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- CAYUSE BASIN:
A STUDY IN MULTIPLE WORKING HYPOTHESES
 - A LITTLE FLOOD GEOLOGY-PART V: CONCLUSION
 - MUCH GREATER COSMIC RAYS DURING THE ICE AGE
AND BEFORE
 - THE HEART MOUNTAIN CONUNDRUM-PART 2:
A SCIENTIFIC CRITIQUE OF SIX UNANSWERED QUESTIONS
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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

Heart Mountain Fault Papers

In the previous issue of *CRSQ* (Vol. 57, No. 4, 2021), and in the current issue, John Matthews properly points out many of the major problems facing traditional explanations for the Heart Mountain Detachment Fault (HMD) (Matthews, 2021a, 2021b). I agree that standard uniformitarian explanations, in general, offer poor mechanisms for overthrust fault movement and little justification for the resulting fold geometries. And Matthews correctly concludes that none of these published accounts fully satisfy the observational data. But, then he suggests the “possibility that HMD was not a detachment or a slide” (Matthews, 2021a). Further, he insinuates that HMD may be just a stunning exception to the geologic column, resulting in “older” rocks on “younger” rocks.

I disagree. Just because there is not a satisfactory mechanism to explain the faulting does not mean that the slide or detachment did not occur. There still remains sufficient geological evidence to piece together the fault and its movement. Over the course of several field seasons, I have examined many of the HMD blocks scattered around the Cody, Wyoming area (Fig. 1) (Clarey 2012, 2013), including a visit to White Mountain (Fig. 2). There is a 3 m (10 ft.) thick fault breccia exposed at White Mountain that is resting on the detach-

ment surface (Fig. 2). And there are clastic dikes or “injectites” that extend upward from the fault breccia into the hanging wall rocks (above the fault), indicative of extremely high fluid pressures in the fault breccia prior to lithification (Fig. 2). Craddock et al. (2012) found that one of these injectites extends up to 120 m (400 ft.) vertically. So, there is plenty of field evidence of high fluid pressures and brecciation associated with the detachment surface. More breccia has been observed at many other locations on the HMD surface by both Tom Hauge (1993) and Bill Pierce (1987) in the 50 years that one or both of them has studied the area.

Additionally, the identical rock sequence observed in each of the HMD blocks is consistent from the point of origin (Breakaway zone) to the Heart Mountain klippe itself. In fact, the order of the Paleozoic strata never deviates across the entire northwest Wyoming region, whether drilled by oil wells (5000 meters below the surface in the Bighorn Basin) or observed in outcrop. The Cambrian section is always beneath the Ordovician and the Mississippian units are always on top, with the exact same rock types in place. Along the flanks of the Bighorn Basin, a complete local stratigraphic column (local geologic column) is observed from the Cambrian upwards

through the Eocene. And throughout all of these locations, the Lower Paleozoic section is exactly the same, everywhere. For all intents and purposes, the rocks are the same across the entire region. It is only where they have become separated by volcanic rocks and/or have been found on top of younger rocks that Matthews raises any doubt.

Examine the cross section at the bottom of Fig. 1 (or Matthews, 2021b, his Fig. 1). Notice there is volcanic rock lying on the same surface (the detachment surface) in between the individual carbonate blocks. If the HMD didn’t move on this detachment and scatter the carbonate blocks across the northwestern flank of the Bighorn Basin, how did this unusual rock pattern develop? How could the exact same sequence of carbonate rocks be deposited in some locations and in the same order and in between, deposit an equally consistent sequence of volcanic rocks. No river or flood event could deposit carbonates and volcanic rocks simultaneously, resulting in these stratigraphic variations. What mechanism, other than a fault, could place carbonates on the same “bedding surface” as volcanic rocks and alternate them from place to place? This is not a case of the geologic column failing as suggested by Matthews (2021a, 2021b). This rock sequence is best explained

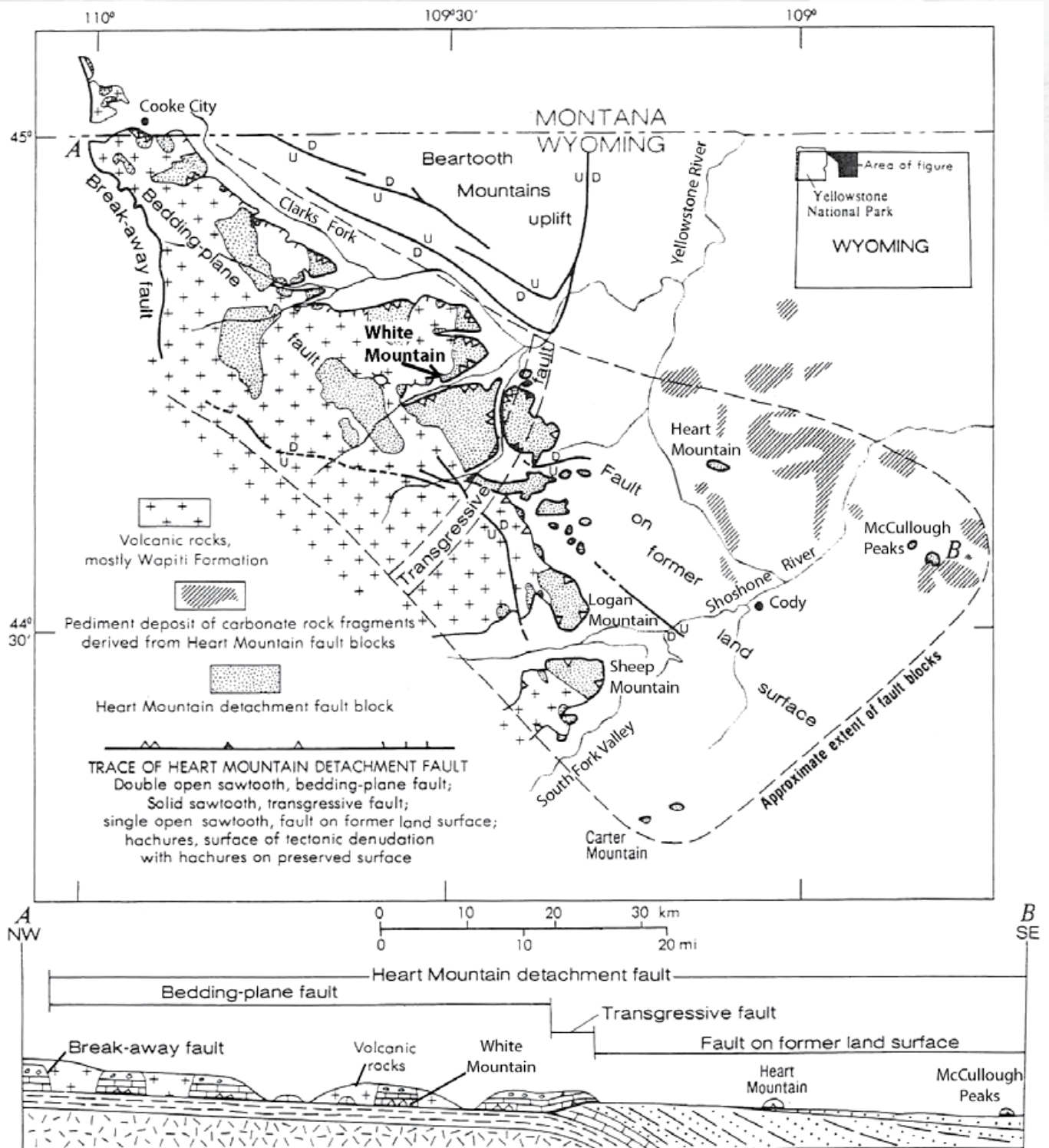


Figure 1. Map of the Heart Mountain Detachment Fault, modified from Pierce (1987). The location of White Mountain is shown.

as a detachment. How it happened is irrelevant. Although, I do believe that the conditions of the Flood provide the best explanatory power (Clarey, 2013).

Uniformitarian explanations for overthrusts or large detachments in general are poor, not just for the HMD. But that also doesn't mean they are not real features. Thousands of oil well penetra-

tions and 1000s of kilometers of seismic data have shown that overthrusts are real. And plenty of folds in these thrustured terranes have been found to contain oil and natural gas deposits. Finding oil in an overthrust does not require a mechanism to explain the fold origin. Oil geologists merely have to understand the resulting fold geometry and fault sequences.

How the thrusts moved into position is irrelevant in an economic sense. It is only important in an academic sense.

My research on the South Fork Fault, which overlaps the HMD, demonstrates many typical overthrust geometries are also developed in this fault system (Clarey, 2012, 2013). I concluded that only the global Flood could provide the conditions necessary to create the tight folds we observe in overthrust belts. If the rocks had had time to fully lithify, they could not have folded so tightly without completely breaking apart. These folds developed at or near the surface so they were not under great pressures or temperatures. Rocks at this depth would not behave plastically. But unlithified sediments would. And there must be a component of extremely high fluid pressure too to serve as detachment surfaces for these vast thrust sheets. These conditions cannot persist for vast amounts of time either. So, uniformitarian arguments for slow thrust movements over millions of years also fail.

Previously, I had suggested that rapid sediment deposition during the Flood, combined with compaction and dewatering from loading, created overpressured zones along impermeable stratigraphic boundaries, such as shales. Envision water trapped between two plexi-glass sheets. This overpressured water supports the weight of the overlying layers, making the sedimentary layers above susceptible to movement. All that was necessary was a sudden tilt or rapid erosion that allowed a pathway for the slide to proceed. In the case of the South Fork Fault and HMD, late Flood volcanic activity, uplift, and erosion from receding Flood waters likely exposed the Paleozoic and Mesozoic section, setting the stage for initiation of the HMD (Clarey, 2012). In addition, there must have been an overpressured zone near the base of the Ordovician Bighorn Dolomite that facilitated movement. Once the HMD was emplaced, tectonic loading by the HMD blocks likely

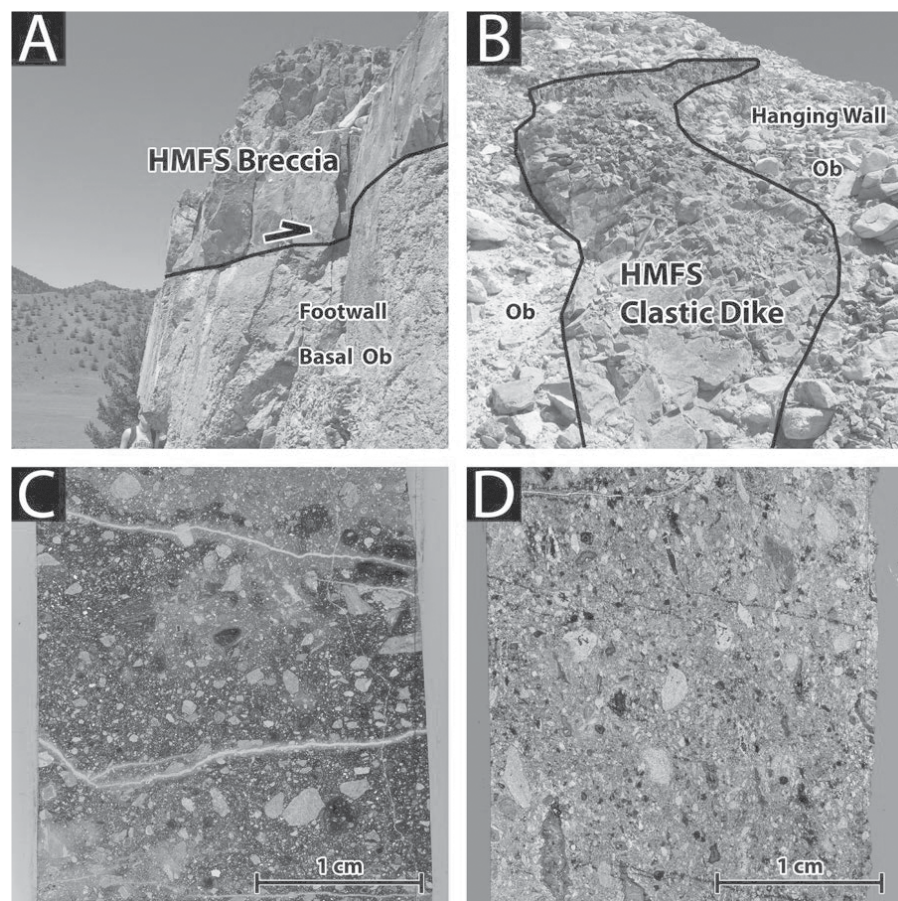


Figure 2. Photographs of the HMD detachment surface and clastic dike (injectite) at White Mountain and respective macro-thin-section images. (A) HMD breccia at White Mountain with a thickness of about 3 m. The hanging wall, composed of metamorphosed Ordovician Bighorn Dolomite (Ob), is out of view. The footwall consists of 2 m of unmetamorphosed, basal Bighorn Dolomite (Ob) on top of Cambrian Snowy Range Formation (out of view). (B) Clastic dike (injectite) in hanging wall of HMD at White Mountain. Dike is over 1 m wide at base and is injected upwards into marbleized Bighorn Dolomite (Ob). (C) Macro-thin-section image of HMD breccia or carbonate ultracataclasite (Craddock et al., 2012); feldspar and double carbonate stained. (D) Macro-thin-section image of clastic dike carbonate ultracataclasite; feldspar and double carbonate stained. The green minerals are volcanic fragments. Vertical flow texture within injectite is visible.

caused another overpressured zone in the Jurassic section to develop, causing subsequent slippage of the South Fork Fault (Clarey, 2012, 2013). Likewise, late Flood uplift of recently deposited strata in other locations caused similar sliding along overpressured horizons, creating so-called “overthrust belts.”

All data suggest overthrust faults like the South Fork Fault and HMD moved rapidly. Fault breccia has been observed along the detachment surfaces of both fault systems (Clarey, 2013). The breccia thicknesses varied from several meters to just a few millimeters. In addition, clastic dikes were observed in the hanging wall of both fault systems, further supporting overpressured conditions and the catastrophic interpretation. Unlithified sediments are also essential to the development of overthrust faults in order to explain the tightly-folded geometries that are observed. We see similar tight-folded strata in the South Fork Fault system (Clarey, 2013). These conditions must have occurred late in the Flood after most of the sediments were deposited, but while they were still not fully lithified (uncemented).

Overthrusts and detachments like HMD should not be used as an argu-

ment against the geologic column. As creationists, we should instead embrace them as unique historic events that could have only happened under the conditions created by the global Flood. The exact mechanism(s) of their movement may not be fully understood at this time, but a Flood model seems to provide the best explanatory power to date.

Timothy L. Clarey
Editor
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The Heart Mountain Conundrum, Part 2: A Scientific Critique of Six Unanswered Uniformitarian Questions

John D. Matthews*

Abstract

Hearth Mountain, Wyoming, USA, is a geological puzzle. “Paleozoic” carbonates overlie “much younger Mesozoic and Cenozoic” rock. The implication is that several mountain-sized blocks broke from a detachment fault and slid up to 45 km. Part 1 of this series critiqued recent models that propose low-friction cushions to move the Heart Mountain blocks. This paper compliments that study by examining how the proposed movement started and was sustained over uneven terrain via seven questions raised by uniformitarian researchers. Current models, uniformitarian and creationist, cannot explain the location of Heart Mountain as a detachment and slide. Unless fresh ideas are forthcoming, the implication that these “Paleozoic” rocks of Heart Mountain are younger, not older, than the underlying “Mesozoic” rocks needs exploring.

Key Words: Heart Mountain, detachment, slide, phreatomagmatic event, conundrum, tectonics, unanswered uniformitarian questions, geologic column

Introduction

Heart Mountain, Wyoming, USA, is a large block of “Paleozoic” carbonates found atop “much younger Early Cenozoic (Eocene)” rock (Figure 1). Most researchers believe that this and several other mountain-sized blocks broke, with or without the involvement

of volcanic rocks, and slid up to 45 km east-southeast (Pierce, 1957; Hauge, 1993). If not, it presents a significant local exception to the geological column. One path to a correct understanding of the Heart Mountain Detachment and Slide (HMD) is an analysis of proposed models of the event.

In Part 1 (Matthews, 2021), one of the more intensely-studied aspects of the uniformitarian dilemma was examined—whether a low-friction cushion could explain the assumed sliding. Three models were examined: (1) self-generated CO₂, (2) high-pressure water, and (3) a carbonate melt. Without a low-friction cushion, friction during movement would have produced large amounts of breccia which is not there. The conclusion of that paper was none of those models met the physical requirements of breccia-free sliding.

This paper examines the issues and problems with other aspects of the supposed event; how movement was initiated, was sustained over uneven terrain, and was terminated. It centers on seven

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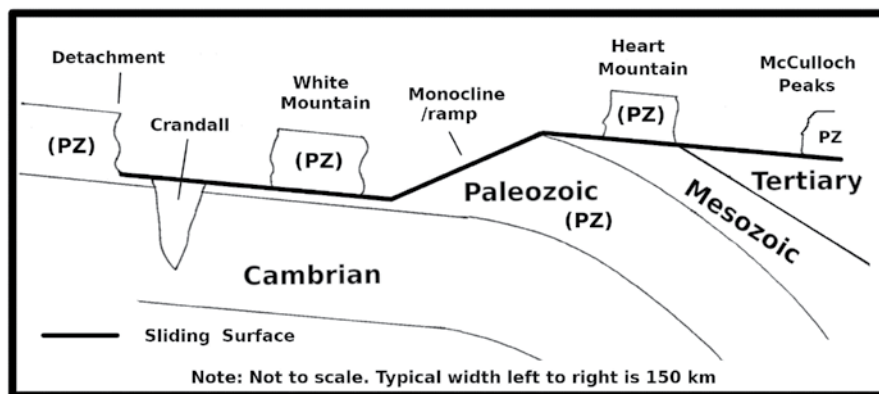


Figure 1. Cross Section of Heart Mountain; modified from Beutner and Gerbi (2005).

questions developed by uniformitarians. If models, uniformitarian or creationist, cannot answer these questions, then the visible order of the strata likely reflects their depositional order, providing a striking exception to the geological column.

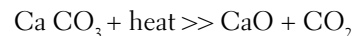
A more detailed study (Matthews, 2019) is available as a pdf from the author upon request.

Why Uniformitarians Think the HMD Occurred

The key reason geologists think Heart Mountain moved is stratigraphic—the relative dating of the overlying “Paleozoic” blocks and the underlying “Mesozoic” and “Cenozoic” rock. This requires a tectonic (or phreatomagmatic event), rather than a traditional sedimentary, explanation. Uniformitarians have suggested five additional reasons for the HMD event:

1. Petrological evidence (Beutner and Gerbi, 2005), including certain layering interpreted as “microbreccia.” However, internal layering features show “sedimentary character that appear[s] to record deposition from suspension rather than friction.” (p. 724). This evidence is therefore equivocal.
2. Beutner and Gerbi (2005) also note that groove casts, typical of those created by ice sheets, suggest sliding. These are significantly up-dip from White Mountain and Heart Mountain but not well documented down-dip. Furthermore, the dominant angle is only *approximately* that of the proposed direction of movement. Additionally, the range of angles of the grooves is about 40° (p. 731). This evidence is problematic, especially given the distance of movement.
3. In the Beutner-Gerbi (2005) model, sliding occurred atop a low-friction CO₂ cushion. The CO₂ was gener-

ated from heating the carbonate at the base of the moving blocks to the point at which CO₂ was released. This would have left lime, based on the endothermic reaction:



Since large amounts of lime (CaO) are not present today, the model requires that, after the slide, lime recombined with local CO₂ to return to its native (carbonate) state. Again, this point is equivocal, being an argument from an absence of evidence. Beutner and Gerbi (2005, p. 734) also note that there should be residual magnesium minerals (which do not re-combine with CO₂) because the carbonate is not pure CaCO₃, but dolomite. Since these minerals are not present, no movement is a better explanation.

4. Igneous dikes are present in the blocks. These cannot be traced down into the rocks beneath them. This suggests that movement could have occurred, though it has not been possible to correlate the different sets (between the allochthons and the open surface) to determine the amount and direction of supposed movement.
5. There is no direct information available on relative radiometric dating which might clarify the question of movement. However, Clarey (2012) notes that the HMD post-dates the deposition of the Eocene Willwood Formation (which it lies upon) and pre-dates the volcanic-rich Wapiti Formation (which lies atop some of the HMD blocks). Using this relationship, and radiometric dates from the volcanic rocks, secular scientists have concluded that the movement on the HMD was early to middle Eocene (Clarey, 2012). But the long-standing vexed issue of leakage of the associated high-pressure cushion necessary for movement (Murrell, 1981; Matthews, 2016) of the South Fork system is not explained any

more than there is an explanation for Heart Mountain's movement (see Part 1). As such this interpretation is still equivocal.

The Uniformitarian Dilemma

Beutner and Gerbi (2005, p. 724) listed seven questions that puzzle uniformitarians regarding the supposed movement. These are refined versions of questions mentioned by Prostka (1978).

1. What caused a mass of rock of more than 1,100 km² in area and several km in thickness to detach approximately along a bedding plane and slide on a slope of <2°, while spreading to cover more than three times its original area?
2. What initiated movement?
3. What caused the detachment to form near the base of the Ordovician Big-horn Dolomite rather than in weaker underlying rocks?
4. What was the rate of displacement?
5. What process or processes reduced friction to allow sliding on such a low slope?
6. What role did contemporaneous volcanism play?
7. Why is rock immediately below the slide surface so commonly undeformed?

The authors conclude:

...during the last century numerous geologists attempted to answer these questions. None of the resulting hypotheses [they list 11 ideas] attracted a quorum of supporters because evidence was not offered that unequivocally accorded with one hypothesis and negated others. (Beutner and Gerbi, 2005, p. 724).

If uniformitarians who advocate for the HMD discount prior models, and if subsequent uniformitarian models fail to explain the event (Matthews, 2021), then the logical next step is to ask if this phreatomagmatic event and sliding needs more scrutiny?

Question 5 was discussed in detail in Matthews (2021). Attention must now turn to the other six questions which largely relate to the tectonic issues. These should be related, in turn, to recent proposed models, of which Beutner and Gerbi (2005) is the most detailed available.

The Basic Model of Beutner and Gerbi

Beutner and Gerbi (2005) show, in their Figure 16, three snapshots in time illustrating their HMD dynamic model. Figure 2 encapsulates key aspects of nine distinct stages in HMD. I use "normal fault" nomenclature to explain the model, extending it to "overthrust" nomenclature when necessary.

- Stage 1. Detachment of what will move away from the "mother area" referred to directly in Beutner and Gerbi's Question 1 (Q1).
- Stage 2. The décollement—the freeing of the base of the part(s) that will slide (referred to indirectly in their Q1 but also part of their Q3 and Q7).
- Stage 3. The fracture of the rocks in the "Toe" (monocline) area (referred to indirectly in Q1).
- Stage 4. Injection of kinetic energy necessary to ensure movement (referred to indirectly in Q1, but also part of Q2). It may be related to Q6.
- Stage 5. Low-friction sliding over the fault plane (part of Q4 and Q5).
- Stage 6. Fragmentation of the moving mass into smaller portions (referred to directly, as "spreading," in Q1). Or it could again be related to Q6. The timing of the fragmentation is not discussed but needs to be reconciled with their full model.
- Stage 7. Ascent of the monocline; a point not mentioned in the questions but noted by Beutner

and Gerbi (2005, p. 725) as a problem.

- Stage 8. Moving over the "Mesozoic" layers (referred to indirectly in Q1).
- Stage 9. Coming to a halt, being a point not mentioned in the questions but noted in Beutner and Gerbi (2005, p. 733) as needing an explanation.

Figure 2A shows a paleo-reconstruction of the area before sliding. The Crandall Complex is assumed to have been like a pillar rather than a dike. The HMD movement requires fractures so that portions of rock, which mainly consist of Palaeozoic carbonates (PC) overcapped by "Eocene" volcanic rocks (V-V), could have moved.

Stage 1 was the detachment (DT in Figure 2B). It required three distinct events. On the left of Figure 2B at the site marked "X," faulting separated the back and side edges of the block from the mother mass. The footwall was left behind, while the right-hand side became the hanging wall. Stage 2 was the development of the nearly horizontal sliding surface, or the "décollement" (DC), literally the shearing within the dolomite itself 2.5 m above its base and the ungluing or unsticking of that same "Ordovician" carbonate from the lower layers in other locations. Aharonov and Anders (2006, p. 166) mention this strange position saying that it happened in a "non-descript bedding plane.... We observed virtually no deformation present in the rocks directly below the contact even at the scale of a single thin section." For further comment on how it causes additional problems for the model, see the reference to the work of Hsu in Matthews (2019).

