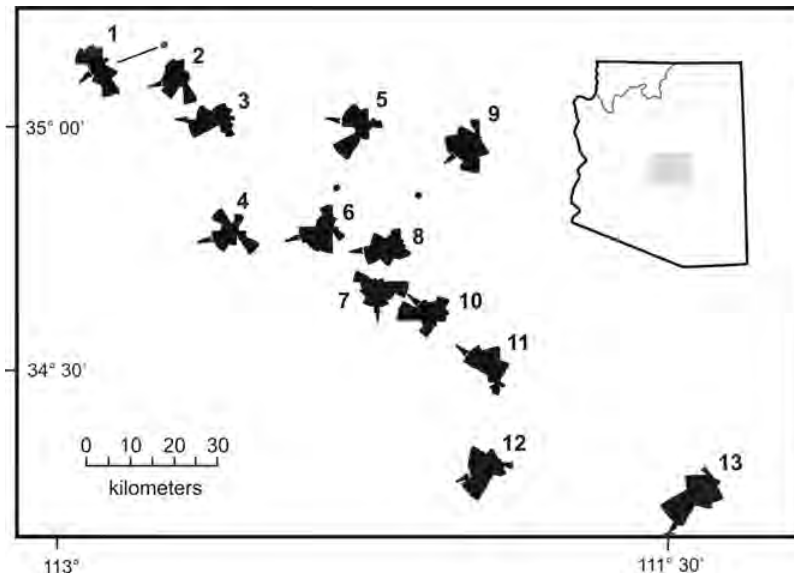


Figure 13. Rose diagram from Central Arizona measured by Hereford (1977, his figure 6) showing direction by percentage of azimuth reading from foresets for each location.

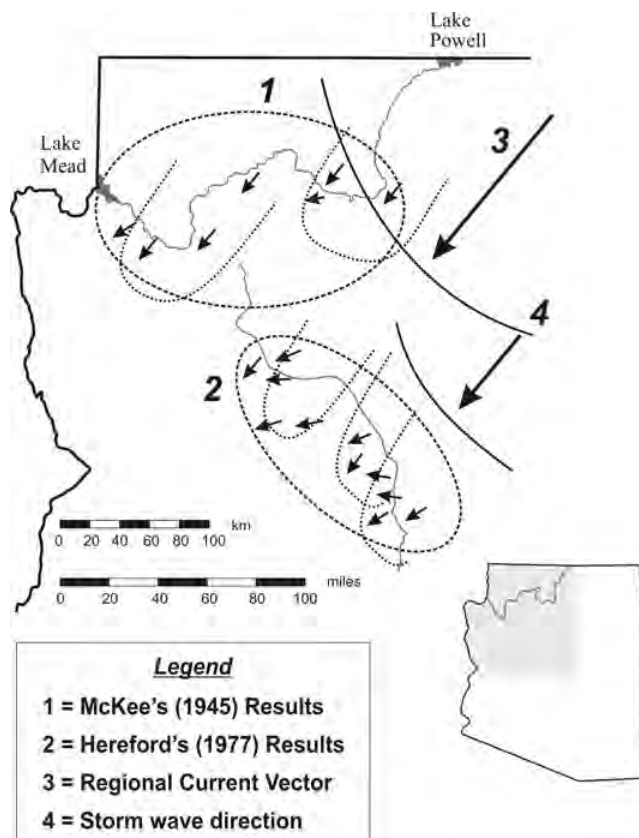


Figure 14. Pattern of lobate deposition in middle and upper Tapeats suggested by distribution of foreset inclinations. Data from McKee (1945) and Hereford (1977).

Smith showed similar diverse foreset inclinations in transverse bar margins in braided streams form as a lobate arrangement. His figure 11, while showing a pronounced preference for the direction of fluvial flow, also shows a logarithmic distribution for 80° on either side of the current. Specifically he recognized “only 40.5% of the foresets measured are oriented within 5° of the current which formed them ... and 86.1% within 45° ” (Smith, 1972, p. 630).

A comparison of McKee's (1945) paleocurrent measurements with Hereford's (1977) rose diagrams shows that no groups fit the patterns described by Klein (1970) or Smith (1972). Instead, they form one-half of an ellipse covering the entire > 300 km (> 186 miles) across the map (Figure 14). McKee's (1945) and Hereford's (1977) Group I form the side of the very wide tongue, while his Group II would be west of the center blending into Group III, the primary current vector.

Hereford (1977, p. 203) suggested “deflections ... around irregularities of the depositional surface” as a reason for his azimuth variations. However, the only significant irregularities on the surface of the Great Unconformity were low monadnocks, and those are restricted to the eastern part of the study area (Barnhart, 2012a, figure 2). In fact, Figures 13 and 14 show the monadnocks occurring precisely where azimuth readings become more regular with less deflection, exactly the opposite of Hereford's (1977) prediction. In the central and western part of the study area—defined by Rose (2006) as a level peneplain without significant vertical variation—current deflections should be less common. McKee (1945, pp. 128–129) said of the monadnocks in the Bright Angel quadrangle,

Only slight variation from the regional direction of movement is indicated even in those sediments that are close to the ancient land

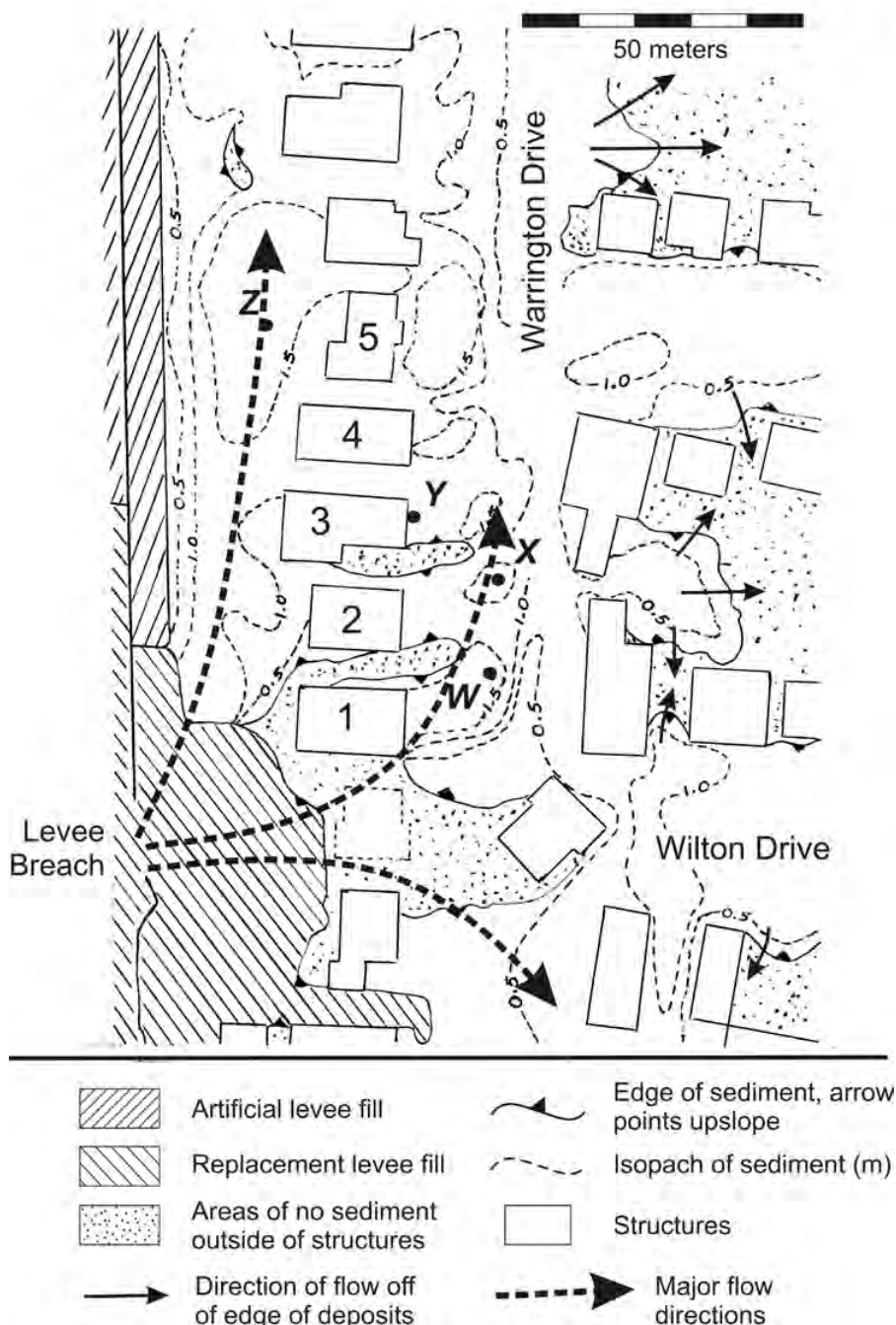


Figure 15. Hurricane Katrina deposits in New Orleans from a single breach in the London Avenue Canal. Dashed lines show major direction of flow around obstructions. Solid arrows show diverse azimuth readings of foreset inclination around tongues at perimeter. From Barnhart (2011).

masses. The conclusion is reached, therefore, that these hills had little influence on the actual deposition near their sides.... Beds of the Cam-

brian sandstone slope away from the hills in all directions, largely as a result of post-consolidations compaction over a hard center ... yet, the

cross-lamination within these beds are constant in direction.

So Hereford's (1977) explanation of deflection around obstacles does not explain variations in direction of flow in the Tapeats Sandstone. Paleocurrent measurements are better explained by seeing the depositional medium of the Tapeats as a broad current of great energy (Figure 14). The levee breaches during Hurricane Katrina demonstrated that azimuth readings will radiate out from the point of origin of the flow, in that case the levee breach (Figure 15). It follows that in a limited area that a narrow current will produce a wider range of azimuths (Figure 16.1) and a wide current will produce a narrower range of azimuths (Figure 16.2).

Thus, Hereford's (1977) rose diagram and McKee's (1945) results correlate well with the concept of a pattern of large-scale depositional tongues (Figure 14) fanning out across Arizona to the east. Although a moving point source (storm or chattering point of slippage on a massive fault motion) for these currents may be simplistic, it does show the feasibility of a high-energy event causing the observed azimuth readings. If sedimentological analyses of bedforms and grains can support a corresponding flow velocity and depth, then this model will gain credibility. Thus, we need to evaluate the grain-size distribution found in the Tapeats Sandstone.

Grain-Size Distribution and Flow Characteristics

The grain-size distribution in strata does not represent the original depositional distribution. Finer grains, carried as suspended load, would occur as a fraction of their original abundance. McKee (1945, p. 51, brackets added) asserted: "skewness [in grain size] is due to competency rather than to lag material." In other words, grain sizes (the determining factor of competency) depend on the ratio of fines carried away

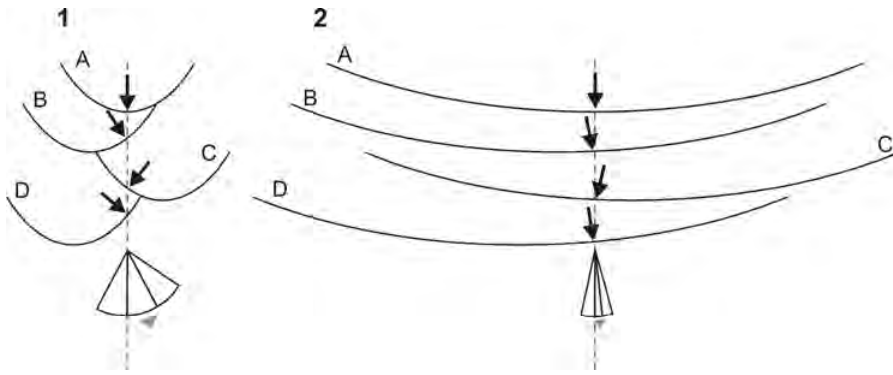


Figure 16. Aerial view of foreset azimuth readings taken through one vertical line through multiple narrow tongues of deposition (1) and wide depositional fronts with the same deviation after each flow (2). Arrows are perpendicular to front at the line and show direction of individual foresets. Sum of arrows shown as simplified rose diagram..

as suspended load to the sizes in the bed load. Careful examination of the grain-size distribution in sandstone can suggest the break in grain size between bed load that was deposited and suspended load that was not. This, in turn, can be used to estimate the flow velocity necessary to remove whatever size grains were carried as the suspended load.

Suspended load grains will not be totally absent because they settle at a constant rate called the *fall velocity*. The fall velocity of fine grains and their resultant rate of settling are largely independent of Bernoulli and turbulence forces (McLane, 1995) that keep larger particles moving above the laminar sublayer (Julien, 1998), where particle motion ceases and grains are deposited.

McKee (1945, his figure 4) took 24 samples of Tapeats Sandstone and measured their grain-size distribution. His histograms are converted to percent in Table I, and representative histograms are shown in Figure 17. Note that modern convention has fine to coarse sizes from left to right; thus, McKee's histograms are reversed. His histograms approximate a bell curve but are all skewed toward the coarser fraction. McLane (1995, his figure 2.2) showed a computer-simulated progression of grain sizes from a random sample of coarse

sediments (Figure 18). Between steps 4 and 6, the curve tails off, producing the characteristic lognormal curve. This skew to the finer fraction becomes more pronounced as the process continues. McLane (1995, p. 14, brackets added) asserted that "the function is not symmetrical but appears to lean towards the origin [positive skew], favoring the smaller values of the variate." Therefore, typical curves resulting from the random breakdown of coarser clasts are skewed to the finer grain sizes. However, this is exactly the opposite of the *observed* spread in all of McKee's histograms. They are all negatively skewed to the coarse fraction.

Despite McKee (1945, p. 39) having "taken [samples] from the upper half of the formation," they approximate a random sample because they are few in number and collected non-systematically over a large area. As such, they do reflect a relatively common distribution of grain sizes with the exception of samples *j* and *l*. These two are uniquely skewed further to the coarse end, perhaps as a result of being collected from a sandy debris flow (Barnhart, 2012a) or from the lag in a cut-and-fill structure. Since both *j* and *l* were collected from opposite sides of the same monadnock, and at the same distance from its peak, they may

both be from the same bedform. Additionally, sample *m* shows a calculation error in McKee's (1945) work, as it sums to a total of 116%. For these reasons, samples *j*, *l*, and *m* were excluded from the *mean* in Figure 17 and Table I. The remaining 21 samples are considered random and representative of normal grain sizes in the flow.

In discussing the separation of sediment between wash load (the part of sediment load moved primarily in suspension), mixed load, and bed load:

Einstein [1950] suggested that the largest size of washload may be arbitrarily chosen as the grain diameter, d_{10} , of which 10% by weight of the bed sediment is finer (Julien, 1998, p. 177, brackets added).

Although it is a valid generality, this might not hold true for a completely random collection of eroded sediment samples. For example, storm runoff may contain a higher percentage of coarse clasts, while farm soil may contain a higher percentage of clay and colloidal particles. However, this generalization should be valid for a well-sorted, mature sandstone like the Tapeats.

McKee's (1945) histograms (Table I and Figure 17) show a consistent break between very fine and fine sand and often a more pronounced break between fine and medium sand. Fine sand is never higher than 7% (Table I), and medium sand shows 10 of the 21 readings to be lower than 10%. Thereby using Einstein's (1950) method, the division between wash load and bed load is found in the range of fine and medium sand.

Another approach suggested by Julien (1998) separates wash load from bed load using the ratio (R_s) between shear (V_o) and fall (ω) velocities:

$$V_o / \omega = R_s \quad (1)$$

Julien (1998) gives a table for values of R_s based on the percent concentration of grain sizes carried in suspension (Table II). If percent is graphed versus

Table I. Grain-size percentages taken from histograms with location. From McKee (1945, his figure 4 and table 5).

Grain Sizes (mm)									Geographic Location	Stratigraphic Location
Sample	< 0.06	> 0.06	> 0.12	> 0.25	> 0.50	> 1.0	> 2.0	Total %		
<i>a</i>	2	3	14	25	29	22	4	99	Grand Wash	50' below transition
<i>b</i>	1	1	2	31	62	3	1	101	Peach Springs Wash	upper transition
<i>c</i>	2	4	6	38	41	8	2	101	Peach Springs Wash	upper transition
<i>d</i>	4	5	9	38	35	6	1	98	Toroweep Valley	10' below transition
<i>e</i>	1	6	26	30	26	9	1	99	Toroweep Valley	20' below transition
<i>f</i>	2	2	5	42	44	5	1	101	1/2 mile west of Kaibab Trail	10' below top
<i>g</i>	0	4	12	39	33	9	3	100	West Fork Pipe Creek	70' below top
<i>h</i>	1	2	5	20	56	14	2	100	West Fork Pipe Creek	50' below top
<i>i</i>	1	6	25	45	20	2	0	99	East Fork Pipe Creek	100' below top
<i>j</i>	1	1	4	15	39	28	16	104	SE of Yaki Point monadnock	50' below top
<i>k</i>	1	2	6	20	45	21	4	99	NE of Yaki Point monadnock	75' below top
<i>l</i>	1	2	9	16	33	28	10	99	NE of Yaki Point monadnock	50' below top
<i>m</i>	2	4	9	39	43	18	1	116	Plateau Point	top
<i>n</i>	2	4	19	35	28	11	1	100	Plateau Point	30' below top
<i>o</i>	1	2	4	18	52	19	3	99	Clear Creek Trail	20' below top
<i>p</i>	1	2	25	46	16	10	1	101	Clear Creek Trail	50' below top
<i>q</i>	2	2	5	25	58	10	1	103	Phantom Bay west end	lower cross-bedded
<i>r</i>	2	5	9	27	53	5	0	101	Phantom Bay west end	lower cross-bedded
<i>s</i>	4	5	15	49	28	1	0	102	Phantom Bay east end	flat bedded 30' above base
<i>t</i>	4	7	12	48	28	1	0	100	Phantom Bay east end	flat bedded middle
<i>u</i>	1	1	4	18	65	10	1	100	Phantom Bay east end	flat bedded top
<i>v</i>	4	5	14	39	37	2	0	101	Phantom Bay east end	flat bedded 2.5' below top
<i>w</i>	1	3	16	36	39	5	1	101	Phantom Bay east end	cross-bedded near base
<i>x</i>	2	5	20	26	39	10	1	103	Phantom Bay east end	cross-bedded base
<i>mean</i>	1.86	3.62	12.05	33.10	39.71	8.71	1.33	100.38	average without <i>j, l, m</i>	see text for explanation

Table II. Modes of sediment transport given shear (V_0) and fall (ω) velocities. $V_0 / \omega = R_s$. $C_{0.8} = 0.75 C_{0.2}$ reads: the concentration at 80% of height from the bed equals 75% of the concentration at 20% of height from the bed. From Julien (1998, his table 10.2).

R_s	Mode of Sediment Transport
< 0.2	No motion for all possible grain sizes
0.2	Lowest possible motion for turbulent flow over rough boundaries
0.2–0.4	Sediment transport as bed load
0.4–2.5	Sediment transport as mixed load
> 2.5	Sediment transport in suspension
25	$C_{0.8} = 0.75 C_{0.2}$
100	$C_{0.8} = 0.93 C_{0.2}$
400	$C_{0.8} = 0.98 C_{0.2}$

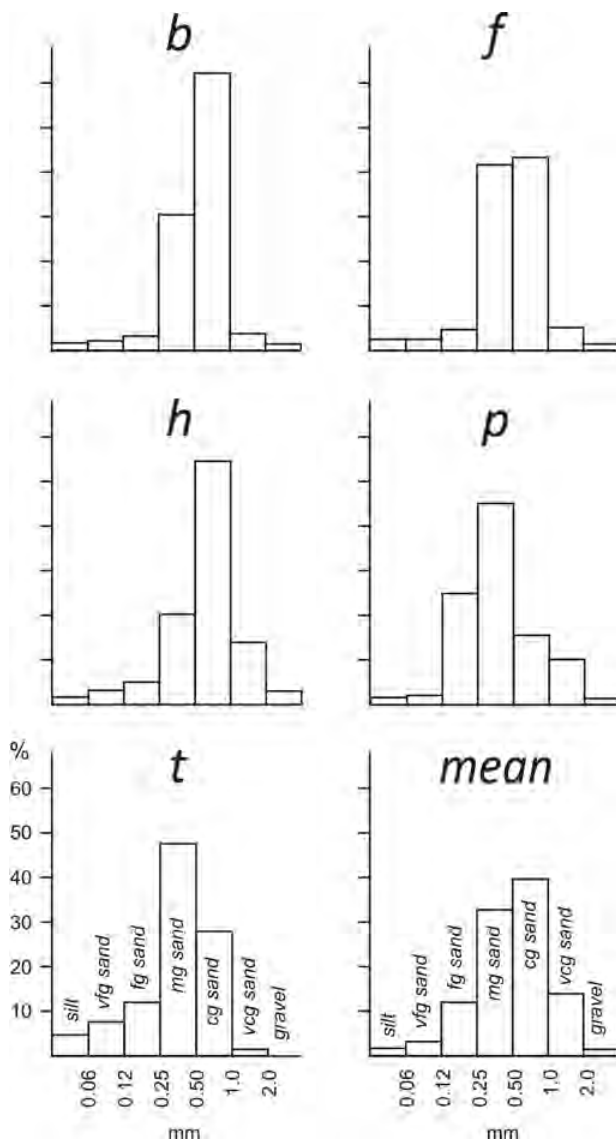


Figure 17. Histograms of grain-size distribution. Five samples taken from McKee (1945, his figure 4) and the calculated *mean*. See text for discussion.

the R_s values, Figure 19 can be used to extrapolate the suspended load as a percent of the total load. Values for ω at 20° C, obtained from Julien (1998), and R_s values from Table II, rearranging formula (1), V_0 is derived and compared in Table III. Using Figure 19, these values convert to the percentage of grains missing in each size range up to and including the suspended load.

Converting McLane's (1995) graph in Figure 18 step 8 to a line, McKee's (1945) histogram *h* and the *mean* derived in this study (Figure 17) are imposed below the lognormal line (Figure 20.1 and 20.2). The lognormal distribution curve from McLane and McKee's histograms do not appear similar in shape, especially in the first 5 grain-size columns (up to coarse sand). This illustrates the positive and negative skew discussed above. If the first columns are underrepresented, it is likely due to the loss of suspended load in transport. Table III gives the percent suspended by grain size at various shear velocities.

In Figure 20.4, McKee's *mean* histogram and lognormal curve, comparing the point of suspension, at $V_0 = 15$ cm/s (0.15 m/s) the coarse sand fraction is still less than 10% in suspension and is thus the closest critical grain size (Einstein, 1950). At the same shear velocity, the very fine sand has reached 82% in suspension. This means that the fraction shown on the *mean* histogram measuring 3.62% of the total grains would represent less than one percent considering the original grain concentration for that size range.

Comparing the lognormal line of McLane's and McKee's histogram *h* in Figure 20.3, the change seems to be in the area of $d > 1.0$ mm, very coarse sand. At 30 cm/s (0.3 m/s) from Table III, the fraction $d > 1.0$ mm passes the critical 10% portion in suspension, and so that column and all those to the left would be overrepresented in McKee's (1945) histogram. For the $d > 0.0625$ mm, the very fine sand fraction at 30 cm/s, Table III shows 92% suspended load. Table I

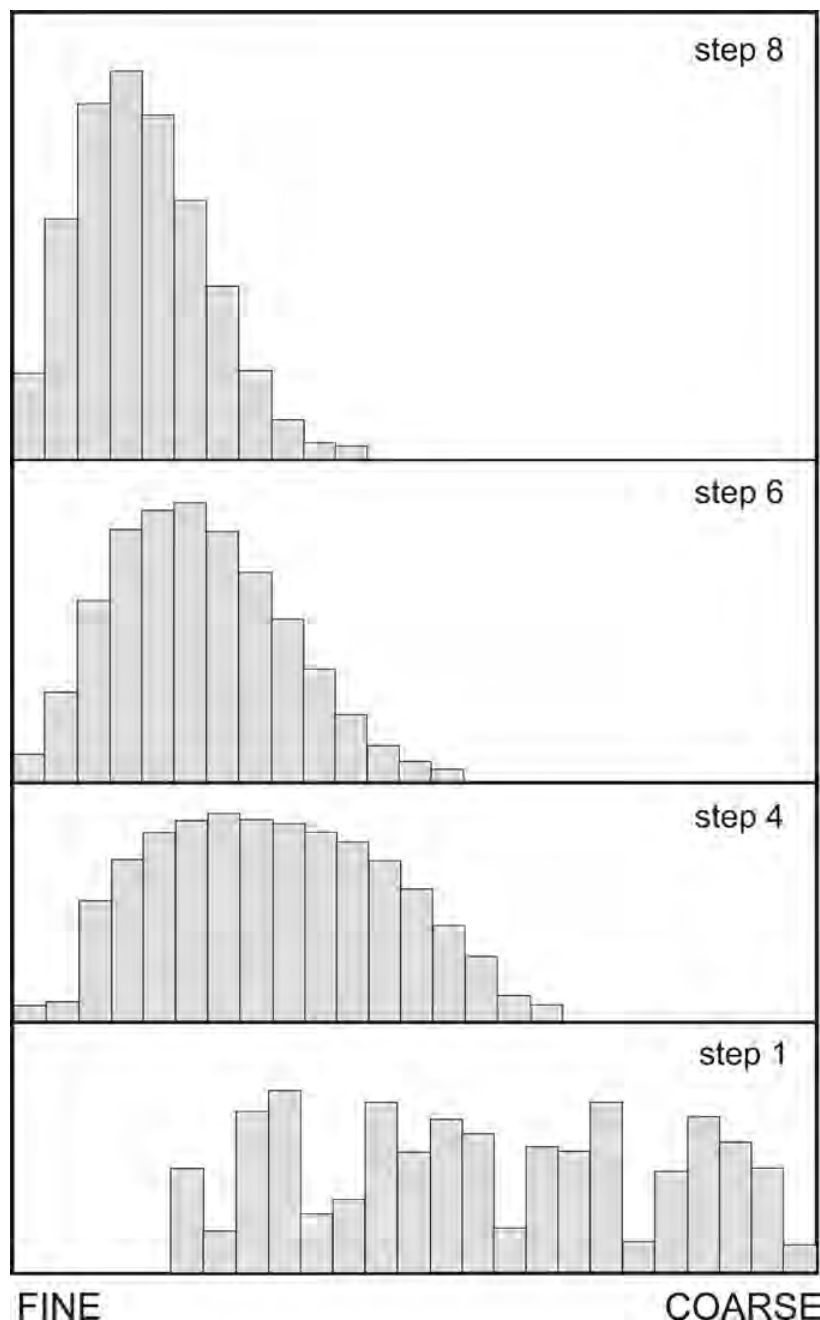


Figure 18. Histogram of computer-simulated progression from random clast size to lognormal distribution of smaller sizes after repeated application of proportional-effect rule. From McLane (1995, his figure 2-2 showing his steps 1, 4, 6, and 8).

shows $d > 0.06 = 2\%$ of the total, and if the total under the lognormal curve for $d > 0.06$ is approximately 20% then the adjusted amount for very fine sand would be about 2%. Similar adjustments must be made for each column

in Figures 20.3 and 20.4. The hatched area would be the grains missing, based on the calculations in Table III using the R_s method. Figure 20.4, the *mean*, would represent deposition under shear velocity (V_0) of 0.3 m/s.

Shear velocity is the flow velocity at the boundary layer, where a stable particle is put into motion. It is almost always much slower than the average velocity higher in the flow. Ruben and McCulloch (1980), using Keulegan's (1938) classic work, give the following formula for converting between the two velocities, where h = flow depth and f = friction factor:

$$=V_0 (5.75 \log (0.37 h/f)) \quad (2)$$

Lalomov (2007, p. 276) provided the formula for Keulegan's friction factor (f), where d = critical grain diameter:

$$f = (2.03 \log (12.2 h/d_{max}))^{-2} \quad (3)$$

Table IV shows representative conversions between shear and average velocity for possible flow depths.

For Figure 20.4 and $V_0 = 0.15$ m/s, using $d > 0.5$ mm as the critical grain size for determining suspension and assuming the shallowest depth of flow that would deposit a 10 cm (3.93 in)-thick compound cross bed, Table IV yields an average flow velocity of 1.04 m/s. As flow depth increases (for thicker layers), up to $h = 9.0$ m, increases to 2.24 m/s. Using Figure 20.3 and using $V_0 = 0.3$ m/s, $d > 1.0$ mm as the critical grain size, and a minimal depth of 0.6 m, we find that = 1.96 m/s. For the greater depth of 9.0 m, = 4.38 m/s.

A possible environmental explanation for these numbers would be a wave. It would begin by depositing the thicker diagonal flat beds (compound cross bedding) at the maximum depth of 9 m (30 ft) and a velocity of over 4 m/s (about 9 mph). As the wave passed, it would deposit the thinner horizontal flat beds as the depth decreased to less than a meter and the tail velocity of the wave diminished to about 2 m/s (about 4.5 mph).

These velocities will result in the deposition of dunes to upper-regime flat beds (Figures 21.1 and 21.2). As

Table III. Shear velocities and R_s factors for histogram separation of sizes when deposited at various velocities. Percentages represent % solids as read from Figure 19.

column	d (mm)	W (cm/s)	$V_o = 10$ cm/s		$V_o = 15$ cm/s		$V_o = 20$ cm/s		$V_o = 30$ cm/s		$V_o = 40$ cm/s	
			R_s	%	R_s	%	R_s	%	R_s	%	R_s	%
1	< 0.0625 SILT	---	---	---	---	---	---	---	---	---	---	---
2	> 0.0625 VERY FINE	0.347	29	77	43	82	58	86	86	92	115	94
3	> 0.125 FINE	1.28	7.8	52	11.7	59	15.6	68	23	72	31	78
4	> 0.25 MEDIUM	3.6	2.8	20	4.2	34	5.6	43	8.3	53	11	58
5	> 0.5 COARSE	7.03	1.42	< 10	2.1	< 10	2.8	20	4.3	34	5.7	41
6	> 1.0 VERY COARSE	11.2	---	---	---	---	1.8	< 10	2.6	15	3.6	28
7	> 2.0 GRAVEL	---	---	---	---	---	---	---	---	---	---	---

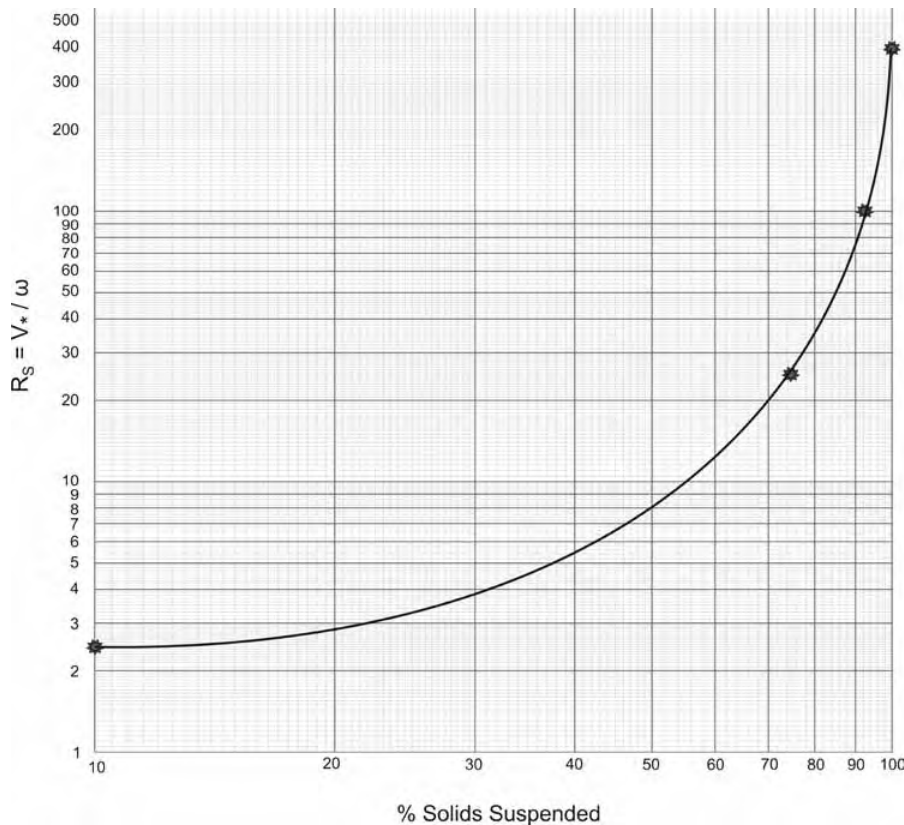


Figure 19. Percent of clasts carried in suspension as determined by R_s values. Graphed curve based on four points of Julien (1998, p. 188) marked with stars. See also Table III.

noted above, changes between these two bedforms are a function of competency, which in turn varies with depth; changes in rheology are not necessary. As both are high-velocity bedforms, the current was most likely a high-velocity unidirectional current.

What became of the missing fine fraction represented by the hatch marks in Figure 20.3 and 20.4? Hereford (1977) did not provide significant grain-size information for central Arizona; thus it is unclear whether or not grain size decreases downstream. Or are fines simply missing because they were transported out of the area? This question needs further research.

Rhythmic Patterns and Rate of Deposition

Figure 22 is an outcrop in the eastern part of Chuar Canyon (Figure 1), where the still-plastic sandstone of the Tapeats is deformed and tilted upward. The East Kaibab monocline runs north-south for about 300 km (186 miles) and probably extends both north and south beyond its exposure (Huntoon, 2003). Although this post-depositional deformation absent extensive fracturing is an interesting

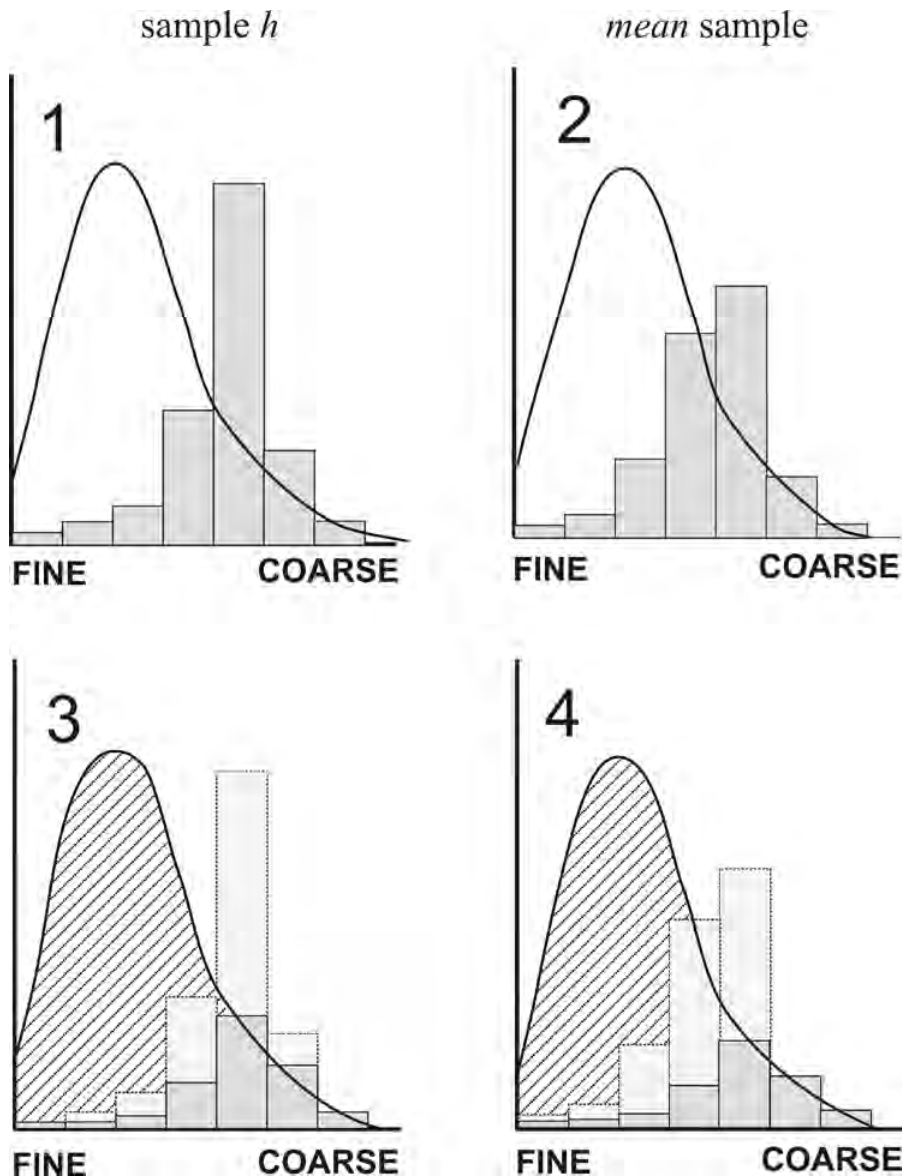


Figure 20. Comparison of lognormal curve from Figure 18, step 8, superimposed over (20.1) a representative sample (p) from McKee (1945, his figure 4), and (20.2) *mean* from Figure 17. 20.3 and 20.4 are same samples with histograms adjusted to reflect percentages of original lognormal grain sizes still present. Hatched areas represent missing clast due to suspension in wash load.

question (cf., Snelling, 2009), this study is more interested in the alternating thick and thin layers in the Tapeats at this location. Figure 22 shows nine of these repetitions at about 3 m thick, while Figure 4 shows greater detail of five repetitions.

Similar repetitions were observed in the Hurricane Katrina splay deposits (Barnhart, 2011), interpreted as evidence of repeated pulses of energy. Those alternating beds repeated at intervals of 18–25 cm (7–9.8 in) and were interpreted as products of the rhythmic

passing of storm surges as the waves propagated down the canal from Lake Pontchartrain and through the breach, each leaving deposits about 3 cm (1.18 in) thick.

In Figure 4 a similar pattern can be seen in a 1.0–1.5 m (3.3–4.9 ft)-thick group of thin layers, each about 3–4 cm (1.18–1.57 in) thick, separated by a thick layer of cross bedding about 1.5 m thick, or by several thinner layers about 10 cm (3.93 in) thick. The complete cycle makes a repeating pattern about 2.5–3.0 m (8.2–9.8 ft) thick, which is consistent with the approximate 3.0 m rhythmic pattern of Figure 22.

Allen (1976) estimated flow depth to be about 6–8 times dune height, which suggests flow depth of 0.3–12 m (0.98–39.4 ft). Based on modern storms, the initial wave at the front of the storm surge would be larger, followed by less energetic waves between storm pulses. While there is no firm evidence in the Tapeats for a causal mechanism, a repeating sequence of relatively small waves interspersed by larger waves (up to 12 m) would be consistent with large compressional waves produced at regular intervals by a storm or by significant recurring fault motions but cannot be explained by normal tidal cycle deposition, as proposed by secular geologists. The Tapeats does not conform to modern facies models.

Another failure of modern facies models is found in the energy at deposition. Barnhart (2012a) estimates it at 9–54 m/hr (29.5–177 ft/hr) for the lower Tapeats. Given the thickest measured section of Tapeats (Noble, 1922, at the Bass Trail) is 120 m (393 ft), the entire sequence could have been deposited in as little as 3 hours. No modern depositional environment provides an analog for that scale and rate of sedimentation. Though the rate seems very high, the wave pattern—one 12 m wave followed by smaller waves repeating at a rate of the largest wave every 10 minutes—yields a total depositional rate of 15–18

Table IV. Some shear velocities converted to average velocities for some representative flow depths. Froude numbers (Fr) provide a relative measure of flow agitation as it approaches $Fr = 0.84$ where antidunes start to form.

d (m)	h (m)	f	$V_0 = 0.1$	Fr	$V_0 = 0.15$	Fr	$V_0 = 0.2$	Fr	$V_0 = 0.3$	Fr	$V_0 = 0.4$	Fr
0.001	0.6	0.016	0.65	0.27	0.98	0.40	1.31	0.54	1.96	0.81	2.61	1.07
0.0005	0.6	0.014	0.69	0.28	1.04	0.42	1.38	0.57	2.07	0.85	2.76	1.14
0.00025	0.6	0.012	0.73	0.30	1.09	0.45	1.45	0.58	2.18	0.93	2.90	1.19
0.001	3.0	0.012	1.14	0.21	1.71	0.32	2.28	0.42	3.41	0.63	4.56	0.84
0.0005	3.0	0.010	1.17	0.22	1.75	0.32	2.34	0.43	3.51	0.65	4.68	0.86
0.00025	3.0	0.009	1.20	0.22	1.80	0.33	2.40	0.44	3.60	0.66	4.80	0.89
0.001	6.0	0.010	1.34	0.17	2.01	0.26	2.68	0.35	4.03	0.53	5.36	0.70
0.0005	6.0	0.009	1.37	0.17	2.06	0.27	2.74	0.36	4.12	0.54	5.48	0.71
0.00025	6.0	0.008	1.40	0.18	2.10	0.27	2.80	0.37	4.20	0.55	5.60	0.73
0.001	9.0	0.010	1.46	0.16	2.19	0.23	2.92	0.31	4.38	0.47	5.84	0.62
0.0005	9.0	0.009	1.49	0.16	2.24	0.24	2.98	0.32	4.47	0.48	5.96	0.63
0.00025	9.0	0.008	1.52	0.16	2.28	0.24	3.04	0.32	4.56	0.49	6.08	0.65

m/hr (49–59 ft/hr). Even the lower end would deposit the entire Tapeats 120 m thickness in only 8 hours. At that same rate, the entire thickness of the Grand Canyon sedimentary sequence (1,829 m, or 6,000 ft) would require only 122 hours. Of course, this does not include thickness lost to erosion or compaction, but the essential point remains: the Tapeats was laid down in hours, not millions of years.

Even creationists can underestimate the depositional potential of the Flood. At these rates, much of the sedimentary record could have been deposited even in the first 40 days of the Flood! As Henry Morris (2003, p. 7) wisely said:

Veneration of the Bible for its 'spiritual value' only is ... inconsistent with rejection of its scientific and historical teachings. If the latter cannot be trusted—that is, statements which

are susceptible to actual human investigation and proof—then how can its spiritual teachings, which are not susceptible of proof, be trusted?

Conclusion

Classic studies of the Tapeats Sandstone have interpreted its depositional environment as a low-energy beach or nearshore settings, promoting slow deposition and a facies model approach. However, the different approach of these two papers has shown that template to be inadequate; the hydrodynamic method suggests a quite different mode of deposition.

Monadnocks are not the scattered remnants of shoreline highlands, but are infrequent irregularities in a rapidly formed planation surface in excess of 23,000 km² (8,880 miles²) cut into both

crystalline basement and sedimentary strata (Figure 23B). They are typically a few meters high, though some reach as high as 140 m, and the only breccia that remains is in scattered aprons in close proximity to some of the highs. These scattered elevations resulted from the vagaries of the current and are independent of the substrate hardness. Immediately following erosion, while breccia remained on the monadnocks (Figure 23C), the inrushing high-velocity hyperconcentrated current (Figure 23D), probably accompanied by considerable precipitation, washed the loose breccia down into the incoming current (Figure 23E), producing high-density turbulent currents that deposited cross beds from sandy debris flows (Figure 23F) within the otherwise flat hyperconcentrated laminae (Figure 23G) formed by the primary current.

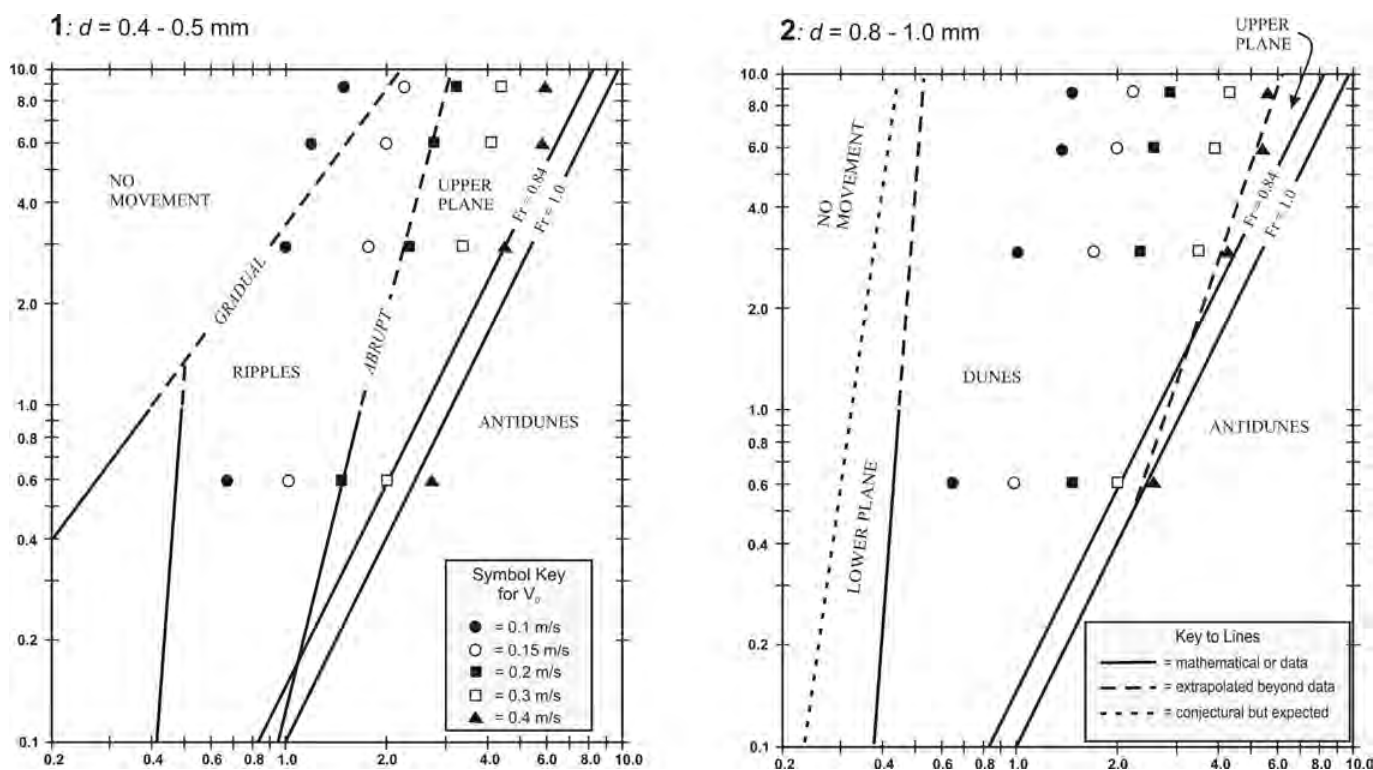


Figure 21. Bedform stability graphs for grain sizes (21.1) $d = 0.4-0.5$ mm and (21.2) $d = 0.8-1.0$ mm. Solid lines represent transitions between bedforms as presented by Southard and Buguchwal (1990, their figures 2H and 2K) and mathematical derivation. Dotted lines extrapolated beyond data. Long dashed line conjectural but expected. Symbols show values of shear velocity (V_o) at varied flow depths as represented in Table IV.

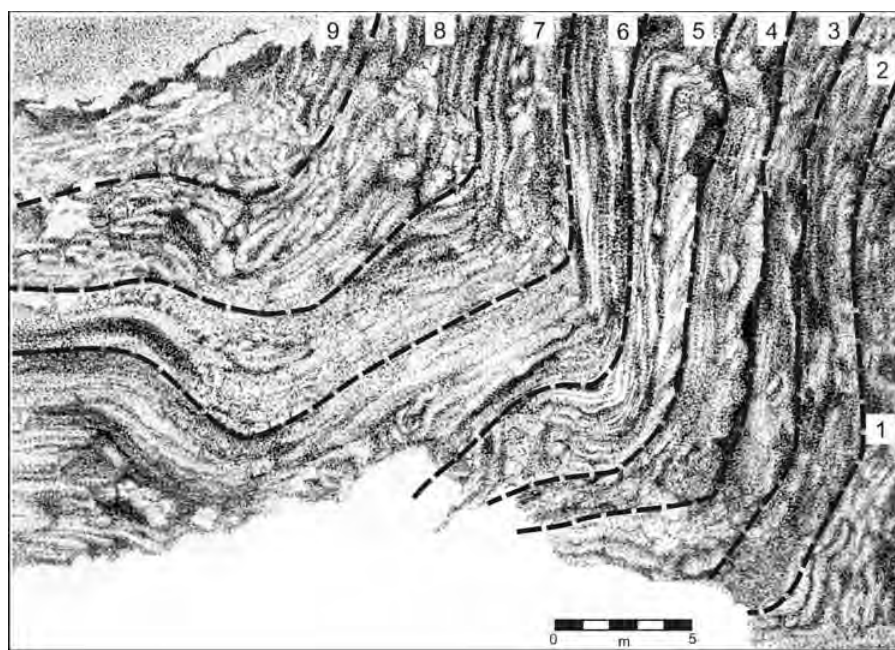


Figure 22. Chuar Canyon (Carbon Canyon?) exposure of East Kaibab monocline showing nine repetitions of thick and thin sequences. Modified from Snelling (2009).

The depositing current, with 20–30% solids, was plastic, like a mudflow off a steep, denuded hillside after a heavy rain. However, the Tapeats was deposited across a broad flat plain with a slope of only about 0.001 or 0.14%, and with no nearby highlands to provide the gradient and thus the energy for the current. That the monadnocks are not a residual highland at the time of deposition is seen in their only minor effect on the broad laminar bedforms; the sandy debris flows caused by cascading breccia are quite limited in extent.

This high-velocity hyperconcentrated current flowed northeast to southwest and was shallow—1–2 m—but reached velocities of 2.0–4.7 m/s (4.5–8 mph). In comparison, the present-day Colorado River flows at around 3 mph. With no nearby gradient, it is likely that this current, as broad as it was, was instead powered by the head pres-

sure of a large storm surge or by that created by crustal motion. It was also abrupt; whatever water was present beforehand (but after planation) was insufficient to transport the breccia off the monadnocks.

The nature of the current is seen in the Tapeats sands; deposition was so rapid

that the sequence of the lithology was dependent on the order of entrainment and the sorting provided by the highly turbulent flow. There is little evidence of post-depositional reworking or differential settling. At no time did this high-velocity, unidirectional current provide any period of slack energy within its flow.

As sedimentation progressed to the middle and upper Tapeats, more water was entrained with the sediments and the rheology changed from plastic to fluidal flow. With deposition taking place across a 300-km front, the current separated into multiple shifting tongues (Figure 23H). Increasing fluidal conditions resulted in decreased viscosity and increased velocity to over 4 m/s (9 mph). Individual tongues were still highly turbulent under their 12 m wave fronts (Figure 23I). Higher energy at the wave front eroded channels into the unconsolidated substrate (Figure 23J), resulting in cross beds up to 1.5 m followed by thin high-velocity flat beds deposited in the shallowing wave train (Figure 23K), which had increased competency. These sets of strata reached 3 m; each deposited by a major wave front and the following wave train. This rhythmic repetition of bedforms persists for over 200 km along the axis of flow. This pattern

Table V. Revised velocities calculations based on lower slopes and increased flow depth (h). Set of velocities obtained by increasing Froude number to 1.2.

S	$d_{\max}$ (m)	% solid (vol)	τ_0 (Pa)	h (m)	n	$\bar{V}$ (m/s)	Fr	$\bar{V}$ (m/s) at Fr = 1.2
0.0014	0.038	20	24.6	1.35	0.0156	2.85	0.78	4.37
			21.6	1.05		2.44	0.76	3.85
	0.064	30	41.5	2.28		4.10	0.87	5.67
			36.3	1.77		3.46	0.83	5.00

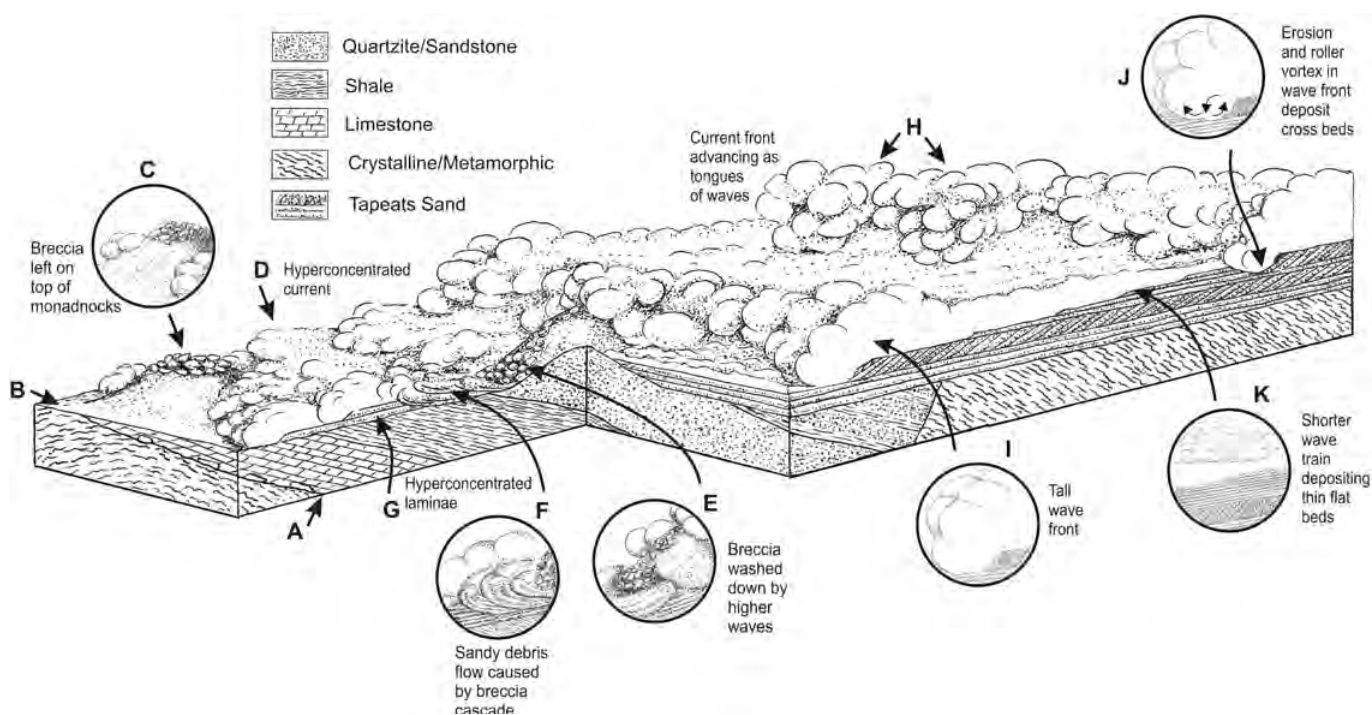


Figure 23. Cartoon diagram of lithology in the Tapeats and its spatial relationship to lithology below the (A) Greater Unconformity and (B) Great Unconformity planation surface. Comparative height and turbulence of waves from the northeast to southwest is suggested. See text for further explanation.

of waves is reminiscent of storm waves created by hurricanes or compressional waves generated by stuttering crustal motions such as submarine earthquakes.