That allowed the block bordered by the hanging wall to slide to the right without disturbing the lower surface—the remaining thickness of dolomite and the "Cambrian" clastics (CC). The last

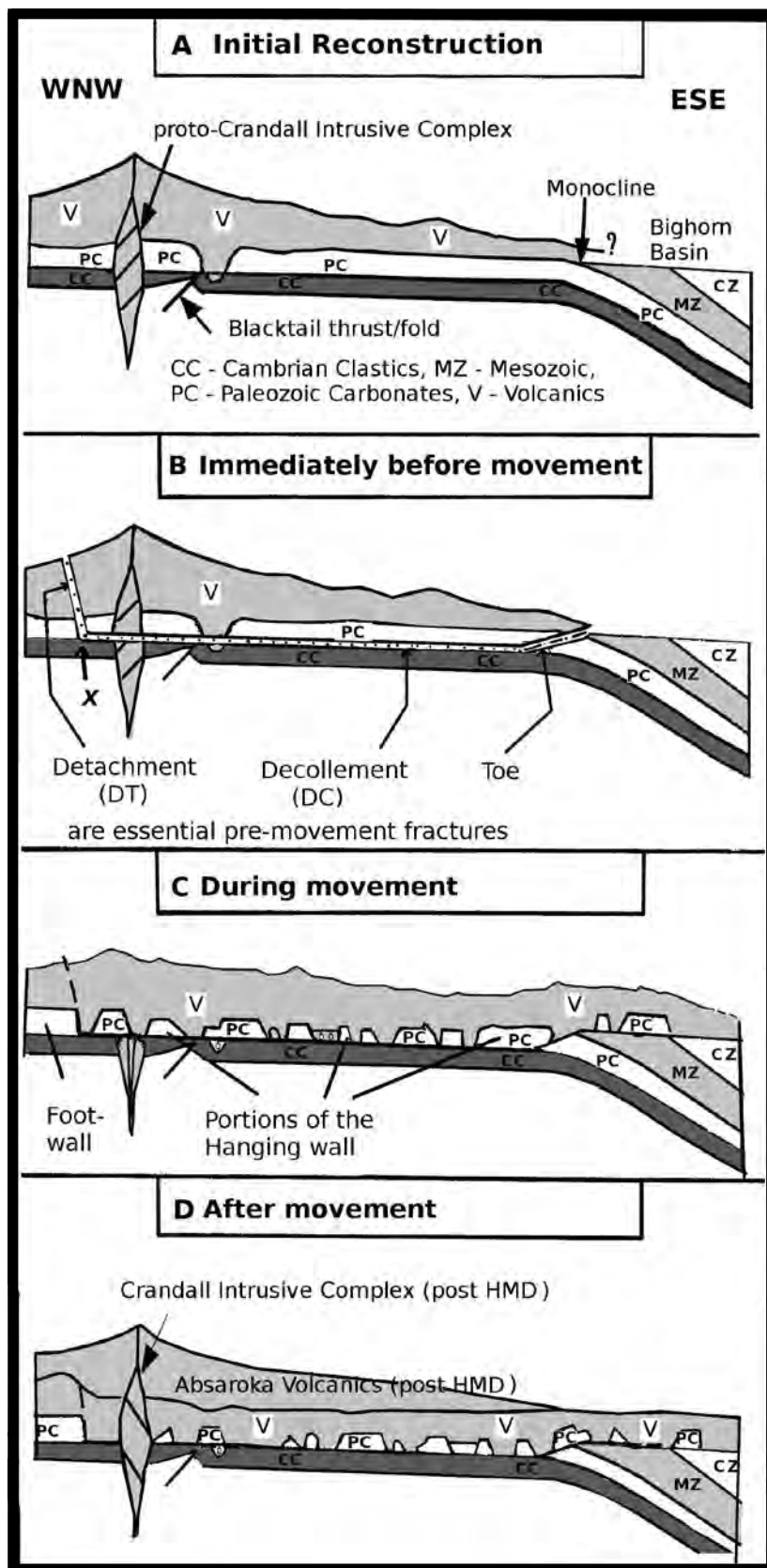


Figure 2. The assumed sequence of events at HMD (Heart Mountain Detachment and Slide).

event, Stage 3, formed the “Toe,” which is a fracture at the leading edge of the block (Figure 2B), at a low, but non-trivial angle abutting the “Mesozoic” clastics (MZ) at the monocline.

To dismiss these essential stages as the product of some vaguely described “major volcanic or phreatomagmatic event” (Beutner and Gerbi, 2005, p. 734) is obfuscation. The closest model that could be offered to meet Beutner and Gerbi’s need is to imagine that high-pressure water had been conveniently forced from depth at position “X,” at lithostatic pressure (around 80 MPa based on ~3 km of overburden). It would have had the potential to fracture the “Palaeozoic” carbonate and volcanics up to the surface thus initiating the “detachment.” Note that it had to be left of the Crandall Intrusive Complex (CIC) and so cannot be related to it. In fact, the pre-existence of the proto-CIC suggests that it was already a geological valve relieving excessive underground pressures, which leads to the question of the need for a new “valve” so close to the CIC.

Though possibly sufficient to form the Stage 1 detachment, such water probably could not have simultaneously formed the “décollement.” That would have required sustained pressure much higher than lithostatic, so that the “hanging wall” was lifted and freed to move. Such water would have more likely moved *vertically* because, as Cosgrove (1997) reminds us, the minimum horizontal stresses are around 70% of the lithostatic pressure (i.e., ~56 MPa), though it could be as low as 40 MPa (Aharonov and Anders, 2006). For the décollement to have propagated horizontally from this point would have required an additional pressure of ~10 MPa at the tip, to part the formations, because of the natural cohesion of rock, ~80 MPa to overcome the lithostatic pressure, and an amount possibly up to 10 MPa to force the water from position “X” to the “Toe” along the gap of the décollement.

So, in total, the pressure at the fracture tip must have been around 100 MPa. But with a potential escape route for the fluid of just 3 km through a vertical fracture (requiring a pressure of no more than 56 MPa) rather than 30–40 km horizontally, there is no obvious explanation for the décollement to propagate to the “Toe.” Finally, Q3 invites a comment on why the décollement was not in the lower, weaker rock or, for that matter, why the assumed décollement was 2.5 m above the base of the dolomite (Q3). Also note that it would have had to cut across the pillar of the CIC and avoid riding up the strata at the Blacktail Thrust (Figure 2A).

Even if these unlikely events occurred, the remaining stages are equally problematic. First, the HMD must have happened quickly; otherwise, the fractures would have healed due to natural earth stresses, migration of magmatic fluids, and their potential to re-cement fractures. Hot, high-pressure magmatic water might have created fractures, but it could also heal them, being rich in dissolved minerals that would precipitate as pressure and temperature fell. Sliding requires a mechanism that explains a *long-term* low-friction zone, and the initial propulsion of the blocks. Also, kinetic energy *has* to be injected into the system for most models (Stage 4). Otherwise, we cannot move past the stage illustrated in Figure 2C.

Furthermore, how and when the initial block divided into smaller blocks (Stage 5) is not addressed in any model. Some of these sub-blocks only “travel” over a thin dolomite layer, such as White Mountain, but Heart Mountain proper rode up the monocline, then slid atop the “Cenozoic” rock (Figure 2D).

Figure 2C shows where the portions of the hanging wall move right, over regions of very low friction on the décollement (Stage 6). Some models claim that the force of gravity down the $<2^\circ$ slope is sufficient for movement, but this is less than 3.4% g (0.3m/s^2). Fur-

thermore, there are the forces needed to have overcome the stratigraphic and physical rise (Stage 7) at the “Toe,” near the monocline. The physical rise would have been 300–500 m, based on the mapping in Prostka (1978) and a basic consideration of how the monocline and subsequent unconformity would have formed. This “wastes” about half the value of the already low slope as a mechanism for movement. Furthermore, we cannot explain why these terrain irregularities did not break up Heart Mountain. In fact, the fragmentation shown in Figure 2C is more likely to have occurred *after* the monocline ramp than before it.

Q4 is effectively linked to Q5, and the low-friction zone. Models of it were critiqued in Matthews (2021). All were deficient. Stage 8 did not involve White Mountain, since it did not climb the monocline.

Figure 2D shows where the sliding blocks came to a halt (Stage 9), with Heart Mountain resting on “Cenozoic” rocks (CZ). As this happened, the hypothetical low-friction cushion would have disappeared. Rock-to-rock contact would have slowed and stopped motion. This brings us back to Q7, and the lack of deformation in the rocks.

Beutner and Gerbi (2005) briefly mention how a fast-moving block (40 m/s given their assumptions or Mach 4 from Matthews, 2021) could have stopped without deformation, given the absence of a brecciated zone and an undeformed underlying layer (their Figure 3). To resolve the dilemma, they write that there was an “abrupt cessation [of] movement due to lateral contact between blocks” (p. 733) based on an analogy with the Elm, Switzerland (1881) rockslide, which an eyewitness claimed ceased dramatically. But their analogy is totally inadequate. Elm was a mining accident. The mass of rock in it was minuscule compared to HMD-S, and the velocity, significantly smaller. There were several pulses of movement.

The Elm Slide was on a mountain side substantially steeper than HMD. Finally, the way energy is lost in a granular mass of moving rock (Elm) is a very different process for a solid mass (Kilburn, 2001). Their confusion shows in their final words:

As the slide slowed and *thinned*, however, it would lose its cushion of gas and at some point frictional drag would dominate, and motion would *abruptly* cease. (Beutner and Gerbi, 2005, p. 735, emphasis mine)

It surely is an *ad hoc* suggestion with a touch of obfuscation (by trying to link it back to Elm) that such a large mass can come to a halt *abruptly* without brecciation and significant deformation, regardless of the velocity. And what “thinned”? Based on normal rock-to-rock friction, the mountain would have slid about 150 m with thick beds of breccia forming as the low-friction cushion disappeared. If it had been moving at Mach 4 (given more realistic assumptions), it would have hardly survived the monocline, and if it did, would have slid out of the basin area when the cushion ceased and almost certainly shattered in the process.

The Model of Aharonov and Anders

Other models share many of the same faults. Aharonov and Anders (2006), in a short paper, do not mention the seven questions, but implicitly attempt to answer parts of Questions 1, 2, and 5. They suggest that dikes, emerging from depth at high pressure, on what would become the fault plane, could explain how the slide started on a near-zero-friction surface of water. Their calculations of rock mechanics, temperature changes and overpressure show that, with the right series of assumptions, the pressure of the interstitial water could have been raised by the Skempton effect to the lithostatic value.

The Skempton effect (Jaeger et al., 2007) is the way pressure on rock is partially transferred to interstitial water.

If they were correct, the block could then start to move down the small slope without the need for adding kinetic energy, as Beutner and Gerbi require. But with a slope of $<2^\circ$ the mass would have moved slowly. The high-pressure water would leak out of the edges, so the key problem to be answered is how the slide continued, travelled up the monocline and across the “Mesozoic” rock. The block would have moved away from the high-pressure stress point of the dikes and onto an unpressurised surface. Any high-pressure water that emerged onto the open surface would have disappeared while the block accelerated, resulting in rock-to-rock contact, and the inevitable halt.

There is a further problem with the model. The very mechanisms that increase the pressure in the interstitial water would have hampered the essential detachment (Stage 1) by raising the horizontal stress in the rock. So, in total, the model does not do justice to the essential requirements for a detachment or a 45-km slide.

The Model of Craddock et al.

Craddock et al. (2009) wrote about White Mountain (about 30 km “upstream” of Heart Mountain). Since White Mountain was initially part of the HMD event, its study was done to cast light on HMD, and indirectly provide support for interpreting HMD as a slide.

This model simply assumes detachment (Stages 1–3). It posits the block moving at an unknown velocity that can be calculated by assuming that the low-friction cushion on which it moved was a layer of molten carbonate. The heat to melt it came from the friction of sliding, which begs the question of how the motion began. So, Questions 1 to 3 are ignored, Q4 is answered by assuming that the slide took place (circular reasoning). Q5 is answered by a less-than-sophisticated heat transfer calculation which ignores the inevitable heat lost to the base plate, and Q6 and Q7 are

ignored. When the corrected equation is used, the block is predicted to have a *negative velocity*. See Matthews (2019).

While the paper of Aharanov and Anders (2006) appeared shortly after that of Beutner and Gerbi (2005) (though they make a brief reference to it), the paper of Craddock et al. (2009) appeared sufficiently later for the authors to re-assess the models of Beutner and Gerbi, and Aharanov and Anders. But there was no such assessment. The contrast in the models is so stark that the only natural conclusion is that both previous models were thought unworkable by Craddock et al. (2009). Their model fares no better.

Searching for Analogues

In a later paper, Craddock et al. (2012) compared the apparent movement of White Mountain to the Mt. St. Helens eruption. However, the block sliding was much more intense; they do not have a good analogue for HMD because (p. 436, emphasis mine):

The relationship of hanging wall displacement to fault gouge generation, and the presence of vertical, 120 m, fault gouge injectites, makes the Heart Mountain slide *anomalous* to all fault systems, especially as this fault system had only one episode of motion.

Furthermore, this paper did not shed more light on mechanisms, where we might have expected them to try and integrate earlier ideas of Beutner and Gerbi (2005), Aharanov and Anders (2006), and Craddock et al. (2009). White Mountain is on a base of “Ordovician” carbonate ultracataclasite (>90% matrix), different from the “Cenozoic” base of Heart Mountain. So, there is no new information on how HMD might have occurred. Their quote (above) can be read as implying that HMD was not a slide.

In conclusion, *all* uniformitarian models are inadequate. In fact, those authors present evidence (and not just through their list of unanswered ques-

tions) that the detachment and slide did not take place. Is it possible that the distinct Flood paradigm can generate a creationist model that solves those problems?

Creationist Responses to HMD as a Slide

At least two creationists (Garner, 2011; Clarey, 2013) identify secular studies that conclude that Heart Mountain moved at high speed. They note that this admission of a major catastrophe by uniformitarians is surprising in itself but do not challenge the details of the studies.

Oard (2010) dug deeper and reviewed three of Beutner and Gerbi’s (2005) seven questions. He accepts that a detachment and slide occurred, but subaqueously, during the Flood. He uses that environment to help explain the necessary catastrophic release of energy to get HMD detached and moving (thus addressing, but not quantifying, Q1 and Q2). A submarine slide would address Q5, the water providing a basal cushion for the slide. This short paper was, of course, written before several of the secular papers analyzed above and is not detailed.

Developing Oard’s (2010) model further is hampered by the following. First, a block moving under water, particularly when propelled by gravity, has less force on it (because buoyancy acts in the opposite direction to gravity). So, the ratio of frictional drag to gravitational forces is unchanged. Motion cannot be enhanced by a *submarine* slide. Second, there is an additional viscous drag due to the water surrounding the moving block. Thus, a *rapid* underwater slide is not realistic. Q3 (the detachment mechanism) is not answered by Oard (2010) and Q4 is answered by the timescale of the Flood (but not quantified by physics). In a model with a more-than-adequate supply of lubricant (water), the velocity does not have to be fast. However, there

is no physical model that will explain the lubrication that needs to be sustained at low or high speed without postulating a supply of high-pressure water emerging from depth moving exactly beneath HMD on its journey to its final resting place. With viscous drag capable of bringing it to a halt rapidly when the lubrication ceases, there would probably be less brecciation than predicted by any of the uniformitarian models described above. Q7 remains unanswered because a block moving underwater still has the potential to deform the underlying strata. So, although there are some new ideas here, a robust Flood-explanation for a slide has yet to be worked out.

A Brief Summary

Geologists have been baffled by Heart Mountain for over 100 years (Hauge, 1993). Based on their relative age dating, it appears to have detached and slid up to 45 km in the early to middle “Eocene” (Clarey, 2012). Beutner and Gerbi (2005), prompted by Prostka (1978) posed seven questions that need answering before HMD can be categorically interpreted as a slide. There have been several attempts to explain HMD by analogies to smaller slides. However, the circumstances were sufficiently different as to be of no help.

Beutner and Gerbi (2005) proposed a basic model that focused on just one of their questions—the low-friction cushion. Their proposal, using CO₂ generated from the dolomite, was shown to be deficient in Matthews (2021). Their failure to address the other six questions leaves their model unsustainable. Aharonov and Anders (2006) attempted to answer two of the questions. Although the paper appeared after Beutner and Gerbi (2005), it does not build on their model, thus it indirectly challenges it. However, they offer no mechanism for *sustaining* a low-friction zone to keep the rock mass moving away from the initial high-pressure water source. They

fail to address four of the questions, leaving their model seriously deficient. The Craddock et al. (2009) model requires a calcite melt-layer for a cushion. But it must be present before movement starts. So, it suffers from similar problems as the Aharonov and Anders (2006) model. It does not offer answers to six of the questions. Likewise, Oard’s (2010) creationist model of submarine sliding fails to answer most of the questions, and thus fails the test.

In summary, the failure of any model to adequately answer even one of the seven questions leads to the possibility that HMD was not a detachment and a slide. The nine stages of the proposed process are untenable. If true, it presents a stunning local exception to the geological column. Other papers (e.g., Reed and Oard, 2006; Matthews, 2011) show many other geographical exceptions to the column. Thus, creationists must seriously consider that the geological column may not be valid for modeling the Flood and indeed should offer this evidence as a contra-indicator of evolution as noted originally by Whitcomb and Morris (1961).

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Cayuse Basin: A Study in Multiple Working Hypotheses

Peter Klevberg*

Key Words: Cayuse Basin, impact crater, multiple working hypotheses, models, dome, Central Montana Alkaline Province, sequence stratigraphy

Abstract

Impact craters in the landscape and subsurface have received increasing attention in recent decades, particularly after popularization of the impact theory for the demise of the dinosaurs. Diluvialists also debate the possible role of impacts in the Genesis Flood. Thus, both uniformitarians and diluvialists have been on the lookout for more impact craters. In 2012, we investigated a candidate crater, Cayuse Basin in Judith Basin County, Montana. While we did not discover evidence for a crater, the process itself provided good lessons for both impact enthusiasts and detractors.

Introduction

Cayuse Basin is a topographic basin in Judith Basin County in Central Montana (Figure 1). Michael J. O'Brien, a coworker who formerly piloted small planes, once flew over Cayuse Basin and told me about what seemed to be a meteorite crater. I looked on Google Earth (Figure 2), and there definitely appeared to be an impact crater. A friend joined us for a site visit on May 19, 2012.

Cayuse Basin is owned by the Hayes Livestock Company. When I contacted the landowner for permission to hike the basin, he told me I was not the first person to come hunting for an impact crater. There are other structures in Central Montana that have attracted similar attention.

Perhaps much of this attention arose from the dinosaur extinction impact theory (Alvarez, 1997; Alvarez et al., 1980; DePalma et al., 2019). Impacts have been increasingly popular among creationists too, as a possible trigger for the Deluge (Stevenson, 1975; Unfred, 1984; Northrup, 1987; Fischer, 1991; Auldane, 1992; Spencer, 1992; 1994; Froede and DeYoung, 1996; Froede and Brelsford, 1998; Oard, 2009). While catastrophic plate tectonics appears to be the most popular geologic model among creationists at present, many entertain bolide impacts as an addition or alternative.

Oard and Reed (2020, p. 5) list five possible diluvial models:

1. Catastrophic plate tectonics

2. The hydroplate model
3. Meteorite impacts followed by differential vertical tectonics
4. Combinations of parts of these models
5. A totally new model

Oard and Reed (2020) convinced me that writing up our Cayuse Basin experience could be beneficial for those interested in Flood models, not to vindicate any existing model, but to show the research process, potential pitfalls, and how to avoid them. Non-geologists may benefit from the glossary at the end of this paper.

The Problem

The origin of Cayuse Basin, like most geologic features, is a matter of history, not science. Its origin cannot be recreated or measured or tested or observed, but a forensic hypothesis can generate predictions to test. This is what we set

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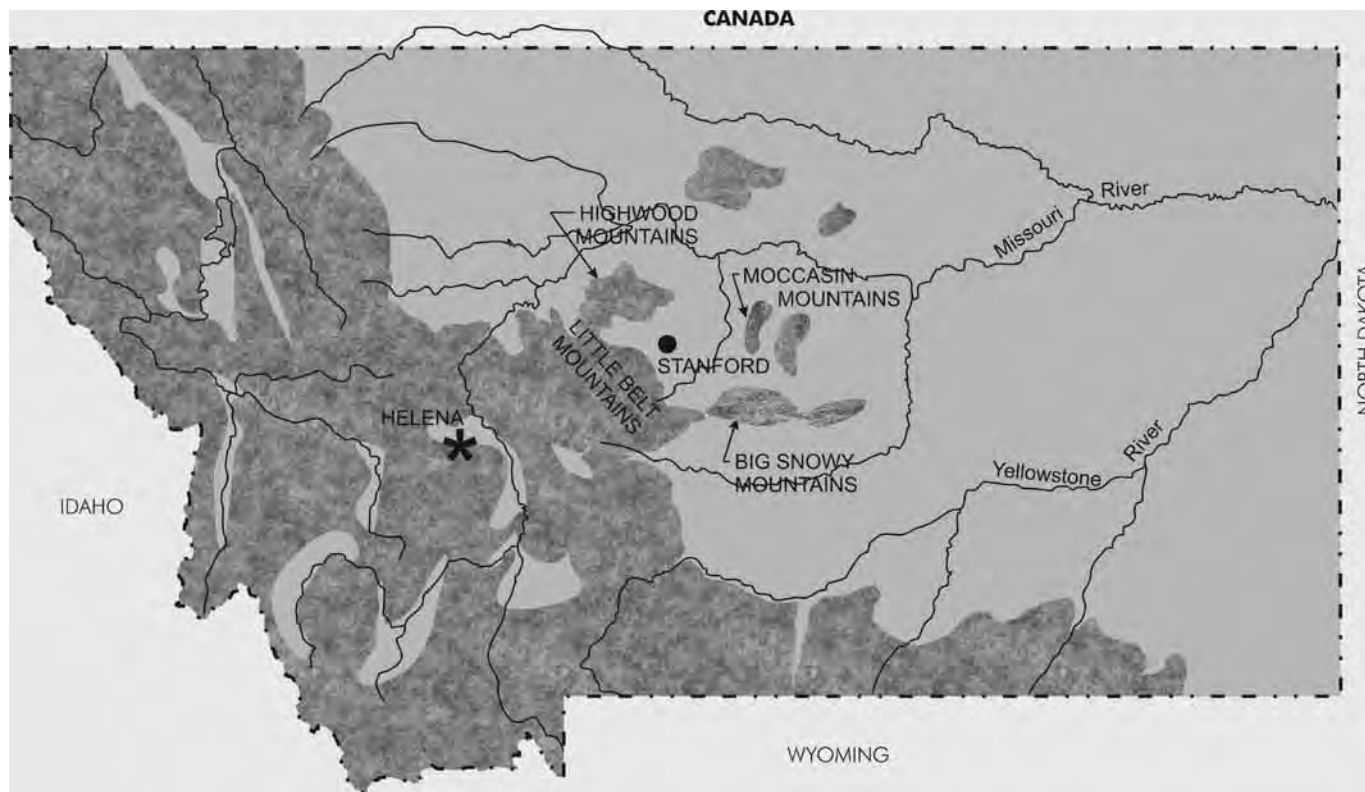


Figure 1. Map of Montana showing major rivers, mountains, the capital (Helena) and Stanford, seat of Judith Basin County. Cayuse Basin is four miles southwest of Stanford.

out to do. The idea of an impact crater had occurred to Mike O'Brien when he flew over Cayuse Basin and to me when I saw it on Google Earth®. But as Acrey (1968, p. 120) pointed out, "Scientists must always be mindful of the fact that deficiencies in present knowledge will be reflected in our interpretations of past events." We needed to investigate in person.

Investigation

The principle of multiple working hypotheses (Chamberlin, 1890) is a good one. It facilitates an open mind and sharpens observational skills. I thought of four potential origins for Cayuse Basin:

1. Impact crater

2. Volcano
3. Dome
4. Other

Each generates a set of predictions (Table I). While the hypotheses themselves belong to the field of history, their predictions can be investigated via geology. They therefore qualify as "mixed questions" (Adler, 1965; Reed and Klevberg, 2017, 2018). Hypothesis #4 should always be included per Acrey (above), but it is nebulous and would be favored by a failure to find supporting evidence for the first three.

Observations in the Basin

We started on the east side of Cayuse Basin and headed straight toward the rim. I took measurements of bed attitudes with

a Brunton compass and examined the scattered outcrops. What we observed is summarized in Table II.

The entire rim, except where it is breached on the northeast side (Figure 3), consists of limestone (micrite). The limestone resists erosion (Figure 4). The attitude of the beds is uniformly dipping away from the center of Cayuse Basin. Most of my dip measurements were in the range $22 \pm 5^\circ$ away from the center of the basin. The steepness of the slope on the outside of the rim or crest reflects the bedding plane attitude of the limestone (Figure 5). At the northeast side of Cayuse Basin, the rim, here a medium-grained sandstone, is cut by Skull Creek (Figure 6).

The outside slopes are well vegetated, making identification of contacts dif-



Figure 2. What could be better proof that Cayuse Basin is an impact crater than this Google Earth image?

ficult (Figure 7). The interior is similar. Less-resistant strata formed regolith, the parent material for the soil of well-developed grassland. Isolated outcrops were observed; most sandstones (Figure 6), but a few locations along Skull Creek exposed dark gray fissile shale. The mounded center (Figure 3) appears to be primarily composed of this shale, while sandstone outcrops form the lower slopes of the rim. The lowest part of

Table I. Working Hypotheses and Their Predictions

Hypothesis	Predictions
Impact Crater	coesite, stishovite, shatter cones, shocked quartz, rebound structure, ejecta
Volcanic Crater	extrusive rocks, contact aureole, ejecta (pyroclastics), dikes
Dome	upwarped sedimentary rocks, possible igneous core with contact aureole at bottom
Other	none of the above evidence, various other phenomena than the above

Table II. Comparison of Hypotheses and Observations

Hypothesis	Observations
Impact Crater	no quartz, high pressure minerals, rebound structures, or metamorphism of basal shale
Volcanic Crater	lack of igneous rocks, lack of contact metamorphism
Dome	upwarped sedimentary rocks, eroded core with unaltered shale in bottom, nearby domes
Other	no unusual phenomena observed

Cayuse Basin is the toe of these slopes (Figure 8).

Additional Information

After field investigation, I sought additional information from published sources. In the years since, work on water well projects in the area supplied more knowledge of the subsurface.

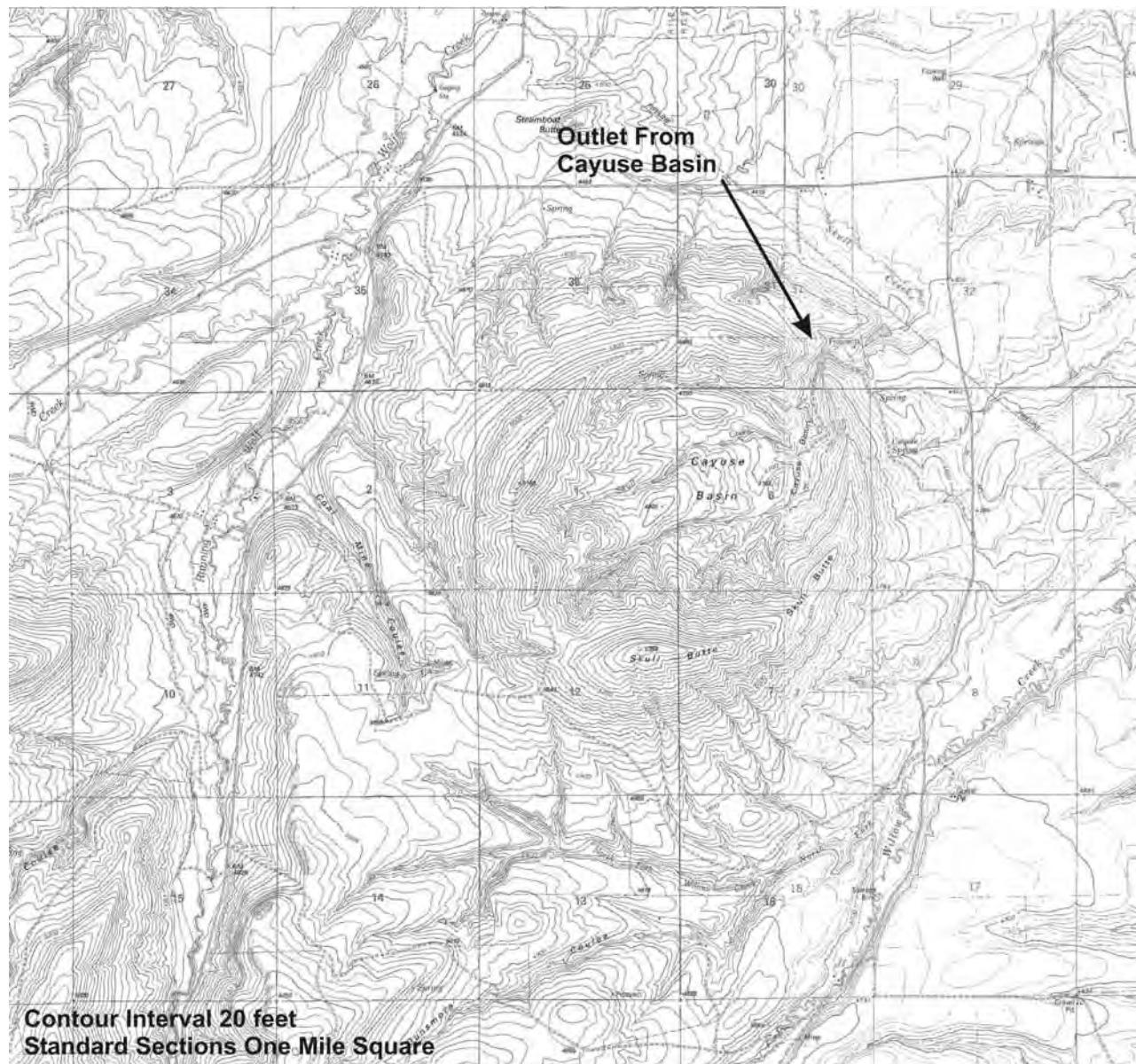


Figure 3. U.S. Geological Survey topographic map of Cayuse Basin with 20-foot contour interval. Interior of basin is roughly one mile in diameter, rim is two miles in diameter, exterior roughly three miles in diameter. South rim abutting spur ridge from Little Belt Mountains is known as Skull Butte. Coal mines operated on its southwest flank a century ago.



Figure 4. View southwest from east rim of Cayuse Basin. Michael J. O'Brien, trip instigator, stands on outcrop of Alaska Bench limestone. While over half of the geologic contacts are obscured by soil and vegetation, Alaska Bench outcrops provided many good opportunities to measure bed attitudes all the way around the basin.



Figure 5. View north from just below east rim toward Stanford, Montana, and Square Butte. Rocks in foreground are in situ slabs of Alaska Bench limestone. This resistant formation forms most of the basin rim. Stanford is 5 miles (8 km) northeast of Cayuse Basin at an elevation of 4,285 feet (1,303 m) above sea level.



Figure 6. Ephemeral drainages converge at the northeast side of Cayuse Basin where Skull Creek flows through a gash in the rim. Slow erosion of the interior of the basin under present climatic conditions could be expected to produce topography more like the Arrow Creek Badlands several miles to the northwest rather than the slit in the northeast rim and rounded, much lower interior topography seen here.

Geologic setting

Skull Butte is a northeastern foothill of the Little Belt Mountains (Figure 1), northeast of the mountain ranges and intermontane valleys that form the edge of the Basin and Range Province of Southwestern Montana. The geography changes markedly to the north and east. The Highwood Mountains, Bears Paw Mountains, Moccasin Mountains, and Judith Mountains (Figure 1) are “island mountains” cored by igneous rocks (Woodward, 2010). Isolated buttes, such as Round Butte and Square Butte (Figure 9) resemble the buttes of the Little Belt foothills except for their shapes and full exposure of the igneous rocks. The only exception to these igneous cores is the great anticline of the Big Snowy Mountains. Between these “island



Figure 7 (*left above*). Many of the geologic contacts are obscured by soil and grass but are discernable with scrutiny. Here the author shows companion Mark Nelson a contact. Dotted line added to image to indicate approximate location of Kootenai-Morrison contact.

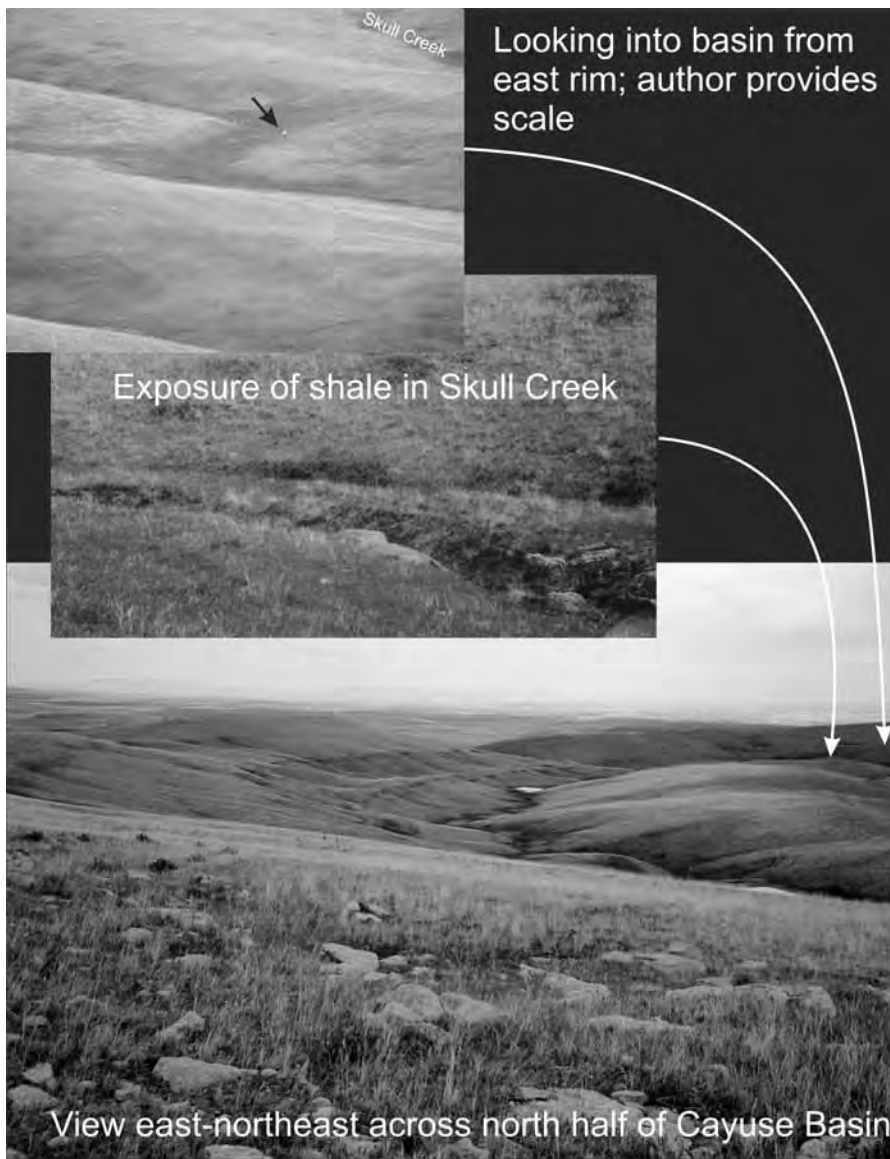


Figure 8 (*left below*). The bottom of Cayuse Basin is a broad, grass-covered dome with minor gullies. Isolated small outcrops reveal the lithology to consist of unmetamorphosed black or dark gray shale. Black arrow points at author for scale.

ranges” stretch the nearly horizontal sedimentary strata of the Judith Basin.

Cayuse Basin has a circumference of approximately 9 miles (15 km) (Figure 3). A spur ridge from the prominent Little Belt Mountains to the south encounters the south rim of Cayuse Basin and is called Skull Butte. Coal mines operated on its southwest side and a few miles east of it until about a century ago. I did field work on these abandoned mines years ago but had never been in Cayuse Basin before 2012. Skull Creek originates in the basin, and the structural dome is often referred to as Skull Creek Dome (Vine, 1956).

Lithology

Sedimentary rocks outcrop in and around Cayuse Basin. The prominent rim (Figure 9) is light gray micrite. Sandstones (Figures 6 and 8) are primarily thin- to medium-bedded, fine-to-medium-grained, medium hard, and gray weathering to a reddish brown. Incom-

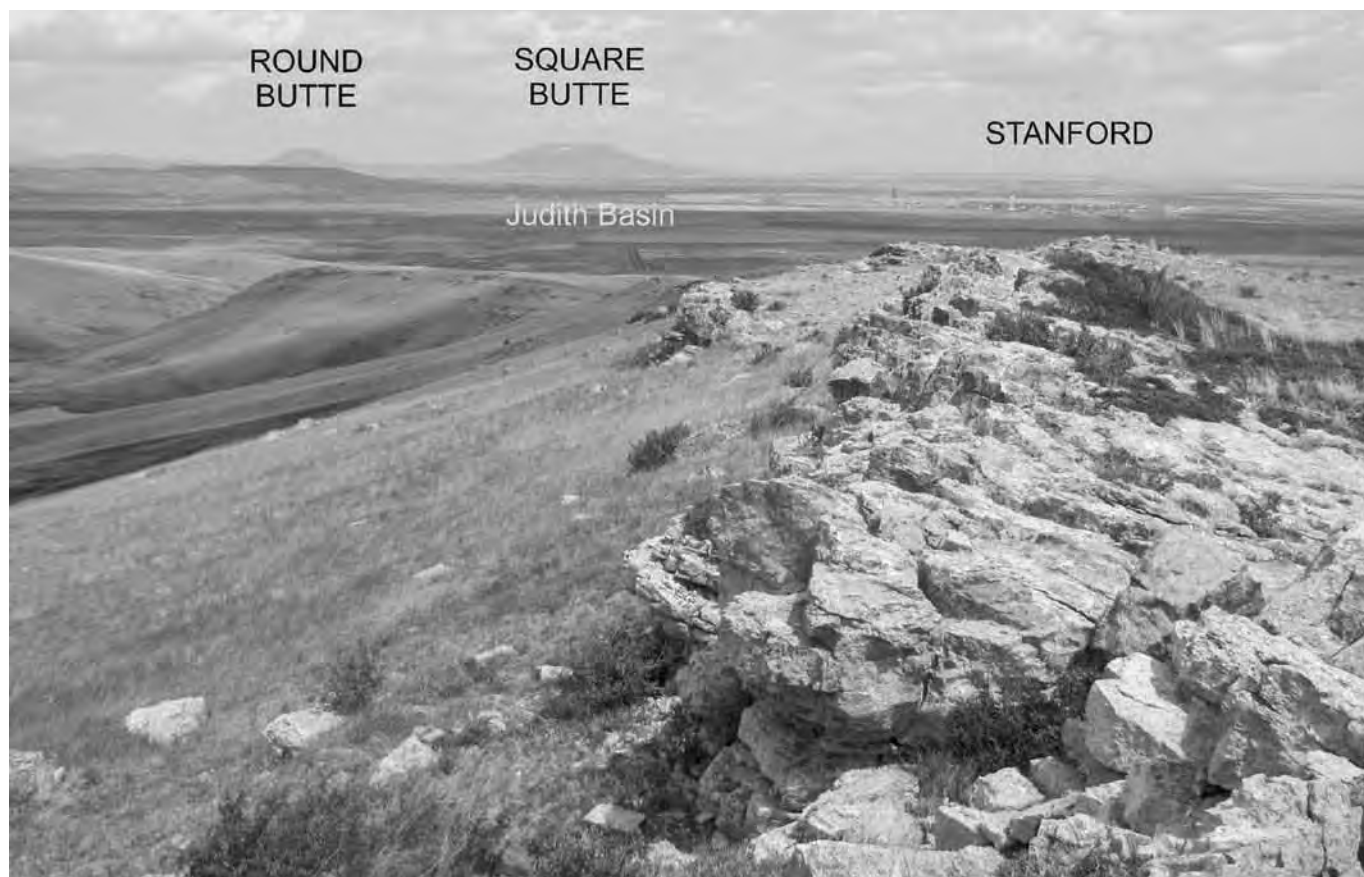


Figure 9. View north-northeast from east rim of Cayuse Basin showing the nearby town of Stanford, with Square Butte and Round Butte in the distance. These buttes are the nearest exposed igneous rocks and are mapped among the laccoliths in the area (Raymond, 1995), though Round Butte appears to be sheeted dikes, and Square Butte appears topped by flows. The top of Square Butte is 1,419 feet (433 m) higher than Stanford and 27 miles (44 km) north-northwest of the town.

petent rocks are difficult to examine due to the development of soil on them, but fissile, thin-bedded dark gray shale was observed (Figure 8). According to Vine (1959) and Vuke et al. (2007), the predominant lithology is shale (Figure 10).

Igneous rocks are common in the mountain ranges ringing the Judith Basin. Laccoliths are present west of Cayuse Basin along the front of the Little Belt Mountains, in the Highwood Mountains, and in scattered locations east of the Highwoods. These are mostly plutonic rocks, with some volcanics, and are principally mafic phonolite or shonkinite with associated syenite (Vuke et al., 2007). Quartz latite porphyry is mapped

at Windham Dome approximately 7 miles (12 km) northeast of Cayuse Basin (Figure 11), but this is covered by a sheet of surficial gravel. Other igneous lithologies outcrop several miles to the southwest in the Little Belt Mountains. These rocks are part of the Central Montana Alkaline Province (Raymond, 1995; Woodward, 2010), and a quick look for shonkinite in the index of nearly any textbook on igneous petrology will take one to a description of the Highwood Mountains' main claim to fame.

Metamorphic rocks have been observed by the author as very thin zones at contacts of sedimentary rocks with flows and dikes of shonkinite in the Highwood

Mountains and buttes farther east. I have seen them nowhere else in the area. Metamorphic rocks are not described proximate to Cayuse Basin by Vuke et al. (2007). High grade metamorphic rocks do occur far to the southwest in the central Little Belt Mountains.

Stratigraphy

Figure 10 shows a composite column for the rocks at Cayuse Basin derived from Vine (1959) and Vuke et al. (2007). The stratigraphic nomenclature is shown in Table III. The uppermost consolidated formation is the Kootenai, and the lowest exposed at Cayuse Basin is the Otter Formation or possibly the Kibbey Forma-

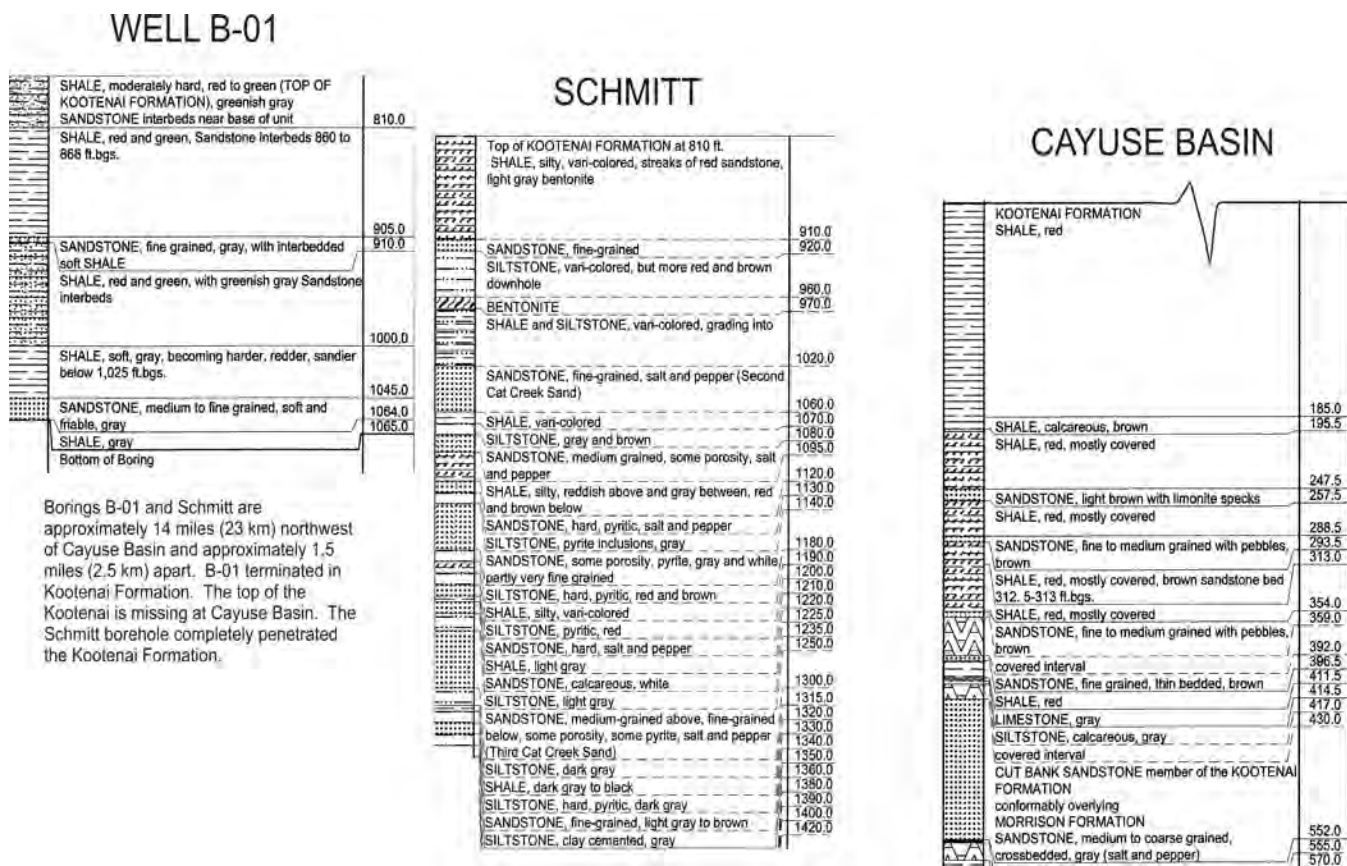


Figure 10. Bottom portion of log from well B-01, a water well completed in the Kootenai Formation 24 km (15 miles) northwest of Cayuse Basin, and a portion of the log from the Schmitt wildcat well drilled 2.5 km (1.5 miles) southeast of B-01, compared with top portion of log from east side of Cayuse Basin derived from Vine (1959) and Vuke et al. (2007). Numbers are depths in feet (precision varies from 0.5 to 5.0 ft.). Tracing or correlating formations such as the Kootenai laterally can be difficult, and workers rely heavily on a few key marker beds.

tion. For readers who prefer traditional geochronologic designations, I recommend instead using the Sloss sequence terminology (Table III) for its more empirical basis (Dott, 2014).

The Kibbey Formation was mentioned in Vine (1959) and Vuke et al. (2007) but not observed by the author. Shale observed resembled instead the Otter Formation (Figure 8).

The inside of the rim exhibits prominent sandstone (Figure 6) of the Tyler Formation, the basal formation of the Amsden Group. On the outside of the rim, similar sandstones are mapped as the Swift Formation of the Ellis Group

(the only Ellis formation present), then Morrison Formation, overlain by Kootenai Formation. The Swift and Morrison together are approximately 200 feet (63 m) thick, and an unconformity is thought to exist in the Morrison (Vuke et al., 2007). The Ellis Group farther west consists of generally three formations, the Swift being the uppermost. An unconformity is thought to exist at the base of the Ellis Group, but Ellis strata pinch out rapidly eastward, and exhibit lateral facies changes.

Between the Tyler and Swift is the prominent limestone of the Alaska Bench Formation, the upper formation

of the Amsden Group. The unconformity described between the Amsden and Ellis Groups is a major sequence boundary (Absaroka to Zuni) but was not observed in the field despite supposedly 100 million years (or *mega annum*, Ma) of allegedly missing time (Carstarphen et al., 2011). Unfortunately, traditional ages are often cobbled to the Sloss sequences, undermining their empirical status. This apparent conformity and lack of transgressive-regressive cycles between the Swift and Alaska Bench Formations makes this sequence boundary designation inapplicable in the Cayuse Basin. An intraformational unconfor-

Table III. Stratigraphic Nomenclature

Sequence	Group	Formation	Remarks
Zuni		Kootenai	
		Morrison	Unconformity posited within formation
	Ellis	Swift	Unconformity posited at base
Absaroka	Amsden	Alaska Bench	Unconformity posited at top
		Tyler	
Kaskaskia	Big Snowy	Heath	
		Otter	
		Kibbey	Unconformity posited at base
Sequences correlated with Williston Basin, but originally traced from Rocky Mountains by Sloss.	Madison Group, Lodgepole Formation, underlies Kibbey. Petroleum geologists in author's acquaintance may refer to Madison as "Mississippian" and Kootenai, the shallower production zone, as "Lower Cretaceous" without referencing lithologies or formations or even supposed ages. "Second Cat Creek Sand" and "Third Cat Creek Sand" are drillers' terms for locally important aquifers and sometimes oil producing zones within the Kootenai Formation.		

mity is speculated for an uncertain location within the Morrison Formation.

Early on, the Morrison and Kootenai Formations were biostratigraphically determined (Fisher, 1909). These were assembled like a culch bin: as any potentially useful machine part or scrap is tossed into the bin, so strata "dated" by fossils were "tossed" into the "bins" corresponding to "Morrison time" or "Kootenai time." This imaginative departure from science to create a chronologic geologic column has unfortunately not been limited to Central Montana (Woodmorappe, 1999). Imaginary time makes a poor field marker for drillers, so the top of the Kootenai came to be recognized as the first red bed (hematite rich unit). The first coal was originally classified as basal Kootenai but later assigned to the upper Morrison.

The Kootenai portion of Figure 10 is compared with portions of logs from water well B-1 and wildcat well Schmitt (1.5 miles or 2.5 km apart) approximately 14 miles (24 km) northwest of Cayuse Basin. As with most of the formations

both up and down section, the Kootenai strata are dominated by shale and claystone with significant amounts of siltstone and sandstone, and minor bentonite and limestone. Subjectivity and technology could explain some differences but there is a lack of lateral continuity. This is considered the consequence of a continental depositional environment, though similar formations deeper in the section are marine.

First rate marker beds are not common in the study area. There are color changes evident with the Kootenai and Otter Formations, and the presence of coal is used to infer Morrison. As shown in the logs, there is repetition in some lithologies, but poor lateral correlation. For example, medium grained sandstones (litharenites) with limonite flecks are not uncommon in the Kootenai but may occur elsewhere too. Whether the light gray micrite of the Alaska Bench Formation differs lithologically from the light gray micrite of the deeper Madison Group or the thin unit in the Kootenai Formation is unclear. What is

evident is this: the source materials for these various lithologies were available throughout the depositional history of the section, appearing virtually identical at various points throughout the rock column, a supposed span of over 200 Ma. This episodic deposition and the subtlety of the unconformities—or paraconformities—appears more compatible with a relatively quick depositional history with few hiatuses—or none.

Structure and geomorphology

Sedimentary strata in the Judith Basin dip northeast at a very slight angle. Their dip becomes steeper against the north side of the Little Belt Mountains, and they form a dome at Cayuse Basin (Vine, 1956; Vuke et al., 2007). While my bed attitude measurements were more numerous and scattered than those on Figure 11, they were similar.