The high velocity of the initial wave in the train is suggested by the tangential toe contact of the cross bedding and in the internal compound cross bedding. The presence of tangential toe contacts in the cross beds associated with the high-velocity flat beds shows no significant loss of velocity, only a change in competency, with a decrease in depth to only 0.3 m. If a wave train passed a given point every 10 minutes, a depositional rate of only 1.5 m per wave train would deposit the entire 120 m thickness of the Tapeats in only 8 hours. If a wave train striatal package was 3 meters per wave, the Tapeats would have been deposited in as little as 4 hours.

There is no clear evidence as to whether or not deposition took place under subaerial conditions with significant precipitation or as a hyperpycnal flow under standing water. Perhaps it was the former since precipitation would add extra water to produce fluidal flow. However, it is hard to imagine the necessary waves moving over such broad distances with such shallow water on almost no gradient. Further research may offer better explanations as it shows subtle changes in the bedforms over the full flow distance.

An interesting inference of this hydrodynamic assessment is the surprising presence of trace fossils in such a high-energy environment. *Diplocraterium* occur in the tangential toe contacts of cross bedding and throughout the upper Tapeats. Typical interpretations would suggest a low-energy, stable marine environment. This strongly suggests that these traces are escape structures generated by organisms transported inland by the wave trains. It implies that the presence of ichnofossils should not immediately preclude deposition under high-energy conditions.

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The Little Ice Age in the North Atlantic Region

Part IV: Norway

Peter Klevberg, Michael J. Oard*

Abstract

The first two parts of this series (Klevberg and Oard, 2011a, 2011b) introduced methods of studying past climate change, the historicity of the Medieval Warm Period and Little Ice Age, and the importance of the Little Ice Age in understanding climate change and constraining climatic models. The third part (Klevberg and Oard, 2012) provided more detailed reasons for concentrating on the North Atlantic region and summarized the rich climatic and glaciologic history of Iceland. Our study of the effects of the Little Ice Age in the North Atlantic region continues with this paper, which presents a summary of climate change indicators and the history of the Little Ice Age in Norway.

Overview of Norwegian Glaciers

Both Norway and Iceland benefit from the warming effects of North Atlantic Ocean currents (Figure 1). In contrast with Iceland, Norway has significant landmasses to the east with their continental climate. Mainland Europe's largest ice cap, Jostedalsgreen, is significantly smaller than Iceland's Vatnajökull, which edges Svalbard on a volume basis as the world's third largest ice cap. Important Norwegian glaciers are shown on Figure 2 and summarized in Table I.

Norway occupies the western half of the Scandinavian Peninsula, which



Figure 1. The North Atlantic Region. Cold ocean currents shown in black, warmer currents in gray.

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is large enough to provide significant climatic contrast. Glaciers near the coast are considered maritime, and respond differently to climatic variation than the inland glaciers (Bakke et al., 2008).

Evidences of Ancient Climate Changes

Evidence of markedly colder and warmer temperatures in the past than the present is plentiful in Norway (Bakke et al., 2005; Lillehammer, 1994). Fjords are overdeepened valleys flooded by the sea. Their form and location in high latitudes lend credence to the almost universal belief that they were shaped by moving ice. It is largely believed Norway was virtually buried by ice during the “Pleistocene,” with outlet glaciers forming the fjords (Figure 3) and sculpting the interior (Follestad and Fredin, 2007; Lillehammer, 1994; many others—see virtually any book on Scandinavian geography), though evidence of lack of glaciation on many highlands (*vidder*) and *blokkhav* (alpine boulder fields) in high mountains is becoming more widely known. Yet even though much geologic work that led to development of fjords and mountains and other landforms was likely not glacial (Lidmar-Bergström et al., 2000), the extent of features that do appear glacial is extensive and much greater in magnitude than what has occurred in recorded history. Evidence in Norway of arctic wildlife and very different conditions from today is easy to come by (Lillehammer, 1994).

Some have speculated that Norwegian glaciers disappeared entirely during the “early Holocene climatic optimum” (Nesje et al., 2008; NORPAST, 2001), which is believed to have been more than 1°C warmer than at present (Bjune et al., 2005; Dahl and Nesje, 1994) and possibly 3°C warmer (Jensen and Vorren, 2008). Pine stumps are present on the high mountain plateau Hardangarvidda, far above the present treeline, and the treeline in Ranafjorden just southwest



Figure 2. Principal Norwegian glaciers.

of Svartisen (Figure 2) was 185 m (610 feet) higher than today (Lillehammer, 1994) in what we interpret to be early postdiluvian time (perhaps immediately following the Great Ice Age). Comparable treeline differences have been found in studies in northern Norway (Bakke et al., 2005), and the Varanger Peninsula at the northern tip of Norway (Finnmark), which today is treeless, was forested (Lillehammer, 1994). Some researchers believe the equilibrium line altitude (ELA) in Finnmark was 100 to

200 m higher than now, meaning an average temperature +1.2°C relative to today (Karlen and Kuylenstierna, 1996). Major inferred climatic periods are summarized in Table II (traditional interpretation).

Climate change in recent centuries is also documented. In the region of Jostedalsbreen (Figure 2), trails documented in the twelfth century between farms crossed areas that to this day are covered by ice (Grove, 1988). This indicates that the climate had been

Table I. Summary of Norwegian Glaciers.

Figure Number	Glaciers/Locale*	Glacier Type(s)	Area (km ²)*	Maximum Elevation (masl)	Elevation of Termini (masl)	E.L.A. (masl)
2	Blåmannisen	ice cap	87			
2	Folgefonna	ice cap	> 83		1050–1235	> 1659
2	Hardangarjökulen	ice cap	73		1020–1360	> 1860
2	Jostedalsbreen	ice cap	486		350–1200	
2	Jotunheimen (Storbreen, Hellstugubreen, Gråsubreen; total)	cirque, valley	5.4			> 2090
			3.0			> 2200
			2.2			> 2290
			37.9		1390–1830	> 2290
2	Langfjordjøkulen	plateau	8.4			>1050
2	Lyngen, Storsteinsfjellbreen	cirque, valley	141	1833–1894	400–1000	
2	Okstinden	ice cap	15.1		730–1090	
1	Svalbard (total)	ice cap, cirque, valley, piedmont	36,500		typically near 0	200–800
2	Svartisen	ice cap	> 40		10–774	
2	Ålfotbreen	ice cap	7.6			>1382

*Indicated area typically includes multiple glaciers.

Data from Bakke et al., 2005; Kjølmoen, 2007; and Liestøl, 1967.



Figure 3. Looking south down Sunnlyvsfjorden from Klevberg, Sunnmøre, Norway. Photograph by Helge Klevberg.

relatively warm (or very dry) for a considerable period (Medieval Warm Period?). Even then, considerable variation was possible. Cold years are spoken of just after AD 1000, but only for a short time (Krag, 1995). The forest chopped down on the Rørosvidda during the Little Ice Age never grew back; it apparently had formed during a warmer period (Sogner, 1996). Proxy data from Folgefonna do not provide unequivocal evidence for the Medieval Warm Period (Bakke et al., 2005). Recent melting in Jotunheimen (Figure 2) has exposed artifacts indicating areas were bare 1,500 years ago that have been under ice since (Lepperød, 2010). If the dating is correct, then ice covered this area before the Little Ice Age and did not melt during the Medieval Warm Period, even though land use indicates the Medieval Warm Period was significantly more clement than at present (Helle, 1995)—evidence that the

Table II. Paleoclimatology of Norway.

Conventional Nomenclature*	Uncorrected ^{14}C date**	Corrected ^{14}C date**	Paleoclimatological Data & Interpretations
Paleolithic - immediately after deglaciation (Boreal)	10000–9000 B.C.	3060–3020 B.C.	Oldest ^{14}C -dated habitation site (Sarnes på Magerøya)
<i>“Lower Atlantic time”</i>	9000–8000 B.C.	3020–2975 B.C.	<i>Cold period, glacial advance</i>
	8000–7000 B.C.	2975–2915 B.C.	Climatic amelioration, forest advance
	7000–6000 B.C.	2915–2835 B.C.	At least 12.5°C avg. summer temperature (14°C+ in Østlandet based on <i>Cladium mariscus</i>)
<i>“Wet Atlantic time” — Mesolithic</i>	6000–3000 B.C.	2835–2315 B.C.	Treeline in Ranafjord area 185 m higher than today (Hardangarvidda similar)
<i>Sub-Boreal time — Neolithic</i>	3000–1000 B.C.	2315–980 B.C.	Somewhat lower precipitation and mild winters, average temperature 2–3°C warmer than present
Bronze Age	1000 B.C. - 0	980–0 B.C.	Markedly colder, forest disappeared from Varanger coastal areas
<i>Sub-Atlantic time — Older Iron Age</i>	0–400 A.D.	0–400 A.D.	Markedly warmer at time of Christ, with average temperature ca. 1°C warmer than present
Younger Iron Age to Viking Era	400–700 A.D.	400–700 A.D.	Return to colder climate
Viking Era to High Middle Ages	700–1200 A.D.	700 – 1200 A.D.	Generally warmer climate; land suitable for pasture was at least twice present area
High Middle Ages to Mid-Nineteenth Century	1200–1850 A.D.	1200–1850 A.D.	LITTLE ICE AGE
Modern Era	1850 A.D. – present	1850 A.D. – present	Global warming relative to Little Ice Age (climatic recovery)

Table generalized from a large number of sources.

*Conventional paleoclimatological terminology italicized, conventional anthropological/archaeological terminology not italicized.

**First Approximation Correction of ^{14}C Dates Using Brown (2006) Equation. Dates from Medieval times to present generally established independent of radiocarbon.

complexities of climatology, including variations in both temperature and precipitation, must be taken into account in attempting to explain glacial history in Norway, especially at these sites 2000 m above sea level.

The Little Ice Age Advances

In general, the coming of the Little Ice Age parallels that observed in Iceland, Switzerland, and elsewhere. Norway experienced a change toward a cooler and wetter climate beginning in the

1200s (Helle, 1995) and worsening after 1590 (Rian, 1995). The 1600s were a time of difficulty in Europe from a variety of sources, but “cold weather” featured high on the list (Rian, 1995, p. 222). Grove (1988, p. 78) states that government reports from 1702 reveal widespread evidence of “dramatic and swift” climatic deterioration after 1667. Late and early frosts and ice in fresh and saltwater bodies that today are virtually ice-free are recorded from the 1700s (Sogner, 1996). After somewhat milder but unstable years at the end of the

eighteenth century, the early 1800s had cold winters and often cold summers (Dyrvik and Feldbæk, 1996; Seip, 1997).

Records of destruction of Norwegian farms by advancing glaciers, though limited, appear contemporary with (or up to a century later than) similar events in Iceland and Switzerland (Table III). Norwegian agriculture also suffered from the cooler climate and shorter growing seasons, even where glacial advance was not a threat (Grove, 1988).

Newer research has confirmed that deterioration in climate occurred

beginning in the latter half of the 1200s. The summer temperature was lower, and the average temperature decreased. This was a weather pattern that came to dominate clear into the 1700s, with warmer periods between. (Bjørvik, 1996, p. 33)

Norwegian glaciers grew in all parts of the country, though more so in the south than the north, and with some differences in timing. Figure 4 compares glacial fluctuations for major Norwegian glaciers. The locations of these glaciers are indicated on Figure 2. In general, Norwegian glaciers reached their maximum extent in the mid to late 1700s (Grove, 1988). Historic fluctuations of important Norwegian glaciers are shown in Figure 4 and described individually below. The locations of these glaciers are shown in Figure 2.

Folgefonna

Folgefonna is Norway's third largest body of ice, after Jostedalsbreen and Svartisen (Kjøllmoen, 2007). It experienced three significant advances: (1) at approximately AD 1750, (2) in AD 1870, and (3) around 1930 (Bakke et al., 2005). As is typical, minor advances and retreats occurred between these major episodes. Folgefonna is a maritime glacier and is strongly influenced by winter precipitation.

Jostedalsbreen

Abandonment of some of the farms in the Jostedal area purportedly preceded the Black Death (Grove, 1988), which may indicate a glacial advance at that time. Bjørvik (1996, p. 34) states, "The 'Little Ice Age' fits the Jostedalsbreen region well from the middle of the 1200s." Grove (1988) cites Schøning's record

from 1761, which states that cold years and bad harvests occurred from 1294 on. "The earliest reliable evidence of direct damage to farmland by advancing ice in Scandinavia comes from Jostedal in a brief account, dated 1684" (Grove, 1988, p. 69). Jostedal had been resettled in the 1500s (it had been abandoned as a result of the Black Death), contemporary with the demise of farms from the Mont Blanc glaciers in the Alps (Grove, 1988). Accounts from the early 1700s indicate significant glacial advance that overran relatively large areas that had been farmed for long periods, though the advances were typically interspersed with smaller recessions (Strøm, 2001). "In sum, evidence from the farm histories of Jostedalen dates the descent of the ice from the high tributary valleys to the 1680s and the subsequent encroachment onto permanent farm sites to the period

Table III. Farm or Settlement Overrun by Ice During Little Ice Age.

Farm or Settlement	Location	Glacier	Date Overrun
Fjall	Iceland	Breiðamerkurjökull	ca. 1700
Breiðá			1697–1700
Kári Sólmundarsson's tomb			pre 1712
Breiðamersandur farms			ca. 1350–1750
Trimilsstaðir		Drangajökull	ca. 1600
Öldugil			ca. 1400–1710
Sviðningsstaðir			ca. 1700?
Þaralátursfjörður valley			ca. 1450–1650
Nedra Horn		Reykjafjarðarjökull	pre 1650
Fremra Horn			pre 1650
Various farms	Switzerland	Mont Blanc	late 1500s
Krumdalsætra	Norway	Tuftebreen	
Various farms		Jostedalsbreen	1680–1745
Tungøen			December 1743
Helleseier			
Various farms	Greenland	Greenland outlet glaciers	ca. 1350 ff.
Le Châtelard	France	Mer de Glace	pre 1600
Le Bois			

Sources: Evans and Twigg, 2002; Fagan, 2000; Grove, 1988.

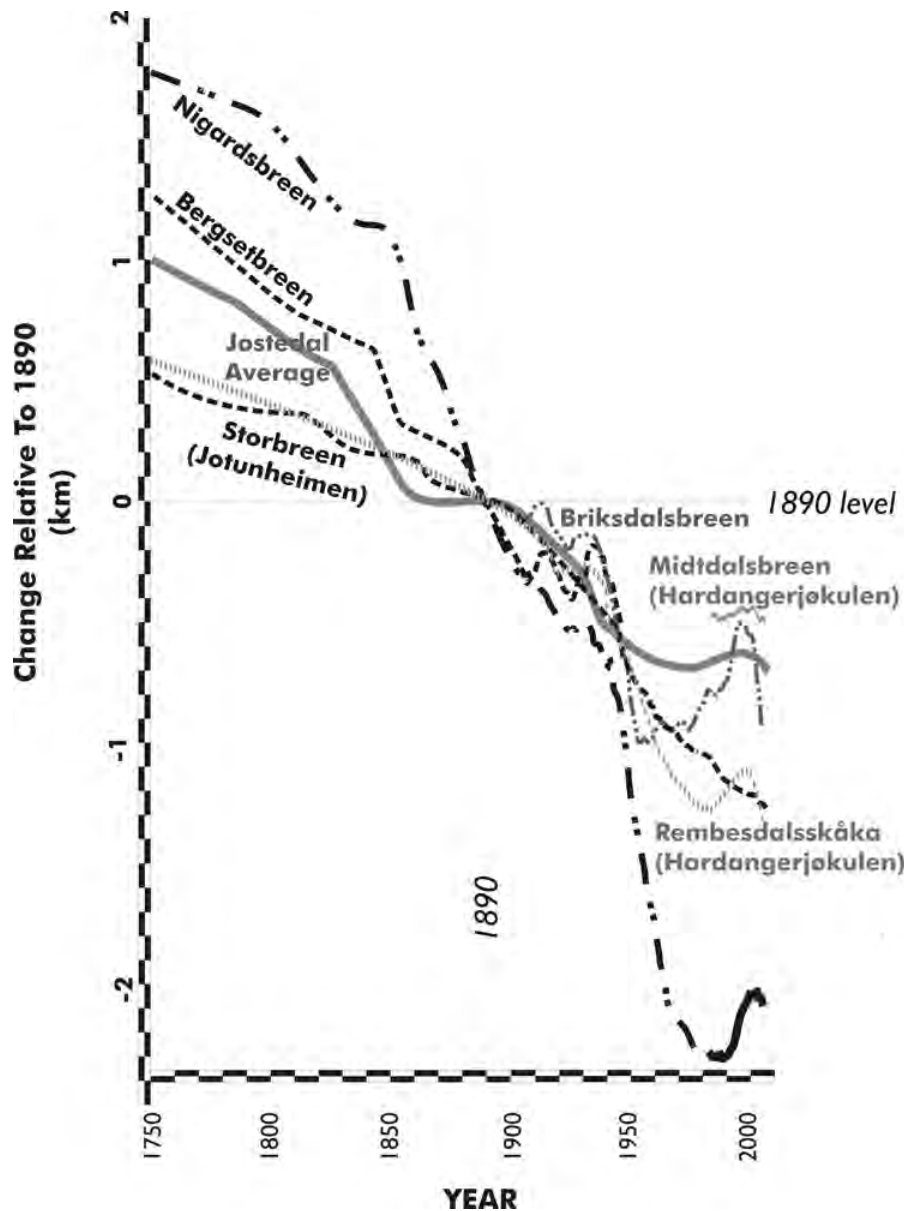


Figure 4. Variations in frontal position of several Norwegian glaciers. Values are standardized to 1890 frontal positions.

between the 1680s and 1745, a period of increased winter snowfall and short cold summers” (Grove, 1988, p. 73).

Hardangerjøkulen

The inferred drop in ELA for the Hardangerjøkulen parallels that of the maritime Folgefonna and Jostedalsbreen (Bakke et al., 2005) or leads it in phase with the inland Jotunheimen (Nesje et al., 2008). The latter seems more

probable for the more continental (i.e., inland) Hardangerjøkulen, though the complexities of different lag times for outlet glaciers and the relative importance of summer temperatures and winter precipitation between interior and coastal glaciers can make the comparison difficult (Dahl and Nesje, 1994). Inferences of climatic change based on these differences must be made with care.

Jotunheimen

Data for Jotunheimen, an inland ice cap, are much sparser than for Jostedalsbreen, which is the better documented. In general, they correspond to the growth and retreat of Jostedalsbreen, though the contrast between the maritime (Jostedalsbreen) and continental (Jotunheimen) is also documented (Bakke et al., 2008; Grove, 1988). The recent discoveries at Juvfonna reported by Lepperød (2010) suggest that ice accumulated in Jotunheimen long before the Little Ice Age, perhaps indicating cloudier conditions relative to the present, lower maximum summer temperatures than today, greater precipitation, or some similar combination of conditions.

Svartisen

Lacking good historical documentation, dating of Svartisen events depends largely on interpretation of data from radiocarbon testing and lichenometry (see the appendix in Klevberg and Oard, 2011a and Appendix B in Klevberg and Oard, 2011b). However, Petter Dass, Norway’s famous hymnist and poet, noted that the Svartisen outlet glacier Engabreen reached the seashore about 1693 (Grove, 1988). The same maritime-continental contrast is observed in the north as has been noted farther south: “Whereas in the more maritime areas, although variations in temperature have been almost the same as in the interior, increased accumulation has played the decisive role” (Grove, 1988, p. 107).

Svalbard

Advances of glaciers on Spitsbergen, the largest island in the Svalbard Archipelago north of Norway, were the greatest “in at least 8,000 years” (Grove, 1988, p. 318). Not all of the Svalbard glaciers overtopped their terminal moraines, however. Presumably these moraines are relicts from the Great Ice Age, meaning advances were significantly less during the Little Ice Age.

Table IV. Equilibrium Line Altitude Comparisons for Iceland and Norway.

Little Ice Age Inferences				References	
Glacier/Region	Year	Temperature Difference	E.L.A. Difference	Base Year(s)*	Author
Solheimajökull	ca. 1800	-1.6 °C		1960–90	McKinze et al., 2005
Eiríksjökull	ca. 1875	-1.5 °C	-250 m	ca. 1990s	Guðmundsson, 1998
Tröllaskagi	pre-1925		-200 m?	post 1925	Caseldine, 1987; Björnsson, 1980
Tröllaskagi-Hörgárdalur	1800s		-5 m	ca. 1920s?	Häberle, 1991
Tröllaskagi – observed		-2 °C	-50 m	1925–1960	Caseldine & Stötter, 1993
Tröllaskagi – theoretical			-300 m		
Iceland in general	1600–1920	-3 to -4 °C	ca. 200 m/°C	<i>clima optima</i>	Björnsson, 1980
			-400 m	1960–90	Grove, 2001
Western Norway	<i>clima optima</i>	+2 °C		1980–2005	Bjune et al., 2005
		-0.4 °C			Grove, 1988
Northern Norway			-150 m +		Grove, 1988, p. 414
		-1 °C			Grove, 1988
			- 100 to 250 m	1960–90	Bakke et al., 2005
Spitsbergen		-2 °C	-110 m		Grove, 1988
Western Norway	ca. 1750		-125 m	ca. 1990	Aa, 1996
					Grove, 1988

*estimated in some cases from context

Elsewhere

Small glaciers and ice caps grew or formed in many parts of the country distant from the larger glaciers. This was true in Sunnmøre; this part of the country was affected neither most nor least by the climatic change and may be more or less average. The preponderance of figures in this paper from Sunnmøre primarily reflect the fact the lead author's father is a *sunnmøring*; similar features could be found elsewhere in the country. Many of the small glaciers and ice caps observed during the Little Ice Age (Strøm, 2001) still exist, though they have often melted back severely (Figures 6, 7, and 8).

Interpreting the Glacial Record

Common ideas call for multiple glaciations in Norway, and examination of mo-

raines and other features indicates this may have been the case. As was shown in Part I of this series (Kleverg and Oard, 2011a), it is especially important to note the limitations of proxy data because many of these are interdependent and rife with uniformitarian bias. Table II shows paleoclimatologic inferences for Norway; the dates become increasingly speculative and errant toward the top of the table (see appendix).

Dates of glacial events are often established using radiocarbon test results. Even for relatively recent materials, these dates are often believed to be greatly in error, much more than that reported by the testing laboratory, especially when efforts are made to date buried soils (Bakke et al., 2005; Karlén, 1981; Matthews, 1982; Matthews et al., 1996; Winkler et al., 2003). This has proven true for Little Ice Age deposits,

and the error becomes worse with older samples (Brown, 2006).

Detailed reconstructions of Little Ice Age temperatures for western Norway have been based largely on historic proxy records (Nordli, 2001; Nordli et al., 2003). They are therefore particularly valuable. While evidence of cooler temperatures begins as early as the 1200s, glaciers did not advance enough to threaten habitations until at least the 1300s and probably much later in most places.

ELA estimates are calculated based on elevations of terminal moraines. ELA fluctuations are summarized in Table IV and indicate a drop in ELA between zero and 250 m, depending on the year maximum extent was reached and which base year is chosen for comparison. In general, results indicate a drop of 100 to 250 m (325 to 825 ft.), equivalent to tem-

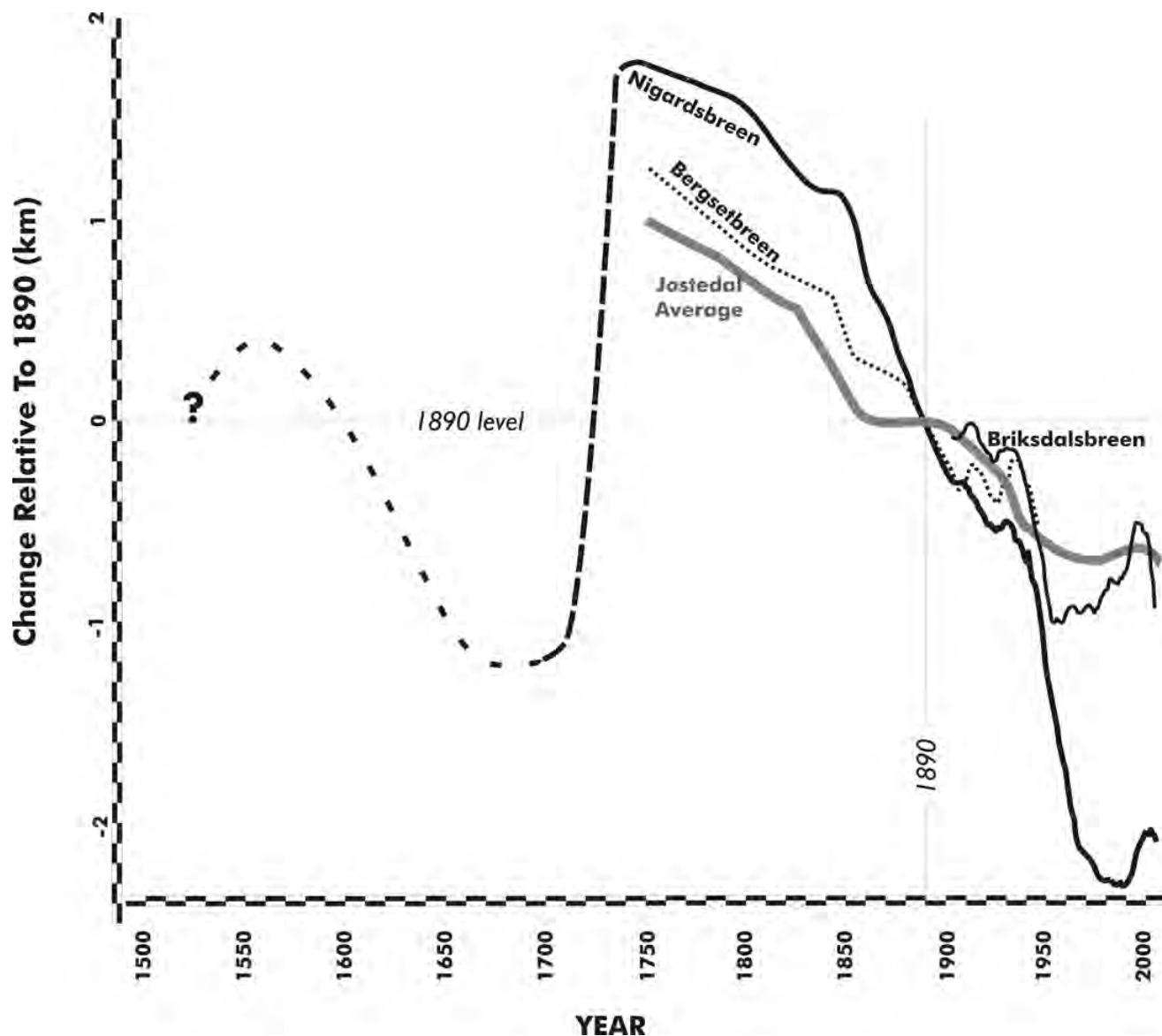


Figure 5. Fluctuations in end position of Jostedalsgreen outlet glaciers standardized to 1890 frontal positions.

perature anomalies between zero and -2.5°C (i.e. $\pm 0^{\circ}\text{F}$ minimum to -4.5°F).