Knife Edge Ridge, the flat, narrow top of the Big Snowy Mountains flanked by dry cirques, is approximately 8,500 ft. (2,620 m) above sea level and truncates the top of the anticline. In my youth, I

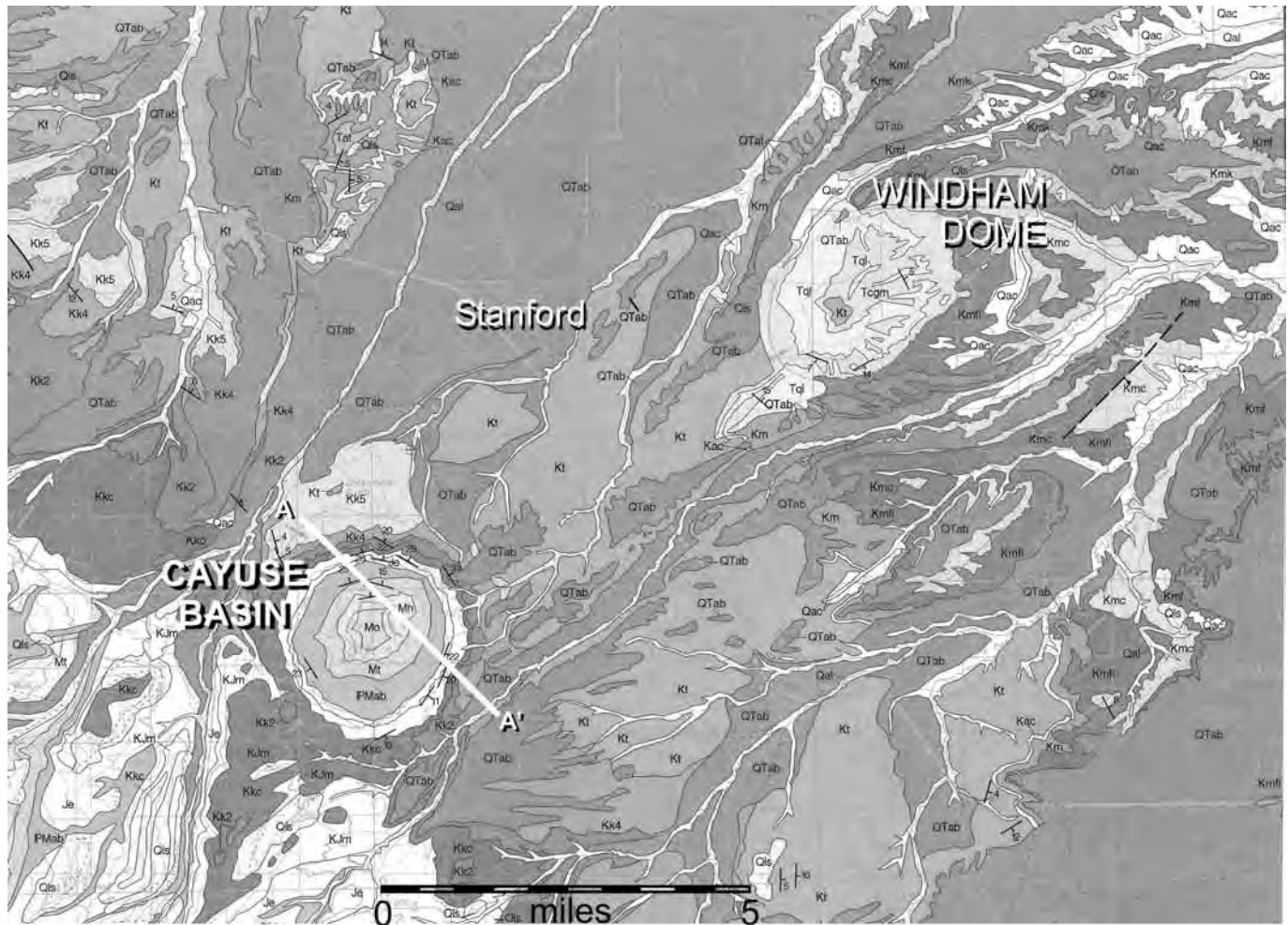


Figure 11. Portion of geologic map (Vuke et al., 2007) showing Cayuse Basin and Windham Dome. Line A–A' is location of cross section in Figure 13.

was taught this was a peneplain, a now discredited concept (Oard and Klevberg, 1998). High planation surfaces such as this are seen at the tops of other Montana mountain ranges, such as the Beartooth Plateau and the Highland Mountains. Planation surfaces occur in a smaller, more channelized form at lower elevations; the Judith Basin is an excellent example (Figure 12). These lower surfaces, called “benches,” are generally smaller and ramp into each other. The Judith Basin planation surfaces are mantled by coarse gravel sheets (Klevberg and Oard, 1998; Oard and Klevberg, 1998), but here the predominant lithology is limestone from nearby

mountains, not quartzites from halfway across the continent.

The center of Cayuse Basin consists of soft shale. The rim is hard sandstone capped by limestone. Only a slit in the northeast rim affords drainage, yet its erosional history is problematic. Much material appears to have been removed from Cayuse Basin. Slow erosion over deep time would have resulted in a very different topography. Hard blocks of sandstone and limestone would have accumulated on the basin floor and hindered erosion of the soft underlying shale. Yet above the shale inside the basin, these hard lithologies are absent. Not only are the planation surfaces testi-

mony to the violent sheet flow of a megaflood, but Cayuse Basin itself appears to have been scoured out, exposing the softer shale. Similar is Windham Dome (Figure 11), which was razed to the level of the surrounding plain and covered with a sheet of gravel. Planation surfaces often cut indiscriminately through hard and soft strata, the opposite of what would be expected from uniformitarian erosion (Oard and Klevberg, 1998).

Interpretation

Meteor Crater, Arizona, is perhaps the most famous obvious impact crater. Chicxulub is famous for the dinosaur extinction theory, but many others have

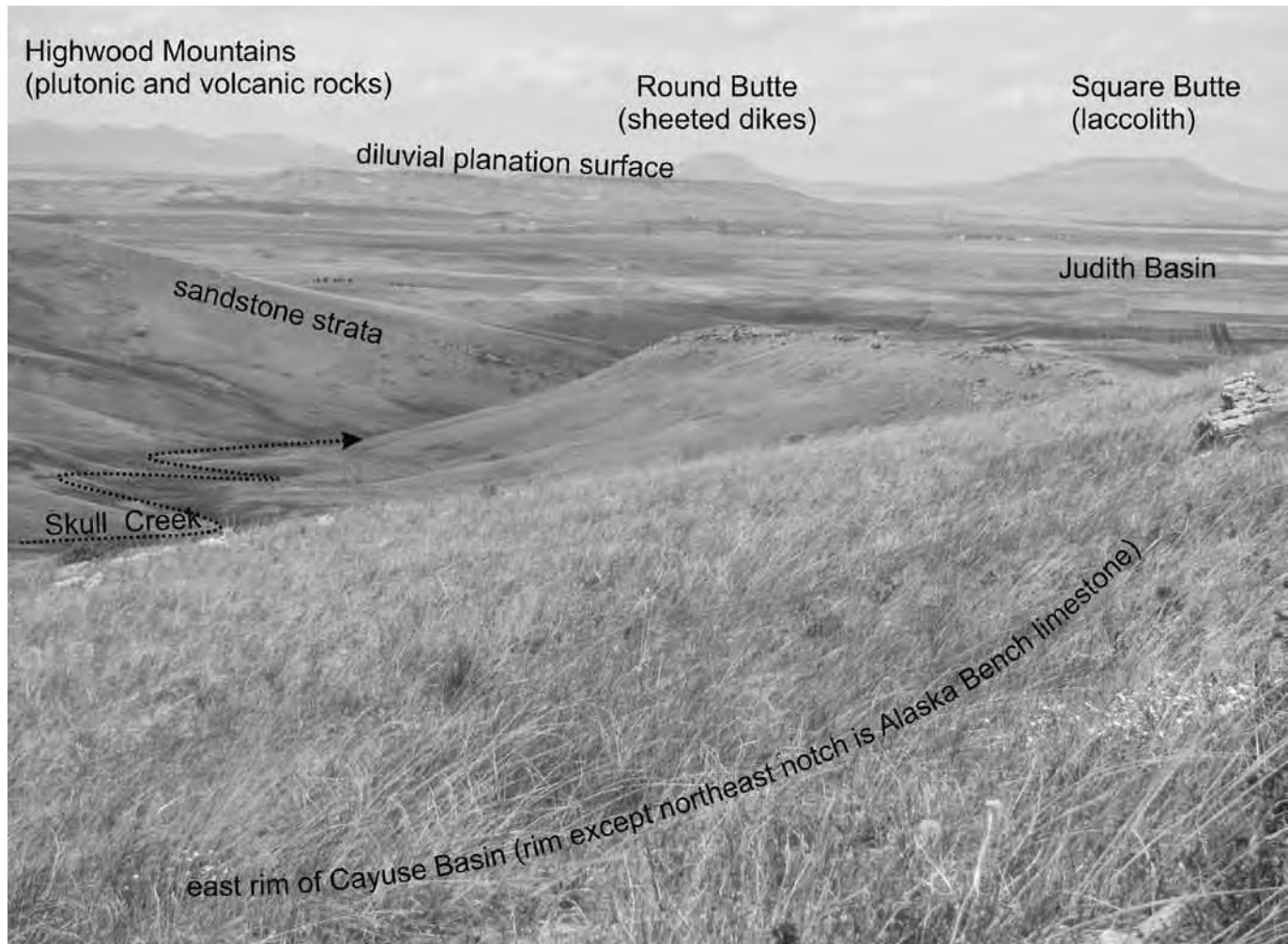


Figure 12. View north-northwest from east rim of Cayuse Basin showing various plutons on northern horizon beyond high bench that is a gravel-capped planation surface (diluvial). Like Cayuse Basin, the Judith Basin is a topographic basin, but whereas Cayuse Basin is a couple of miles across, the Judith Basin is twenty times that broad.

been imaged in the subsurface. There are sites where the evidence shown in Table I is found, but not Cayuse Basin. Furthermore, the undisturbed fissile shale in the bottom of the basin is hard to reconcile with an impact.

Cinder cones often look like Figure 3. Volcanic rocks are present north and northwest of Cayuse Basin (Figure 9). However, the basin contains only sedimentary rocks. It is clearly not a volcanic feature.

The geologic map of Vuke et al. (2007) was vindicated by field evidence. Cayuse Basin is a sedimentary dome

(Figure 13). It appears likely that a laccolith underlies Cayuse Basin, causing the dome. Drainage of Floodwaters late in the Deluge (Abative Phase per Walker, 1994) could readily explain removal of debris from the interior of Cayuse Basin, planing of the Windham Dome flush with the bench, and its decreasing flow forming benches in the Judith Basin.

Catastrophic Plate Tectonics

Central Montana is believed by some to have been a foredeep at the northwest end of the Wyoming Craton and the

south end of the Medicine Hat Block as part of the Rodinian supercontinent (Sims et al., 2004). It is distant from subduction zones and well over one hundred miles (200 km) north of Yellowstone. Cayuse Basin has no obvious connection to plate tectonics, catastrophic or otherwise.

Hydroplate Model

The Hydroplate Model may be thought of as catastrophic plate tectonics with a different mechanism and perhaps greater stress on horizontal compressive

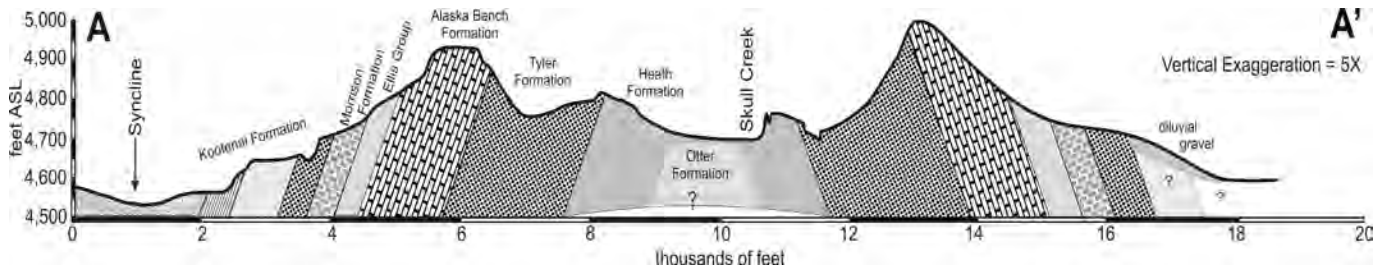


Figure 13. Section through Cayuse Basin as shown on Figure 11. See Vine (1956) and Vuke et al. (2007).

folding. The fold axis for the Big Snowy Mountains (Figure 1) is east-southeast by west-northwest, oblique to many other folds in the area, and the rest of the mountain ranges surrounding the Judith Basin have igneous cores. While this does not disprove the Hydroplate Model, neither does it support it.

Impacts with Vertical Tectonics

Cayuse Basin is not a crater. Other sites (e.g., Meteor Crater, Arizona) show impacts. Vertical motion on normal faults appears to have occurred over much of the study area (Vine, 1956; Vuke et al., 2007). Basement faults inferred from gravity and aeromagnetic data along the north flank of the Little Belt Mountains and the Great Falls Shear Zone do not appear to have been reactivated (Sims et al., 2004). Thus, Cayuse Basin neither refutes nor supports the model combining meteorite impacts with vertical tectonics.

Other Models

Laterally extensive strata with few or subtle unconformities are more readily explained in the diluvial geologic paradigm than uniformitarianism, as are the extensive planation surfaces and “cleaning” of debris from inside Cayuse Basin.

Structural effects related to plutons of the Central Montana Alkaline Province indicate this emplacement was contemporary with late diluvial erosion, calling into question the 40-Ma age assigned to the plutons (Woodward, 2010). While good evidence for the Deluge, Cayuse Basin does not appear to provide a strong argument for or against any one model.

Conclusions and Admonitions

If Cayuse Basin does not show us which “Flood Model” is right, does studying it have any value? Much indeed! One of the most important lessons is not to jump to conclusions. Chamberlin (1890) was right. Second, do not rely on Google Earth®. While a useful tool, aerial imagery has inherent limitations, and conclusions should not be based solely on them. Third, do not rely on geologic maps. Even though the maps were quite accurate in this case, they are not always so. Marker beds, geophysical data, or other means of correlation are not always readily available, and mappers are fallible, particularly in stratigraphic interpretation. Rocks with little or no relation to a given type locality may be given a formation name simply to fill a gap in a presumed stratigraphic column. I typically look at the map *after* my first site visit lest I fail to make key observations. Maps are

generally more reliable, however, than Google Earth®.

There is no substitute for boots on the ground. It is sometimes surprising what one may notice in the field that could never be learned from published sources. This works both ways relative to models. In the field, observations are readily made at various scales that may not have been made before, or not published.

Geologic research is not dependent on models and does not always validate or invalidate any of the popular geotheries or “Flood models.” These models should be treated as multiple working hypotheses and not as colored glasses or blinders.

Acknowledgements

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Glossary

Bentonite. Earth material composed of at least 90 percent smectite (a phyllosilicate).

“clay mineral” that is very moisture sensitive); bentonite is apparently to a large extent the end product of alteration of volcanic ash in sea water.

Bolide. A large, crater-forming meteorite of unknown composition.

Diluvialist. One who believes the Deluge of Noah’s day was the most important geologic event of history and explanative of most geologic phenomena.

Fissile. Readily breaking into thin sheets.

Hydroplate Model. A plate tectonics model formulated by Walt Brown (2008) in which the plates moved on water.

Laccolith. A pluton (igneous intrusion) with a domed top that apparently pushed up the strata above it.

Latite. An extrusive (volcanic) rock in which alkali feldspar and plagioclase feldspar are present in approximately equal amounts.

Limonite. A hydrous iron oxide mineral.

Mafic. Igneous rocks high in magnesium and iron (basic rocks).

Micrite. Limestone with crystals too small to discern with the naked eye.

Paraconformity. An alleged unconformity for which physical evidence is lacking; it is inferred based on stratigraphic interpretation only.

Peneplain. An erosion surface marking the final stage of the cycle of landscape evolution as envisioned by uniformitarians in which a nearly flat surface results from erosion nearly to base level.

Phonolite. An extrusive rock equivalent to trachyte (either a porphyry or a lithology without visible crystals that is dominated by alkali feldspar) except that it includes feldspathoid minerals instead of the more common feldspars.

Porphyry. An igneous rock with relatively large crystals (phenocrysts) in a fine-grained groundmass.

Regolith. Mineral matter composed of weathered bedrock that forms the parent material for soil.

Shonkinite. A mafic intrusive (plutonic) rock that is a mafic syenite composed primarily of augite and alkali feldspar.

Syenite. An intrusive rock dominated by alkali feldspar (mineralogically equivalent to trachyte).

Unconformity. A contact between rock units that is discordant, implying that the top of the lower one was eroded to some degree before the next was deposited.

Wildcat well. A well drilled in search of oil in a location lacking detailed information or previous exploration.

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Much Greater Cosmic Rays During the Ice Age and Before

Michael J. Oard*

Abstract

The RATE project was a huge breakthrough for creation scientists. It especially explained why secular scientists get millions and billions of years from radiometric dating. Quaternary dating methods also need evaluating. One of these dating methods is cosmogenic nuclide dating caused by the bombardment of the Earth by cosmic rays. Production rates of cosmogenic nuclides vary by location on the Earth, altitude, and time and depend upon many variables. They have many geological applications, such as inferring erosion rates and the burial rates of sediments. Carbon-14 is the most well-known cosmogenic dating method, but it has a practical age limit to only 50 ka. In situ beryllium-10 (^{10}Be or Be-10) can be easier to use and can ‘date’ the rest of the Quaternary. Another cosmogenic dating method calculates the ratio of Al-26/Be-10 in sediment, which can determine the time since burial. Seven Be-10 measurements are used as showcases for an old Earth. They produce tens to hundreds of thousands of years in the uniformitarian timescale. When transforming the Be-10 values into Biblical earth history, creation scientists run into four complications which make it impossible to be accurate. In spite of this, it appears that the cosmic rays were very high during the Flood and tailed off rapidly during the Ice Age. These measurements have four implications: 1) high cosmic rays could be due to a nearby supernova or supernovae that may also be a cause for accelerated radiometric decay during the Flood and Ice Age; 2) it accounts for the rapid increase in C-14 after the Flood; 3) accelerated radiometric decay after the Flood telescopes other Quaternary dating methods to the time after the Flood; and 4) finally, we can account for the Be-10 measurements in ice cores.

Keywords: Accelerated radiometric decay, Aluminum-26, Beryllium-10, Carbon-14, cosmic rays, cosmogenic isotope dating, geomagnetic field, Quaternary dating methods, supernovas

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Introduction

Deep time challenges Biblical young-Earth history (Oard, 2019). Creation scientists have been working on understanding why some dating methods calculate millions of years ever since the late Drs. John C. Whitcomb and Henry M. Morris published *The Genesis Flood* (Whitcomb and Morris, 1961). Great progress was made with the completion of the RATE project (Vardiman et al, 2000; 2005; DeYoung, 2005). Humphreys discovered there was a period or periods of accelerated radiometric decay sometime in the past 6,000 years (Humphreys, 2005). Just when accelerated radiometric decay took place in Biblical history is still being debated among creation scientists, although most creation scientists favor just before or during the Genesis Flood. Many more dating questions and challenges are still in the process of being answered. One is how Quaternary dating methods also produce old ages of hundreds of thousands to a few million years.

Quaternary Dating Methods

The Quaternary is the past 2.6 million years (Ma) in the uniformitarian time scale, and is divided up into the Pleistocene from 2.6 Ma to 11,700 years ago (11.7 ka) and the Holocene from 11.7 ka until the present (Figure 1). There are numerous Quaternary dating methods (Noller et al., 2000), which often extend into the Pliocene Epoch (2.6–5.3 Ma) or even “older.” The Quaternary is considered the general period of ice ages in the uniformitarian system of which there are now about 50 ice ages, separated by interglacials (Walker and Lowe, 2007). These ice ages are claimed to have cycled either every 40 ka more than a million years ago (40 ice ages) or every 100,000 years during the past 1 million years (10 ice ages). The post-Flood Ice Age corresponds primarily with the ‘last’ uniformitarian ice age. Terrestrial evidence for previous ice ages is skimpy

with the main evidence coming from wiggles of certain variables, primarily the oxygen isotope ratio, down deep-sea cores. These wiggles can be due to other mechanisms that occurred during the Flood and/or the Ice Age.

Quaternary dating methods are used to anchor deep-sea core oxygen isotope variations. The isotopic variations in the cores are then used to ‘validate’ the Milankovitch mechanism (cyclostratigraphy) that causes cyclical changes in the Earth’s orbital geometry. Changes in the orbital geometry cause changes in the seasonal and latitudinal distribution of solar radiation, but not the total amount of sunlight striking the Earth. The Milankovitch mechanism is why scientists claim that ice ages cycle every 40,000 years, matching the tilt cycle, and every 100,000 years, matching the ec-

centricity cycle, for the past 2.6 Ma. The Milankovitch mechanism is assumed to be proven and now is used to ‘date’ other climatic data sets, such as other deep-sea cores, ice cores, pollen cores, lake sediment cores, etc., at a finer scale (Oard and Reed, 2020b). However, the Milankovitch mechanism is too small to cause glacial/interglacial oscillations (Oard and Reed, 2020a).

The deep-sea cores that supposedly validated the Milankovitch mechanism depend upon Quaternary dating methods, one of which is paleomagnetism. Jake Hebert of the Institute for Creation Research noticed that the date of the transition from the Matuyama Reversal to the Brunhes Normal was changed from 700,000 years ago to 780,000 years ago (Hebert, 2017a, 2017b). This change affected all the other dates of the

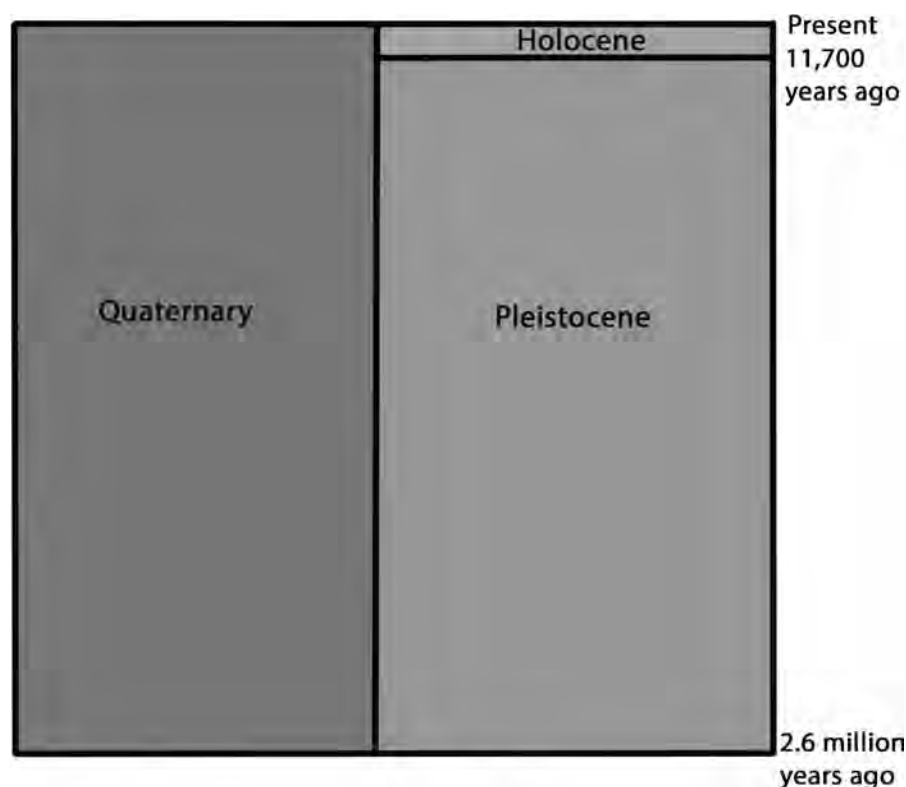


Figure 1. The “Quaternary Period” subdivided into the “Holocene” ‘interglacial’ and the “Pleistocene,” the general time for the secular ice age cycles (drawn by Mrs. Melanie Richard).

cores and threw off the cycles. Under the assumption of uniformitarianism, Hebert reran the spectrum analysis, which determines major frequencies in a time series, using the new date for the paleomagnetic transition. The Milankovitch cycles no longer showed up, which means that the Milankovitch mechanism has *not* really been proven! Secular scientists have attempted to rescue the *Pacemaker of the Ice Ages* paper, but Hebert (2019) shows that this “rescue” may be influenced by “selection bias” and requires arbitrary, capricious handling of seafloor sediment data, which is not convincing. It also means that thousands of papers that assume the Milankovitch mechanism to be true are suspect, even by uniformitarian reckoning.

Cosmogenic Isotope Dating

Another Quaternary dating method is cosmogenic nuclide dating. Cosmogenic nuclides are formed by the bombardment of primary, energetic cosmic rays from space on the atmosphere, causing a cascade of numerous particles as ‘secondary cosmic rays’ (Figure 2). Primary cosmic rays are very high energy particles and consist of about 90% protons, about 8% alpha particles (He nuclei), and the remainder heavier nuclei and electrons with an extremely minute proportion of positrons and antiprotons (Lifton et al., 2005). The latter likely were made by recent energetic processes. Cosmic rays vary significantly in energy. The cascade of particles and energy result in neutrons that penetrate the atmosphere to the surface. The fast neutrons and ‘thermal’ neutrons (those that have slowed to the temperature of the surrounding molecules) mostly form the in situ cosmogenic nuclides (Gosse and Phillips, 2001; Desilets and Zreda, 2003; Balco et al., 2008).

The origin of cosmic rays is a mystery. Very-high-energy cosmic rays are believed to have formed mostly in the Milky Way Galaxy, but extra-high-energy

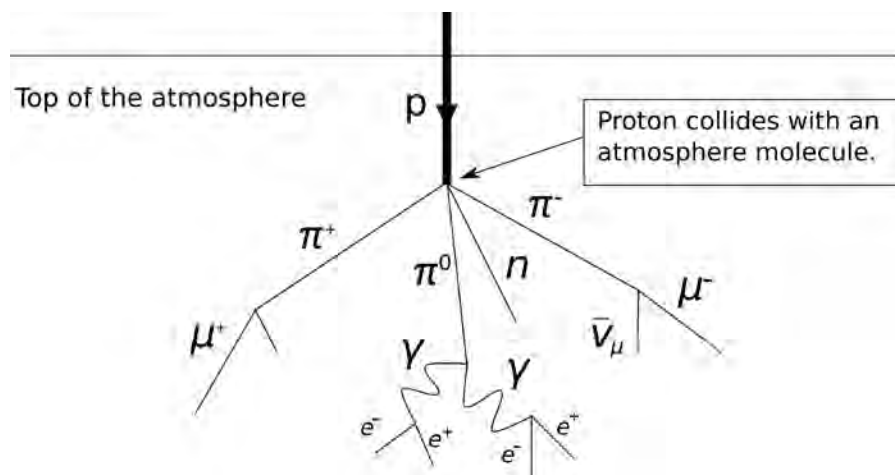


Figure 2. Primary cosmic-ray particle (a high energy proton) collides with a molecule in the atmosphere (User:SyntaxError555, Wikimedia Commons CC-BY-SA-3.0 mitigated).

cosmic rays are believed to have come from outside our galaxy (Cockburn and Summerfield, 2004). Scientists mostly think cosmic rays are from supernova remnants (SNRs), which have somehow accelerated the cosmic rays to relativistic speeds (Ackermann et al., 2013; Morlino, 2017). Others think that such very high accelerations come from supermassive black holes, such as the one believed to be in the center of the Milky Way Galaxy (Hess Collaboration, 2016).

The secondary cosmic rays start forming high in the atmosphere and continue to react with the atmosphere below with some eventually striking the Earth’s surface in their downward trek (Zreda and Phillips, 2000). Numerous interactions with the atmosphere and many different particles, of various energies, are produced. The cosmogenic nuclides are formed especially by high-energy neutrons from these secondary cosmic rays, mostly by spallation. Spallation takes place when a cosmic ray particle collides with matter and dislodges protons and neutrons from the atoms, forming new atoms and

residual particles. High energy protons account for 5% of the in situ cosmogenic nuclides (Reedy, 2013). Around 2% of in situ cosmogenic nuclides, those formed at the surface, are formed by negative muon capture and fast muon interactions and are usually ignored (Granger et al., 2013; Balco, 2017a). A muon is an elementary particle similar to an electron with a charge of -1 but with a much greater mass. Neutrons in the atmosphere are difficult to measure, and the physics of the production of cosmogenic nuclides, except for carbon-14, has not been worked out (Argento et al., 2015; Phillips et al. 2016). Each cosmogenic nuclide has its own unique production from nuclear reactions, with the energy of the cosmic rays important (Reedy, 2013). The pathway and molecular bombardment are different for the various cosmogenic nuclides (Gosse and Phillips, 2001).

Because cosmic rays are predominantly electrically charged, their fluxes into Earth’s atmosphere are influenced by the interplanetary magnetic field (the part of the solar magnetic field that

extends into the interplanetary region), whose strength depends on the level of solar activity, which produces low-energy cosmic rays (Lal, 1987). Because solar activity is cyclical and averages out, the effect of solar cosmic rays will not be considered further. However, once in a while, coronal mass ejections occur that increase the flux of solar cosmic rays, but these are rare enough to also ignore (Argento et al, 2015).

Thus, production rates of cosmogenic nuclides vary in latitude, longitude, altitude, and time and depend upon many variables: “Cosmic-ray produced production is a complex process that is affected by many variables” (Argento et al., 2015, p. 40). Numerous cosmogenic nuclides are generated, but only the stable atoms, ^3He and ^{21}Ne , and the radioactive isotopes, ^{10}Be , ^{14}C , ^{26}Al , ^{36}Cl , ^{39}Ar , and ^{60}Fe are considered significant for geological work (Lal, 1991).

One of the main variables that affects the production rate of cosmogenic nuclides is altitude and geomagnetic latitude. Because cosmic rays are predominantly charged particles, they often get caught up in the geomagnetic field. Because the geomagnetic field tends to funnel these charged particles to higher latitudes, the low to mid geomagnetic latitudes are shielded to a certain extent. The high energy cosmic rays can better penetrate the geomagnetic field at high latitudes. There is little geomagnetic blocking poleward of about 60° geomagnetic latitude in a dipole field. Researchers use “scaling factors” from one or several locations, primarily at high latitude and sea level, to determine the production rate of cosmogenic nuclides globally and at all altitudes.

The production rate of cosmogenic nuclides is especially high in the upper atmosphere with most of them produced in the stratosphere (Adolphi and Muscheler, 2016). Production decreases downward to the surface, which is believed to produce only several atoms per gram of quartz per year. Quartz,

being a ubiquitous molecule on Earth, is the standard substance used to measure cosmogenic nuclides. Cosmogenic nuclides increase greatly with altitude by a factor of about 1,000 in the upper atmosphere. These nuclides usually reach the Earth’s surface, for instance adhering to aerosol particles that sink through the atmosphere. As a rule of thumb, for every 10 m increase in elevation gain from sea level, the production rate goes up about 1% (Stone, 2000). But, it is questionable whether this rule of thumb applies for moderate to high altitudes (see below).

Cosmogenic nuclides have a number of applications in geology. They are primarily used to determine the length of time a surface has been exposed, such as a large boulder in a terminal moraine or a polished, striated surface left over from the Ice Age. Cosmogenic nuclides can be used to estimate the rate of erosion and the rate of burial of a surface (Portenga and Bierman, 2011). However, many complications enter into the procedures (Gosse and Phillips, 2001). For instance, in measuring surface exposure, the researchers must assume that the surface or the top of a boulder did not have any previous exposure, called inheritance. Previous exposure would presumably be ruled out if the boulder was dislodged from a depth below 3 m, since secondary neutrons generally cannot penetrate matter more than three meters of ground. However, it is commonly found that striated surfaces have a component of inheritance, which usually is not known until the measurements turn out different from the ‘known’ age (Balco, 2017b). Researchers usually choose the top of large boulders, since they are believed to have little inheritance, and it is unlikely they have moved since emplacement, been covered by soil, or slowly weathered and eroded. A long deep snow cover can also shield the boulder for a while, but this is commonly factored in during the interpretation of the measurements.

Moreover, researchers must be careful not to measure atmospheric produced nuclides (Bierman, 1994), a problem for unconsolidated sediments. With an “understanding of the secular history” of the environment, cosmogenic nuclides have been used to estimate surface erosion rates and burial times for sediments and soils (Balco and Rovey II, 2008), although several uniformitarian assumptions go into the calculations.

Carbon-14 Dating

Carbon-14 is one of the cosmogenic nuclides which many people recognize. In the upper atmosphere, it forms from nitrogen-14 and quickly combines with oxygen creating carbon dioxide. The carbon dioxide spreads through many carbon reservoirs: the atmosphere, the biosphere, and the ocean, so it is simpler to use Be-10 (Adolphi and Muscheler, 2016). Most people mistakenly think that carbon-14 dates the Earth as old, but it is primarily used to date the remains of once-living organisms (Oard, 2019). Also, with a half-life of 5,730 years, its practical dating limit is 50,000 years, since after that time the sample of carbon-14 becomes too small to measure with current technology, making contamination more of a problem.

Carbon-14 was the first Quaternary dating method developed in the 1950s and 1960s. It has been used to date numerous archeology sites, Late Quaternary animals, etc. Scientists discovered that carbon-14 is not particularly accurate, so it needs to be “calibrated” to dates of “known” age, produced by other, presumably more accurate dating methods. It is assumed that counting of tree rings, dendrochronology, is one of the most accurate dating methods and can date to nearly the precise year by counting rings of living and *dead* trees. The rings in dead trees are supposedly cross matched to each other and “connected” to the end of the living trees. Secular scientists have only been able to compare

tree rings to around 14 ka years BP (before the present or 1950), by correlating dead trees often found in river terraces (Muscheler et al., 2014). How tree ring chronologies are developed, and why they extend to beyond the Flood dated at about 4,500 BP (Thomas, 2017) is beyond the scope of this article. However, it has been addressed by other creation researchers (i.e., Woodmorappe, 2018). The assumption of old age plays a large part. Secular scientists also correlate the carbon-14 method beyond tree-rings to 50 ka by using “varves,” speleothems, corals, ice cores, etc. (Reimers et al., 2013) with deep time assumed in all of these systems.

The Beryllium-10 Dating Method

Because carbon-14 dates reach a practical limit of only 50,000 years, and the Quaternary is said to be 52 times this length, secular scientists have been actively searching for dating methods that provide ages well beyond the limit of carbon-14. They have developed many such dating methods (Noller et al., 2000). Beryllium-10 (Be-10) is one.

The formation of Be-10

Cosmogenic Be-10 is one of the main cosmogenic nuclides that is used in geology because of its long half-life. Once formed in the atmosphere, it is absorbed by aerosol particles that fall to the Earth's surface or become absorbed into precipitation. Its atmospheric life is about 2 years, but it is complicated in that the stratosphere has a higher concentration of Be-10 than the troposphere, and so the variable air exchange between the stratosphere and troposphere must be taken into consideration (Adolphi and Muscheler, 2016). A slight amount of Be-10 is formed at the surface (in situ Be-10) from bombardment of oxygen and silicon in quartz (Gosse and Phillips, 2001), which can be measured by sensitive mass spectrometers.

The cosmic rays will penetrate slightly into matter, generally within about 3 m of rock, except for the secondary cosmic ray muons, high energy neutrons, and gamma rays that penetrate much deeper (Balco, 2017a). The production of Be-10 decreases exponentially with depth with an e-folding depth of 60 cm in rock and 1.5 m in ice (Schaefer et al., 2016). The e-folding depth is the depth at which production is decreased by a factor of $1/2.71828$, or 0.37. The depth of penetration depends upon the density.

Be-10 is radioactive with a half-life that has been variously estimated between 2.9 Ma to 1.386 Ma, but recently researchers have settled on the lowest half-life of 1.386 Ma (Chmeleff et al., 2010) based on a measurement of the $^{10}\text{Be}/^{9}\text{Be}$ isotope ratios. Thus, the Be-10 dating method has the potential to date to around 3 half-lives or well into the Pliocene.

Be-10 is commonly measured in ice cores and its oscillations are correlated with various Quaternary events, such as the Laschamp polarity excursion about 40 ka. A polarity excursion is like a reversal but represents a dramatic deviation of the axial dipole of around 45° , or sometimes more, with a decrease in intensity to 0 to 20% of normal that lasts tens to hundreds of thousands of years in geological time (Neuendorf et al., 2005, p. 504). However, the Be-10 values in ice cores depend upon the amount of wet versus dry deposition of aerosols on the ice sheets and atmospheric circulation processes (Adolphi and Muscheler, 2016), which are difficult to estimate in the present and especially for the past. So, I will use the much simpler dating method developed from in situ Be-10.

As already stated, little in situ Be-10, as well as other cosmogenic nuclides, is formed on the Earth's surface by secondary cosmic rays. The geomagnetic field at low to mid latitudes deflects some of the cosmic rays with about 50% shielding near the equator. Geomagnetic shielding does not take place at latitudes

higher than 60° assuming a dipole field. So, it is claimed that at sea level only about 4 atoms/gm/yr. are formed at high geomagnetic latitudes (Young et al., 2013) and about 2 atoms/gm/yr. at low geomagnetic latitude (Blard et al., 2019). These are rough estimates.

Be-10 calibrated to surfaces of ‘known’ age

In the past, observed production rates have been estimated from physics (Masarik and Reedy, 1995), but the physics is so complex that researchers estimate the production rate based on surfaces of “known” age (Balco et al., 2009; Balco, 2017b; Blard et al., 2019). Such a procedure is in fact circular reasoning and adds an old-age bias to the measurements. One of the problems in using physics to calculate production rates is that it is difficult to measure the flux of neutrons (Reedy, 2013). Some other complications are that there are eight reactions with matter that form Be-10 (Gosse and Phillips, 2001), and objects such as trees, buildings, and even distant mountains in the field of view cut down the production rate (Cerling and Craig, 1994), but usually only slightly. So, it has been difficult to determine the production rate, with different models yielding estimates varying by a factor of two (Kovaltsov and Usoskin, 2010).

In reference to calibrations to ‘known’ age surfaces, Balco (2017a, p. 151) states:

Here ‘geological calibration data’ means measurements of concentrations of naturally occurring cosmic-ray produced nuclides in settings where independent knowledge of the geological history of the site allows one to infer nuclide production rates from the concentration measurements.

This specifically refers to muons but it also applies to all in situ cosmogenic nuclides. Borchers et al. (2016, p. 189) further state:

The production rate parameter is calibrated by finding the value that

best fits measured concentrations from a collection of sites for which independent age measurements are available.

This of course is how deep time automatically enters into the calculations, and why production rates are assumed to be particularly low.

Scientists commonly measure the amount of Be-10 on surfaces to about 10^4 to 10^6 atoms/gm, and with low production rates, they arrive at ages of tens of thousands to millions of years within the uniformitarian paradigm. This is way beyond the timescale of the young Earth, based on the genealogies in Genesis 1–11.

Aluminum-26 (Al-26)

Aluminum-26 (Al-26) is also another cosmogenic nuclide that scientists work with. It has a shorter half-life of 7.17×10^5 years, about half that of Be-10. But more atoms of Al-26 are formed in situ than Be-10, but the ratio varies by altitude, latitude, depth below the surface, and other variables (Luo et al., 2020). Although the ratio has been measured up to 7.3 (Corbett et al., 2017), the ratio of $^{26}\text{Al}/^{10}\text{Be}$ used today is about 6.8 (Luo et al., 2020).

Secular scientists have developed another dating method using these cosmogenic nuclides. Since Al-26 decays faster than Be-10, the $^{26}\text{Al}/^{10}\text{Be}$ ratio will decrease with time. Since both isotopes are generally formed the same way, when they measure Be-10, it is rather simple to also measure Al-26. Any system that changes with time is a potential dating method, although the further back in “time,” the more “iffy” the results. Different values of the half-life of this dating method have been published, probably because the production rates are difficult to determine. One value from the literature for the half-life of the $^{26}\text{Al}/^{10}\text{Be}$ ratio is 1.4 Ma (Schaefer et al., 2016) and another value is 2.08 Ma (Granger et al., 2015).



Figure 3. View of the divide of Unaweep Canyon through the Uncompahgre Mountains of west-central Colorado, USA (view west).

Examples of Be-10 Measurements

Numerous Be-10 measurements have been made, especially on glacial features or deposits (Balco, 2017b). Assuming a dipole field, high geomagnetic latitude measurements do not need correction for the changing geomagnetic field in the past, but lower latitude measurements do (Lifton et al., 2008). I will provide some representative samples from the secular literature starting from likely Flood-formed features, to early Ice Age, and then late Ice Age.

Be-10 in Unaweep Canyon fill

Unaweep Canyon is a wind gap carved through the Uncompahgre Mountains (Figure 3). In the process, thin-bedded sediments, interpreted as lacustrine by secular scientists, collected in the canyon west of the rock divide. After the ‘lacustrine’ sediments were laid down, the top was covered by alluvium/colluvium mostly from the canyon sides.

The total depth of this amazing canyon fill is about 350 m (1,150 ft.) (Figure 4). Uniformitarian scientists have difficulty explaining the sediments of the canyon fill. They suggest a landslide dam at the western end of the canyon. It would have had to be several hundred meters high, of which there is no evidence of such a landslide dam, as far as I know.

The scientists dated the ‘lacustrine’ sediments with Be-10 (Balco et al., 2013). At several levels in the core, they found Be-10 concentrations that ranged from 1.12×10^5 atoms/gm at 112.7 m (370 ft.) to 3.42×10^5 atoms/gm at 243.6 m (800 ft.) depth down the core. Based on these concentrations, uniformitarian scientists derived dates of 0.71 to 1.69 Ma.

Granite inselbergs in Southern Australia

Granite inselbergs in Southern Australia are believed to be very slowly eroding, as slow as 0.6 m/Ma (Bierman and Turner,

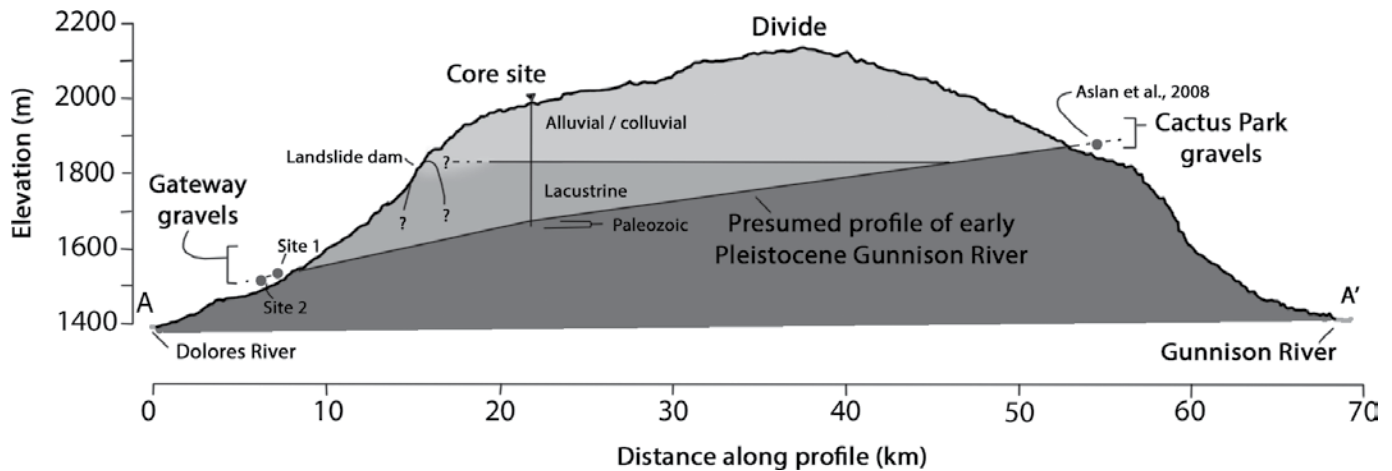


Figure 4. Longitudinal Unaweep Canyon profile (from Balco et al., 2013, p. 150, Figure 2, used in accordance with federal copyright (fair use doctrine) law. Usage by CRSQ does not imply endorsement of copyright holder). The mountains around the wind gap are not shown.

1995). Be-10 values on these inselbergs range from 0.71 to 4.43×10^6 atoms/gm for minimum uniformitarian ages of 114 to 628 ka. For uniformitarian ages this old, the decay of Be-10 must be taken into account. The figures are minimums because a little erosion would have already taken place between the time of formation and today.

Hickory Run boulder field

Numerous boulder fields worldwide have been dated with an age range of 70–600 ka. For instance, Hickory Run boulder field in east-central Pennsylvania in the northern Appalachian Mountains, the largest in North America, is 120 by 550 m (400 by 1,800 ft.) (Figure 5). These sandstone and conglomerate boulders are large, less than 1 m (3.25 ft.) to more than 10 m (32.5 ft.) in long axis. The secular scientists dated the boulders that they assumed have not moved for a long time and whose tops were assumed not to be significantly eroded. The boulders have a Be-10 accumulation of 0.44 to 3.26×10^6 atoms/gm equivalent of 70 to 600 ka of surface exposure (Deen et al., 2017). The vari-



Figure 5. Hickory Run boulder field, east-central Pennsylvania (Mtruch, Wikimedia Commons CC-BY-SA-3.0 mitigated). Note the people in the background for scale.

ability is attributed to boulders moving and flipping. The production rate for that altitude and latitude is believed to be about 6 atoms/gm/yr.

Beryllium-10 in bedrock below the Greenland Ice Sheet

Just recently scientists dated 1.55 m of granite bedrock penetrated by the

GISP2 ice core drilled at the top of the Greenland Ice Sheet (Schaefer et al., 2016). The scientists applied the Be-10 method and discovered that the Be-10 bedrock concentration varied from 9,800 atoms/gm at 1.55 m to 24,800 atoms/gm at the surface. The researchers assumed a production rate of 4.1 atoms/gm/yr. at the latitude of GISP2. If there was no rock or soil above the current bedrock surface, the age would be 6,049 years. Erosion of bedrock and/or soil may have occurred during exposure, so that the measurements represent Be-10 occurring at depth. Although there are various scenarios, the researchers assumed the best fit of the data meant that 1.3 meters of rock or 1.7 m of soil had been eroded. Thus, the secular scientists came up with an age of exposure of 280 ka for the current bedrock surface. So, the current top of the bedrock was not the original surface, and it would have received much fewer cosmic rays.

It is interesting that these results are causing controversy among uniformitarians. Climate models have shown that the Greenland Ice Sheet should have existed throughout the whole Quaternary, for more than 2.6 Ma (Schaefer et al., 2016). Because of their age of 280 ka at the bottom of the ice sheet, it means that the ice sheet must have been totally or almost totally melted, for a total length of time of at least 280 ka during the past 2.6 million years. They think that since exposure is additive, this 280 ka of Be-10 exposure could have come in 10,000-year increments during the numerous 'interglacials.'

Furthermore, Camp century may also have been ice-free 400 kyr. ago (Voosen, 2019), but should have been ice covered for 2.6 Ma, according to climate models. DNA at the bottom of several ice cores came from plants that would thrive with summer temperatures averaging 10°C.

The scientists of course have related this result to global warming by claiming that since the Greenland Ice Sheet

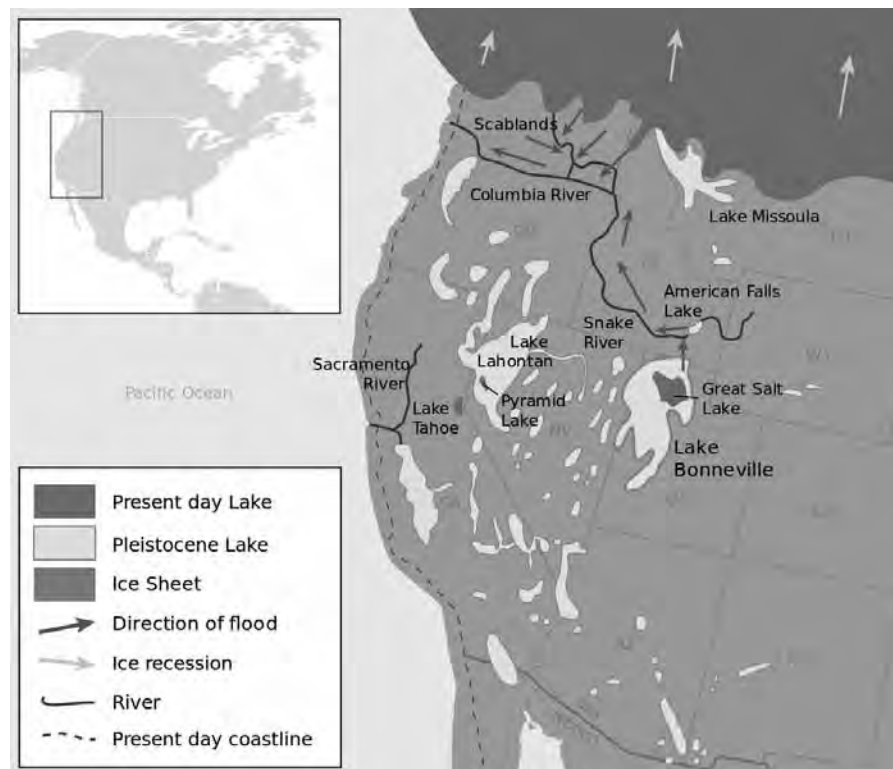


Figure 6. Ice Age lakes in the western United States, including glacial Lake Missoula in western Montana. The arrows show the path of the Bonneville flood and the later Lake Missoula flood (Fallschirmjäger, Wikimedia Commons CC-BY-SA-3.0).

melted during presumed, previous interglacials, it can melt today (Voosen, 2019), reinforcing global warming hysteria.

Be-10 associated with the Bonneville flood

Based on C-14, the Bonneville shoreline of pluvial Lake Bonneville in Utah is believed to be 18.5 ka old and the Provo shoreline 18.5 to about 15 ka old due to a long stillstand at the Provo level after the Bonneville flood (Lifton et al, 2015). Lake Bonneville at its maximum depth was about 350 m (1,150 ft.) deep, compared with 3.7 m (12 ft.) average depth today (Figure 6). It was 12 times larger than the Great Salt Lake. Uniformitarian scientists have difficulty explaining the filling of this pluvial lake. When the lake rose to the level of a wind

gap in southeast Idaho, the Bonneville flood happened. It lasted about 8 weeks (O'Connor, 1993) causing pluvial Lake Bonneville to drop about 100 m (330 ft.) from the Bonneville to the Provo shoreline. By assuming the carbon-14 date of 18.3 ka for the two shorelines, and the measured amount of Be-10 of 2.75×10^5 atoms/gm at Promontory Point, they calculated a production rate of 15.1 atoms/gm/yr. They recognize some shielding due to its mid latitude location and higher production at an altitude of about 1,280 m (4,200 ft.). However, according to the rule of 1% more Be-10 per 10 m altitude increase, the production rate should have been about 128% of the sea level production at this latitude, which is in the neighborhood of about 3 atoms/gm/yr. The production



Figure 7. A striated and polished granite surface from the glaciation in the Sierra Nevada Mountains.

rate should have been about 6.8 atoms/gm, if this rule of thumb applies to this altitude. Regardless, the uniformitarian procedures are crude at best.

Dating boulders from a moraine in the Scottish Highlands

Boulders, assumed to be continuously exposed since deglaciation in a glacial moraine in the Scottish Highlands, were measured for Be-10, which turned out to be 6.93×10^4 atoms/gm (Putnam et al., 2019). Based on C-14 dates of organic matter associated with the moraine, they arrived at a date of 12,480 BP for the moraine. Thus, the Be-10 production rate turned out to be 5.50 atoms/gm/yr. at the altitude of 320 m (1,050 ft.). For sea level, the production rate was estimated at 3.95 atoms/gm/yr. The rule of thumb works out well in this situation.

Sierra Nevada glaciation measurements

Many Be-10 dates have been measured on glaciated Sierra Nevada granite sur-

faces and moraine boulders. Nishiizumi et al., (1989) were probably the first to measure Be-10 on glacially polished rocks (Figure 7) to calibrate production rates with measurements on this 'known' age surface, based on their assumed ice age paradigm (Gosse and Phillips, 2001). It was assumed that Be-10 started at zero when the ice melted, and no erosion has occurred since then, which is reasonable since the surface is still polished and striated. They measured Be-10 at about 5.0×10^5 atoms/gm. Based on the 'age' of deglaciation of about 11,000 years BP, they estimated a production rate at that altitude of 3,340 m (10,950 ft.) of about 60 atoms/gm/yr. Lal (1991) also calibrated his well-used global production rates to these Sierra Nevada surfaces: "Accurate estimations of production rates are generally not possible because of lack of knowledge of the probabilities of formation of nuclides in the different reactions" (Lal, 1991, p. 25). This is one reason why they do not use physics to directly calculate the production rates.

Using the rule of thumb and a sea level production rate of 3 atoms/gm/yr. results in a production rate of only 13 atoms/gm/yr. at the high altitude of the Sierra Mountains. Something seems wrong with their assumptions, the rule of thumb, or both.

Creation Science Explanation

Creation scientists have a lot of research to do when it comes to Quaternary dating methods. We also have several extra complications to consider when examining and translating Be-10 concentrations on a surface into the Biblical timeframe (Table I).