Little Ice Age advances appear to have been approximately equal to previous maxima in the south of the country based on terminal moraines (Winkler et al., 2003), though evidence of previously more advanced termini is present both above sea level (Dahl and Nesje, 1994) and below sea level (Larsen et al., 2006) at some locations, such as Hjørundfjord and Sunnlyvsfjord (Figures 2, 6, 7, 8,

and 9). Difficulty in dating moraines contributes to confusion (Mathews et al., 1996). Topographic factors also complicate interpretation (Aa, 1996). Glaciers in the north of the country did not always reach their terminal moraines during this period (Grove, 2001), though they often erased earlier marginal moraines both in the north (Bakke et al., 2005) and the south (Dahl and Nesje, 1996).

Glacial maximum for the Little Ice Age in Norway occurred between 1700

and 1900, with most glaciers reaching their maximum extent around 1750, but some (especially in the north) reached maximum extent around 1900 or even later. Accounting for lag times and differences in response to temperature and precipitation, glacial extent data fit well with historical and proxy evidence for a gradual warming trend over the past 150 years or so. Interior (continental) glaciers have been observed to shrink while coastal (maritime) glaciers fluctu-

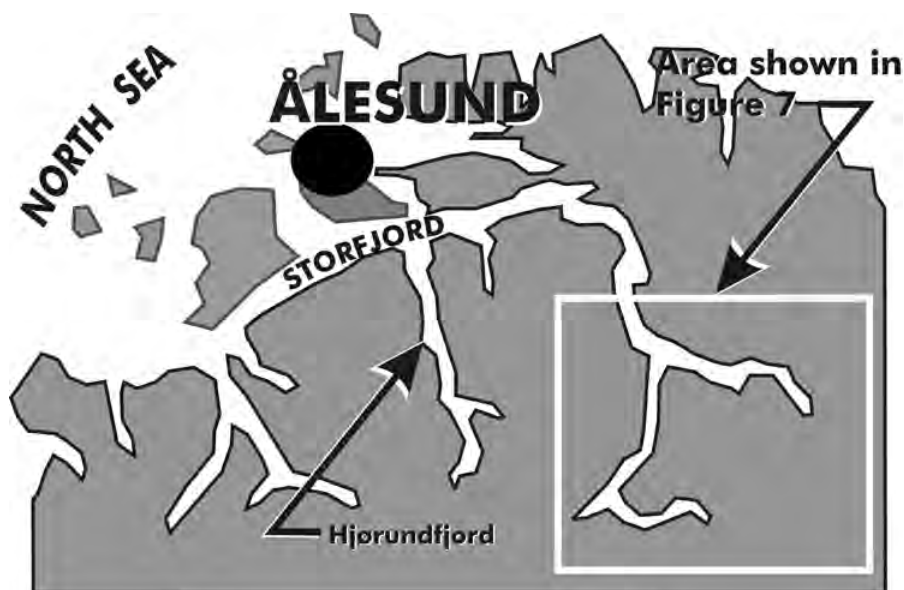


Figure 6. Map of Storfjord area, Sunnmøre, Norway.

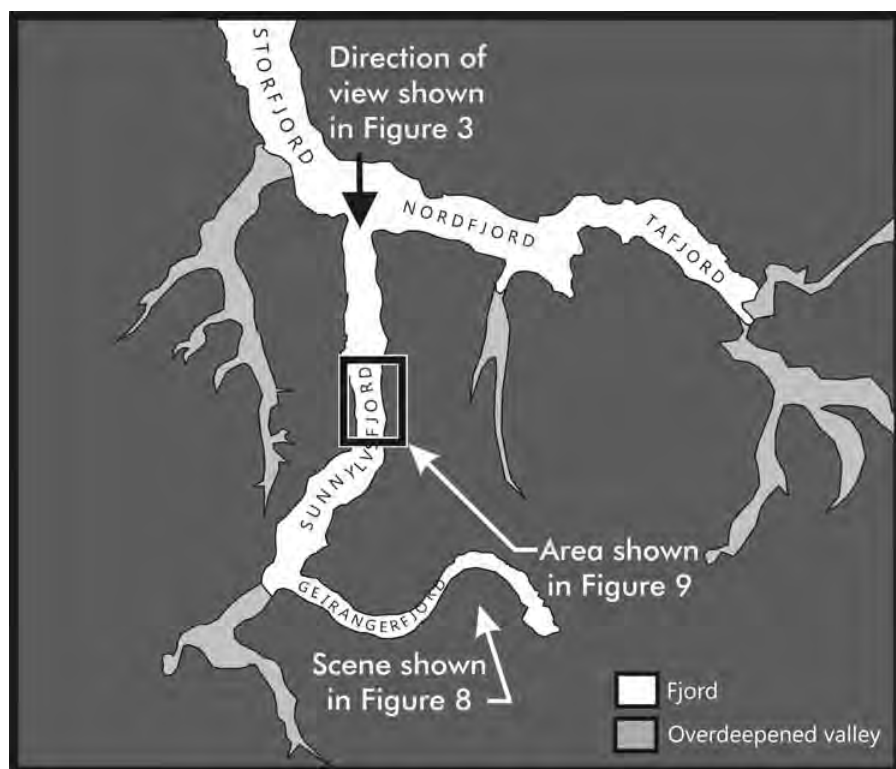


Figure 7. Map of inner Storfjord area.

ated or continued to grow in response to what were often simultaneous increases in temperature and coastal precipitation (Grove, 1988; Nesje and Dahl, 2003).

The longest record comes from Jostedalbreen, for which fluctuations in outlet glacier frontal position are indicated in Figure 5. In general, a date of ca. AD

1750 seems appropriate for the peak of the Little Ice Age in Norway.

The Little Ice Age Was Little

The observed effects of the Little Ice Age in Norway are minuscule compared to what is inferred to have happened in the unobserved (or at least undocumented) Great Ice Age. While existing glaciers advanced and small ice caps formed (Figure 8), these changes were orders of magnitude smaller than the valley widening and deepening inferred to have occurred thousands of years ago in the same areas (Figure 3). While it had profound impacts for people living proximate to the extant glaciers, and climate change (climatic deterioration) impacted thousands more, the Little Ice Age was nothing approaching the ancient icebound country with polar bears on the southwestern coast (Lillehammer, 1994).

Summary

That the Little Ice Age profoundly affected Norwegians living in proximity to glaciers is indisputable, and that its effects extended for centuries and to areas more distant from major glaciers is also documented (Figure 8). However, the name "Little Ice Age" appears appropriate, for not all marginal moraines and only a minority of terminal moraines were overtopped between 1450 and 1900. This indicates that in Norway the Little Ice Age, though noteworthy and measurable, was significantly smaller than the event or events that produced many of the topographic and geologic features we recognize as glacial. In the fjord country of western Norway, in particular, the differences are orders of magnitude in scale.

In general, the Little Ice Age appears to have peaked in Norway about the year 1750, similar to the record in Iceland (Klevberg and Oard, 2012). Grove (1988) noted the remarkable



Figure 8. The summer pasture areas (sætre) belonging to the Knivsflå and Horvdrag farms on the south side of Geirangerfjorden (Figure 5) were separated by this wall of dry-stacked rock in the late 1800s. While it may appear they simply quit building the fence, it actually ended at an ice field. The ice field is now gone. Photograph courtesy of Jens-Petter Grebstad.

correspondence between advances and retreats of similar glaciers in Iceland and Norway. Climate change during this period produced a drop in ELA in Norway of 100 to 250 m (325 to 825 ft.), indicating a depression in average temperature of as much as 2.5°C (4.5 F°) relative to AD 2000.

Landforms, sedimentary fabrics, and surface features that appear to be glacial in origin are found throughout the country, far beyond the limits of Little Ice Age glaciation, including far below present sea level. This appears to indicate a fundamental distinction between the inferred Great Ice Age and all subsequent glaciation; any subsequent glaciation may be expected to have resembled the Little Ice Age in both cause

and character. Further significance of these observations to the climate change debate and ice age inferences will be addressed in future papers in this series.

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interest in our research. We gratefully acknowledge the assistance of the Creation Research Society. *Deum laudamus* (Isaiah 65:1).

Glossary

Black Death—the devastating spread of bubonic plague in Europe in medieval times. It reached Norway from England in 1349 and killed nearly two-thirds of the inhabitants.

cirque—a rounded basin eroded into a mountainside by a glacier.

continental glacier—This term is typically applied to glaciers or ice sheets covering large portions of continents, but Norwegian researchers regularly apply the term to inland glaciers af-

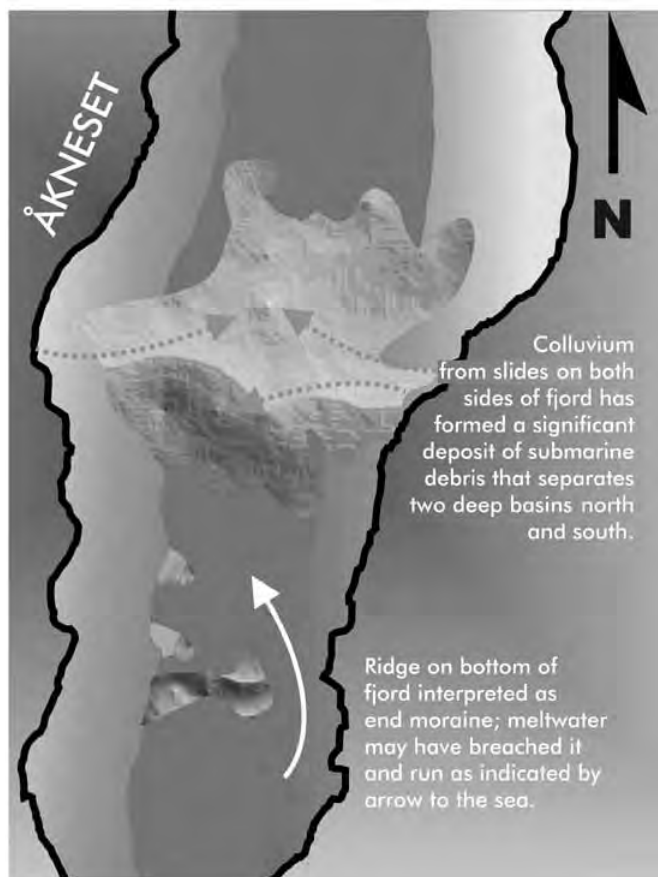


Figure 9. Moraine and landslides mapped beneath Sunnylvsfjorden, Sunnmøre. Deepest part of fjord in mapped area is nearly 500 meters (1,500 feet) deep and approximately 1,400 m (0.9 mi.) wide. Mountains flanking the fjord are about 850 m (2,800 ft.) above sea level, making the total glacial valley depth approximately 1,350 m (4,300 ft.).

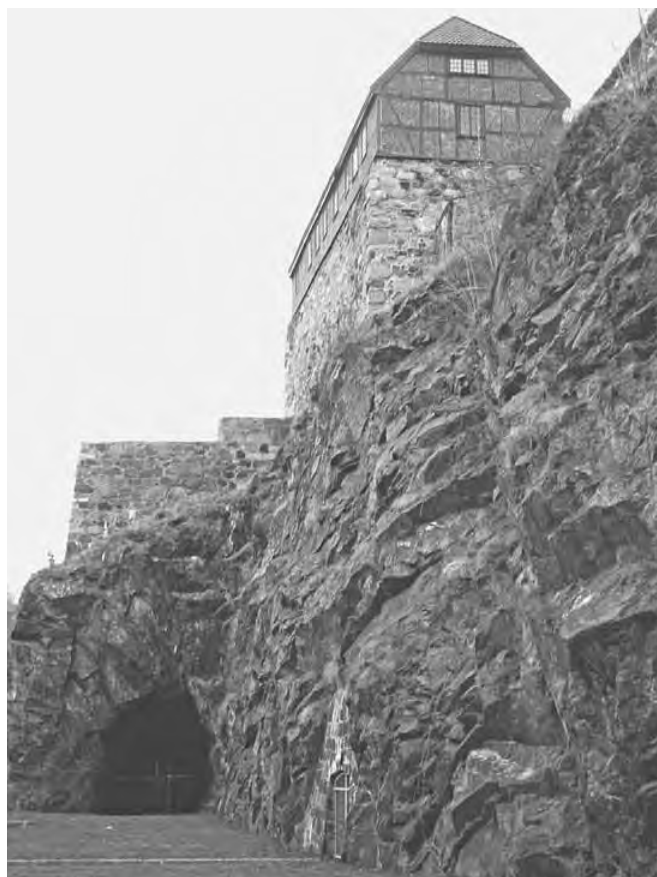


Figure 10. West side of Akershus Fortress, Oslo. The arched opening at lower left was an entrance for boats during medieval times. It is now two meters (a good six feet) above sea level.

fectured by a continental rather than maritime climate.

equilibrium line altitude—the altitude at which the balance point occurs, with ice accumulating faster than it melts above the ELA and melting faster than it accumulates below the ELA.
fjord—a long, narrow arm of the sea; a deep valley, typically a drowned valley with a U-shaped section and shallower at the mouth where it meets the sea.

piedmont—at the foot of a mountain or mountain range

Appendix:

Isostasy, History, and the Great Ice Age in Norway

Early conclusions on “varves” and isostatic rebound formed the basis for opinions that affect the thinking of many to this day, despite the revelation that these rhythmites are generally not annual layers (Oard, 2009) and may often represent single depositional events (Berthault, 1986; Julien et al., 1994). Historical

evidence of a much quicker and more recent isostatic adjustment is common (Figure 10—Akershus festning). Researchers routinely account for isostatic rebound in estimating treeline elevations and equilibrium limit altitudes (ELA's) in Norway and western Sweden (Bakke et al., 2005; Grove, 1988; Dahl and Nesje, 1996; and others—see many resources in paleoclimatology, e.g., the website of Norges Geologiske Undersøkelse). Dates, of course, are linked to typical uniformitarian assumptions and methods (Lillehammer, 1994).

Many places in Norway attest to the significance of *landheving*, the gradual elevation of the land over time. The same effect could be produced by eustasy, that is, change in sea level. This would require a significant drop in sea level, something not observed elsewhere. Instead, *landheving* has occurred in a roughly bullseye pattern (isostatic rebound), and with what is believed to be a modest *rise* in sea level (Grove, 1988; Lillehammer, 1994) widely attributed to global warming.

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RATE Study: Questions Regarding Accelerated Nuclear Decay and Radiometric Dating

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Abstract

Secular arguments supporting the use of radiometric dating in defining natural history have been rebuffed by many creationist critiques. However, recently, several young-earth creationists have suggested that radiometric dating can be accepted with one or more episodes of accelerated nuclear decay having occurred during Earth's past. A number of theoretical and practical problems face this hypothesis, such as excessive heat generation, variability in the rate of nuclear decay among radioisotopes, and, perhaps most important, the lack of any radiometric age-date conversion factor that would allow the use of secular dating results in creationist field work.

Introduction

The old-age results from various methods of radiometric dating have been and remain one of the most serious challenges to biblical earth history, and so young-earth creationists have examined the science and, to a lesser extent, the philosophy behind radiometric dating. They have come to varying conclusions: (1) some have accepted the age-dates without question, and abandoned literal biblical history, (2) some accept the results, but propose mechanisms to bring them into line with literal biblical history (e.g., accelerated radiometric decay), and (3) some remain skeptical of radiometric dating methods/results,

reject the assumptions that they require, and hold to a literal biblical history.

Any evaluation of radiometric dating must include an examination of its links to the naturalistic view of earth history. Therefore, any use of radiometric dating methods or results in creation science should be cautious and lean heavily on empirical evidence. An analysis of various radiometric methods has been done by young-earth creationists, dating back several decades. The results demonstrate sufficient leeway that naturalistic geologists can often "cherry-pick" dates they deem appropriate to their particular studies, and if results do not agree with expected dates, the "error" is attributed

to any number of possible problems (Froede, 2010). Although radiometric dates are used to defend the evolutionary geologic column, it is important to remember that the column preceded dating methods, and does not require them for validation.

The largest and best-known study by young-earth creationists to date was the Radioisotopes and the Age of The Earth, or RATE, Project (Vardiman et al, 2000, 2005). This group investigated potential problems with using standard radiometric age-dating methods, as well as possible adjustments to results necessary to defend a young earth. One interesting conclusion from the RATE scientists was that some form of accelerated nuclear decay occurred in the past. However, many questions remain regarding the potential to verify and then use results based on the concept of a period of faster decay. These challenges

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are both theoretical and practical. For example, how would one derive a “conversion factor” to correct conventional results to younger ages, and what is the role of the geologic timescale? Many opportunities exist for expanding this interesting area of research, but providing a defensible conversion factor for each of the age-dating methods should be a top priority. Until we can do so, the use of radiometric results in young-earth creation studies appears to be limited.

Radiometric Age-Dating in Creation Science— A Brief History

Beginning with the publication of *The Genesis Flood* (Whitcomb and Morris, 1961), radiometric age-dating was deemed incompatible with biblical history. Over the years, many young-earth creationists have documented the problems and unbiblical assumptions of various dating methods (Acree, 1965; Armstrong, 1966; Clementson, 1970; Cook, 1968; Lammerts, 1964; Whitelaw 1968, 1969a, 1969b; Woodmorappe, 1979, 1999).

In 1968, Gentry proposed a bold idea based on his work on radioactively damaged zircons. He stated, “While there might be other alternatives, one possible explanation of these ‘fractures’ or ‘blasting’ halos is that *the rate of radioactive decay was at one time greater than that observed today*” (Gentry, 1968, p. 85; italics added). The idea that decay constants possibly varied in earth’s past was also deemed possible by DeYoung (1976). Talbot (1977) supported varying constants, claiming that current physical laws may not have been constant in the past. Based on his examination of the Oklo natural uranium reactor, Chaffin (1982, 1985) suggested that accelerated radiometric decay had likely occurred during the Flood. But no one could offer a mechanism for decay acceleration. The possibility of “variable constants” (including variable rates of radiometric

decay) was reviewed in a minisymposium in the *Creation Research Society Quarterly* (Baumgardner, 1990; Brown, 1990; Byl, 1990; Chaffin, 1987, 1990; Gentry, 1990; Heinze, 1992; Morton, 1990; Williams, 1990). These authors accepted the idea that “constants” may have varied in the past (most likely during the Flood), but none proposed a viable and quantifiable mechanism. Chaffin (2000) proposed that a variation in the fifth dimension of our universe early in the Creation Week might have led to accelerated nuclear decay.

RATE Project

As a joint project between the Institute for Creation Research and the Creation Research Society, the RATE group convened in 1997 to discuss issues with radiometric dating within the framework of a young earth. Vardiman (2000, p. 7) summarized their goals: “Radioisotopes and the age of the earth were significant problems which must be addressed if young-earth creationism was to continue to have significant impact on the issue of origins both within and outside the Christian community.”

Research seemed predicated on the belief that

at some time in the past much higher rates of radioisotope decay may have occurred, leading to the production of large quantities of daughter products in a short period of time. It has been suggested that these increased decay rates may have been part of the rock-forming process on the early earth and/or one of the results of God’s judgment upon man following the Creation, that is, the Curse or during the Flood (Vardiman, 2000, p. 4).

The results of the eight-year study were published in 2005 (Vardiman et al, 2005), and the RATE scientists determined that

accelerated nuclear decay was the most promising explanation for the large amount of daughter products.

Initially, the concept of accelerated decay was only a hypothesis, but evidence from several different sources resulted in *accelerated decay becoming the primary explanation for the findings of RATE* (Vardiman, 2005, p. 7).

However, not all creationists accept accelerated decay as the best explanation for the data. In spite of the overall helpfulness of the study in many areas, such as empirical tests of various methods and the documentation of detectible Carbon-14 in coal and diamond samples purported to be billions of years old, several issues remain problems for accelerated decay theory. These include: (1) excessive heat generation, (2) the variability in the rate of nuclear decay among radioisotopes, and (3) the lack of any defined use for the theory.

Problem of Massive Heat Generation

Any episode of rapid nuclear decay should result in the release of large amounts of heat (Humphreys, 2005; Snelling, 2005; Vardiman, 2005). This heat would profoundly affect the planet, whether it happened during the Creation Week, following the Curse, or during the Flood. It is strange that there was limited discussion of the problem. Humphreys (2005, p. 68) stated,

The RATE initiative has found several lines of evidence implying that rapid cooling occurred along with accelerated nuclear decay, resulting in a smaller rise of temperature than would have occurred without such cooling. Andrew Snelling’s successful model for the formation of Po radiohalos requires *rapid cooling*.... John Baumgardner solved a long-standing geothermal mystery by assuming a burst of heat from accelerated decay accompanied by rapid cooling. In both these cases, most of the cooling could not be by the normal processes of conduction,

convection, or radiation. Instead, the process would have to cool the entire volume of material simultaneously (“volume” cooling) and abnormally fast.

But what is the source of this “rapid cooling,” and how would it offset the heat produced by rapid decay? Also, if Snelling’s model requires rapid cooling, then he must be able to demonstrate the cooling independently of his model, or the two do not reinforce each other, and rapid decay and rapid cooling remain in the realm of speculation. If a new type of cooling (“volume cooling”) is proposed, then this is certainly an area that requires extensive investigation.

The heat carried by the water [acting as a cooling agent] has to go somewhere else on earth, and that heat would be more than enough to melt the earth’s crust globally. Thus, we require significant volume cooling to compensate for the otherwise large amount of heat from accelerated nuclear decay.... In my feasibility study, I pointed out a little-known and less-understood phenomenon in standard General Relativity theory that seems quite relevant. The mechanism causes photons and moving material particles in an expanding cosmos to lose energy. The equations clearly show the loss of energy but where and how the energy goes is less clear.... This mechanism offers good potential for removing heat on a large scale. We do not need to resolve the experts’ confusion about where the energy goes in order to utilize this mechanism (Humphreys, 2005, pp. 69–70).

The real problem is how to keep non-radioactive materials from getting *too cold* at the same time (Humphreys, 2005, p. 73).

But if volume cooling is to be believed, then data should be supplied in defense of this mechanism. If the phenomenon cannot be empirically demonstrated, then it remains specula-

tion. We look forward to future creationist research in resolving this interesting hypothetical proposal. Another area of research should address the accelerated decay of isotopes in apparent parallel stability with other physical phenomena. At a minimum, we should expect to find empirical evidence of rapid-to-instantaneous crustal cooling.

Variability in the Rates of Nuclear Decay

K-Ar, Rb-Sr, Sm-Nd, and Pb-Pb Isochron Discordance

Other questions warrant further investigation. For example, in his analysis of the parent/daughter radioisotopes for the Beartooth amphibolite (Wyoming) and the Bass Rapids diabase sill (Grand Canyon, Arizona), Austin determined that changing decay rates created discordances in the K-Ar, Rb-Sr, Sm-Nd, and Pb-Pb radioisotope age-dates. He noted,

Furthermore, our data are consistent with the possibilities that, at some time or times in the past, decay of the α -emitters (^{238}U , ^{235}U , and ^{147}Sm) was accelerated more than decay of the β -emitters (^{87}Rb and ^{40}K). (Austin, 2005, p. 386)

Snelling and others reached this same conclusion in their investigation of the Bass Rapids diabase sill:

Changing decay rates in the past could account for the demonstrated discordances between the resultant isochron “ages.” Furthermore, our data are consistent with the possibilities that, at some time or times in the past, decay of the alpha emitters (^{238}U , ^{235}U , and ^{147}Sm) was accelerated more than decay of the beta emitters (^{87}Rb and ^{40}K), and the longer the present half-life of the alpha or beta emitter the more its decay was accelerated relative to the other alpha and beta emitters. (Snelling et al, 2003, p. 283)

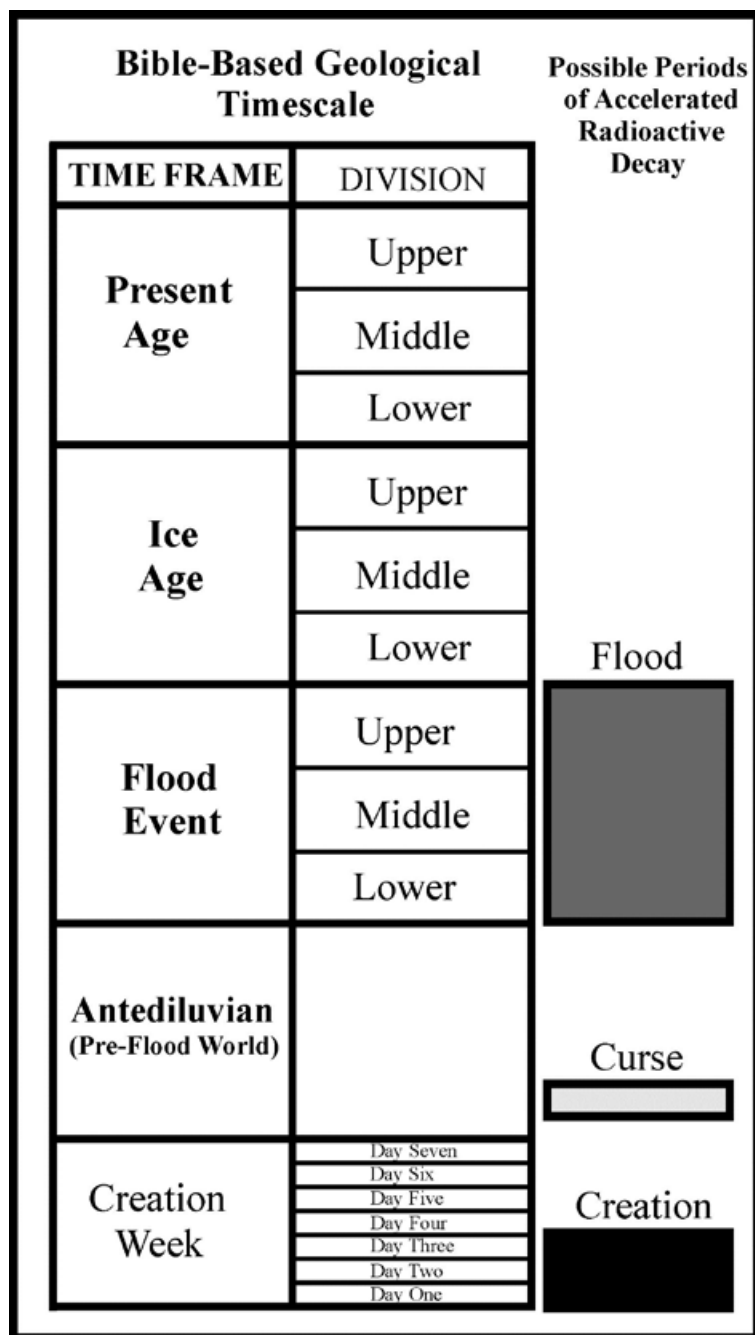
Both projects concluded that there

was decay-dependent variability in the rate of nuclear decay that should show consistent differences between *different* radiometric dating methods, yet some level of consistency in the *same* method. For the two sites studied, the Beartooth amphibolite had a reported radiometric age ranging between 2.52 billion years (Ga) ± 110 million years (Ma) and 2.89 Ga ± 190 Ma, and the Grand Canyon diabase sill returned ages between 0.842 Ma ± 164 thousand years and 1.38 Ga ± 140 Ma. These differences are reportedly a function of the different radiometric dating methods (Austin, 2005). No specific relationship between the results and period(s) when accelerated nuclear decay occurred were provided. In other words, what radiometric age-dates would indicate Creation Week rocks, post-Curse antediluvian rocks, or Flood rocks and sediments? (Figure 1) If the results (using accelerated decay) are to be useful, the ability to link rocks/sediments to biblical history is essential. This also raises the question of a quantifiable conversion factor for each radiometric method; such numerical factors would be invaluable for creationist analyses of radiometric age-dates (Figure 2).