Four complicating variables

In translating the raw bedrock measurements, creation scientists have four major complicating variables. The uniformitarian scientists infer a production rate based on an assumed age, but ages in Biblical Earth history are much younger. To find a production rate in Biblical Earth history, we must adjust for Biblical ages. Since, the Sierra Nevada Mountains are complicated by high elevations, I will use the low-altitude Scottish moraine to adjust the production rate based on Biblical ages. Deglaciation and exposure of this site in Scotland likely occurred at about 4,000 BP. This compares to the uniformitarian age of 12,480 BP. This is about three times the Biblical age, suggesting the production rate in the Biblical timescale would be roughly three times that of the secular timescale. We can probably apply this correction factor worldwide for all the measurements. This is the first complicating variable in transforming measured values of Be-10 into the Biblical timeframe (Table I).

But even at three times today's production rate, Be-10 measurements are still usually calculated to be much older than the Biblical timescale, especially those of Hickory Run boulder field and the Australian inselberg. There seems

Table I. The effects of four variables that must be considered in translating Be-10 concentration measurements from uniformitarian sources into the Biblical time scale.

Variable	Effects on Be-10 production rate in Biblical timescale
1. Uniformitarian production rates	Production rate at surface increased by three times.
2. Accelerated radiometric decay	Unknown but will assume small
3. Geomagnetic quadrupole and/or non-dipole field	Decreased production at high latitude and increased production at lower latitudes. Effect likely small
4. Oscillating magnetic field	Increase production rate, mostly at lower latitudes

to be only one way to explain such old dates within Biblical history, and that is by assuming *cosmic rays were much greater during the Flood and Ice Age*.

A second complicating factor is that the Al-26/Be-10 ratio turns out less than its present-day formation ratio of about seven, because there should not have been enough time in 4,500 years for this ratio to measurably change. But, secular scientists find values around three or four. Such a ratio implies hundreds of thousands to a few million years of age. This means that *much accelerated radiometric decay has taken place after the Flood*. Snelling (2005) found very few radiohaloes in Tertiary-aged granites, interpreted as post-Flood, suggesting that accelerated radiometric decay had ended. But this result could be due to the lack of enough radioactive nuclides settling in one precise spot to form a halo, since halos first appear after 10^8 atoms have collected in that one spot. Besides, the Tertiary likely is mostly from the Flood (Oard, 2014). Therefore, *accelerated radiometric decay continued for a while after the Flood* (Table I).

Such accelerated radiometric decay has two implications for Be-10 dating. It

means the measurements of the amount of Be-10 and Al-26 have been decreased compared to what they would have been in the absence of accelerated decay. However, it is possible that accelerated radiometric decay is less for low atomic number nuclides (Vardiman et al., 2005). On the other hand, accelerated radiometric decay could cause an increase in these isotopes, because of an increase in neutrons from the rapid fission of ^{238}U and the alpha decay of ^{235}U , ^{238}U , and ^{232}Th (Heisinger et al., 2002). It is the neutrons that mostly cause in situ Be-10 and Al-26. It is difficult to know the outcome of these two competing processes for cosmogenic nuclide dating. It could be they cancel each other and the net effect would be small.

A third modification that must be considered is that cosmogenic nuclide measurements assume a geomagnetic axial dipole field, but secular scientists often recognize a significant non-dipole contribution of 10 to 25% (Dunai, 2001). These non-dipole contributions could be because the Earth could have had a quadrupole pattern for a while after the Flood (Humphreys, personal communication, 2020) (Figure 8).

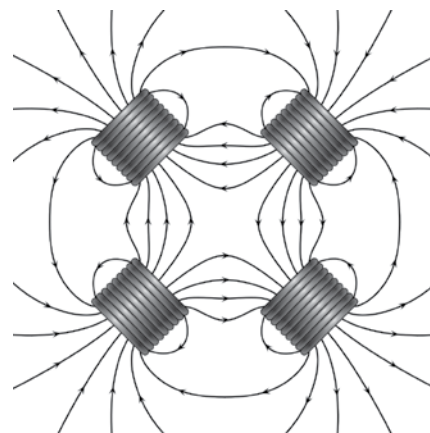


Figure 8. Quadrupole magnetic field generated by four coils (Geek3, Wikimedia Commons CC-BY-SA-3.0).

Since a dipole field has no effect poleward beyond about 60° latitude and about a 50% reduction at the equator, a more complicated field would tend to even out the geomagnetic shielding. There would be fewer cosmic rays beyond 60° latitude and more south of 60° (Table I). We don't know the net effect of these more complicated magnetic fields, but since the difference between shielding at polar locations and the equator is only 50%, the effect is probably small.

A fourth modifying effect on cosmogenic production rates is that the magnetic field oscillated between north and south polarity for some time after the Flood (Humphreys and De Spain, 2016). During reversals the geomagnetic field would have been low intensity. More cosmic rays would penetrate the surface of the Earth at low to mid latitude. But since reversals in the Biblical timescale were quick, the net effect likely was small (Table I).

Because of these variables, it seems impossible to translate the measurements on surfaces, or in the case of Unaweep Canyon in sediments, into Biblical Earth history. Therefore, I will

give some rough qualitative estimates using the examples above and assuming variables 2 through 4 are small. Thus, the uniformitarian estimated production rate, assumed to be the same as today for millions of years, will be multiplied by a factor of three.

Unawep Canyon formed during the Flood

Within the Flood model, Unawep Canyon is a wind gap (Oard, 2014) and abandonment of the canyon cutting likely occurred when the Floodwater was still high and was diverted from cutting the Unawep wind gap deeper by flowing north through Grand Valley and around the north end of the Uncompahgre Mountains. It is likely that as this happened, the flow through Unawep Canyon became sluggish and fine-grained sediments were deposited. A landslide dam is not needed. Then, alluvial/colluvial sediments filled on top of the fine-grained sediments within the canyon as the water level declined. When driving through this amazing wind gap, it is impossible to tell that the fill below the pass (Figure 3) is 350 m (1,150 ft.) thick.

It is difficult to interpret the Be-10 results within Biblical Earth history. The fine-grained sediments have been buried since the end of the Flood and would not accumulate any significant Be-10 in the post-Flood period. Then how did this sediment gain such high concentrations of Be-10?

One way would be if the sediments were at or near the surface during the pre-Flood or Flood period and then were eroded or re-eroded ending up as canyon fill in the Unawep Canyon. The Be-10 concentrations would imply a very large flux of cosmic rays. Another possibility is that abundant accelerated radiometric decay of uranium and thorium and the fission of ^{238}U during the Flood caused the high values of Be-10. It would appear that a large flux of cosmic rays occurred during the Flood.

Australian Inselbergs

The values of Be-10 of quartz on southern Australian inselbergs vary from 0.71 to 4.43×10^6 atoms/gm. These are considered minimums by secular scientists, since they believe these inselbergs are millions of years old and would have experienced variable, but slow erosion with much radiometric decay. Inselbergs are Flood features (Oard, 2014), and erosion since the end of the Flood 4,500 years ago would have been slight. Thus, the secular values should be a reasonably good estimate since the end of the Flood.

The estimated production rate for this middle latitude site is about 3 atoms/gm/yr. at sea level, interpolating between 4 atoms/gm/yr. for high latitudes and 2 atoms/gm/yr. at the equator (Young et al., 2013; Blard et al., 2019). I will take the top of Yarwondutta Rock at 190 m (625 ft.) for my calculation within the Biblical timescale. At a 1% increase in production rate for every 10 m, the production rate would be 19% more than at sea level, or about 3.57 atoms/gm/yr. (Stone, 2000).

Multiplying the production rate by three and applying this production rate for 4,500 years since the Flood would have produced a concentration since the Flood of only 4.8×10^4 atoms/gm, assuming cosmic rays have not changed with time. The measurement for this rock is 3.57×10^6 atoms/gm. This is 74 times the expected concentration, indicating a high flux of cosmic rays since the end of the Flood.

Hickory Run Boulder Field

The Hickory Run boulder field was likely formed at the end of Flood runoff. Be-10 concentrations range widely on the boulders from 0.44 to 3.26×10^6 atoms/gm. This suggests that some, or maybe all, boulders have rotated (or flipped) within the last 4,500 years. The higher value is more representative, but still a minimum since even all boulders may have turned and a little weathering

has occurred in 4,500 years. This boulder field is in east-central Pennsylvania, USA, where freeze-thaw weathering and relatively high precipitation occurs. The present-day production rate was estimated by secular scientists at about 6.3 atoms/gm/yr. for this latitude and altitude. If we multiply this rate by three for 4,500 years of post-Flood exposure, we should have a Be-10 concentration of about 8.5×10^4 atoms/gm. The highest secular value is 38 times the expected Biblical value, implying roughly 38 times the amount of cosmic rays bombarded of the Earth since 4,500 years ago.

The Greenland Ice Sheet Production Rate

In the Biblical Ice Age model, Greenland would have been surrounded by warm ocean water and isostatically uplifted due to lack of an ice sheet (Oard, 2004a). So, the Greenland Ice Sheet would develop slowly. This fits with Greenland having plants at low elevations early in the Ice Age with relatively warm temperatures, while the mountains were starting to collect snow (Oard, 2004a, 2005). It would have begun in the eastern mountains within 50 years (Figure 9), the eastern and western mountains in 100 years (Figure 10), and much of Greenland by 200 years (Figure 11). The location where the GISP2 ice core was drilled was just west of the eastern mountains. So, the location would have been exposed for a while before glaciation. Only 10% of Greenland needs to be covered by ice and mainly in the eastern highlands for GISP2 to be exposed. Thus, it would probably take 100 to 200 years for this low-altitude, high-latitude location to be covered by ice. If we take the average of 150 years, GISP2 would have been covered since about 4,350 years BP. We assume no erosion and no surface sediments originally covered the location, and 24,800 atoms/gm of Be-10 were measured at the surface of the rock. The isostatic altitude correc-

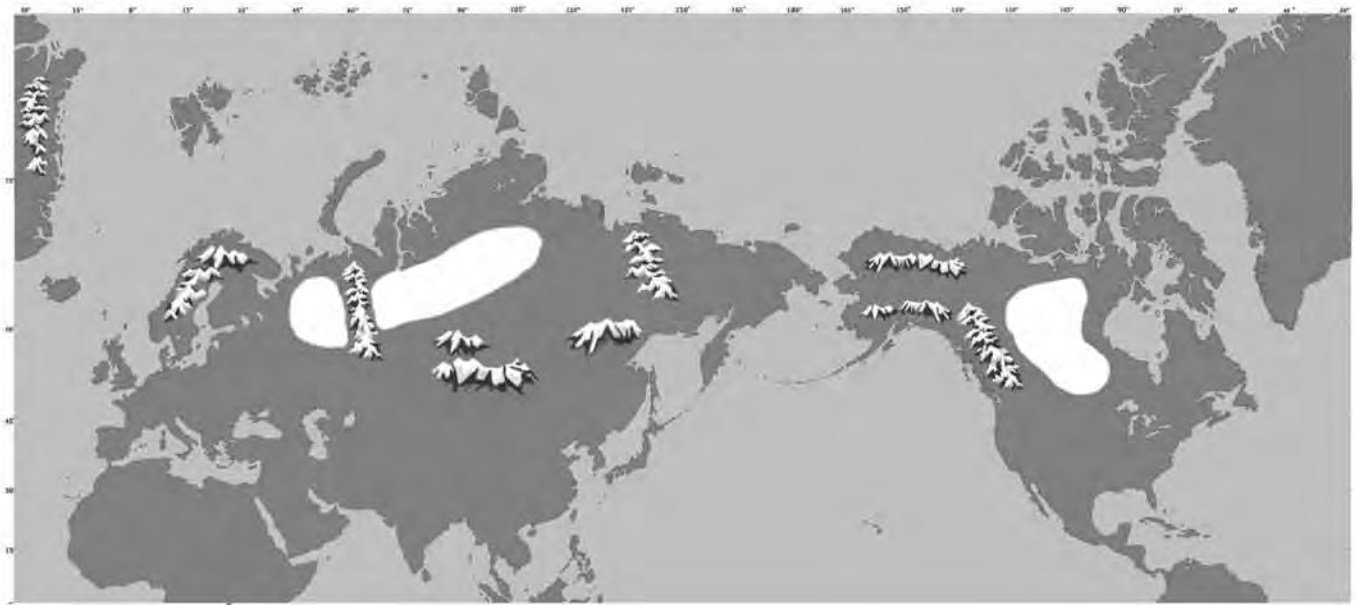


Figure 9. Postulated snow and ice after 50 post-Flood years in the Northern Hemisphere (Drawn by Mrs. Melanie Richard).

tion of about 1,000 m higher right after the Flood (Oard, 2020a) would result in an isostatic corrected production rate of 8.2 atoms/gm/yr. If the production rate for Biblical Earth history (Table I) was three times the uniformitarian production rate for 150 years, there should

be 3,700 atoms/gm on the surface at today's rate. The surface measurement is 24,800 atoms/gm, 6.7 times the rate with Biblical assumptions and isostatic compensation.

However, it is likely that erosion occurred before glaciation. As a reasonable

first estimate, the secular researchers estimated 1.3 m of rock or 1.7 m of soil had been eroded before glaciation. With an e-folding depth of 60 cm in rock, the current bedrock would have received about 1/9th the in situ Be-10. So, we would have to multiply 24,800 atoms/

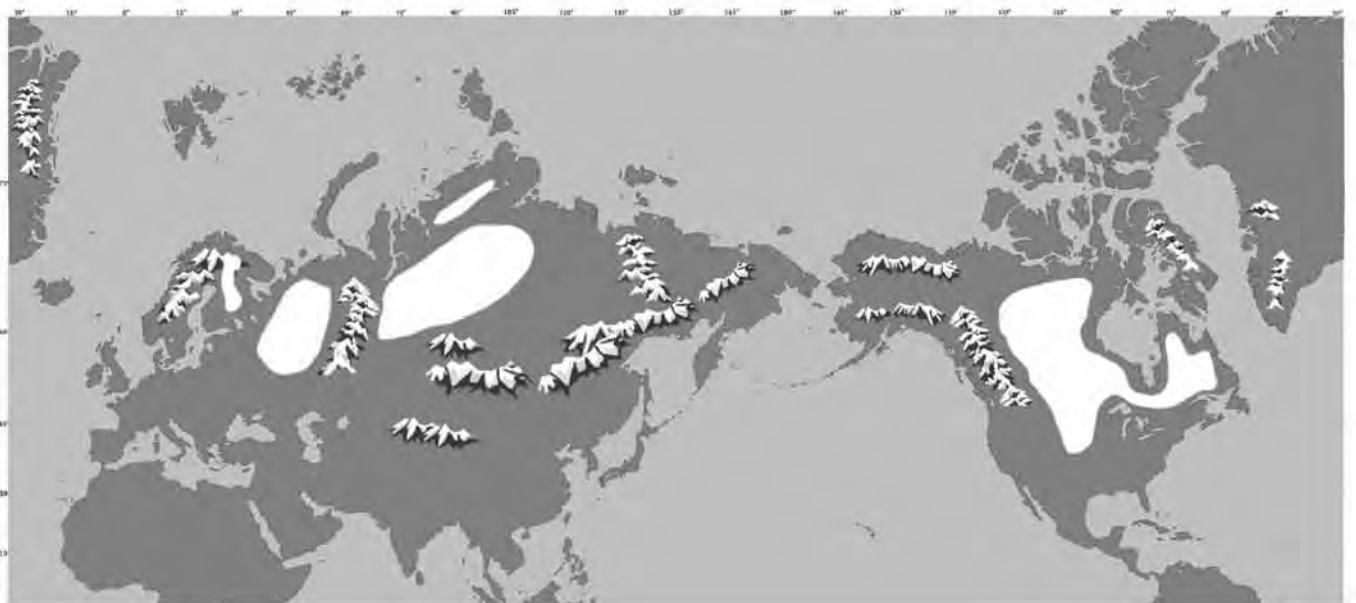


Figure 10. Postulated snow and ice after 100 post-Flood years in the Northern Hemisphere (Drawn by Mrs. Melanie Richard).



Figure 11. Postulated snow and ice after 200 post-Flood years in the Northern Hemisphere (drawn by Mrs. Melanie Richard). Notice that the Sierra Nevada Mountains are glaciated by 200 years after the Flood.

gm by nine and divide by 3,700 atoms/gm. The production of Be-10 is then 60 times the current rate, signifying a high flux of cosmic rays early in the Ice Age.

Lake Bonneville Production Rate

According to the Biblical Ice Age, the Lake Missoula flood occurred at the peak of the Ice Age about 4,000 BP (Oard, 2004b). The Bonneville flood broke just a little before the Lake Missoula flood, since the Missoula flood sediments overlie Bonneville flood sediments downstream in the Lewiston, Idaho, area. Therefore, we can date the Bonneville flood to about 450 years after the Flood, or 4,050 BP. Lake Bonneville and all the other pluvial lakes of the southwestern U.S., were first formed by ponded water during late Flood runoff. The lake levels continued to rise during heavy Ice Age precipitation and cool summer temperatures.

The secular production rate for Lake Bonneville shorelines at this relative

high-altitude location is estimated at 15.1 atoms/gm/yr. If there was three times as much production in the Biblical timescale, there should be 1.83×10^5 atoms/gm on the surface since 4,050 years ago, if there was no inheritance of Be-10 for 450 years. This compares to the measured amount of Be-10 of 2.75×10^5 atoms/gm at Promontory Point, which is only about 1.5 times the Biblical estimate. This value would be a maximum, since there could have been some inheritance before the shoreline formed. It looks like the production rate of Be-10 dropped off dramatically during the Ice Age.

Scottish moraine boulders

The British-Irish Ice Sheet would have developed about midway in the Ice Age, about 300 years after the Flood (Figure 12), starting with the northern mountains, the Scottish Highlands. This is because of onshore flow of warm, moist air early in the Ice Age (Oard, 2004a). The ice would then spread south after 300 years and to lower altitudes by the

end of the Ice Age at 500 years after the Flood. It probably took 100 years to melt the ice in the Scottish Highlands. However, we need to consider the low elevation of the Be-10 measurement, which melted by 550 years after the Flood or 3,950 BP. So, its total exposure time in the Biblical time scale would have been 3,950 years assuming no inheritance. The uniformitarian production rate was estimated at 5.5 atoms/gm/yr. for this latitude and altitude. Multiplying by three and 3,950 years, the Biblical accumulation would be 6.5×10^4 atoms/gm. The secular measurements gave 6.93×10^4 atoms/gm, close to the Biblical measurement. This result is close to that of the Sierra Nevada Mountains and suggests that the production rate was close to the present rate near the end of the Ice Age.

Sierra Nevada production rate

Secular scientists first estimated the production rate of Be-10 on striated pavements in the Sierra Nevada Mountains. Based on other 'age' indicators,



Figure 12. Postulated snow and ice after 300 post-Flood years in the Northern Hemisphere (drawn by Mrs. Melanie Richard). Note that the Scottish Highlands are glaciated by 300 years after the Flood.

the Biblical production rate would be three times the secular value. Because of the high altitude, the secular geologists estimated a production rate of 60 atoms/gm/year. However, for a mid-latitude sea level site, production would be 3 atoms/gm/yr., and if we increase production rates by 1% per 10 m, the uniformitarian production rate should be about 9 atoms/gm/yr. It could be that production rate value increases by more than 1% per 10 m as one goes higher up. Regardless, using the secular estimate of the production rate, we would estimate the production rate of 180 atoms/gm/yr. in the Biblical timescale. These surfaces may not have been glaciated until a little after 100 years after the Flood (Figure 10 and 11), and deglaciation likely was complete at this high altitude about 3,900 years ago. This would mean a total exposure of about 3,900 years if there is no inheritance and 4,000 years if there was inheritance. Thus, the concentration in the Biblical time scale would be

7.0×10^5 atoms/gm. The secular measurement of 5.5×10^5 atoms/gm is fairly close, indicating also there likely was no inheritance for the first 100 years after the Flood. Like the Scottish moraine, these glacial pavements indicate that cosmic rays were today's rates near the end of the Ice Age.

Further Implications

If all Be-10 concentrations were due to cosmic rays, then it appears that the production rate dropped rapidly during the Ice Age. This would imply that the cosmic rays were especially intense during the Flood. However, it is likely that some Be-10 was formed by accelerated radiometric decay, making a Flood estimate difficult. So, the best we can say from the in situ Be-10 measurements is that *cosmic rays were very high during the Flood and decreased rapidly during the Ice Age*. Such an increase in cosmic rays have a least four further implications.

Supernova explosion close to the Earth and accelerated radiometric decay

Since cosmic rays are believed to have been caused by supernovas, increased cosmic rays could be due to a supernova explosion, or more than one, relatively close to the Earth during the Flood. Reedy et al. (1983, p. 133) state: "Rare external events (nearby supernovae) or solar variations (a Maunder minimum) can cause short-term [cosmic ray] flux changes." This would support Chaffin's (2017, 2019) contention that a nearby supernova or supernovae could be a cause of accelerated radiometric decay.

Great increase in carbon-14 after the Flood

Since C-14 is caused by cosmic rays in the upper atmosphere and becomes spread through the carbon reservoirs, including the biosphere, increased cosmic rays would produce much more C-14 after the Flood.

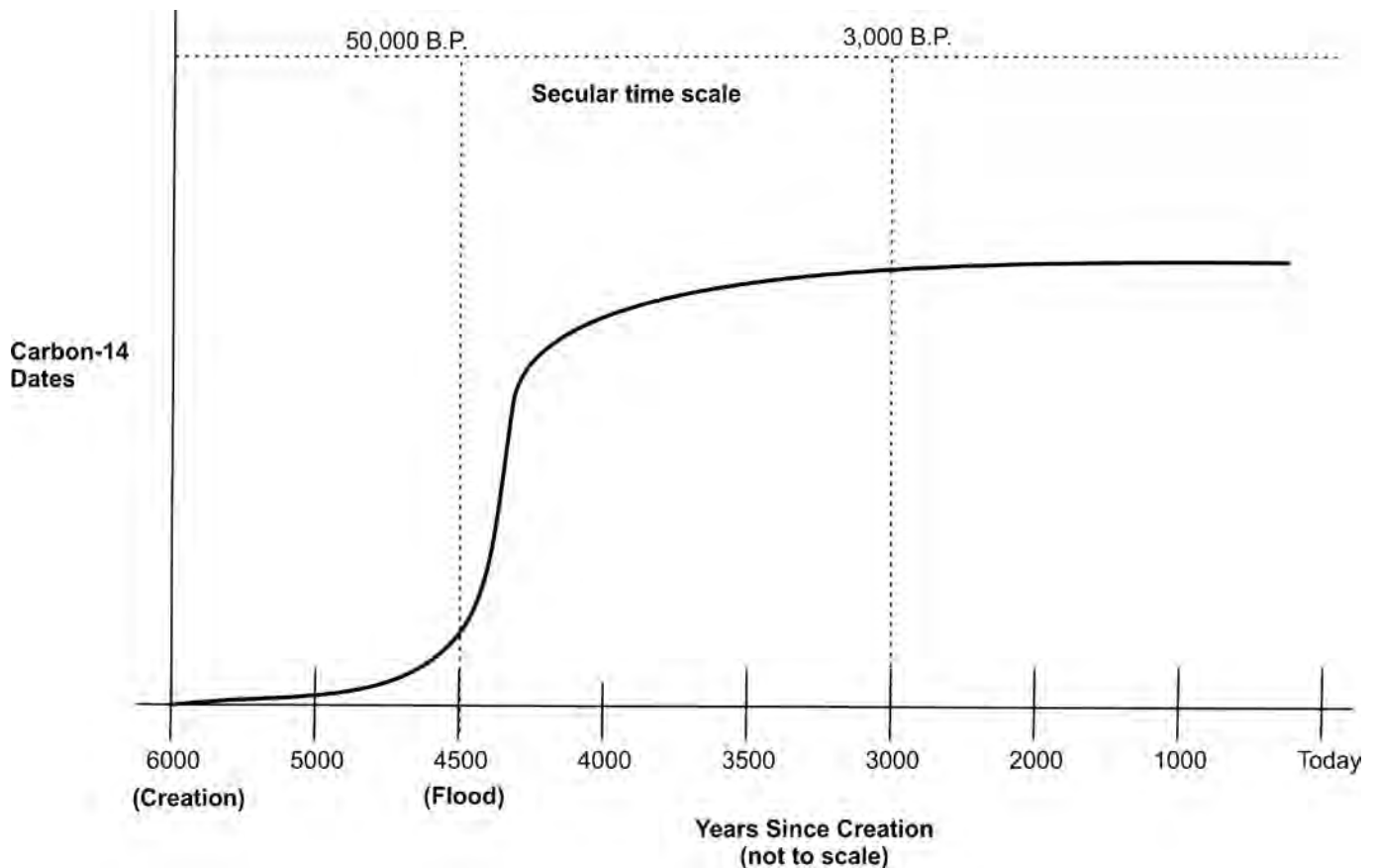


Figure 13. Estimated plot of the increase in carbon-14 dates with time since Creation based on the high cosmic-ray flux early in the Ice Age (plotted by John Reed).

It appears that carbon-14 dates are good for the past 3,000 years, but then 47,000 C-14 years needs to be telescoped into 1,500 years after the Flood (Figure 13) with the greatest increase early in the Ice Age. So, increased cosmic rays during the Flood tailing off early in the Ice Age can explain the telescoping of dates within the Biblical timescale.

Aardsma (1991) recognized that there was too much carbon-14 in the atmosphere, oceans, and biosphere for an Earth about 6,000 years old, but he assumed that the production rate of carbon-14 has been constant. Based on the carbon-14 inventory for the Earth, he pushed back the date of the Flood

to 14,000, plus or minus 7,000 years. He is no longer a young-Earth creation scientist as a result. However, based on this Be-10 research, increased cosmic rays during the Flood, dropping off during the Ice Age, can likely produce the current inventory of carbon-14 in about 6,000 years. This is an example of adding a new variable that changes a result considerably.

Other Quaternary dating systems can be telescoped to within Biblical Earth history

We can now deduce from at least the Al-26/Be-10 ratio being well below 7 that accelerated radiometric decay continued into the post-Flood period. Thus,

other Quaternary dating methods can potentially be telescoped into post-Flood time because of accelerated radiometric decay. For instance, U-series dating on speleothems, which gives dates as old as 500 kyr., can be explained. Contamination from ^{230}Th does not seem to be much of a problem, and the dates are usually consistent from the bottom (the oldest) of a stalagmite to the top (the youngest). Several characteristics of the Ice Age can explain the rapid growth of speleothems (Oard, 2020b,c). However, accelerated radiometric decay presents a problem of too much radiation during the Ice Age, as pointed out by Vardiman et al., 2005, pp. 764–765) for the occupants of the Ark.

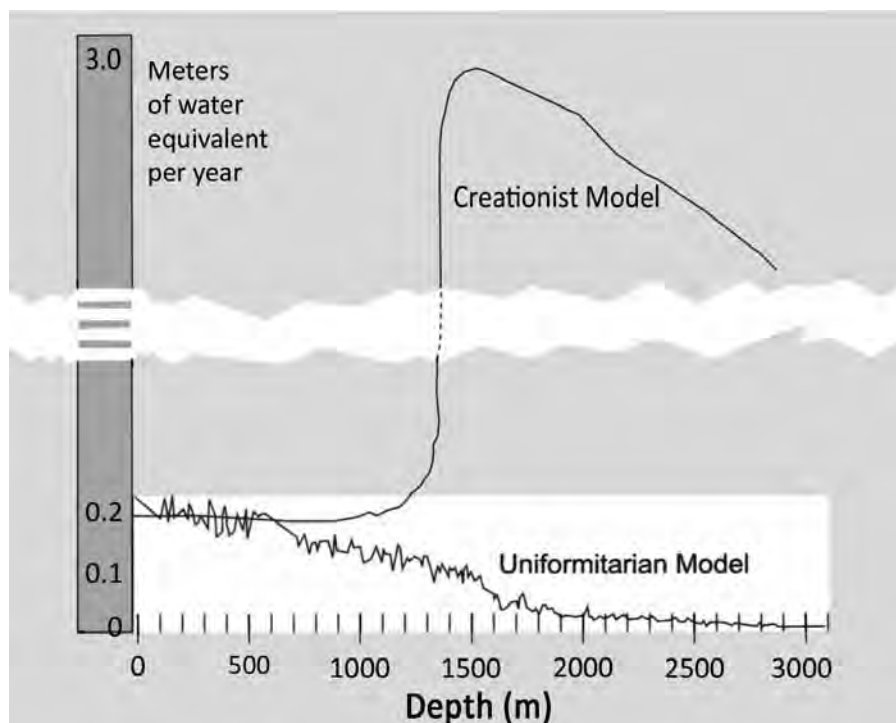


Figure 14. The thickness of annual ice layers down the GRIP ice core on central Greenland, calculated according to the uniformitarian model (from De Angelis et al., 1997, p. 26683) and a rough estimate of annual layers in the Biblical model.

Can explain atmospheric Be-10 in ice sheets

In the Biblical model for the Greenland and Antarctic Ice Sheets, the estimated accumulation rate could be around 3–10 m/yr. for the Ice Age portion of the ice cores, tailing off sharply after the Ice Age. The uniformitarian rate is around cm–mm/yr. (Figure 14). The secular atmospheric Be-10 measurements in the Greenland GRIP ice core show an increase from about $1\text{--}2 \times 10^4$ atoms/gm after the Ice Age to about $3\text{--}5 \times 10^4$ atoms/gm during the Ice Age (Yiou et al., 1997). Because the secular annual layer thickness is much less than the creation science annual layers, these values, especially during the Ice Age, would represent production rates that are much higher than today. This supports the deduction of much higher cosmic rays early in the Ice Age.

Conclusions

I have examined the amount of in situ Be-10 on quartz from Unaweep Canyon formed during the Flood, an inselberg, and several glacial surfaces. It appears that the amounts of cosmic rays that form Be-10 were much higher during the Flood and tailed off rapidly during the Ice Age. The increased cosmic rays have at least four implications. High cosmic rays could be due to a nearby supernova or supernovae during the Flood that may be a cause for accelerated radiometric decay during the Flood and Ice Age. Increased cosmic rays can account for the rapid increase in C-14 during the first 1,500 years after the Flood so that all post-Flood C-14 dates can be telescoped within 4,500 years of post-Flood time. I showed that because many Al-26/Be-10 ratios are less than the current value of around seven, there has

been accelerated radiometric decay *after* the Flood. Increased cosmic rays also allow us to telescope other Quaternary dating methods into 4,500 years. We can also account for the atmospheric Be-10 values measured in ice cores.

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A Little Flood Geology

Part V: Conclusion

Peter Klevberg*

Abstract

Part I argued that floods are an important category of geologic processes and showed that hydraulic relationships are nonlinear, resulting in episodic rather than continual geologic change. Part II presented field examples from central Montana in 2011. Part III used information from the central Montana projects to show that geologic processes range from slow and localized to episodic and regional (even unique and global). Geologic paradigms can negatively impact field work for both uniformitarians and diluvialists. These negative effects can be avoided by the “mixed question” approach and “multiple working hypotheses.” In Part IV, limitations of extrapolating from local floods to megafloods and from scientific observation to natural history speculation were discussed. Here, evidence is summarized to highlight some important principles to guide geologic research.

Key Words: Flood geology, sedimentation, fluid mechanics, megaflood, scale effects, scientific method, fractal, polygenetic, creep

Summary

Floods are the largest category of natural disasters in the modern environment and an important category of geologic processes (Klevberg, 2019). Flood geology often forms an interface between physics (fluid mechanics), geology (sedimentation), and history (historical geology). How these three areas relate is part of the philosophy of science.

Fluid Mechanics

Flood geology is a specialty within the study of sedimentation and fluid mechanics. Due to the importance of floods in the modern environment, they have been much studied. From both laboratory and field studies, we know that relationships between independent variables and stream behavior are nonlinear. Critical stream power (ω_c) is the point

at which the critical bed shear stress is reached to initiate movement of bed load. Below ω_c , bed load transport is negligible. Head loss (dissipation of kinetic energy) results from obstacles in the stream bed and channel configuration, and alluvial channels tend to alter their configuration to minimize this loss. Most streams exhibit unsteady, nonuniform flow, but modeling requires approximating this with steady, uniform assumptions, along with reducing a plethora of variables in the natural environment to a manageable number. Thus, model outputs for scour and other hydraulic processes are conservative, and yet they

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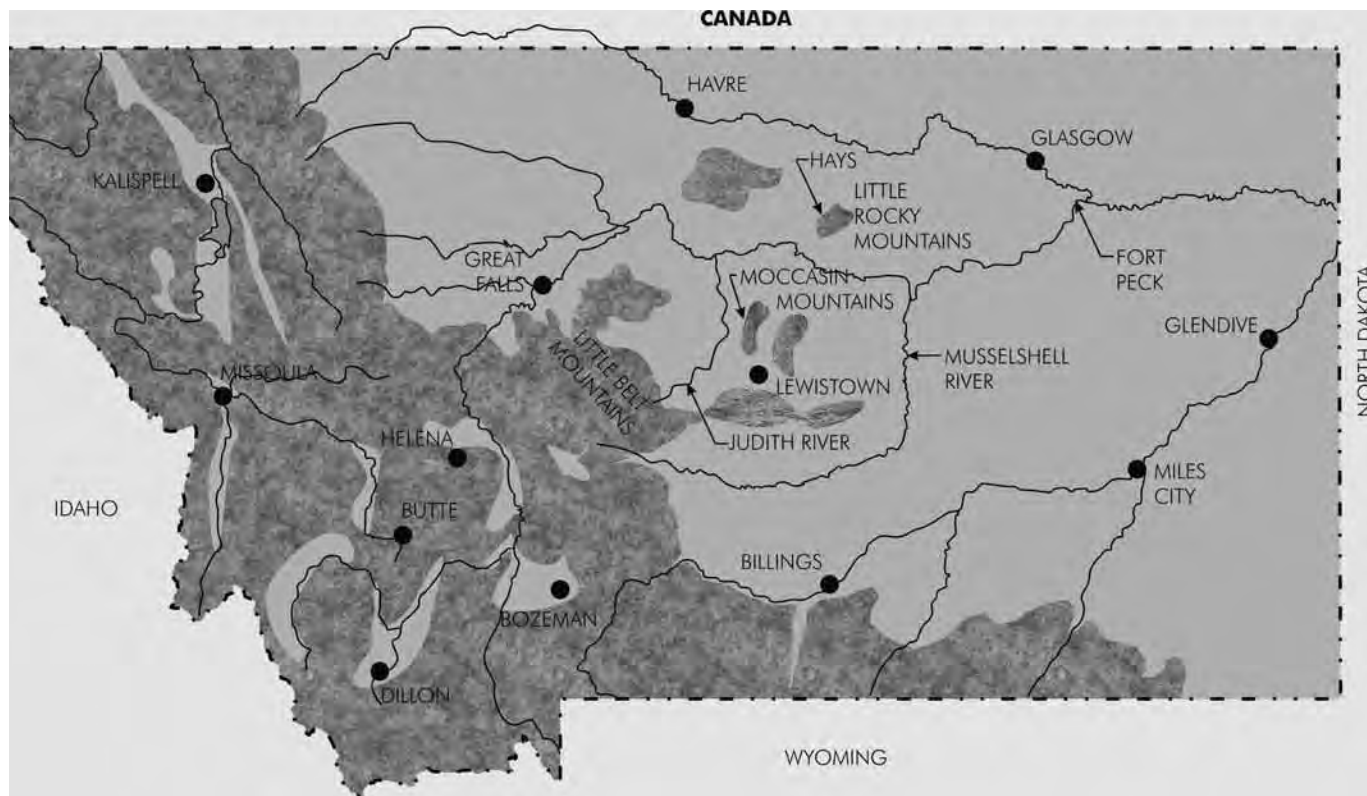


Figure 1. Map of Montana showing major rivers and mountainous areas.

still sometimes undershoot actual observations (Klevberg, 2020a). Laboratory experimentation focuses on sand beds, though gravel may vary greatly from sand bed behavior and show a wide range of responses. Bedrock may also be rapidly eroded as seen at Fort Peck in 2011 and as documented elsewhere.

Sedimentation

Flood *geology* focuses on geologic effects specific to floods—physical weathering, transport, and deposition (sedimentation)—that today are usually confined to rivers. While some studies focus on the architecture of alluvial deposits, most concentrate on erosion since it most threatens man-made structures (McKee et al., 1967; Berthault, 1986; Holroyd, 1990; Froede, 2008a, 2008b).

The term “Flood geology” among creationists is ill-defined. Some use it to refer to the geologic paradigm based on the Biblical historical record and the Deluge. In that sense, it encompasses a great many processes that have nothing to do with flood geology. The idea that every geologic process ceased at the end of the Deluge is a straw man that evolutionists have brandished based on the popularity of this jargon. No creation scientist believes every geologic phenomenon has a diluvial origin. Small-scale processes are in effect today, including those described in this series (Klevberg 2019, 2020a, 2020b).

Historical Geology

Klevberg (2020b) presented cases from Central Montana (Figure 1) showing that geologic processes range from slow

and localized to episodic and regional. Geologic *paradigms* can have negative effects on field work, for both uniformitarians and diluvialists. These negative effects can be avoided by using the “mixed question” approach and “multiple working hypotheses.”

Slow and stochastic processes characterize small-scale, recent features, especially ongoing processes. Geologic evidence from Montana suggests that both ongoing processes and geologic changes of the past are episodic and unique, not uniform and gradual. Modern processes are far smaller than those that shaped the Central Montana landscape, and in the cases of planation surfaces (benches), they were different in type, not just scale. Scale does differ, however, often by orders of magnitude. Ancient events formed landscapes; modern processes are destroying them.

Klevberg (2021) showed scale changes from local floods to megafloods, and how they might affect extrapolation from scientific observation to natural history speculation. Evidence for megafloods is widely acknowledged by evolutionists and creationists, but this was not always so (Oard, 2004). The first step was acknowledging evidence of a significant *scale* difference. Alluvial bedforms were observed at landform scale, suggesting similar depositional processes at much larger scales. Back calculating from relict channels, paleoslopes, and deposits to infer minimum current flows and depths—known as *paleohydrology*—provides powerful evidence for the reality of megafloods in the past (Klevberg and Oard, 1998). As a discipline, paleohydrology has contributed significantly to flood geology. Field evidence shows a greater diversity of landforms from megafloods (Figure 2), indicating that larger floods are more complex (Benito, 1997). Further complicating the topic, some landforms can be formed by multiple distinct processes, a condition known as *equifinality* (Figure 3).

Historical geology is forensic, not descriptive, and thus primarily an exercise in historical study. The more the science of geology can contribute to natural history, the better. A good understanding of the limitations of science and the scientific method is needed for progress in historical geology.

Practical Philosophy of Science

One's philosophic position on Earth's history has practical consequences. Geology has been more afflicted with confusion on this than most branches of science. Science and natural history have been traditionally conflated, and this affects flood geology. The Corps of Engineers method for predicting flood intervals accepts uniformitarian geology without question. Flood deposits in a particular valley may be dated at tens

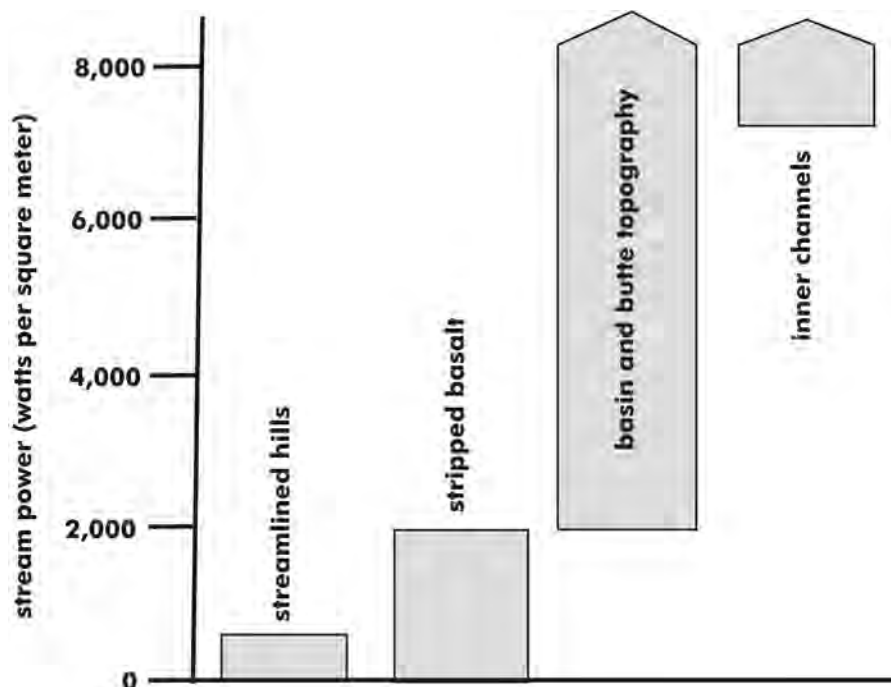


Figure 2. Relation between stream power and landform type. After Benito (1997).

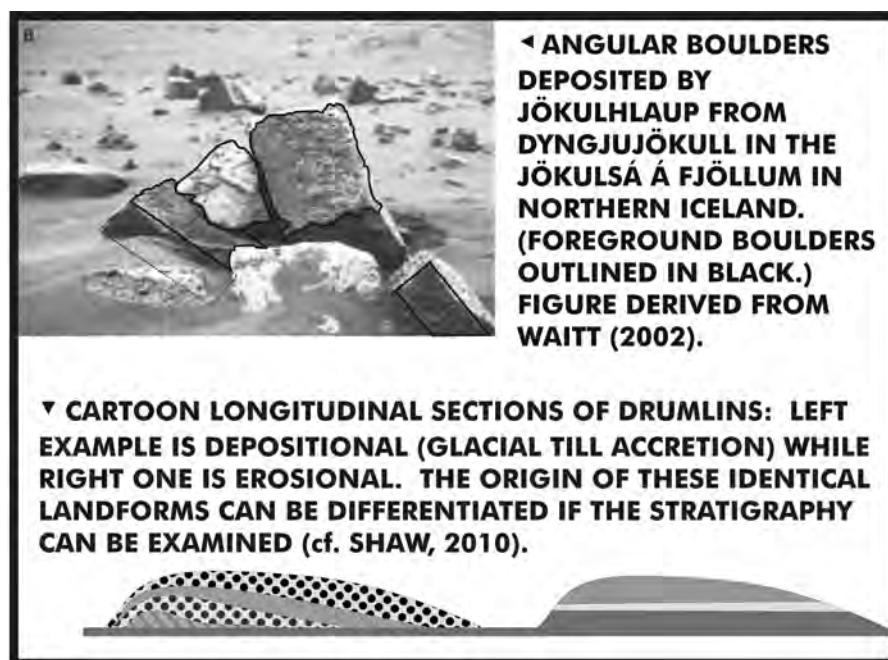


Figure 3. Two examples of equifinality. Upper: angular boulders, commonly associated with glacial transport were here transported by a large flood. Lower: schematic of drumlins formed by glacial deposition (left) and by erosion (right), resulting in identical external form but different internal structure.

to hundreds of thousands of years, leading to a recurrence interval of, say, five thousand years for a catastrophic flood. If the actual dates of those deposits are only a few thousand years, the recurrence interval could be much less and the danger of flooding much greater. Uniformitarianism underlies belief that these floods recur at regular intervals. But if field evidence for huge floods indicates deglaciation, there may be no practical present danger. These are questions of *history*. If they were questions of science, we could go to the field and measure. Assumptions underlie all our estimates, and ideas have consequences.

Historical geology was hamstrung for centuries by insistence it was science instead of history (Rudwick, 2005) or a “mixed question” (Adler, 1965). Traditional education confuses rather than elucidates mixed questions, a carryover from the positivist past (Reed and Klevberg, 2011; Reed, 2013). Descriptive and speculative geology are conflated, and both are equally “science.” The solution is more carefully defining “science” (Figure 4) and more practical use of multiple working hypotheses (Chamberlin, 1890).

Many have concluded there is no *scientific method* per se (see, for example, in D’Amico, 2009), since in actual practice, the scientific method is necessarily iterative, not a cut-and-dried series of steps (Figure 4). While science and history are both valuable and distinct fields of study, they have different limitations and require different methodologies, working together in addressing “mixed questions” in a complementary fashion. This approach is superior to the traditional effort to subsume all disciplines into “science” (Adler, 1965; Reed, 2001; Cleland, 2009; Kravitz, 2013; Reed and Klevberg, 2018).

Everyone sees inescapably through a worldview (Chisham, 2012, 2014, 2015, 2018). This needs to be acknowledged as the deductive part of the methodology (Figure 4), and biasing assumptions

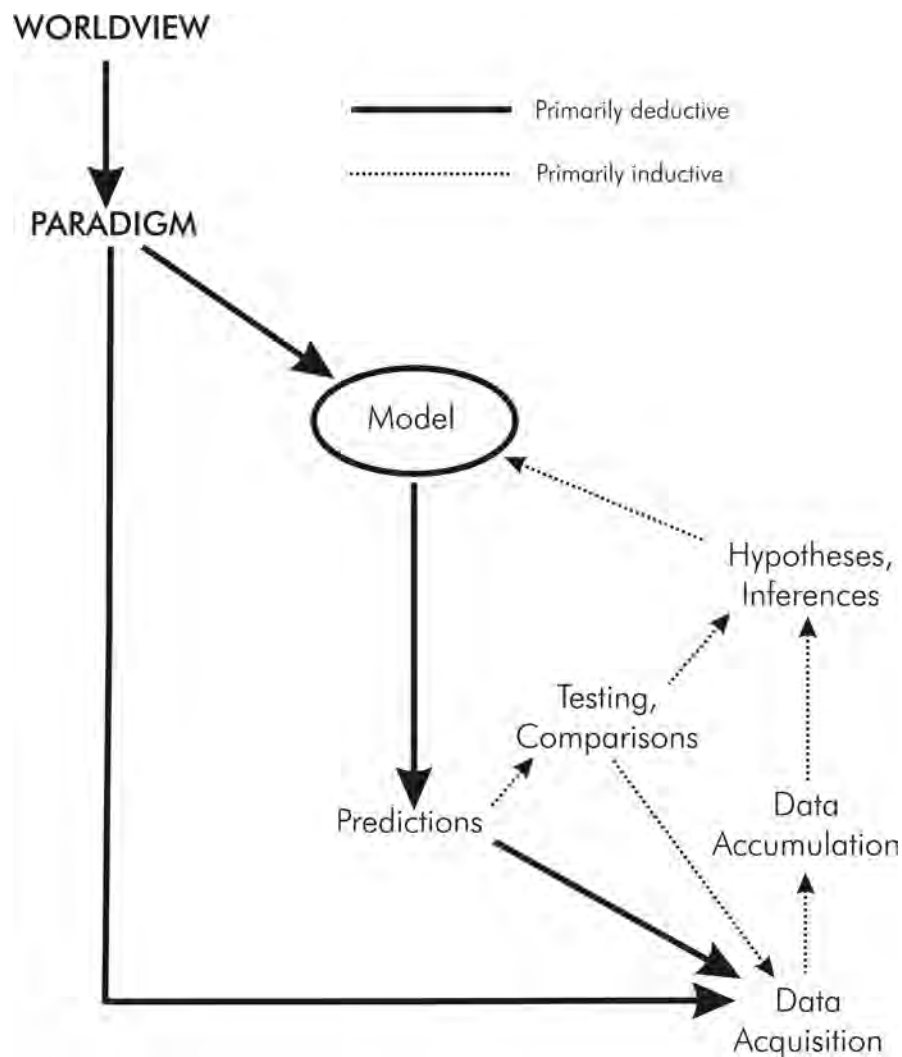


Figure 4. The scientific method is not a step-by-step method, but rather an interaction of deductive and inductive reasoning. Some of these steps are based in worldview assumptions. Bias is inevitable and should be identified. For example, data acquisition (lower right) can be very subjective. Woodmorappe (2018, p. 661), writing about the lack of disturbance research in dendrochronology, said, “This is not surprising, as research in general tends to be paradigm-driven, and nothing in uniformitarianism prompts curiosity in such crossmatches.” Figure adapted from Klevberg (1999).

identified. If acknowledged, researchers with views as disparate as evolution and creation could work effectively together. What can be observed, measured, and tested—the science—is available to all.

Many problems in geology arise from philosophic biases and this misunder-

standing of the scientific method. This stems from a variety of causes:

- Conflation of natural science with other disciplines in traditional education.
- Not recognizing the faith basis of materialism (naturalism).

Table I. Qualitative comparison of various types of floods.

Mechanism	Characteristics			
	Geometry	Duration	Energy	Common Instigators
River flood	channel	prolonged	diffuse	rainfall, snowmelt, ice damming
Storm surge	sheet	prolonged	diffuse	hurricane
Flash flood	channel	brief	focused	rainstorm, dam collapse
Tsunami	sheet	brief	diffuse	subsea earthquake, landslide

- Not understanding that inductive *and* deductive logic play roles.
- Denial of bias.
- Commitment to uniformitarianism *against* evidence (e.g., climate change).
- Commitment to actualism *against* evidence (i.e., denial of unique past processes).
- Specialists who do not understand “big picture” topics—philosophy of science and natural history.

Furthering Research

Natural stream courses are complex. The easiest way to quantify hydraulic variables is laboratory experimentation. But there are significant limits. Flumes are largely limited to sand. To increase the scale to that of a boulder-bedded river would require a river-sized flume! Boulders behave differently from sand. Thus, actual floods are essential to research.

Can modern floods bridge the gap between the laboratory and megafloods? A major problem is the increasing diversity of effects moving up scale, from the laboratory to a river. We would expect even more diversification from a river flood to a megaflood.

Flash floods provide higher stream power but less time and scale. Hydraulic disasters are likewise unpredictable. No one could predict or set up instruments to study man-caused disasters, such as

the infamous Malpasset Dam disaster in France (Ricketts, 2012) or the failure of the Vajont Dam in Italy, where a wall of water descending the valley began as a landslide-caused tsunami that overtopped the dam (a case study from my college days).

Natural disasters are also difficult to study. Tsunamis, hurricanes, and other large storms often result in such large-scale destruction; studying them is difficult. The American Society of Civil Engineers (ASCE) created a task force to rapidly deploy and study effects from these events. Sometimes important data may be lost within days. A good example of the ASCE approach to flood geology is the initial report for Hurricane Harvey (Stark et al., 2017). As summarized in Table I, relationships between storm surges, river floods, tsunamis, and flash floods need to be explored and quantitative relationships discovered to accurately infer megaflood processes where some of these properties are combined (Figure 5). Flood geologists are increasingly able to obtain quantitative data.