Inconsistency between Carbon 14 and Long-Lived Nuclides

Baumgardner (2005) presented an interesting study on detectable carbon 14 (^{14}C) in various “old” coal deposits and diamonds. But the study raises questions for creationists too. If accelerated decay occurred, why were short-lived isotopes such as ^{14}C not eliminated altogether? Baumgardner addressed this issue:

Evidence from this research suggests that several billions of years’ worth of cumulative decay at today’s rates occurred for isotopes such as ^{238}U during the creation of the physical earth and that a significant amount of such decay likewise took place during the Flood cataclysm. An important issue then arises as to how an episode of accelerated decay dur-



Radiometric Age Conversion Table

$$\boxed{X} \times \boxed{Y} = < 10K \text{ years}$$

Where:

X = Radiometric Date

Y = Conversion Factor
(Would be specific to the radiometric method)

The final converted age of the material would be less than 10K and fit within the Time frame/Divisions of a biblical geologic timescale (see Figure 1)

Figure 1 (left). This diagram shows a biblical geologic timescale with three shaded boxes corresponding to the three periods of time when accelerated radiometric decay purportedly occurred. The darker the box, the greater the level of accelerated radiometric decay based on the findings of the RATE project team.

Figure 2 (above). This diagram presents a hypothetical mathematical formula necessary to convert naturalistic radiometric dates to accelerated and acceptable values in the Creation/Flood geologic framework of earth history. Missing are the conversion factors for each of the secular radiometric age-dating methods. These factors will need to be provided in order to demonstrate that accelerated nuclear decay occurred within the anticipated time frame of the biblical record (see Figure 1).

ing the Flood might have affected a short half-life isotope like ^{14}C . The surprising levels of ^{14}C in fossil material from organisms that were alive before the cataclysm suggests that perhaps only a modest amount of accelerated ^{14}C decay took place during the cataclysm itself, an amount insufficient to eliminate the ^{14}C that existed in these organisms prior to the cataclysm. Accordingly, we here

offer the tentative hypothesis that, whatever the physics was describing the decay acceleration, it did not operate in so simple a manner as to reduce temporarily the effective half-lives of all radioisotopes by the same factor. (Baumgardner, 2005, p. 620)

Hence this scaling, speculative as it may be suggests only about 2000 years' worth of accelerated ^{14}C decay occurred during the Flood.

This amount of decay represents ...~20% reduction in ^{14}C as a result of accelerated decay. (Baumgardner, 2005, p. 621)

At present, it is not clear how accelerated nuclear decay could have occurred at very high rates for the K-Ar, Rb-Sr, Sm-Nd, and Pb-Pb systems but at very low rates for short-lived isotopes such as ^{14}C . It would be of interest to all scientists who might use any of these

methods to have quantifiable conversions, based on sound science, which would demonstrate predictable results in the field. Of course, as with any forensic investigation, retrodiction of theoretical or presently observed events renders all historical applications less certain and open to revision.

Certainty and the RATE Results

The results of the Radioisotopes and the Age of the Earth (RATE) initiative are summarized in the last chapter of the second volume:

The major result of the project is that nuclear decay processes appear to have been accelerated during brief periods in earth history (Vardiman et al, 2005, p. 735).

However, as noted above, the specifics of this process remain unknown, yet of intense interest, since radiometric dating remains a popular argument against biblical history. Thus, it is useful that some of the results of the RATE research appear to be critiques of radiometric dating from both theoretical and experimental perspectives (Snelling et al, 2003; Snelling, 2004).

One of the questions to be answered would be the timing of any accelerated nuclear decay event(s).

Accelerated decay during several periods of earth history became the primary hypothesis because of the strong physical evidence the RATE group had accumulated that a large amount of nuclear decay had indeed occurred in the rocks themselves after their initial creation. This evidence suggested that most of the decay occurred during Creation week events, but also that a large amount must have taken place during the Genesis Flood. (Vardiman et al, 2005, p. 737)

These speculations remain uncertain because we do not know the original levels of radioisotopes in the

various earth materials. Unfortunately, the same circularity that afflicts modern secular stratigraphers seems likely to also plague creationists that take this route. Quantifying accelerated decay for each dating method would go a long way toward reducing those uncertainties. Thus, while RATE has shown many problems with the secular use of radiometric dating, it has not yet generated a way to use results to help constrain actual field studies, and the resulting stratigraphic uncertainty remains.

Discussion and Conclusions

The RATE Project would have been stronger had it included the enumeration of clearly defined objectives at the outset, although their absence may simply reflect the inherent uncertainty in the historical application of any of these methods. We applaud and appreciate the valuable work that was done, but the apparent lack of empirical data necessary for understanding accelerated nuclear decay seems to provide no practical use for young-earth creationists. It also has a number of theoretical problems to solve before it can be accepted on even a theoretical basis. Right now, it might best be described as an interesting hypothesis. One issue is the timing, although the RATE group recognized that during certain periods accelerated nuclear decay would be less likely than others.

The RATE group considered the possibility that a substantial amount of decay might have occurred during the Judgment in the Garden of Eden, but then it was concluded that the implied levels of radiation and heating would have been so highly destructive to biology at that point in earth history as to render this possibility unlikely (Vardiman et al, 2005, p. 737).

Humphreys (2005) addressed this problem in his summary chapter. He speculated that heat produced by rapid decay would be removed by “volume

cooling” so quickly that it would not be a problem. The associated issue of excessive radiation generated during accelerated nuclear decay was briefly mentioned, but no clear solution seems possible, given the unknowns at present.

Snelling et al (2003) and Austin (2005) suggested that “older” rocks experienced greater levels of accelerated nuclear decay than younger rocks. If true, then some evidence is possible, such as gradational metamorphism (i.e., the older rocks being of higher metamorphic grade than the younger). However, it may be difficult to tie this kind of evidence to accelerated decay, since metamorphism may have been caused by other factors. Their proposal also raises the inherent problem of knowing the relative ages of rocks in the first place. Some creationists resolve this problem by accepting a compressed version of the standard geologic timescale, although one reason for doing so is the presumption of accelerated radiometric dating (Dickens and Snelling, 2008a, 2008b). However, Reed (2008a, 2008b, 2008c, 2008d) and others (Froede, 2008; Reed and Oard, 2008) have questioned this approach. It is not clear if the RATE results support this conclusion.

An important issue that must be resolved by proponents of accelerated decay is how any field application of their theory can be squared with earlier research that demonstrated a lack of accuracy and precision of radiometric results, and their inconsistency with other field evidence. Some of these studies showed results that were definitively wrong (Austin, 1988, 1992, 1994, 1996, 2000; Snelling, 1995, 1999a, 1999b, 2000a, 2000b). It will be interesting to see if any of these systematic problems can be resolved by accelerated radiometric decay theory.

A competing theory was proposed by Woodmorappe (1999). He asserted that radiometric dating is inherently unreliable and that secular scientists select desired results from a reservoir of

inconsistent results, based on their needs at the time. Future research would be enhanced if creationists used the accelerated decay theory and Woodmorappe's statistical noise theory as competing hypotheses. This would provide a more comprehensive focus on the problem and force the proponents of accelerated decay to address issues that might not have been clear before. It would require researchers to find a quantitative basis for eliciting consistency from apparently inconsistent results. This might provide the basis for conversion factors or equations that would ultimately allow the theory to become useful in field studies. If they cannot, then the skepticism of Woodmorappe (1999) and the earlier creationists who wrote against radiometric age-dating might be vindicated.

But even then, a good result will have been achieved. If creationists can demonstrate the inherent inconsistency of secular results, the argument for a young earth is greatly strengthened. This would force acknowledgment that chronology must ultimately rest on the divinely inspired historical documents provided in the Bible. Similarly, the demonstration of the unreliability of radiometric dating would reinforce the inherent weakness of the geological timescale (Reed, 2008c).

Many opportunities exist for expanding further study and research into this interesting area, but providing a scientifically defensible conversion factor for each of the age-dating methods should become a research priority for those who wish to demonstrate the reality for episodic events of accelerated decay in the past. Such a result would not only validate their theory, but also would provide a useful field tool for geologists. However, in our opinion, too many questions remain unanswered for creationists to adopt this hypothesis at this time. Therefore, at present, it would seem best not to assume that accelerated nuclear decay provides an acceptable pathway for the adoption of naturalistically

derived radiometric age-dates, as it currently lacks functionality or application.

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The Anatomy of a Worldview: The Eternal Self-Identity

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Abstract

Worldview” is a popular term used in a variety of contexts. Unfortunately, its usage is frequently vague and often more descriptive than definitive. A specific definition is possible, however, by condensing the concept to the range of replies to the question, “How do I understand myself relative to ultimate truth?” This paper will explain that: (a) the emergence of a worldview is a natural and necessary by-product of the expansive nature of human thought, (b) it is the reference tool used to emulate objectivity in determining ultimate truth, and (c) this paradigm ultimately defines one’s self-identity. In short, a person cannot think and mature without necessarily constructing a worldview—an eternal self-identity.

Introduction

Reviewing the vast abundance of literature available today regarding the subject of the human worldview, one thing appears to be glaringly absent: an examination and understanding of its fundamental nature. Many define what it does, how it works, and how it affects people and mankind in general. However, the fact that few if any seem to have taken time to examine its essence and nature results in the presentation of general truisms based on intuition without an explanation for their basis, ad hoc definitions created to suit the author’s purposes, or, worse, philosophical mistakes caused by failure to understand

its real nature. Consequently, a serious consideration of the worldview’s nature and origin is long overdue.

Webster’s New World Collegiate Dictionary defines “worldview,” *calque* from German, as “a comprehensive, especially personal, philosophy or conception of the world and of human life” (Neufeldt, 1988, p.1540). Geisler (2002, p. 785) expands,

A *worldview* is how one views or interprets reality. The German word is *Weltanschauung*, meaning a “world and life view,” or “a paradigm.” It is the framework through which or by which one makes sense of the data of life.

Or, consider the view of Christian apologist and founder of Summit Ministries, David Noebel:

Every individual bases his thoughts, decisions, and actions on a worldview. A person may not be able to identify his worldview, and it may lack consistency, but his most basic assumptions about the origin of life, purpose, and the future guarantee adherence to some system of thought (Noebel, 1997, p. 1).

Speaking from a very different perspective, cultural anthropologist Gary Palmer says:

As I use the term [worldview], it refers to the fundamental cognitive orientation of a society ... subgroup or ... individual [encompassing] fundamental existential and normative postulates or themes, values [often conflicting], emotions and ethics; it includes conventional cognitive

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models of persons, spirits, and things in the world.... It includes as well metaphorical ... structuring of thought (Palmer, 1996, pp. 113, 114).

Late anthropologist Clifford Geertz offered a much simpler definition:

Their picture of the way things, in sheer actuality are, their concept of nature, of self, of society ... their most comprehensive ideas of order. (quoted by Palmer, 1996, p. 114)

Alternatively, Palmer also quotes anthropologist Robin Ridington's claim that

worldview cannot be understood without language. It is fundamentally produced by linguistically mediated human thought. (Palmer, 1996, p. 113)

Definitions of "worldview" vary, but even given the above spectrum of perspectives, they appear as variations on a theme. This paper will show all these definitions to be correct, although incomplete. If all are essentially correct, however, what is the unifying principle? One clue is that each simply presumes the worldview's existence, but none explain its origin. To find the point of convergence, then, several questions must be considered: What causes a worldview to exist in the first place? Why must "every individual" have a worldview? Is there a reason one could not function effectively without one?

A logical place to start to understand the origin of a worldview, then, is to ask how a person generally acquires and processes information in an effort to trace what actually causes the worldview to come into existence and to be utilized. To do this, a series of ten premises are presented and discussed (Figure 1).

Premise I: Sensory data is the primary information category and is fundamental to human intellectual development. All higher constructs are based on sense. Consequentially, when an individual's knowledge base

I	Sense experience, relative to the perceiver, forms the basis for all understanding.
II	Raw sense information must usually be interpreted, which is the function of thinking.
III	A second information category - virtual data - is used in the same way as sense data.
IV	The function and purpose of thought is to interpret sensory and virtual data via rationalization processes (or algorithms).
V	Primary sense information is not subjective, but observer bias influences both observation and interpretation of data.
VI	The operation of thinking algorithms described in Premise IV is not the same as instinct.
VII	Thought requires a logical "error-checking" function that also validates meaning. It attempts to answer the question: "What is true?"
VIII	This function also provokes a parallel validation question: "How can I know what I believe to be true actually is?"
IX	Belief that something is true also defines what is true about self. Consequently, the search for certainty leads to the question: "How do I understand myself relative to ultimate truth?" Cumulative answers here provide a matrix that defines a worldview, which defines self-image <i>and</i> perception of truth.
X	Since humans are finite, a worldview is, at best, a self-limiting reflection of truth.

Figure 1. Ten premises underlying a worldview.

is traced back to its origin, *everything a person understands in a larger sense—beginning from basic sensory information and extending to one's most sophisticated understandings—is understood relative to himself.*

Acquired languages (conventional written, conventional spoken, visual symbolic, touch symbolic, and including basic relational observations) are sensory-dependent information structures and cannot develop if the associated sensory mechanism is incapacitated.

Helen Keller serves as a classic example of the compulsive nature of sense-to-language development, which in turn is prerequisite to the human intellectual development. Since she was blind and deaf, her teacher had to help her connect the signs for "water" in her hand, using the faculty of touch, before Helen's intellectual world opened up.

"Languages" as used here includes normal communication languages, specialized (technical) working languages, formal and informal sign languages,

and observed physical relationships or principles requiring observation to be understood, as well as any other language (e.g., body language) enabling an individual to communicate, create, and function within his or her community of individuals.

Sensory information is the lowest intellectual layer and the portal to language and reason. If, for whatever reason, it does not develop, no other layers of cognitive intelligence can or will develop. An individual cannot imagine a sound never heard or a color never seen or understand that water does not run uphill unless it has been observed. Extended or permanent deprivation of the sensory layer is demonstrably destructive to human development (Sonksen and Dale, 2002; Thielke and Shriberg, 1990) and mental well-being (Grassian, 2006).

People learn by way of analogy-to-self, so the sense layer is foundational. For example, children around the world count in base ten simply because most every child has ten fingers! Information that cannot be directly or indirectly related to one of the five senses (i.e., sight, sound, taste, touch, or smell) becomes indiscernible from bald fiction and thus difficult to argue with the certainty that one can know it to be true. Stated differently, sensory data is a necessary but insufficient condition for learning and development of intelligence.

While Premises III and IV will discuss analogy's role in understanding, Behe (2006) presents a classic example of how analogy to sense facilitates human scientific understanding. Chapter 1 of his book, *Darwin's Black Box*, features a section titled "A Very Brief History of Biology," wherein Behe chronicles the history of biological studies or, more precisely, its technological tools of observation. Until technology could assist in visualizing its details, there was simply no way to deduce biology's true nature because life was (and still is) far more complex than could be imag-

ined. Indeed, Darwin's misconception regarding the mutability of the cell is still at the crux of the intelligent design/mechanistic evolution debate today. Scientific methodology requires observation, which simply demands either direct or indirect use of the senses.

Adler refers to sensory data as "sensible objects of perception," as opposed to "intelligible objects of perception" (Adler, 1985, p. 65), and also recognizes sense is always prior.

The extremism just noted is avoided by acknowledging first, that the intellect depends for all its primary apprehensions upon sense-experience; and second, that, while some objects of thought are purely intelligible, our sense-experience provides us with the objects that, with rare exceptions, are never sensible. (Adler, 1985, p. 35)

This is because "intelligible objects" draw on analogy to sense-experience objects for their very existence using "abstraction," according to Locke (Adler, 1985).

Premise I may first appear to be a materialistic argument, denying the supernatural. In reality it only says communication is built on language, which presumes normal formative sense experiences. Even a brief review of prophetic biblical language demonstrates that communication always borrows on analogy to sense. For example, anthropomorphic statements describe God as having arms and hands (Isa. 62:8; John 12:38), eyes and ears (Deut. 11:12; Ps. 34:15), and even wings (Matt. 23:37). The Trinity is described as a Father-Son relationship (John 17:1), and the most ethereal of prophecies borrow heavily on human experience for verbiage (Ezek. 1:4–28; Rev. 12:13–17; etc.). Lacking prior sense experience, these analogies are meaningless. Likewise, every apologetic argument is also owing to language as a basis. Indeed, our very ability to perceive or conceive of God is predicated on correlation to normal life experiences!

Even divine revelation presumes sense experience. Geisler explains:

The question is: How can finite human concepts convey an Infinite God? Aquinas's answer is that they must do so analogically. God is neither identical to nor totally different from our expressions about him. Rather, He is similar to them. (Geisler, 2002, p. 18)

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. Note that while the preceding might hint at solipsism, Premise V will show otherwise.

Premise II: Raw sense information is rarely directly meaningful and must nearly always be interpreted to some degree, which is the function of thinking.

Neurological sensations alone are rarely useful (except as a true instinctive response), and even basic interpreted information does not convey context. By way of illustration, perceiving red requires basic optic functionality and the brain's receiving/processing capacity; no rationalization or "thinking" is required. And, since most human optic systems function similarly (unless the individual is color blind), most individuals report similar experiences. Cognition requires an acquired language to interpret the color as "red," or "rojo" (Spanish), or "красный" (Russian). However, just because a red light is shining and an individual knows the color's name does not mean the observer understands to stop his vehicle. This requires second and third order interpretations of the

data—knowing how to control the vehicle, knowing traffic laws, etc.

Note that objectivity is pursued at higher cognitive levels discussed in Premises VII, VIII, and IX.

Premise III: A second information category exists, referred to here as *virtual data*. These are second, third, and higher order inferences or constructs drawn from first-order sense data, which then become accepted with equal validity to sense data, and used in processing toward even larger general truths. This information layer is dependent on functioning language, as described in Premises I and II, and on the competency of functioning intelligence, described in Premise IV.

Consider this illustrative example. Comparing the existence of energy (sensory observation datum 1) against the second law of thermodynamics (virtual datum 2, drawn from processing datum 1's behavior), one might conclude that something outside the observable universe must have provided its energy (virtual datum 3). Then, evaluating the order found in life (sensory datum 4), one might conclude this source of energy must also be intelligent (virtual datum 5). Based on admitting God as a logical probability (meaning applied through rationalization of virtual data 3 and 5), one might surmise a logical obligation to his Creator (virtual datum 6). Consequently, once one concludes such an a priori obligation, other perceptions and subsequent actions would be influenced.

The previous example illustrates a logical progression based in hard data but consisting of projections where certain inferences become accepted as data using third-, fourth-, and fifth-order conclusions. The point here is not the likelihood that one might accept these particular conclusions, but simply to present a working example of "virtual data." Adler (1985, p. 65) refers

to "virtual data" as "intelligible objects of conceptual thought." Two important concepts here are (a) that virtual data are built based on existing/functional vocabulary using processes such as analogy (or "linguistically mediated thought" per Ridington above), and (b) that vocabularies cannot form absent initial sense experiences.

Epistemologically speaking, human understanding develops by either direct or indirect analogy to self. According to Locke,

We have no knowledge farther than we can have perception of ... agreement or disagreement [between our ideas] 1. Either by intuition, or the immediate comparing any two ideas; or, 2. By reason, examining the agreement or disagreement of two ideas, by the intervention of some others; or, 3. By sensation, perceiving the existence of particular things. (Locke, 1690, book 4, ch. 3, par. 2)

Locke's 1 and 2 represent virtual data; 3 is sensory. Research into "object permanence" suggests the human ability to create virtual data starts as young as just a few months (Baillargeon and DeVos, 1991). Object permanence is the idea that objects continue to exist, even when hidden from view. Infants as young as 3.5 months seem to understand when "impossible" scenarios appear to violate basic laws of physics.

The main point is that an individual's entire intellectual construct is fundamentally subjective, acquired by sensory and processing events unique to each individual. This is true at basic levels of verbal communication right through to high-level concepts such as understanding DNA and advanced physics. *Fundamentally, everything a person truly understands, by definition, must be a function of his perception or he did not understand!* High-level concepts "everyone agrees on" are accepted as such because enough commonly experienced sensory and well-reasoned virtual data

exist to justify them as "facts" within human experience (of course, occasionally "facts" are adjusted to align with reality).

Premise IV: The function and purpose of thinking is to interpret both sensory and virtual data using rationalization processes, which are made in the context of one's existing knowledge base.

Thinking is the process of ordering data to understand context, utilizing rationalization processes or "intelligence algorithms." Processes used to determine larger general truths include analogy (ratio, interpolation, extrapolation), common sense (scenario validation, compare, and contrast), and imagination (creativity).

Our capacity for language (data acquisition) and advanced rational thought (data processing) represent perhaps the two most identifiable distinctives characterizing humanity. Meaning is simply value assignments projected by these processes (effectively the creation of another virtual datum point).

One research field that suggests thinking reflects algorithmic operations on data is artificial intelligence (AI). AI attempts to model human thinking to provide creative solutions in signal, image, and speech processing, automated reasoning, computational theories of learning, heuristic search, knowledge representation, natural language understanding, qualitative physics, robotics, and more, by using software and hardware architectures customized for AI applications.

Definitions of AI generally involve comparison to human thinking. However, exact definitions vary precisely because of the difficulty in understanding and defining how humans think. Philosophically, AI can be generally divided into two broad categories.

The assertion that machines could act *as if* they were intelligent is called the **weak AI** hypothesis, and

the assertion that machines that do so are *actually* thinking (not just *simulating* thinking) is called the **strong AI** hypothesis. (Russell and Norvig, 2009, p. 1020)

Little controversy surrounds “weak AI,” but philosophical challenges like Searle’s (Searle, 1999) “Chinese Room Argument” question whether “strong AI” is achievable. Cole (2009) provides a good philosophical review of strong AI. The philosophical implications of strong AI inescapably highlights the appearance of design in human cognition, as seen in Cole’s closing comments.

This creates a biological problem.... While we may presuppose that others have minds, evolution makes no such presuppositions. The selection forces that drive biological evolution select on the basis of behavior. Evolution can select for the ability to use information about the environment creatively and intelligently, as long as this is manifest in the behavior of the organism. If there is no overt difference in behavior in any set of circumstances between a system that understands and one that does not, evolution cannot select for genuine understanding. And so it seems that on Searle’s account, minds that genuinely understand meaning have no advantage over less mysterious creatures that merely process information, using purely computational processes that we know exist on independent grounds. Thus a position that implies that simulations of understanding can be just as biologically well-adapted as the real thing, leaves us with a puzzle about how and why systems with “genuine” understanding could evolve. Original intentionality and genuine understanding become epiphenomenal. (Cole, 2009)

Endless debate is sure to surround AI’s theoretical and practical limitations to modeling human thinking. However, the point here is that many recognize the

analogy between advanced computer processing and human processing.

More realistically, whether human thinking represents algorithms performed on data can be tested by considering human cognitive difficulties. For example, neuropsychological exploration of autistic spectrum disorders (e.g., Asperger’s) drives research into “executive functioning” or “cognitive control,” which identifies the nature of these “intelligence algorithms,” attempting to understand what constitutes cognitive dysfunction. As a case in point, for an autistic savant who can memorize an entire phone book, the problem is not his ability to acquire data. In that regard the individual is highly functional. His problem is the ability to manipulate acquired information in order to create meaningful virtual data and come to useful conclusions.

American educational psychologist John B. Carroll (1916–2003) authored a three-stratum theory of classification of cognitive abilities. In his seminal work, *Human Cognitive Abilities: A Survey of Factor Analytic Studies*, Carroll explains,

In general, a *process* refers to any action or series of actions by means of which something is operated on to produce some result. A *cognitive process* is therefore one in which mental contents are operated on to produce some response. These mental contents may be representations or encodings either of external stimuli or of images, knowledges, rules, and similar materials from short-term or long-term memory. (Carroll, 1993, p. 10)

Moreover, he continues:

Sternberg ... proposes ... that such tasks ... can be analyzed into the following components:

Encoding: The process of translating each stimulus into an internal representation upon which further mental operations can be performed.

Inference: The process of discovering a rule, X, that relates the A term

of the analogy to the B term, and storing the rule in working memory.

Mapping: The process of discovering a higher-order rule, Y, that relates the A term to the C term, and storing the result in working memory.

Application: The process of generating a rule, Z, that forms an image of the correct answer and tests it against the D term of the analogy.

Justification: The (occasionally necessary) process of deciding whether the D term of the analogy is sufficiently close to the image formed by the application process to be regarded as correct.

Preparation-response: The (control) process of preparing to solve the analogy, monitoring the solution process, and translating the solution into a response. (Carroll, 1993, pp. 10–11)

In reality, reducing cognition to simply “data” or “intelligence algorithms” is overly simplistic. From an imbedded-systems programming viewpoint, better models would surely require low-level adaptive drivers and layered programming techniques, etc. (Stevens, 2009). However, this discussion was intended to highlight the purpose of thinking and the method used to achieve that purpose. The purpose of thinking is to draw logical conclusions from given data, and methodologically it uses processing techniques or “algorithms” demonstrated by these examples.

Premise V: Primary sensory information is not subjective in itself and is based in reality, but observer predispositions will necessarily influence both the observation and the interpretation of the data.

Note that this statement does not infer solipsism. *Solipsism* is “the assertion that everything of which I am aware is a figment of my own mind” (Adler, 1985, p. 24). Rather, Premise V only states “everything of which I am aware

is a product of my own observation,” or more simply, “I am only aware of that of which I am aware” and by extension “I am not aware of aspects of reality I have not directly or indirectly observed.” Whereas solipsism attempts to redefine truth, Premise V makes no statement whatsoever about truth. However, it does speak to observational limitations. This paper, in fact, is about how we mentally model reality, which presumes there is an objective reality to model. The correspondence theory of truth, enjoying a rich history of adherents from Aristotle, Plato, and Aquinas through to modern-day apologists such as Geisler and Sproul, essentially states “truth is that which corresponds to reality.”

While sensory data are fundamentally single-point observations on reality and theoretically should be “objective,” studies abound demonstrating that human interpretations can be directly and indirectly influenced. Nowhere is this more critical on a daily basis than in eyewitness courtroom testimony. As of December 2010, The Innocence Project’s website (www.innocenceproject.org) reported:

Eyewitness misidentification is the single greatest cause of wrongful convictions nationwide, playing a role in more than 75% of convictions overturned through DNA testing.... Research shows that the human mind is not like a tape recorder; we neither record events exactly as we see them, nor recall them like a tape that has been re-wound. Instead, witness memory is like any other evidence at a crime scene; it must be preserved carefully and retrieved methodically, or it can be contaminated.

Likewise, in its “Statement of Best Practices for Promoting the Accuracy of Eyewitness Identification Procedures,” the American Bar Association, Criminal Justice Section (2004) records that factors affecting eyewitness accuracy are typically grouped into five categories:

(1) the witness’s characteristics, (2) the perpetrator’s characteristics, (3) the nature of the event (the crime) itself, (4) post-event experiences, and (5) witnessing or testifying factors. Predispositions and subjectivity in both short-term and long-term observation, recollection, and other factors can lead a fully well-intentioned witness to swear under oath and with full conviction to a false statement.

Regarding solipsism, the validity or failure of a witness’s observations clearly does not redefine reality. As any wrongly convicted individual can easily testify, conviction of the wrong individual does not facilitate justice but creates yet another injustice. Contrary to solipsism, what one believes to be true does not define truth and may have nothing to do with it.

Premise VI: The operation of thinking algorithms described in Premise IV is differentiated from the operation of instinct. Instinctive knowledge fundamentally does not require cognitive process; it is “hard-wired,” predetermined responses to specific stimuli, although secondary observations can be made about instinctive behavior.

Instinct is categorically different from thinking, as demonstrated by examples such as an infant’s nursing reflex, annual global flight patterns of butterflies and birds, or bee communication “language.” And, while humans do possess instincts, they tend to be more abstract than in “lower” animals and thus less obvious. The human propensity toward acquiring and teaching language is instinctive, but the language itself is not. Furthermore, algorithmic processes discussed in Premise IV are instinctive, but their development is limited or, more accurately, facilitated by an individual’s success in acquiring functional languages that enable him to exploit those processes.

Premise VII: The thinking process requires inclusion of a logical “error-checking” function for error correction and validation of meaning. This premise primarily involves first-order fact checking for key data and/or validation of key decision principles, generally asking, “What is true?”

Good thinking requires reevaluating judgments. Carroll’s quote in Premise IV describes this in the cognitive processes of *application*, *justification*, and *preparation-response*. Adler describes this error-checking process as it functions in perception.

What is true of one type of cognitive idea, our perceptions, is true of all other types of cognitive ideas—all of them the means, not the objects, of apprehension; *that by which*, not *that which*, we apprehend.

We remember some past event or happening. But we know ... our memory can play tricks on us. We may, therefore, be cautious enough to ask whether what we remember really happened in the past as we are remembering it. There are various ways of finding this out ... and so we make the judgment that the event that is the object of our memory did really occur in the past as we remembered it.

It is necessary to note here that there are two separate acts of the mind. The first is an act of simple apprehension—the act whereby we remember a past event. The second is a more complex act of judgment, usually the result of reasoning or of weighing the relevant evidence. The judgment may be either affirmative or negative.

For every object of thought that we apprehend by means of our concepts or conceptions, we face the question that calls for a judgment about its existence in reality. (Adler, 1985, pp. 16–18)

Understanding involves two aspects: first, simply apprehending a thing or

concept (acquisition of data and virtual data) and, second, validating the meaning or relevance of that thing or concept. In the global scheme of things, a worldview is the ultimate outgrowth of this second process.

Premise VIII: As a person attempts to validate his information and judgments, Premise VII's "error-checking" function drives introspective review, raising a parallel truth question: "How can I be certain what I believe to be true is *actually* true?" The attempt here is to validate whether his *judgment criteria* are flawed or real. This parallel validation process is inherently subjective, but it pursues the goal of objectivity and correct perception of reality.

A person cannot achieve understanding based on information he does not have. To the contrary, judgments are made in the context of existing knowledge. Moreover, perception presumes a perceiver, which demands awareness of "self" and personal limitations. Philosopher James Fredrick Ferrier coined the term "epistemology" and wrote,

The main result of the epistemology is this: In answer to the question, *What is knowledge or Knowing?* it replies that all Knowing is the apprehension of oneself along with all that one apprehends. This cognisance of self in addition to whatever things, or thoughts, we may be cognisant of—this, and this alone, is knowledge ... further, in answer to the question, *What is absolutely unknown and unknowable?* it replies that everything without a "me" known along with it, and that every "me" without a thing or thought known along with it, is absolutely unknown and unknowable. (Ferrier, 1854, pp. 391–392)

Given Adler's (1985) point regarding the need to validate a memory or understanding, when a person says he or she

understands something, on what basis can the individual know it to be true and to what level of certainty? Achieving objectivity requires one to first clearly define his foundations of understanding. This, of course, must include clear self-awareness regarding personal perceptual limits. In order to assign valid meaning, Premise VII's "error checking" involves validating first-order understandings and interpretations. But this forces a parallel process where the thinker considers whether his judgment criteria are valid. This secondary process involves considering how one's presumptions, bias, or other limitations may have influenced observations, as well as the possible construction of additional virtual data, if necessary, in order to yield a conclusive valuation.

Thus, determining truth as it corresponds to reality requires objectivity, which demands "calibration" of reference data (error correction), as well as determination regarding the possible need for additional information. Again, this is done using the data and virtual data at hand. This seems circular, but a starting point is needed before anything can be falsified. Generally speaking, since increased data corresponds with better perception, leading to more competent decisions, a good thinker will always try to understand context by learning more than the minimum necessary. This introspective error-correction process attempts to validate understanding against reality and the "resolution" of his mental construct depends on his data's density. Consequently, this intrinsic need to evaluate and interpret data before it can be used triggers an expansionary search for knowledge, hoping to clarify context.

This does not mean that more educated individuals are automatically better at determining truth. While true in a limited sense—for example an obstetrician usually knows more than a midwife in regard to delivery and healing—keep in mind there are two

components to thinking: the data being processed and the algorithms performing the processing. One may possess extensive information, while another may be particularly adept at thinking. Both aspects are important, and extraneous information sometimes may only cloud a decision.

On larger life issues, most virtual data are not scientifically verifiable anyway. For example, events outside immediate human experience such as the origin of the cosmos are not open to scientific validation, yet they are relevant to many moral dilemmas. Thus, it is entirely reasonable that a blue-collar worker possessing excellent common sense but minimal education may understand ethics better than a highly educated academic or scientist holding an unethical worldview (e.g., Nazism). The difficulty of an overconfident "intellectual" (of whatever stripe) is that he or she may not objectively recognize actual limitations and, in zeal for understanding, fail to differentiate between objective truth and personal philosophy. Unfortunately, while this qualification had to be interjected to guard against projection to the illogical conclusion that greater education automatically equals greater wisdom, given our stated goals, further discussion will have to be relegated to a later paper.

Premise IX: Something a person believes to be certain truth must apply to the person himself, or it is not universally true (i.e., certain truth). Thus, the "error-checking" process described in Premise VII and expanded in Premise VIII inevitably becomes a mirror asking, "What is the relationship between myself and reality?" Expanded to its most comprehensive expression, this question becomes, "How do I understand myself relative to ultimate truth?" The summation of answers to this question provides the reference criteria defining one's worldview. Con-

sequently, the worldview paradigm provides a matrix of answers used as a tool to emulate true or absolute objectivity and defines what an individual holds to be most true, ultimately about him or herself.

The error-correction process, then, attempts to generate an expansion of knowledge sufficient to encompass all aspects of the subject at hand. This normal validation process is the same at all scales, whether small, immediate problems or large, complex, and perplexing dilemmas. As this process continues to expand, it drives the individual to attempt to integrate all of perceived reality in order to identify errors and observational distortions. The first-order validation process described in Premise VII generates an expansive quest asking generally, “What is true about all of reality?” However, this parallel process forces a philosophically prior question: “How do I understand myself relative to ultimate truth?” which, in fact, defines a person’s worldview! This seeks to both create and validate an *observation platform* from which one can make solid truth judgments. After all, no one wants to be deceived by bad assumptions or unrecognized observational limitations. So, objectivity demands a clear sense of self-awareness. This question of self-awareness is philosophically prior because failing to understand how to square an observation with reality may easily skew correct perception of it. Stated otherwise, if one cannot say what is true with certainty about his ability to observe, what can he say with certainty about any observation made? So, confirming the validity of one’s *observational perspective* is prior to validating judgments about reality.

Thus, since all understanding starts from self (Premise I) and expands to the world around, in practice the worldview paradigm first defines self-identity and then describes truth about the world around, which is why naming (identity establishment) is so important to hu-

man development. Moreover, because individuals act as their own moral agent, having an *accurate* worldview is crucial to valid judgments. Even the choice to defer to another authority becomes a functional judgment. So, from the worldview paradigm (defining truth about the world and, by mirror effect, self) flows judgments, decisions, and actions. Adam’s fall exemplifies how actions follow actual belief regarding reality; one can attempt to predict reality, but possibly be quite wrong if a faulty paradigm is adopted. Thus, Christianity integrally requires faith in the salvation process. Based on the sacrifice of Christ, we each have the opportunity to effectively reverse Adam’s disbelief by embracing the key truth identities defining the faith (a worldview, in fact). Careful examination, however, reveals the fact that all worldviews—theistic, pantheistic, or atheistic—at their most basic levels are arrived at by faith, regardless of view.

These processes as a whole provide the mechanism used to determine truth from falsehood. If truth is unclear, valid judgments and appropriate responses are impossible, whether they involve a single judgment or the integration of a worldview paradigm. A worldview, then, is a matrix of truths solved iteratively, similar to a matrix equation or mathematical curve fitting, with a hierarchy of certainties yielding “calibration coefficients” defining when truth is supposedly clear, similar to how the Hubble telescope’s optical calibration coefficients define accurate aspect ratio and focus. As it is adopted and updated, a worldview serves as one’s cipher code to truth. Just as a surveyor validates alignment of his transit and if his data appears suspect naturally rechecks his transit and measurements, one defines and validates one’s observational framework (i.e., worldview) in order to correlate truth with reality. Using data and virtual data as the physical material, man uses these thinking algorithms to weave a matrix of truths from which to make

solid truth judgments, much as spiders start with open air and attempt to weave their web into a work platform. Some of those platforms are well thought out with mathematical precision, and others apparently are haphazard and perilously thrown together, but they are always crafted by the purposes the individual is attempting to achieve. This inherently individual and subjective process is the tool used to emulate functional objectivity, which is why the worldview question must be stated in the first person. Culturally, worldviews often are shared by countries, religious orders, etc., but that happens to the degree that an individual adopts the society’s worldview paradigm for himself. Thus, regardless of the amount of “group think” and social pressure involved, worldviews are ultimately individually held and maintained.

A worldview, then, exists as a natural result of the expansive nature of thinking and serves to interpret information and correct for observational distortions and/or limitations, providing the reference tool for emulating objectivity in determining truth. Just as computer programs sometimes create working files for reference, the simple act of thinking eventually will generate a worldview and, once created, frequently be referred to and periodically updated. In summary, while the answers assigned may be convoluted and complex, the worldview construct itself is really a straightforward device, perhaps best expressed as answers given to the question, “How do I understand myself relative to ultimate truth?”

As a closing comment, some might reasonably ask if this question could be worded differently or better. For example, since truth is at issue, one might phrase it: “What is true?” However, this fails to clearly recognize the implied personal perspective. A rephrase might ask, “What am I sure is true?” But this fails to emphasize that this search for “truth” hopes to correlate truth with reality and also that self-identity is being framed as well. So, I need to recognize that

other phrasing might be possible, but the debate would likely be endless, as each author emphasizes some aspect of the concept he wishes to promote. The guiding principles, however, are that any wording must consider the causal mechanisms described here. If not, the discussion loses sight of the worldview's true nature and authors may make inadvertent philosophical mistakes, incorporating their views into a definition and/or indulging in unfounded general proclamations. Phrasing goals I used intended to convey that (a) truth is a pursuit common to all but individually understood, (b) a worldview paradigm is aggregated across all time because it seeks to identify universal truth, and (c) ultimately it defines the individual's understanding of himself.

Premise X: Since a worldview is, at best, a reflection of actual truth, the sobering, inescapable conclusion is that a worldview is self-limiting because there is no logical or rational way to objectively get behind this "final question." To do so would require absolute, objective knowledge of truth (which, by theistic definition, is God).

Conclusion

The first nine premises demonstrate that humans inevitably construct a worldview as part of the thinking process, validating Noebel's statement that, "every individual bases his thoughts, decisions, and actions on a worldview" (Noebel, 1997, p. 1). The final premise simply identifies the worldview's natural limitation. The reason Noebel (1997, p. 1) noted worldviews sometimes "lack consistency" is that people often focus on immediate issues, not bothering to consider that their answers may be incomplete or ultimately even conflicting, as Palmer (1996) noted.

A worldview is the tool used to emulate objectivity in the perception/learn-

ing process, and the expansionary nature of that process provides the mechanism generating the worldview. The worldview's root cause is the desire to validate one's understanding and consists of the aggregation of responses to the question, "How do I understand myself relative to ultimate truth?" Those answers effectively serve as the calibration construct or plumb line describing a person's idea of how his or her paradigm(s) actually correlate with reality. As Geertz succinctly said, it is "their picture of the way things, in sheer actuality are" (cited in Palmer, 1996, p. 114). Furthermore, as a person's worldview is defining what he believes is certain truth, that truth becomes a mirror also defining truth about self, thus defining his self-identity unbounded by time. Consequently, a worldview is a mechanism used for perceiving both reality and self.

The term "worldview" is used often and in many ways, touching every realm of human understanding. However, vague definitions and confused usages often stem from failure to understand what generates it and to appreciate how it defines self. A later paper will address contemporary apologetic usages of the term, demonstrating that most subdivide the global self-awareness concept to address specific aspects of personal understanding and that sound definitions are all traceable to the global question: "How do I understand myself in relation to ultimate reality?"

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Editorial

Editorial: There Can Be Only One

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scientists might choose to turn to religion for an answer. Others, however, myself included, would attempt to sort out the surviving less probable scientific explanations in the hope of selecting one that was still more likely than the remainder (Shapiro, 1986, p.130).

I typically find Shapiro's writings to be refreshingly candid and insightful. He is often very willing to acknowledge problems and contradictions in many evolutionary teachings. However, even he is not immune to The Mindset. In his admission, even if the evidence clearly points to a creator, The Mindset does not allow him to consider such a conclusion.

Currently, there is not a shred of evidence that life could have arisen by any natural processes. Instead, the empirical evidence, in the form of repeated verification of the law of biogenesis, strongly supports the concept that life could have only come from life (i.e., a creator). So, how is it more reasonable

to assume that no evidence for a naturalistic origin of life is more scientific than extensive evidence for the creation of life? The Mindset is far less interested in evidence than in its own religious agenda—evolution is the creator and god of the universe.

Sadly, many other scientists are even less immune to The Mindset than Shapiro. In fact, many actively promote it. They often encourage that any peer not fully “immersed in the faith” be ostracized, sometimes to the point of career destruction (see examples in Bergman, 2008). Faculties at many universities have become notorious for “sniffing the underwear of their colleagues for signs of ideological deviance. Much occupied in denouncing theories of intelligent design . . .” (Berlinski, 2009, p. 52). This is a far cry from the *Constitutio Habita* doctrine of academic freedom that universities proudly touted for centuries.

I personally know of several instances where a creationist has submitted a

scientific paper that was subsequently rejected, not because of any significant technical errors. Rather, I am convinced that the journals were concerned about actually publishing work of a known creationist or someone working at a known creationist organization. Even theistic evolutionists, such as Michael Behe (outspoken advocate of intelligent design) find themselves “targets” when they are not sufficiently promoting the evolution agenda. Apparently fearing the wrath of The Mindset faithful, the math journal *Applied Mathematics Letters* withdrew an article after its formal acceptance (see ScienceDirect, 2011) because it teetered on the edge of questioning the plausibility of evolution. This was clearly intolerable, and defenders of The Mindset gloated how they were able to show the journal editor the “error of his ways,” inducing his decision for the late withdrawal (e.g., Elsberry, 2011). In withdrawing the paper, though, the journal had violated its own written rules

of manuscript acceptance procedures, and subsequent threat of legal action obtained a \$10,000 settlement (West, 2011). Confusing? Never expect consistency in the face of The Mindset, nor underestimate its power of intimidation.

Ironically, The Mindset denies this type of discrimination ever happens. Rather, it claims that careers have been derailed strictly because of professional failures. It is important to understand that The Mindset considers evolution the “ultimate truth.” Thus, defending evolution is the role of guardian for scientific purity and truth seeking. Any accusation that The Mindset caused people to be treated unethically or unprofessionally cannot and *will not* be tolerated!

In reality, The Mindset cannot imagine there is even anyone actually educated in science, conducting research in science, publishing papers in science, or winning awards in science that would not be totally committed to its version of science (i.e., evolution). In the late 1960s, Dr. Dean Kenyon wrote a book outlining his proposal for the naturalist origin of life (Kenyon, 1969). At that time it was regarded as the quintessential “origin of life” treatise, and it established Kenyon as one of the leading “origin of life” researchers. Then the unthinkable happened. Kenyon began to have doubts about his own ideas, and eventually he abandoned them. This, in itself, would have been enough of a travesty to The Mindset, but Kenyon had the audacity to embrace “intelligent design.” Such a conversion was a clear sign that this once bright, successful scholar had lost his mind and was no longer competent enough to even be considered a scientist. Predictably, academic and professional conflicts soon ensued.

Most reviled of all are biblical creationists, who typically find themselves ridiculed, regardless of their scientific credentials or achievements. The Mindset concludes that a creationist cannot possibly be a scientist. The very act of

being a creationist suddenly negates any and all scientific accomplishments. Many of us creationists who are practicing scientists (research, publications, conferences, and all that) are well aware of the “you can’t possibly be a scientist” type response (distorted facial expressions included). I was recently reading a book that referred to Henry Morris as a “scientist.” The use of quotation marks was clearly intended to question Morris’s scientific legitimacy. This is in spite of the fact that Dr. Morris had been a department head at a major university and had more publications and research awards than most of his critics. The Mindset says that neither education, nor publications, nor research success makes someone a scientist. That can be achieved only through a dedicated embracing of evolution.

There Can Be Nothing More Significant

The Mindset views evolution as not only a fact beyond question but also as the central, unifying, essential, and fundamental explanation of all biology (perhaps of all science). I’m quickly reminded of Dobzhansky’s claim that “nothing in biology makes sense except in the light of evolution” (Dobzhansky, 1973, p. 125). Before him, the Jesuit priest (and ardent evolutionist) Pierre Teilhard de Chardin wrote that “evolution is a light illuminating all facts, a curve that all lines must follow” (Chardin, 2008, p. 219). Many zealous disciples of The Mindset have recently echoed this sentiment (e.g., Coyne, 2010; Dawkins, 2009).

In contrast, chemist Philip Skell had the audacity to actually question the importance of evolution to advancements in science (Skell, 2005a). He challenged that Darwinism is not fundamental to any experimental progress and that no major scientific insight required a Darwinian framework for its discovery and understanding. He further offered

that few scientists actually need (or even employ) any type of evolutionary paradigm in their research (especially in medical, applied, and industrial settings). Those claiming that evolution is an essential scientific framework are simply imposing a contrivance. As such, they are attempting to give to Darwinism a scientific significance it does not really possess.

Clearly Skell’s arguments defied The Mindset, which requires evolution to be the mainstay of any and all scientific progress (especially in areas of biology). Subsequent letters to the editor attempted to refute Skell’s claim. Interestingly, though, they primarily offered only a weak compilation of scientific advances supposedly attributed to evolution, most of which were merely extensions of evolution itself, such as comparative anatomy, phylogenomics, and ecology. Directed molecular evolution was also offered as a rebuttal without recognizing that such experiments are actually contemporary expansions of classical selective breeding programs (employed well before Darwin proposed any of his ideas). What is more, many approaches used for directed evolution actually invoke the researcher’s guidance (i.e., intelligent design). In his response, Skell notes the circular reasoning found in the letters, and concludes:

The responses still provide no evidence that evolutionary theory is the cornerstone of experimental biology ... What modern experimental biologists study are the mechanisms by which living organisms maintain their stability without evolving ... It has been research on these mechanisms of stability, not research guided by Darwinian theory, which has produced the major fruits of modern biology and medicine (Skell, 2005b, p. 10).

Textbooks also superimpose evolution onto various topics. Metabolism, mitosis, DNA replication, anatomy, neurology, photosynthesis, etc., etc. can

easily be taught without any reference to evolution. However, following *The Mindset*, many textbooks add speculative descriptions of how these systems may have evolved. In so doing, they unnecessarily make evolution a component of the topic, yet it adds nothing to a fundamental understanding of these topics. I have been asked on several occasions how I could possibly teach graduate level genetics without including evolution. “Much better,” I usually respond.

Since *The Mindset* views evolution as fundamental to science, it is not surprising that it further equates evolution with science. The interchanging use of the two words is frequently found in both popular and technical writings. So, it stands to reason that anyone who questions evolution (and all its assumptions of common descent) must be opposed to the scientific process. This position (euphemism for “dogmatism”) has been very effective at creating a “science versus religion” conflict. In this conflict, those defending evolution are portrayed as the humble defenders of science (where science is defined as “truth”) against the emotional and illogical attacks of religious zealots (defined as superstitious ignoramuses). By establishing this conflict, *The Mindset* seeks to create a dichotomy where people must choose either the logical, truth-seeking path of science (i.e., evolution) or the backwards and irrational path of religion (i.e., creation).

This strategy has been sufficiently successful so that it now even heavily influences legal and political matters. Judges and politicians have become products of an education system where evolution is held in high esteem and counter ideas are openly ridiculed and mocked. Any hint that a politician has doubts about Darwin will draw vicious and unrelenting attacks by the media, fellow politicians, Hollywood, and other guardians of the faith. Judges are almost incapable of rendering objective

judgments regarding balanced teaching legislation. Judge Jones’s erroneous and contradictory ruling in the Dover trial (Anderson, 2006) gave clear insight on this. Testimony and evidence had little impact on a ruling that was clearly made before the trial even began. *The Mindset* has little interest in a fair and balanced hearing of other views. Remember, there can be no opposing view.

There Can Be No Contrary Evidence

In fact, no amount of contrary evidence can effectively penetrate *The Mindset*. This is a very powerful aspect of *The Mindset*—casual dismissal of any opposing data, view, or conclusions. Any such claims of opposing evidence are considered to be merely the result of misinterpretation, misunderstanding, or pure fabrication. Contradictory or refuting evidence simply cannot exist.

For example, in 2005, evidence was published showing that a fossilized *Tyrannosaurus rex* femur still contained some non-fossilized tissue (e.g., red blood cells, osteocytes, etc.) (Schweitzer et al., 2005). Since the fossil was “dated” at more than 65 million years, this finding directly challenged the entire evolutionary “millions of years” timeframe. This timeframe is readily (and often uncritically) accepted by most scientists, even many claiming to be creationists. Since 2005, additional studies have documented even more soft tissue in so-called ancient fossils, including the detection of intact proteins (Asara, et al., 2007; Schweitzer et al., 2007; Schweitzer et al., 2009).

Based upon all we currently know about tissue/protein preservation, there is no plausible way this tissue would have survived millions of years. Yet, all too predictably, *The Mindset* cannot comprehend why creationists would view this discovery as evidence that dinosaurs lived only a few thousand years ago (or less).

Meanwhile, Schweitzer’s research has been hijacked by “young earth” creationists, who insist that dinosaur soft tissue couldn’t possibly survive millions of years. They claim her discoveries support their belief, based on their interpretation of Genesis, that the earth is only a few thousand years old. Of course, it’s not unusual for a paleontologist to differ with creationists. But when creationists misrepresent Schweitzer’s data, she takes it personally (Fields, 2006).

When [Mary Schweitzer] found remnants of soft tissue in a *T. rex* bone excavated in Montana, creationists used her find to argue that soft tissue couldn’t possibly survive millions of years. ... “I think the whole subject of [creation] combines really bad science and really weak faith,” she said. “It’s a misunderstanding of what is a science to begin with. ... If you’re doing science, you have to play by certain rules. They’re trying to rewrite the rules of science and call it science” (Healy, 2009).

Apparently, anytime creationists simply point to data that supports their position, it is breaking the “rules.” How dare we state the obvious nature of the data. I guess that is cheating. But when *The Mindset* writes the “rules,” it has little to do with scientific investigation and more to do with excluding opposing views. Remember, there can be no opposing views. There can be no contrary evidence.

Other evolutionists are not so willing to even accept that this is dinosaur tissue. Recognizing the difficulty of explaining such tissue, they choose to completely dismiss the validity of the studies.

On the flip side, Jeffrey Bada, an organic geochemist at the Scripps Institution of Oceanography in San Diego, cannot imagine soft tissue surviving millions of years. He says the cellular material Schweitzer found must be contamination from outside sources. Even if the *T. rex*

had died in a colder, drier climate than Hell Creek, environmental radiation would have degraded its body, Bada says: “Bones absorb uranium and thorium like crazy. You’ve got an internal dose that will wipe out biomolecules” (Yoeman, 2006).

In other words, since we “know” these fossils are millions of years old, the environmental radiation would have destroyed all the original tissue. Thus, these fossils may contain tissue, but it cannot possibly be dinosaur tissue.

Interestingly, I think Bada has a very valid point. There is little doubt that environmental conditions would have destroyed soft tissue millions of years ago. Thus, the dilemma: This cannot possibly be dinosaur tissue because The Mindset *knows* that the fossils are over 65 million years old.

Of course, a far more scientifically consistent interpretation is that the fossils are simply a few thousand years old. But once again The Mindset trumps the evidence—the very type of experimental data creationists are constantly accused of ignoring. Mary Schweitzer even acknowledged that she

had one reviewer tell me that he didn’t care what the data said; he knew that what I was finding wasn’t possible. I wrote back and said, “Well, what data would convince you?” And he said, “None” (Yoeman, 2006).

In my own field of genetics, I see The Mindset squarely at work among my colleagues. Beneficial adaptive changes in organisms are automatically viewed as examples of “evolution,” regardless of their nature or origin. Hence, these changes provide supposed observational verification of evolution. This allows The Mindset to conclude that evolution is verified every day. What more proof of evolution is needed?

However, to truly verify this claim, it is necessary to analyze the mechanisms that actually cause these adaptive changes. One such mechanism is

horizontal transfer of genes from one cell to another. In this manner, cells can acquire new genetic content with functions the cell did not previously possess. As such, horizontal acquisition of genes is viewed as a driving force of evolution. Cells “evolve” by gaining this new genetic material.

Horizontal transfer, though, does not explain the origin of the genes, but only their contemporary distribution. Thus, it offers little as a mechanism to account for the development of novel functions. Case in point, the horizontal movement of genes for amino acid biosynthesis requires the prior existence of such biosynthesis genes. Cells cannot horizontally transfer what does not yet exist.

Mutations are another means of changing an organism. With mutations comes a mechanism to potentially alter the genetic content of a cell. Hence, new systems and functions can be formed. In fact, mutations are usually considered a primary driving force of evolution.

Typically, the only criterion to be this driving force is if the mutational change provides any type of adaptive benefit; any feature that can be positively selected. However, this approach usually focuses upon the phenotype of the organism, with little attention toward the actual type and consequence of the mutation. This can be dramatically misleading.

The work of Richard Lenski and his co-researchers exemplifies just how misleading. Growing cultures of the bacterium *Escherichia coli* for thousands of generations, they have obtained a variety of mutant strains. The phenotypes of these mutants are a diverse collection of adaptive features that provide some limited growth advantage within the very narrow culture conditions of the experiment (Lenski, 2011). Hence, these mutational changes are widely touted as documenting evolution in the laboratory (Lenski, 2011; Wolf and Barrick, 2012).

The genotypes of the mutants, however, tell a different story. When a few of the mutants were genetically analyzed,

they consistently possessed mutations that eliminated preexisting systems and functions (Anderson and Purdom, 2008). Typically, the mutations eliminated systems that were unnecessary for growth in the ever-constant environment of the study. This truncation of its genetic machinery gave the mutants slight growth advantages and hence an experimental benefit.

Lenski refers to this situation as “antagonistic pleiotrophy” (Schneider and Lenski, 2004). This phenomenon suggests that a mutation can be beneficial in one type of environment yet be deleterious in a different environment. For Lenski’s mutants, the benefit of the mutations was limited to phenotypes that result from genetic degradation. Almost lost in the fog of The Mindset is the problem of accounting for the origin of the very systems that are being discarded to produce the benefit.

What is more, Lenski’s work focused upon asexual organisms with small genomes. A recent study attempted to apply his basic approach to a more complex organism—specifically *Drosophila*. After 600 generations no fixed “unconditionally advantageous alleles” were found in the fruit flies (Burke et al., 2010). In fact, this experiment employed a relatively strong selection process, much stronger than would be found in natural settings. This led the researchers to conclude that “the probability of fixation in wild populations should be even lower than its likelihood in these experiments” (Burke et al., 2010, p. 589). No demonstration of evolution here.

So, as interesting as Lenski’s studies are (at least for us geneticists), such mutations offer little in the way of an actual mechanism for common descent. They do not explain the origin of any cellular function, only its demise. They do not provide a mechanism to develop new cellular systems. They do not explain how organisms achieved their current level of complexity—only how they truncate unneeded systems. In other

words, they offer an excellent example of how diversity can occur within a creation model, where a high level of complexity exists at the beginning. But they are a poor example of how common descent could occur within an evolutionary model, where early life-forms lack contemporary complexity.

Evolutionists also repeatedly appeal to the development and spread of antibiotic resistance in bacteria as a clear demonstration of evolution. Yet, antibiotic resistance is acquired either from the horizontal transfer of already existing genes or degenerative mutations (Anderson, 2005). Neither of these events gives the needed “example” that resistant bacteria are claimed to illustrate. Interestingly, my observation has been that most evolutionists who offer this as an example have little understanding of what actually makes a bacterial cell resistant. But it does serve The Mindset, and that is the most important consideration.

Another popular line of genetic “evidence” is the activity of the *Hox* genes. These are a group of genes that express regulatory proteins that control the development of the embryo (i.e., control formation of basic body structures—arms, legs, fingers, etc.). Malfunction of these genes can cause dramatic changes to the physical features of the embryo. Interfering with the action of *Hox* genes in fruit flies gives them a wide array of deformities, such as flies with four wings, no wings, red eyes, no eyes, extra legs, no legs. Because of these dramatic physical changes, evolutionists assume (and I emphasize the word “assume”) that mutations in *Hox* genes are a driving mechanism for evolution. In fact, we are now told that this is a verifiable “proof” of evolution (Carroll, 2005).

Once again, while The Mindset prepares for its victory parade, the true nature of the *Hox* genes’ mutations serves as the proverbial “rain.” It is hardly surprising that interfering with the normal function of developmental genes will create gross morphological distor-

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tions. How could it not? Actually, such dramatic change is a bit of a throwback to Goldschmidt’s “hopeful monsters”—a very unpopular evolutionary mechanism when originally proposed over 70 years ago (Gould, 1980).

Such morphological distortions are analogous to disrupting a computer program for an automated automobile assembly system. The result could be cars missing doors, backwards axels, or seats attached to the roof—an interesting potpourri of designs but not very useful if you are trying to sell cars. Nor is it very useful for any automotive engineer’s attempts to create more fuel-efficient body designs or more effective steering systems. Nor does it provide a useful means of explaining the origin of those body designs or steering systems. In the same manner, mutations of *Hox* genes do little to answer basic questions of origin and are limited to alteration of preexisting biological features. These mutations are not nearly as useful or functional mechanisms as The Mindset has declared.

There Can Be Only One

The Mindset honors a jealous god—all criticism is rejected. Within The Mindset, the evolution paradigm finds refuge from challenge, refuge from testing, and

refuge from falsification. It is the *only* explanation of life that is permissible. There are no alternatives. There is no challenge, test, or contradiction allowed (only minor details left to be debated). As such, there is also nothing more important to science, to history, or to society than evolution.

However, such refuge should never exist for any scientific concept. Strong and vibrant scientific thinking does not need to seek protection. Protection from challenges and counter ideas can easily lead to misinterpretation and ignoring and even fabrication of evidence. Thinking can become extremely closed and impotent. This is the very antithesis of the scientific process.

Ultimately, it is not about evidence, argument, or logic. It is not even about science. It is about a mindset that establishes itself as the answer to life and for life, a mindset that establishes its own worldview, a mindset that claims a power of creation that it does not really possess, answers to questions it cannot really answer, and insights for science it will never provide.

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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.

Unmasking the Secret

Regarding your excellent expose of *The Secret* and *The Power* in the Fall 2011 editorial, "Not So Secret," I kept thinking of how all this relates to neural nets (from artificial intelligence studies).

The mystical definitions stated in *The Secret* are simply not in accord with any known physics. Neural net impulses cannot escape the neural net to impact the physical environment on which the impulses ride. Further, elements

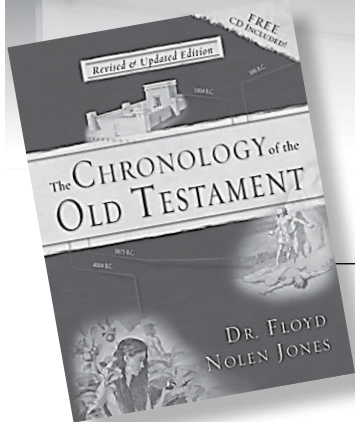
(impulses) riding a neural network have no self-charging capacity; any charge entering the net must be pulsed (created) external to the net itself. Apparently *The Secret* assumes a randomly ordered neural network with no external organization to create and maintain the net; this is not possible. Charges on a net must be set up (created) by external forces/powers and must also enter the net via the same powers. Additionally,

neural networks cannot of themselves interpret/measure the traffic (charges) that ride on such a net; the net itself is a neutral physical medium.

It seems that (according to *The Secret*), we the universe can ourselves manipulate the universe. This is actually Hinduism, occultism, Eastern mysticism (self-delusion) masquerading as truth—the Serpent naked and unmasked.

Erv Bontrager

Media Reviews



The Chronology of the Old Testament

by Floyd Nolen Jones

Master Books, Green Forest, AR, 2005, 385 pages, \$25.00.

This book is not well known but is truly an amazing chronology of biblical events and characters. The subtitle, *Solving the Bible's Most Intriguing Mysteries*, says it all, as it provides credible answers to some of the Old Testament problematic passages. As more conservative Bible scholars get to know this book, it could become the standard Bible chronology, replacing the

chronology of Edwin R. Thiele (1977, 1983), which for the last 50 years has been the definitive scheme used by scholars.

The author interacts with many of the current and historical chronologists, including Edwin R. Thiele, William F. Albright, Eugene W. Faulstich (1986), Robert Anderson, Harold W. Hoehner (1977), Isaac Newton, Bishop Ussher, and others.

In that most chronologists of the last 50 years utilize some slight variation of Edwin Thiele's scheme, the author

spends some 40 pages exposing errors and bias toward the accuracy of the Assyrian eponyms rather than adherence to the Hebrew text. The author states,

That Thiele placed the Assyrian data as his infallible guide over the Scriptures is his own choosing ... It is a decision for which he and all others who follow his example must give an account ... Although this deed is disturbing, that which most distresses is that nearly all conservative, evangelical scholars and schools alike have endorsed Thiele's

dates even though they do constant violence to the written Word of God (pp. 114–115).

The author further writes,

Over and over he [Thiele] claims that his solutions are superior to those of the past as he has not only brought the archaeological findings, especially those of the Assyrian Empire, to bear on the problem involved in Israel's monarchical period but that he has at all points honored the lengths of reign as recorded in the Hebrew text. The frustration for this author is that having so said, Thiele did not do that which he stated. ... He did not honor the Hebrew Scriptures. He did not even come close. Careful study reveals that his faith and loyalty were totally to the Assyrian Eponym List ... When the Hebrew Text did not directly fit into the Assyrian chronological scheme; it was contorted and disfigured until it apparently conformed (p. 115).

A second criticism of Thiele's work by the author is that Thiele came up with a "dual dating technique" (p. 114) that supposedly is responsible for his success in solving the mysterious numbers of the Hebrew kings. On pages 117–118 the author points out three examples where Thiele's error of using Tishri-to-Tishri regnal years clearly leads to erroneous starting and ending dates for the kings in question. On page 119 the author shows where Thiele's assertion that the Hebrew kings always numbered their regnal periods inclusively is clearly wrong.

Regarding the Septuagint the author shows that "the Greek arrangement reveals itself to be a late artificial contrivance brought into being in an attempt to correct something that was actually accurate but appeared wrong to the reviser" (p. 13). The author has studied this issue in depth and has written a book entitled *The Septuagint: A Critical Analysis* (1989) and so should have authoritative knowledge on this

issue. Regarding the Samaritan Pentateuch, the author agrees with and quotes nineteenth-century scholars who state, "It is merely fabricated from the Greek: and those who treat it as an independent authority only show themselves ignorant of the results of criticism on the subject" (p. 10).

The basic starting point for the author's own chronology is 586 BC, which most chronologists agree is the year of the fall and captivity of the southern kingdom of Judah. He uses Ezekiel's 390-day object lesson (Ezek 4:4–5) to determine the year of the split between the kingdoms as being in 975 BC. Figuring in David's 40-year reign along with the 480 years of 1 Kings 6:1, the year of the Exodus is determined to be 1491 BC. This is significantly different from most other conservative chronologists who follow (with slight variations) Thiele's chronology, which dates the Exodus year as 1445 BC.

Chapter 3 is devoted to an analysis and harmonization of the Scripture references pertaining to Israel's sojourn in Egypt (Gen. 12:4; Exod. 11:40; Gal. 3:17; Acts 7:6; 13:14; Gen. 15:6, 13). Jones's conclusion is that Jacob went down to Egypt to be with his son Joseph in 1706 BC. From this the date of the year of Creation is determined to be 4004 BC, which agrees with Bishop Ussher. The genius of the author's chronology is that the 490 years of Ezekiel 4:4–5 allows the author to construct an ironclad chronology for the kings of Judah and Israel. As one who has read both of Thiele's books and others, I find the author's synthesis compelling.

Regarding Daniel's prophecy (Dan 9:27), the author's chronology shows that the starting year for the 490-year prophecy was 454 BC, which allows for the 483 years to be normal 365 ¼-day years rather than the contrived 360-day "prophetic" year used by other chronologists. Yes, the author does provide an analysis of the day and year of Christ's passion. Other highlights include, as mentioned

above, his synthesis of the many different references for the chronology of Israel's sojourn in Egypt and also a harmony for the years of the Judges following Joshua. Jones's harmony of the chronologies given in Ezra and Nehemiah concludes that the individual named Nehemiah in each book is the same individual and not two different individuals as claimed by some chronologists. Likewise, Ezra and Mordecai in each book are the same individual.

One of the unique features of the author's work is his triangulation charts showing the overlap of various events in linear timeline chart form. This allows one to readily see one event juxtaposed upon other events. This is extremely helpful for the chronologies of the kings of Judah and Israel. Events and key individuals of other important nations are also juxtaposed for seeing the overall picture at any chosen time.

This book provides many new insights into Old Testament individuals and events. It provides credible solutions to many intriguing mysteries and is therefore recommended for biblical scholars as well as the layman desiring to obtain better understanding of the timeline of biblical events. One thing lacking is an index of the many Bible references.

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Untold Secrets of Planet Earth: Dire Dragons

by Vance Nelson

Untold Secrets of Planet Earth
Publishing Company, Red
Deer, Alberta, Canada, 2011,
137 pages, \$30.00.

Vance Nelson is a biblical creationist researcher who has spent ten years researching the subject of his book: Did dinosaurs and people live together? His research has led him to conclude that this was indeed the case. *Dire Dragons* is the fruit of his research and presents much never-before-published evidence.

The opening pages of the book briefly discuss the evidence indicating dinosaurs lived recently, including carbon-14 dating of dinosaur bones, soft tissue finds, etc. Nelson demonstrates how early paleontologists used the terms “dinosaur” and “dragon” interchangeably, showing there was a connection between the two in their minds. He also critiques the idea that ancient men could have excavated or observed fossils and accurately reconstructed dinosaurs from them.

The main body of this book contains the photographs and discussion of ancient depictions of dinosaurs and pterosaurs. The evidence is presented by country with five continents represented. At least one photograph of each artifact is presented with discussion. Excellent dinosaur artwork is compared with each artifact, showing the similarities between ancient and modern depictions of what appear to be the same animal. A wide array of creatures are shown in ancient art, including pterosaurs, mastodons, hadrosaurs, ceratopsians, sauropodomorphs, theropods,

nothosaurs, and pachycephalosaurs. Some evidences covered in this book, such as the Kachina Bridge sauropod petroglyph, are already known among creationists. Most, however, have never before been published in creationist literature. Examples include a Peruvian vessel with an apparent *Protoceratops*-like animal, a “salamander” emblem similar to a prosauropod, an apparent young hadrosaur on a sixteenth-century tapestry, and some very compelling ceratopsian depictions from China. Several depictions of the story of St. George and the dragon are also included. Nelson points out that the story itself is probably a myth since it was not recorded until centuries after George’s death; however, the artistic depictions of the dragons still make good evidence for the coexistence of humans and dinosaurs. The various depictions of George and the dragon show different types of creatures, including creatures similar to theropods and nothosaurs (pp. 71, 101, 121).

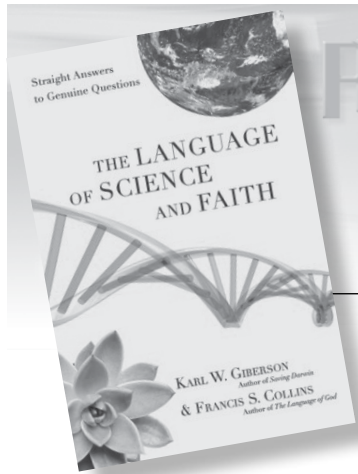
The evidence included in *Dire Dragons* has been well authenticated. Nelson personally examined almost all of the artistic depictions discussed. Since this book is based on personal, scrupulous, primary research and not hearsay evidence, it should prove quite reliable and very useful to creationists.

One area the book discusses is the accuracy of ancient depictions of dinosaurs. Many representations, although quite convincing, show slight inaccuracies, such as a wrong number of toes

or fingers, apparent external ears, etc. Nelson points out that each culture accepts a certain amount of stylization in its artwork, which accounts for some differences. In addition, modern artists have only bones to work with, and thus we do not know the details of soft tissue that the ancients may have had knowledge of, accounting for more differences. Third, while we have the advantage of being able to study fossils and see thousands of dinosaur reconstructions, an ancient eyewitness to a living dinosaur may have only seen one a few times, perhaps while it was moving, obstructed, or at a distance. Thus, absolute perfection cannot be expected in most cases. Fourth, the ancients rarely depicted even common animals perfectly; thus, a few inaccuracies in dinosaur depictions are to be expected.

Dire Dragons is an excellent book with much new, verified information that should be of great usefulness to creationists. In addition to being scientific, it is a beautiful work of art, a coffee-table type book with excellent graphics and beautiful dinosaur reconstructions. This book should be circulated among creationists. It is worth the effort to obtain it from the distributor in Canada. I also appreciate the gospel presentation concluding the book. The Lord Jesus Christ must be the center of all our work.

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Reviews

The Language of Science and Faith

by Karl Giberson and Francis Collins

IVP Books, Downers Grove, IL, 2011, 250 pages, \$20.00.

Physicist Karl Giberson is on the faculty of Eastern Nazarene College, Quincy, Massachusetts, and geneticist Francis Collins directs the National Institutes of Health. Both men are in leadership of the Biologos Foundation, which strongly promotes theistic evolution. The book includes full references and name and subject indexes. Its question-and-answer format includes the following. (1) “Is there proof of macroevolution?” (p. 48). The authors’ answer is affirmative, based solely on DNA. (2) “Does the Bible teach that the earth is young?” (p. 68). The book’s conclusion is negative. (3) “What about evil in nature? [It] has no simple answer; alas it also has no complex answer” (p. 128). The authors state that evil has nothing to do with the Genesis 3 Curse or the Fall of man. Instead, Biologos concludes that evil is somehow a natural outcome of evolutionary progress (p. 132).

The book makes many confident but plainly wrong statements: “There has been no scientific discovery since Darwin—not one—which has suggested that evolution is not the best explanation for the origin of species” (p. 22). It is further written that the transition from scales to feathers is clear from the fossil record (p. 35). Making such a statement does not make it true. It is falsely concluded that “not one isolated piece of nontrivial data, in any form,” points toward a young earth (p. 54). There are references to Answers in Genesis, Reasons to Believe, and the Discovery Institute, but no mention of the Creation Research Society or the Institute for Creation Research.

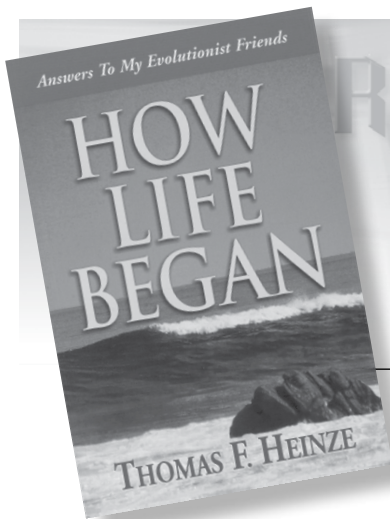
Of serious concern is the radical trend of Biologos toward process theology. Included is the belief that God does not know the details of how history will turn out. “God has endowed nature with a degree of freedom ... with and inherent liberty ... it explores its own inherent potential through its evolving process” (p. 116). This cancellation of God’s omniscience is surely an uncomfortable position for theists to maintain.

It is further stated that a literal Adam and Eve are ruled out by genomics (p. 206). The studies conclude that there is too much genetic variation in humanity for an origin in just two people. Instead, there must have been at least 10,000 prehuman creatures to get us where we are today. The apostle Paul must not have gotten this memo, since he refers to Adam and Eve in Romans 5:12. The Lord makes similar reference in Matthew 19:4.

The genomic results do not include God’s direct involvement in history. They leave out the Genesis Flood event, when humanity was carried on with Noah’s family, eight souls. The results also dismiss the Babel event of Genesis 11, when God separated the earth population into distinct groups. Adam and Eve were literal people, our first parents.

Here is a suggestion: When Biologos or any other group attempts to improve on Scripture, be suspicious.

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Reviews

How Life Began

by Thomas Heinze

Chick Publications, Ontario,
CA, 2002, 159 pages, \$10.00.

Heinze begins unapologetically with the hypothesis that only one of two explanations is valid for explaining how life originated: creation or evolution. The author develops a series of arguments regarding the beginning and inner workings of the cell. Then he passionately explains how the Creator of the cell could be none other than the God of the universe and offers an invitation to believe on His Son, Jesus Christ, for salvation from sin.

The author tells his readers that *How Life Began* is the first book in a series titled *Answers to My Evolutionist Friends*. I have not found any additional titles, but the author's website (creationism.org/index.htm) indicates that additional books may be in process. Heinze discusses complex concepts in layman's terms, but he covers the topics in enough

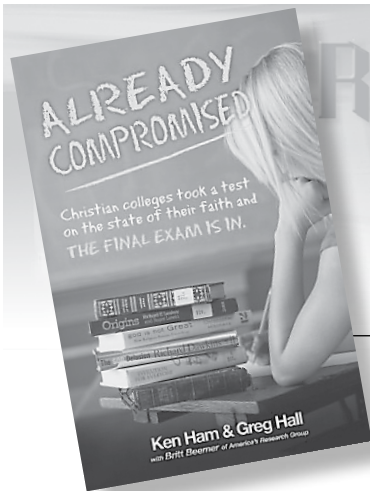
depth to hold the interest of experts in the field. The work is well referenced and has a relatively comprehensive index. I noted few spelling, typographical, and grammatical errors in the book.

The book presents the concepts from the 1953 Miller experiment through an analysis of the complexities of the DNA code known at the time of publication. The author covers the question of deep time leading to complexity and dispatches that argument by stating that abiogenesis has never been observed. Several of the classical experiments are related, proving that life comes from life. Heinze explains how correct information is required for the reproduction and proper operation of all cells, implying intelligence behind the information. Finally, the argument concludes with several examples of intelligent design in the real world, such as a computer chip, a crime scene, and Mount Rushmore.

The final chapter is appropriately titled "The Message." Here Heinze presents the gospel, beginning with a claim that the Bible is the Word of God and concluding with an exposition of Isaiah 53. If the reader has been careful to consider the previous arguments with an open mind, perhaps the Holy Spirit will open his heart to believing the grace gospel after reading this chapter.

I read the book after having it on my shelf for a number of years and was pleasantly surprised at the depth and the simplicity of the author's message. This book is well worth reading and rereading. The low price would allow it to be used as a form of tract in reaching unbelieving family, friends, and acquaintances.

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Reviews

Already Compromised

by Ken Ham
and Greg Hall

Master Books, Green Forest,
AR, 2011, 236 pages, \$14.00.

One of the issues

I encountered as a high school student getting ready to attend college in the sciences was whether or not I wanted to be completely immersed in evolutionary thinking at the undergraduate level. There are many good schools in science, but few that teach creation from a young-earth perspective. This is true in secular schools and, as Ken Ham and Greg Hall point out in this brand-new book, Christian colleges, as well.

This book is a sequel to the 2009 book, *Already Gone*, by Ken Ham and Britt Beamer. The purpose of that book was to determine if there was a link between teaching evolution and young people leaving church when they reached college. This book, based on research done by Beamer and America's Research Group, looks squarely at Christian colleges and universities to determine what is actually being taught about origins in these institutions. The findings are a surprise to no one familiar with the issue: Most Christian schools teach and promote something other than young-earth creation, whether theistic evolution, progressive creation, or similar compromises.

The survey was directed at 200 Christian colleges and universities, most of which were members of the Council of Christian Colleges and Universities (CCCU). However, a number of other mainline schools were also included that are associated with various denomina-

tions including Catholics, Baptists, and Methodists. At each school, the president, vice president, and heads of the religion and science departments were asked to respond to the survey. Of 800 people asked, 312 people responded. The results of the survey in aggregate form are presented in the book.

Unfortunately, there is some ambiguity in the results as reported by Ham and Hall. The comparisons they give show little effort at making good correlations. For example, when comparing responses given by different groups such as presidents and vice presidents, it is not clear whether these individuals served at the same or different institutions. Some of the results indicate that there may have been confusion over the meaning of questions. Thus some of the conclusions may not be valid, if ambiguous. In addition, the survey made no distinction between small Christian colleges and major denominational universities such as Baylor. Some may consider this unfair and an inappropriate caricature of all Christian colleges. Certainly there are many who do not subscribe to evolution or an old earth.

In spite of the shortcomings, the book presents an excellent case on a number of issues such as the following.

1. The authors point out very clearly the need for young people to be prepared to enter college knowing that not everyone at their institution, whether secular or Christian, will agree with all of their beliefs about the Bible and Creation.
2. They follow in the strong tradition of Answers in Genesis in showing the

importance of Genesis to a consistent biblical worldview.

3. They demonstrate that parents and young people need to carefully weigh the pros and cons of Christian versus secular schooling and recognize the fact that not all Christian schools are alike.
4. They emphasize that creation is only one part of a biblical worldview. Salvation, the importance of regular fellowship with other believers, and personal study of the Bible are also vital for growing in faith while in college.
5. They bring up a number of arguments that biblical scholars have suggested allow room for evolution and millions of years, and these arguments are challenged.

The last point is important because until recently most creation research had focused primarily on scientific issues. However, biblical scholarship has its own history of interpretation of Genesis, including ideas such as the documentary hypothesis, ancient Near Eastern parallels to Genesis, form-versus-function arguments, and the literary framework hypothesis. All of these have received limited attention from creationists, perhaps because they were once thought to belong only to "liberal" scholars. However, there are many Christians who hold to these ideas, and some attention is finally being given to addressing these issues. Although refuting these arguments is not the primary purpose of this book, space is devoted to them, including a chapter devoted to the documentary

hypothesis written by Terry Mortenson and Bodie Hodge.

Part of the book specifically addresses quotations from Christians who have embraced evolution, including John Walton, Paul Davis, William Dembski, John Collins, and Karl Giberson. Some of these men have been at the forefront of scientific or biblical scholarship and have made valuable contributions to science and biblical studies. Some may not consider mentioning these individuals by name, as well as their institutions, appropriate for a book of this nature. However, quotes are included to show the extent to which some scholars have gone to accommodate evolutionary

thinking to the biblical text. At the very least, it shows that these scholars are attempting to retain belief in the Scriptures while accepting what they believe to be true about science. Their efforts may be misguided, but much of their work can and should be appreciated and used by creationists.

In summary, this book presents a careful look at how many Christian institutions view Genesis and Creation. I especially recommend it for those who are preparing to attend college or who have children doing so. Although the choice of university or college is complex and should be guided by more than

just a school's position on Creation, the authors do a phenomenal job discussing many of the issues that young college-bound adults will encounter as they make this important step.

This book is well referenced but contains no index. It includes four appendices covering quotations from old-earth Christians, the meaning and importance of a worldview, the documentary hypothesis, and a potential questionnaire that can be used when visiting prospective institutions.

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Originality Throughout the Universe

by Joseph Mastropaolo

Trisphere Publishers,
Huntington Beach, CA,
104 pages, 2010, \$20.00.

Mastropaolo documents with many color photographs the fact that enormous variety exists in the natural world, both living and nonliving parts. This variety he correctly calls *originality*, because the term *variety* may be satisfied by some superficial quality like a different color hue. Instead, the book uses the term "originality" because each individual object examined is uniquely different beyond some superficial quality. Furthermore, the originalities are mediated by certain boundary conditions. For example, although each human face is always uniquely different, it is recognizably human and does not transgress the boundary conditions for a different kind of face, like that of a dog or cat. The universe is composed of numerous populations, any one of which would be impractical to investigate completely because of the enormous numbers involved. This problem is dealt with

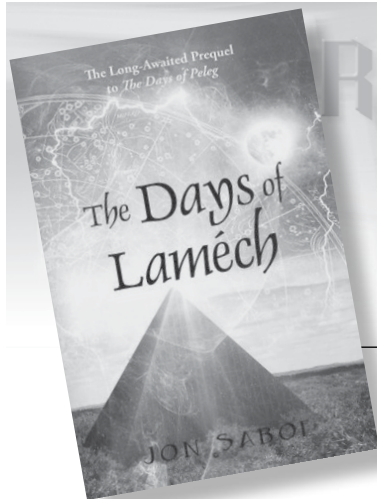
by studying a manageable sample and then inferring the results to the entire population.

Mastropaolo begins with the account of Wilson Bentley, who spent much of his life photographing snowflakes, finding that of the 5,381 examples that he photographed, no two were identical. Mastropaolo documents that the same is true in each example of the natural world that he examines. For example, of 619 bodies in our solar system (he includes the sun, the planets, dwarf planets, the moons, and other objects), he finds they are all unique. He then examines minerals, plants, animals, and other natural objects. Mastropaolo also examines plant parts such as leaves and animal parts such as wings, showing that much variety exists even when comparing leaves or wings from the same species. He even examines grains of sand and table salt,

documenting that uniqueness applies to gross mineral samples.

The variety in humans is well known, but Mastropaolo shows that even for paramecia much variety exists. This book gives new appreciation for the natural world and its enormous level of originality of designs everywhere. Darwin's law of survival of the fittest reduces variety, and the enormous level of variety existing in the natural world is a counterargument. Evolutionary attempts to explain variety in nature are often ad hoc. For example, evolution teaches that bright colors are selected for in birds to facilitate mate attraction, but evolution also selects for lack of color because bright colors attract predators. The author is well qualified to write this book, with 22 science articles in peer-reviewed publications.

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Reviews

The Days of Lamech

by Jon Saboe

Outskirts Press, Inc, Denver,
2011, 503 pages, \$18.00.

There are two Lamechs mentioned in the early chapters of Genesis. One is a descendent of Cain, who has the distinction of being the first mentioned polygamist (Genesis 4:18–24). The other Lamech, a descendant of Seth, is the father of Noah (Genesis 5:25–31). This book is a fictional account of the latter as he lives out his life in the world before the Great Flood. Lamech, a skeptic throughout the book, is given a mission by his grandfather Enoch (or Aenoch) to spy on the Semyaz, who are systematically taking political and military control of the world's great pre-Flood cities.

The era before the great Genesis Flood is one shrouded in mystery with little detail presented in the biblical text. Nearly 1700 years of human history are covered in three short chapters. Over the years I have considered it to be a time similar to the medieval period of more recent centuries. There was city building, farming, metalworking, and music. Author Saboe acknowledges that much of the science and technology portrayed in his book is speculation (p. 477). His imaginative pre-Flood world is a rather high-tech epoch with long distance crystal radio sets, genetic en-

gineering, electro-magnetic "rail guns," advanced lighting sources, and other wonderments.

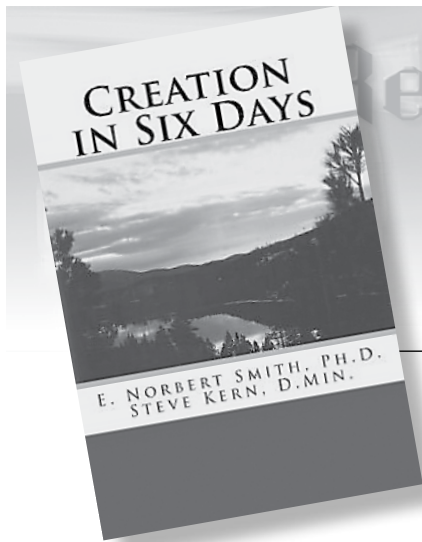
Some of Saboe's pre-Flood world description reminds one of the writings of Edgar Rice Burroughs (i.e., John Carter of Mars stories) and the fantasy work of Andre Norton. This is a world with a supercontinent surrounded by massive floating islands of special, water-adapted vegetation. Saboe acknowledges his debt to the work of Kurt Wise (p. 467) for this innovative "land" form. The antediluvian earth is made up of vast forests, grasslands, and great coastal cities named for the pre-Flood patriarchs, with groups of human outcasts inhabiting the woodlands. These forest people had "amazing abilities to tame and domesticate the great reptilian beasts that shared the forest with them" (p. 236). One unique mode of transportation used several times by Lamech and his allies are "dragons" (likely pterodactyls). The book is filled with adventure, romance, and mystery, as Saboe unrolls his verbal tapestry, so the reader is engaged throughout the narrative. Saboe gives just enough information to whet the reader's appetite to explore this unknown world. It seems as if given such a large time period, there is so much more to be told. At the end of the book, the inevitable deluge sweeps the old world away

in a catastrophic conflagration of outer space planetary breakup, massive plate tectonic movements, uplifting ocean bottoms, and explosions of subterranean rivers and springs. Noah, his family, and the animals in the ark are the only ones to survive.

The fallen angels named Semyaz are genetic engineers, set on making a "perfect" human for the replacement of the race created by God. This is an interesting twist on the biblical account, which states, "The sons of God came in to the daughters of men, and they bore children to them. Those were the mighty men who were of old, men of renown" (Genesis 6:3 NKJV). In Saboe's book, the mighty men were larger and stronger than normal men, glorying in military discipline, savagery, and immoral actions. We are given some plausible insights about the wives of Lamech, Noah, and Noah's sons. Shem, Noah's second son from whose line the "seed" would come and who plays a pivotal role in Saboe's first book, makes a brief but important appearance in this story.

The Days of Lamech is a prequel to his earlier book, *The Days of Peleg*. Jon Saboe has written a plausible and compelling fictional narrative of the world before the Flood.

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Reviews

Creation in Six Days

by E. Norbert Smith
and Steve Kern

CreateSpace, 2012, 182 pages,
\$20.00.

The authors, one a biologist and the other a pastor, dedicate their book “to the Creator of all things” and affirm that “the book of Genesis is the most important book in the Bible” (p. 5). The foreword is presented by botanist George F. Howe, a well-known scientist and creationist. The book is enhanced by the inclusion of eleven photographs.

A 60-page Introduction is followed by consideration of events transpiring during each day of the first week. On the first Saturday the creation was finished. “The origin of life was a miracle. It was not a process” (p. 56).

The authors conclude that “Evolution is not supported by the scientific evidence. ... The evidence of intelligent design by the God of the Bible is truly overwhelming. ... We know of no other explanation and firmly believe that delusion today is evolution” (p. 165). “God created our world complete, wound up

and fully functional. ... The fact of the matter is that the earth is not nearly as old as it looks. It has just had a hard life” (p. 107).

Further, they assert, “To believe in evolution is to believe in a different god than the one true Creator-God of Genesis 1” (p. 38). “Few people are aware of the extent religious persecution abounds today right here in ‘the land of the free’” (p. 39). The authors are well qualified and exercise restraint where it is justified.

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Correction to “Evaluation of the Ar/Ar Dating Process”

By Richard L. Overman, M.S.

While rereading my paper on the “Evaluation of the Ar/Ar Dating Process” [Overman 2010], I realized that I made a mathematical error on page 24. While discussing equation 8, I state, “In Equation 8, tau is the ‘mean life,’ which is the half-life divided by 0.693. The half-life is assumed to be constant with a current value of 1.25×10^9 years.” I realized that in all of my calculations I used 1.25×10^9 years for tau rather than 1.8×10^9 , which is $1.25 \times 10^9/0.693$.

Equation 11 below replaces equation 11 from the original paper. It is noted that the final value did not change.

$$(11) ((e^{t/\tau})-1)/(e^{t'/\tau})-1)=((e^{(3300/1.8 \times 10^9)}-1))/((e^{(1.19 \times 10^6/1.8 \times 10^9)}-1)=1.83 \times 10^{-6}/7 \times 10^{-4}=2.77 \times 10^{-3}$$

Tables V–VII replace the same numbered tables in the original paper.

Table V. Calculation of Ar and Age Ratios for Dalrymple et. al. and Mt. Vesuvius data

Irradiation	GLN3-1	105-1	105-2	105-3	108-1	JD06-1	JD08-1
Sample #	90G15K	90G15K	90G15K	JFL-500C	JFL-500C	83-O-05	83-O-05
Sample Material	Haiti Tektites	Haiti Tektites	Haiti Tektites	Z-Coal Bentonite Sandine	Z-Coal Bentonite Sandine	Z-Coal Bentonite Sandine	Z-Coal Bentonite Sandine
Monitor Mineral	MMhb-1	TCR	TCR	TCR	TCR	TCR	TCR
lambda(λ)	5.54E-10	5.54E-10	5.54E-10	5.54E-10	5.54E-10	5.54E-10	5.54E-10
t'	5.14E+08	2.79E+07	2.79E+07	2.79E+07	2.79E+07	2.79E+07	2.79E+07
$\lambda t'$	0.2849	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155
$e^{(\lambda t')}$	1.3296	1.0156	1.0156	1.0156	1.0156	1.0156	1.0156
$e^{(\lambda t')}-1$	0.3296	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156
J	0.004376	0.010398	0.010452	0.010452	0.009474	0.006862	0.006910
$(^{40}\text{Ar}/^{39}\text{Ar})'$	75.3128	1.4999	1.4922	1.4922	1.6462	2.2729	2.2571
Average $(^{40}\text{Ar}/^{39}\text{Ar})$	8.4331	3.5784	3.5672	3.5264	3.9478	5.3816	5.4098
Ar Ratio	0.1120	2.3857	2.3906	2.3632	2.3981	2.3678	2.3968
Tau (τ)	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09
t	6.45E+07	6.44E+07	6.44E+07	6.44E+07	6.52E+07	6.45E+07	6.45E+07
t/ τ	0.0357	0.0357	0.0357	0.0357	0.0361	0.0358	0.0357
$e^{(t/\tau)}$	1.0364	1.0364	1.0364	1.0364	1.0368	1.0364	1.0364
$e^{(t/\tau)}-1$	0.0364	0.0364	0.0364	0.0364	0.0368	0.0364	0.0364
t'/ τ	0.2849	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155
$e^{(t'/\tau)}$	1.3296	1.0156	1.0156	1.0156	1.0156	1.0156	1.0156
$e^{(t'/\tau)}-1$	0.3296	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156
Age Ratio	0.1104	2.3305	2.3305	2.3305	2.3596	2.3338	2.3323
% Error	1.400%	2.313%	2.513%	1.385%	1.604%	1.433%	2.690%

Table V (Continued)

Irradiation	108-2	108-3	JD06-2	JD08-2	GLN3-2	105-4	MV
Sample #	90G15K	90G15K	90G15K	90G15K	JFL-500C	JFL-500C	
Sample Material	Haiti Tektites	Haiti Tektites	Haiti Tektites	Haiti Tektites	Z-Coal Bentonite Sandine	Z-Coal Bentonite Sandine	
Monitor Mineral	TCR	TCR	TCR	TCR	MMhb-1	TCR	
λ	5.54E-10	5.54E-10	5.54E-10	5.54E-10	5.54E-10	5.54E-10	5.54E-10
t'	2.79E+07	2.79E+07	2.79E+07	2.79E+07	5.14E+08	2.79E+07	1.19E+06
$\lambda t'$	0.0155	0.0155	0.0155	0.0155	0.2849	0.0155	0.0007
$e^{(\lambda t')}$	1.0156	1.0156	1.0156	1.0156	1.3296	1.0156	1.0007
$e^{(\lambda t')}-1$	0.0156	0.0156	0.0156	0.0156	0.3296	0.0156	0.0007
J	0.009452	0.009495	0.006862	0.006910	0.004404	0.010322	0.00001413
$(^{40}\text{Ar}/^{39}\text{Ar})'$	1.6501	1.6426	2.2729	2.2571	74.8340	1.5110	46.6974
Average $(^{40}\text{Ar}/^{39}\text{Ar})$	3.9914	3.8938	5.3875	5.5703	8.3400	3.5820	0.1290
Ar Ratio	2.4189	2.3705	2.3704	2.4679	0.1114	2.3706	0.00276247
Tau (τ)	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09
t	6.45E+07	6.45E+07	6.45E+07	6.45E+07	6.46E+07	6.45E+07	3.30E+03
t/τ	0.0357	0.0357	0.0357	0.0357	0.0358	0.0357	1.83E-06
$e^{(t/\tau)}$	1.0364	1.0364	1.0364	1.0364	1.0364	1.0364	1.0000
$e^{(t/\tau)}-1$	0.0364	0.0364	0.0364	0.0364	0.0364	0.0364	1.83E-06
t'/τ	0.0155	0.0155	0.0155	0.0155	0.2849	0.0155	0.0007
$e^{(t'/\tau)}$	1.0156	1.0156	1.0156	1.0156	1.3296	1.0156	1.0007
$e^{(t'/\tau)}-1$	0.0156	0.0156	0.0156	0.0156	0.3296	0.0156	0.0007
Age Ratio	2.3323	2.3323	2.3323	2.3323	0.1106	2.3323	0.00277220
% Error	3.580%	1.610%	1.603%	5.493%	0.792%	1.615%	-0.352%

Table VI. Comparison-of-means data

Ar Ratio	Mean	Std. Dev.	n	s^2
MMhb-1	0.1117	0.000373366	2	1.39402E-07
TCR	2.3910	0.030623973	11	0.000937828
Age Ratio				
MMhb-1	0.1105	0	2	0
TCR	2.3345	0.008405919	11	7.06595E-05

Table VII. Comparison-of-means calculation

Comparison of Means calculation	MMhb-1	TCR
Pooled Estimate of Variance (s_p^2)	6.97011E-08	0.000504244
$\text{SQRT}(s_p^2(1/n^1+1/n^2))$	0.00026401	0.009575002
y^1-y^2	0.0012	0.0565
df (n^1+n^2-2)	2	20
$t_{\alpha/2}$ @ 90% confidence	4.303	2.086
t stat ($D_0=0$)	4.639940872	5.900548284

Table VIII. Average Error

Monitor	Age (Ma)	Avg % Error
ACs	1.19	-0.352
TCR	27.92	2.349
MMhb-1	513.9	1.096

Graph 1 replaces graph 1 from the original paper.

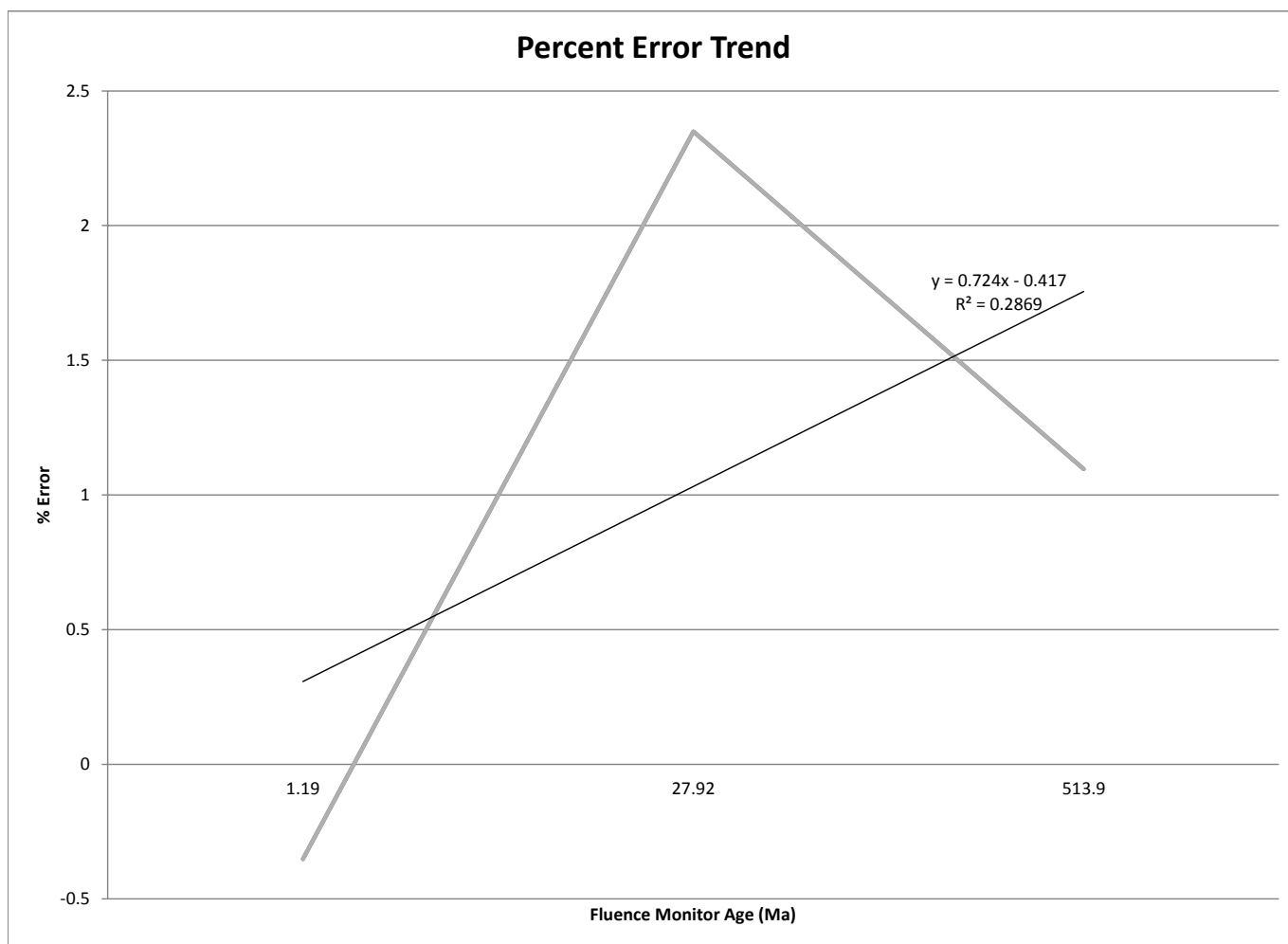


Table 9 provides conclusions drawn in the original paper and the effect of the new calculations on those conclusions with the changes in bold.

Page	Original conclusion	Revised conclusion
23 (Abstract)	The analysis in this paper shows that when the results of dating studies are validated against the foundational equations upon which the Argon-Argon dating method is based, the “older” the standard sample the greater the results differ from the foundational equations.	The analysis in this paper shows that when the results of dating studies are validated against the foundational equations upon which the Argon-Argon dating method is based, the standard sample may have an effect on the age of the unknown sample.
26	Within rounding error, equation 9 seems to be valid at least to 3 significant figures. It is noted that if the 1925 date is used in equation 11 rather than the 3300 date, equation 11 equals 1.62×10^{-3} which is not equal to equation 10. Therefore, the 3300 date for the Mt. Vesuvius lava is more correct and the $^{40}\text{Ar}/^{39}\text{Ar}$ dating process gave a date that is 72% higher than it should be.	This paragraph is valid and correct in all respects.
27	From table VII, we see that the T-stat is greater than the $t_{\alpha/2}$ @ 95% confidence. Therefore, we can conclude that the differences in the mean are statistically significantly different to the 95% confidence level so the underlying assumption of equation 9 is not met. This means that J and J' are not equal and the dates calculated for the unknown samples are not valid. With only one data point, we cannot draw conclusions about the difference in the means of the Mt. Vesuvius analysis.	This paragraph is valid and correct in all respects.
29	From table VIII, it appears that the older the assumed age of the fluence monitor, the greater the average error between the Ar and Age Ratios.	This relationship is no longer shown. This paragraph should be disregarded.
29	From graph 1, we see that there is a strong correlation between the assumed age of the fluence monitor and the % error. This indicates that the older the assumed age of the fluence monitor, the less valid the ages calculated from the process.	This conclusion is no longer valid. The entire paragraph should be disregarded.
29	This study begins to show that $^{40}\text{Ar}/^{39}\text{Ar}$ dating may not be as valid as an absolute dating technique as some would like. There appears to be a relationship such that the older the assumed date of the standard sample, the more the results err from the foundational equations. This relationship needs further exploration.	This study begins to show that $^{40}\text{Ar}/^{39}\text{Ar}$ dating may not be as valid as an absolute dating technique as some would like. The assumed date of the standard sample, may cause err from the foundational equations. This needs further exploration.
29	A method for validating $^{40}\text{Ar}/^{39}\text{Ar}$ dates was introduced and used to show that the $^{40}\text{Ar}/^{39}\text{Ar}$ dates obtained by Dalrymple, et. al., (1993) are not valid. There also appears to be a problem with the assumed age of the fluence monitor affecting the calculated age of the unknown sample. The observed relationship is that the older the assumed age of the fluence monitor, the greater the percent error of the analysis. The ability of $^{40}\text{Ar}/^{39}\text{Ar}$ dating to provide absolute ages is questionable.	A method for validating $^{40}\text{Ar}/^{39}\text{Ar}$ dates was introduced and used to show that the $^{40}\text{Ar}/^{39}\text{Ar}$ dates obtained by Dalrymple, et. al., (1993) are not valid. There also appears to be a problem with the assumed age of the fluence monitor affecting the calculated age of the unknown sample. ~~The observed relationship is that the older the assumed age of the fluence monitor, the greater the percent error of the analysis.~~ The ability of $^{40}\text{Ar}/^{39}\text{Ar}$ dating to provide absolute ages is questionable.

Reference

Overman, Richard L. 2010. Evaluation of the Ar/Ar dating process. *Creation Research Society Quarterly* 47:23–30.

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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.

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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:*

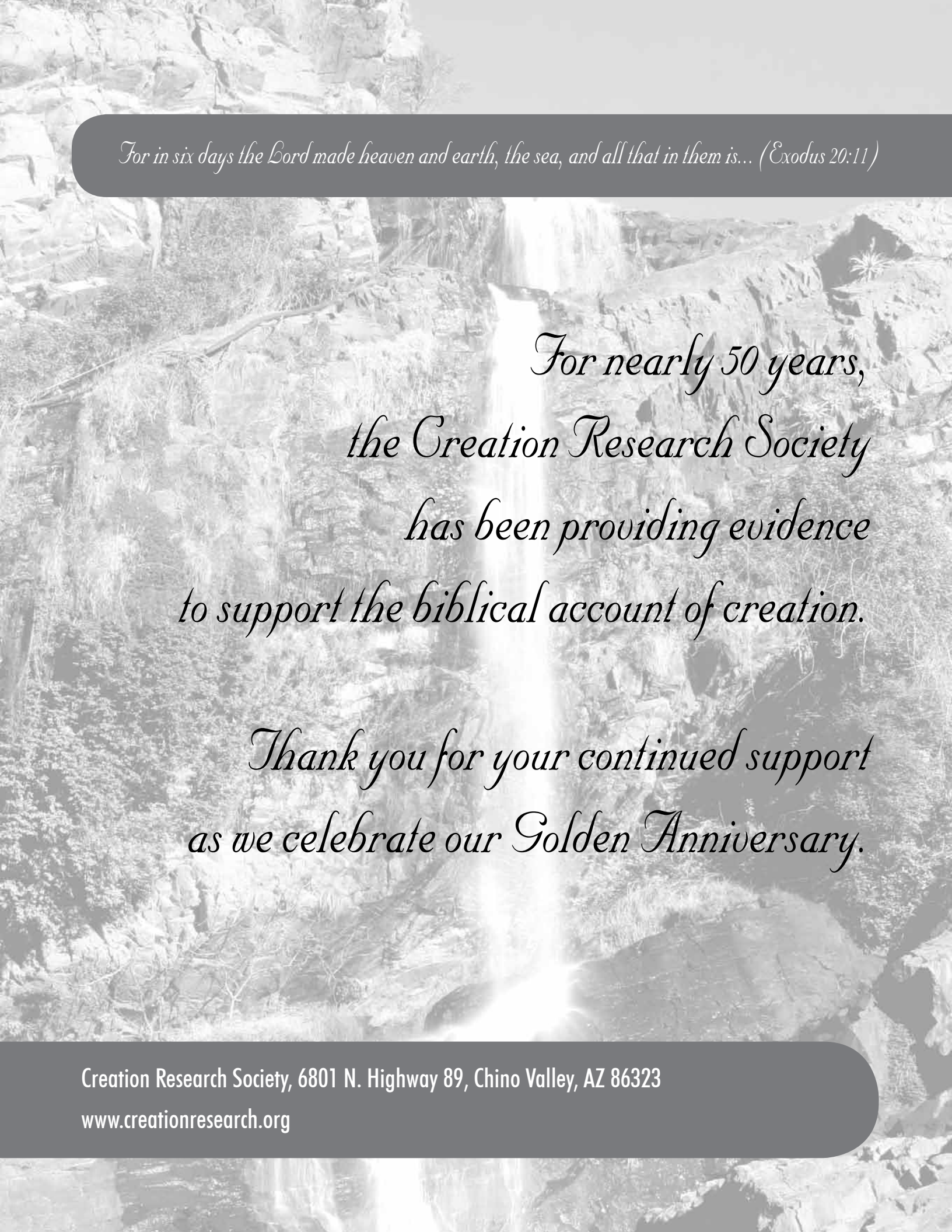
1. The Bible is the written Word of God, and because it

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.



For in six days the Lord made heaven and earth, the sea, and all that in them is... (Exodus 20:11)

*For nearly 50 years,
the Creation Research Society
has been providing evidence
to support the biblical account of creation.*

*Thank you for your continued support
as we celebrate our Golden Anniversary.*

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www.creationresearch.org