As illustrated by poor scour estimates in this series, understanding of flood geologic work is far from comprehensive. Amassing more data from floods is necessary, especially larger floods. Rapid data collection, such as attempted by ASCE after Hurricane Harvey, is important. Hurricanes may also provide opportunity to study the interface between traditional flood geology (i.e., rivers)

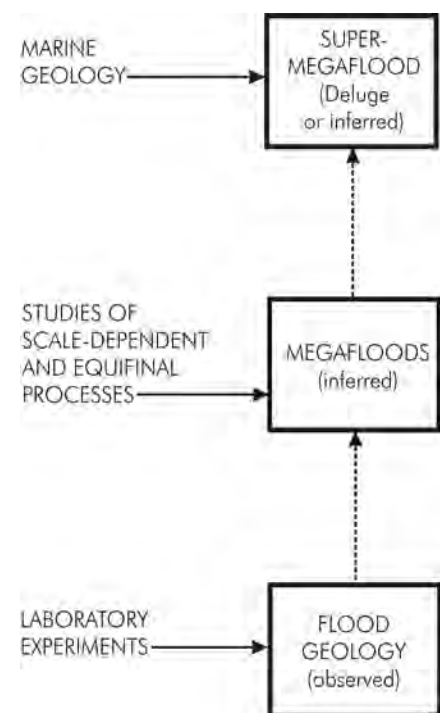


Figure 5. A logical hierarchy exists by which the observations of flood geology can be used to build an understanding of the constraints on probable diluvial processes. This is largely a “bottom up” or inductive process.

and marine geology, possibly granting insights into the differences between “ordinary” floods and megafloods. It is possible that a fractal relationship will be discovered in these recent deposits as it has been in recent studies of larger scale

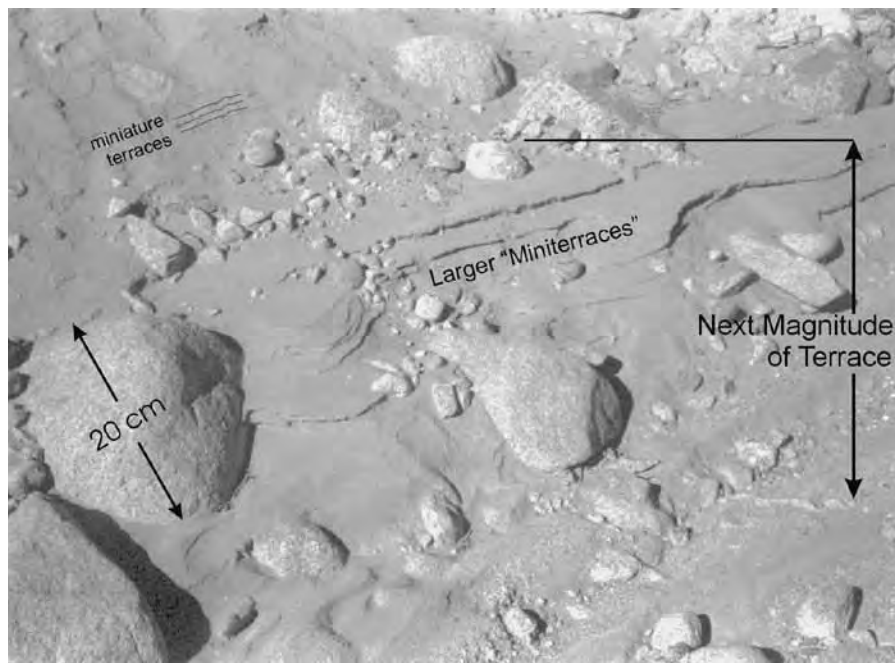


Figure 6. Large terraces have smaller terraces affixed upon their edges. Increasing numbers of geologic phenomena are being recognized as fractal.

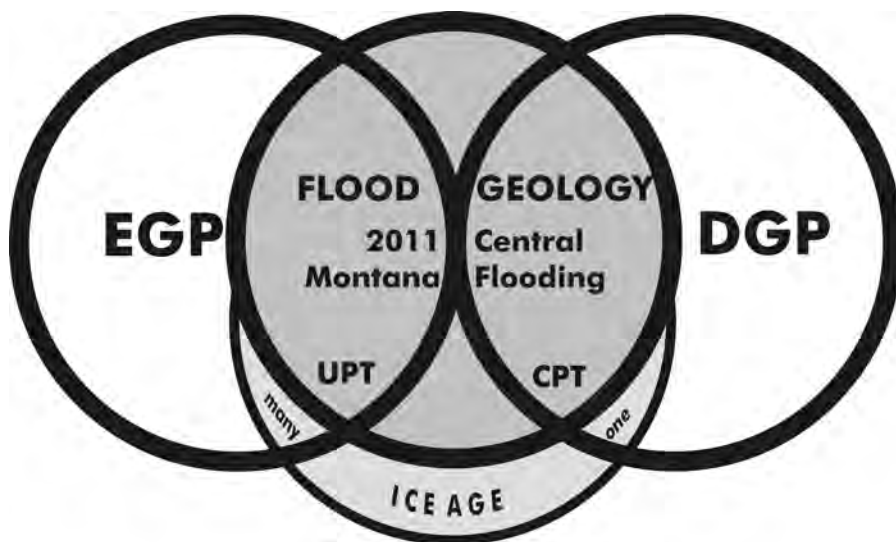


Figure 7. Venn diagram illustrating areas of agreement and disagreement between diluvialists (DGP) and evolutionists/uniformitarians (EGP). Many creationists believe in plate tectonics but hold to a catastrophic version (CPT), while believers in a 4.5-billion-year Earth history hold to the standard uniformitarian version (UPT). Agreement and disagreement are similarly distributed relative to continental glaciation (ice age). Other geologic and Earth history questions could be similarly displayed.

stratigraphy (Neal and Abreu, 2009; Bailey and Smith, 2010). The stratigraphic result must have had a paleocurrent cause (Figure 6). The more knowledge of flood geology increases, the better we can temper predictions and the greater the possibility of unraveling clues in the rock record.

Agreement and Disagreement

Flood geology as science is an area of agreement between evolutionists and creationists; it is in natural history that the viewpoints are opposed (Figure 7). Studying observed floods generally does not undermine either creationist or uniformitarian confidence in their respective views of the overall history of the Earth. The same is true of continental glaciation, though creationists propose a single ice age lasting a few centuries, while evolutionists believe in many ice ages. Evolutionists long downplayed catastrophic events, such as megafloods, but since evidence is now overwhelming, they make them cyclical and thus “normal” and “uniform” and “actualistic.” This has often impeded science (Figures 8 and 9). Uniformitarians have been hamstrung in geologic research for generations due to their faith in philosophically untenable and scientifically discredited assumptions. While diluvialists have the advantage of a constraint on their speculations from taking the written Biblical historical account seriously, natural history speculations are still natural history speculations.

A commitment to pure uniformitarianism or pure catastrophism is today untenable. With a proper understanding of the scientific method and commitment to the values that undergird it, there is no reason researchers with conflicting worldviews cannot cooperate effectively in research, even those researchers whose worldviews do not provide adequate philosophic support (coherence and correspondence) for the scientific method.



Figure 8. Judith River in Central Montana from west end of Central Montana Rail trestle. Meander migrated down valley (right to left) and abandoned former channel (midground) during 2011 flood. New channel is at east (distal) side of flood plain. Note channel forms in floodplain gravels that might suggest a long period of meander migration with each curved form representing a distinct flood, but this was not the case.

Conclusions

We have learned much about floods and their geologic work. Knowledge gained from observation of floods and geologic processes has significance for geologic paradigms that guide research and data interpretation. While this series focused on specific Central Montana projects, these conclusions apply to other geologic contexts and should be put to the test wherever possible.

Hydrology

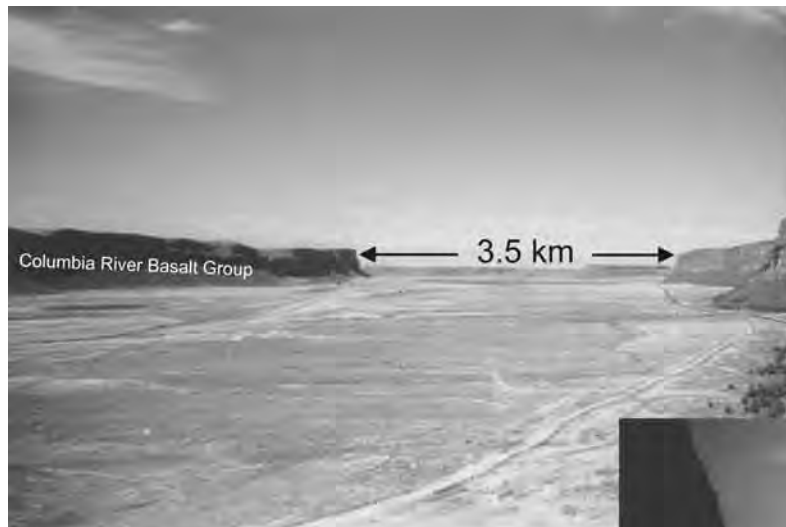
1. Most geologic work by rivers occurs during infrequent floods, contrary to the traditional uniformitarian idea that small changes over extended time produce geologic features seen today. This results from hydraulic relationships:

- Velocity, and thus stream power, is proportional to flow depth and bed slope; thus, the stream power equation is nonlinear.
- Head loss, determined by bed shear stress, is partly proportional to the square in the loss of current speed down the reach, resulting in a nonlinear function with considerably more geologic effect as current energy dissipation increases.
- Since stream power must exceed the bed shear stress threshold before significant erosion commences, flow below that threshold results in very little erosion.
- The rate of erosion is a nonlinear function of the surplus of stream power above the critical stream power (ω_c).

2. Alluvial channels tend toward a minimal energy loss state. This requires geologic work to reduce dissipative losses from channel constrictions and obstructions.
3. The assumption of steady flow is usually appropriate when the peak flow is of interest. The assumption of uniform flow can be more problematic, especially at larger scales.
4. Estimation of scour depth is complex, and observed scour depths sometimes exceed predictions. Scour depths may significantly exceed water depth, as seen on the Judith River in 2011.
5. Most geologic modeling is based on analogues with only limited ability to maintain controlled conditions and model using dimensionless parameters (e.g., flume experiments). “Ordinary” floods must be *extrapolated* to megaflood scale. Extrapolation is only valid if *scale* does not affect the process.
6. Extrapolating from flume-scale, controlled conditions to rivers is useful but incomplete, since “real world” conditions are more complex. This is illustrated by difficulties in accurately predicting scour.
7. Ground and surface waters often interact, and geologic changes caused by floods can induce sudden changes in ground water systems.

Geology

8. Geologic changes before and after the 2011 floods were “ordinary” effects in both type and scale but provided a good baseline for work during floods.
9. As witnessed in Kootenai and Telegraph Creek Formation claystone and shale strata, ground water can influence strata high in montmorillonite and other smectite physils via lubrication, crystal entrapment, and pore pressure increases to mobilize movement on very low angle faults or creep planes.



The Grand Coulee, Eastern Washington.

Relict channel is cut
over 250 m through
extensive flows of the
Columbia River Basalt Group

Views upstream--toward the northeast.
Hood of brand new 1948 Plymouth at
lower left--today, the channel bottom
is flooded by Banks Lake, an irrigation
reservoir of the Columbia Basin Project.



Photographs by Henry Klevberg

Figure 9. Grand Coulee in Eastern Washington in 1948 prior to filling of the bottom with Banks Lake reservoir. Grand Coulee is a large relict channel, part of the famous Channeled Scablands. Photograph courtesy of Henry Klevberg.

10. Megafloods ($>10^6 \text{ m}^3/\text{s}$) have not been directly witnessed but are inferred from geologic features that resemble those formed during floods. Evidence of megafloods has been observed from many places in the world.
11. Megafloods produced many flood features and landforms, though often at much larger scales, including giant current ripples or antidunes, boulder deltas, and outsized ramparts and terraces.
12. Megafloods also produced landforms and features not commonly observed

- in floods, including deposits of poorly rounded clasts, streamlined hills and erosional drumlins, hummocky terrain, diamict, fluting, potholes, butte-and-basin topography, and large erratic boulders. Some of these features are common with glacial processes.
13. Care must be exercised in extrapolation. Just as megaflood effects are more varied than those of "ordinary" floods, so the Deluge could have generated more varied features than megafloods. In many cases,

megaflood (and particularly diluvial) processes may be more accurately thought of as instances of *marine* geology rather than *flood* geology.

Uniformitarianism versus Catastrophism

14. Floods are major disasters. Their geologic change is a large part of that in the modern environment. Most important geologic processes, like megafloods, appear episodic.
15. The Judith River is a small, underfit gravel-bed stream with a gradient

of approximately 0.5 percent in the vicinity of Kolin and Danvers, Montana. Despite its size and resistant bed, it did considerable geologic work in the 2011 floods, including scouring to or nearly to bedrock—in some places as much as 20 feet. The Judith River Trestle had been in operation for 99 years at that time with only four of the piers having been endangered by river scour previously.

16. Large amounts of sedimentary bedrock were eroded from the spillway plunge pool at Fork Peck Dam in 2011. Similar rapid, flood-related erosion in soft and hard bedrock and in concrete has been observed elsewhere.
17. Geologic formations and landforms observed in the Judith Basin of Montana do not show evidence of gradual accretion from localized floods. The scale of the valleys accords with megafloods, and the Judith Basin planation surfaces exceed that scale.
18. Movement and mass wasting are seen on the relatively steep sides of valleys. Persistence of steep slopes indicates “youthful” ages relative to deep time. The slopes show how large amounts of earth materials lose potential energy through mass wasting.
19. Many features of Earth’s crust indicate a catastrophic origin, but not all do. Some processes observed today can explain some geologic effects. These are often orders of magnitude less extensive than catastrophically formed features, but are still important. Each geologic locale must be investigated for itself, and researchers need to recognize the likelihood of polygenetic formations and features.

Philosophy of Science

20. Many geological problems arise from philosophic biases and misunderstanding the scientific method. This is often due to an inability or

refusal to recognize the faith basis of materialism (naturalism).

21. Enthusiasm for natural history paradigms or theories may cause researchers to miss valuable data. A “top down” approach can greatly hamper understanding.
22. Historical geology is a “mixed question” that properly belongs in the category of natural history. Geology as a science can contribute to it, but results will be tentative and speculative. The “multiple working hypotheses” approach and field research reduce subjectivity, but never eliminate inherent historical uncertainties.
23. During modern times, historical geology has been mistakenly viewed as natural science, despite its uniformitarian foundation. Geology contributes much to our understanding of erosion and deposition, especially through flood studies; ironically, the *science* has discredited uniformitarian philosophy, though this philosophy still dominates the geologic community.
24. Common flood prediction methods assume deep time, and this assumption may produce false confidence in our ability to predict the magnitude and frequency of floods. Climate change may further complicate this and limit our ability to predict flood events.

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Errata

There was an error on page 254 in the first sentence in the last paragraph in the left-hand column in Johnson and Clarey’s paper “God Floods Earth, yet preserves Ark-borne Humans and Animals: Exegetical and Geological Notes on Genesis Chapter 7,” CRSQ 57(4): 248-262.

The sentence should read:

The Bible offers a clear explanation for this newly identified spike (in volcanic activity and the rapid release of massive amounts of carbon dioxide): **volcanism**, i.e., sub-oceanic volcanoes denoted in Genesis 7:11 (*ma’yenôth tehôm rabâh* = “fountains of the great deep”) and in Genesis 8:2 (*ma’yenôth tehôm* = “fountains of the deep”).

A review comment was inadvertently left in the text.

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.

Location of the Waters Above

Mark McGuire's (2020) recent article was an excellent discussion of three views among recent creationists of the location of the waters above of Genesis 1:6–8. Those three views were that at least initially the waters were above earth's atmosphere, at the edge of the solar system, or in interstellar space. However, there is at least one other possibility that was omitted. I (Faulkner, 2016) have proposed that the waters

lie at the edge of the universe. This possibility may provide an explanation for the cosmic microwave background that is widely accepted as the primary evidence for the big bang model but has yet eluded explanation within a recent creation framework.

Danny Faulkner
Kentucky, USA

Reference

- Faulkner, D.R. 2016. Thoughts on the *rāqīa'* and a Possible Explanation for the Cosmic Microwave Background. *Answers Research Journal* 9:57–65.
- McGuire, M. 2020. The Waters Above—A Comparison of Three Models. *CRSQ* 56:154–169.

^{56}Ni - ^{56}Co - ^{56}Fe Decay Series

Prof. Chaffin's wide ranging article, "Supernova Light Curves and Accelerated Decay," *CRSQ* Vol. 57, No. 3, raises numerous issues, the outcome of which naturally depends on the underlying presuppositions, as well as the accuracy of formulae and calculations. This letter will focus on what can be learned from the ^{56}Ni - ^{56}Co - ^{56}Fe decay series highlighted by Chaffin.

Chaffin admits (p.186) that there are material uncertainties in the determination of the forces governing the particles, and that calculations involve many approximations. Further, he adduces Feynman who states (p.187) that it "...makes one wonder whether the mental pictures we associate with the mathematics are

adequate." Then, Feynman later states (p.188), "...energy must be conserved in the final states." The following examination of these electron capture reactions will overcome all these difficulties by using only elementary arithmetic to show conservation of energy.

Checking internet articles sponsored by NASA, et al., the energy liberated by the Ni to Co reaction was stated variously as 2.13 to 2.16 MeV. That for the Co to Fe electron capture as 4.566 or 4.57 MeV. These were the totals of gamma radiation, kinetic energy of positrons, and neutrinos (in the case of the 2nd reaction). To see if these reactions conserved energy between the initial and final states, one may check the NIST

data (downloaded 2015) on amu's for the isotopes. That data is ultra precise, and important to note, was simply not available to researchers when current theories of nuclear structure and forces were first formulated.

^{56}Ni "weighs" 55.942132(12) amu, and ^{56}Co 55.9398393(23) amu. The difference of .002303 amu = 2.145 Mev, in close agreement with the stated energy released by the reaction radiation, based on 1 amu = 931.5 MeV.

The NIST data for the ^{56}Co - ^{56}Fe reaction shows 55.93983939(23) – 55.9349375(7) amu = .0049018 amu = 4.566 MeV.

Thus, *both* of these reactions which are supposed to convert an electron and

a proton into a neutron have *no* available energy left over to do so. All the available energy is accounted for in the radiation products emitted. The binding energy of a neutron of .78235 MeV is no where to be found. Thus, there is no evidence here for the existence of neutrons living a separate existence from protons and electrons *in nuclei*. These reactions are supposed to be governed by the “weak force.” But these reactions provide no evidence of such a force being necessary to “bind a neutron into the nucleus.”

If this situation were isolated to one example of EC, it might be ignored as “anomalous.” However, the case of the supernova gives us *two* examples right off the bat; and many other examples of EC have been checked with the same

result. Moreover, the weak force is presumed to govern beta decays. But, the same conclusion is reached as in EC, using the ${}^3\text{H}$ to ${}^3\text{He}$ decay, where the energy of the escaping electron, is only .01859 MeV, “and no energy produced that even suggest that there had been an initial neutron binding energy of .782MeV.”¹

Thus, Feynman’s criteria of energy conservation has been fulfilled using simple arithmetic by combining the NIST data with experimental results of other careful workers for the energy of emitted radiation &c. This does not deny that unstable, *free* neutrons with their relatively short half-lives and .78235 MeV energies of formation exist. Only that the former ideas about their

structural nature and role in nuclei must be abandoned. How the abandonment of the weak force would affect Prof. Chaffin’s work on accelerated decay is unknown, but might be quite significant. Regardless of the particle model adopted, where there is the possibility of phase transitions, excited states, and changes of shape, changes in half lives would seem not only reasonable, but necessary.

George P. Drake

¹Lucas Jr., Charles W., Why are the Fundamental Force Laws of Modern Science False? Part 3, *Foundations of Science*, Vol. 24, No. 2, p. 8 (2021)

Reply to George Drake

While I appreciate the interest shown by the author of this letter in my article, unfortunately I cannot agree with the main conclusions.

Electron Capture decays of nickel-56 and cobalt-56 have been observed experimentally in the laboratory and observationally in the spectra of supernovae, as several articles cited in my articles will attest. As the authors of this letter noted, about 2.14 MeV of energy is released in the electron capture decay of nickel-56. Nickel-56 has 28 protons and 28 neutrons, and decays to cobalt-56 with 27 protons and 29 neutrons. The masses of these nuclei have been known for several decades, and are in agreement with the amount of energy release in these decays. Data of this type was freely available when I was in the Navy in the late 1970’s, or even before that in my student days. When I was a student trainee at Argonne National

Laboratory in summer 1969, a giant mass spectrometer that had been used by A. O. Nier in previous decades was still on station in the physics building. For electron capture decay, modern physics textbooks (Weidner and Sells, 1980, p. 342; Tipler and Llewellyn, 1999, p. 527) state that it is energetically possible if the mass of the parent atom exceeds that of the daughter atom. The 0.78235 MeV energy difference between neutron (1.00865 u) and proton (1.007825 u) is fully accounted for in the atomic masses as is explained in textbooks. For beta-plus decay, the textbooks state (Weidner and Sells, 1980, p. 342; Tipler and Llewellyn, 1999, p. 527) that mass of the parent atom must exceed the mass of the neutral daughter atom *plus* two electronic masses ($0.00055 \text{ u} \times 2$). This condition is fulfilled for cobalt-56, and laboratory experiments find that beta-

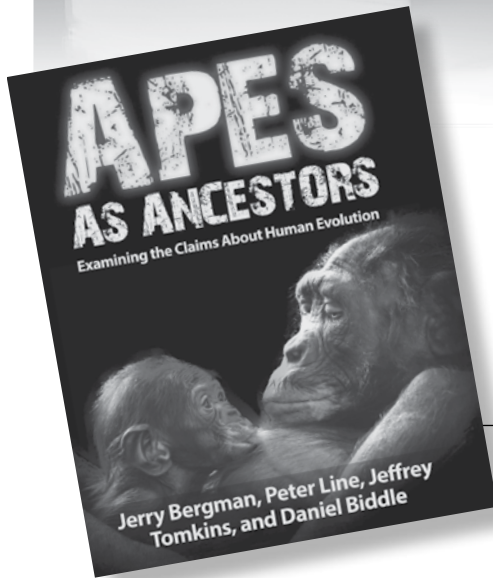
plus decay occurs 19% of the time, as noted on page 186 of my article in the Winter 2021 CRSQ. Simple arithmetic thus shows that the energetics of these beta-plus and electron capture decays are self-consistent. They provide no factual basis for denying the existence of the weak nuclear force.

Eugene Chaffin

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Media Reviews



Apes as Ancestors: Examining the Claims About Human Evolution

by Jerry Bergman, Peter Line, Jeffrey Tomkins, and Daniel Biddle

BP Books, Tulsa, OK, 2020,
359 pages, \$45.00

When asked what is the most powerful proof of evolution, most say it is the evolution of apes to man. At first glance, the parade of fossils presented in museums and textbooks seems insurmountable evidence for evolution. However, after examining the actual evidence as it stood in 2020, the apes to man story does not hold up to scrutiny.

The four authors of this book carefully examined each of the ape to man candidates and conclude that some of the fossils are apes and some are varieties of people groups. They also discover that there is a large and important gap between apes and people. Various Australopithecines, such as Lucy, are not pre-humans, but apes. So also are the newer *Ardipithecus*, *Orrorin tugenensis*, and *Sahelanthropus tchadensis*. The people groups include Neanderthal Man, the new Denisovans, *Homo erectus*, *Homo heidelbergensis*, and *Homo floresiensis*. Evolutionists admit *Homo habilis* is a waste basket group in which they categorize fossils of questionable

validity. The authors find that most of these are apes.

The authors also address the general challenges and problems involved in an ape to man transition. This includes the highly subjective nature of finding ape-man fossils. There is discussion of how researchers are bent on finding the missing link, and how this one hundred- and fifty-year-old quest has driven ambitions and forced conclusions. The result has been bold claims for favored fossils, often drawn from scraps of bone, teeth, and jaws.

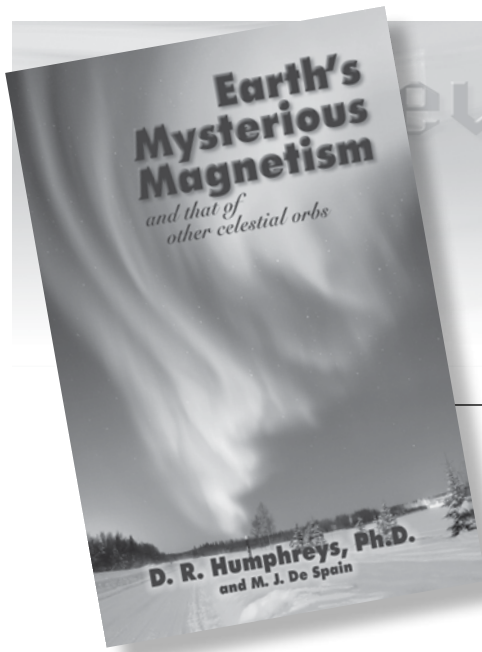
The authors also examine the difficulty of an ape face evolving into a human face, the problem of hair loss required for an ape to evolve into naked humans, and the challenge of explaining how ape teeth change into human teeth over time. The story of human evolution constantly changes as new fossils are added and old fossils deleted. Future updates will be necessary to keep this book current.

Chapter 6 by Tomkins and Bergman is reserved for the bold claim of evolutionists that the DNA of humans and chimps are 98 percent similar, which almost guarantees human evolution.

However, a detailed analysis reveals this claim is false and derived from preliminary and faulty data. Newer data shows the similarity between ape and mankind is no more than 84 percent. This represents a whooping change of 480 million base pairs that would have to mutate to evolve from apes to humans. Even more convincing is that humans have 46 chromosomes while apes have 48. The mental gyrations to decrease the number of chromosomes in apes by 2 is exposed as wishful thinking. The DNA claim alone shows the willingness of scientists to jump to conclusions and publish misinformation that they believe “proves” evolution.

This is an in-depth book; however, a layman can understand many of the arguments. It has an excellent introduction and each chapter begins with a clear summary. In conclusion, this book is a thorough examination of the ape-man controversy and reveals beyond reasonable doubt that there are no legitimate transitional fossils between apes and man.

Michael Oard
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Earth's Mysterious Magnetism

by D. R. Humphreys
and M. J. De Spain

Creation Research Society,
Glendale, AZ, 2016, 121 pages,
\$19.00

This book is a layman's version of Humphreys' work on magnetic fields, described this way in the preface:

My friend Mark De Spain, an electronics engineer and producer of a good video on my first cosmology ("Starlight and Time"), has distilled all of those articles down into this book. Following the publishers' dictum, "Every equation you include cuts your audience in half," Mark has reduced the number of equations to zero. The result is highly readable, even for people who have fled from science ever since those interest-killing, evolution-promoting classes in public schools. This is exciting science that glorifies God and encourages Christians. I hope and expect you will enjoy it (p. xiii).

The first half of the book is a comparison of the Dynamo theory which Humphreys calls the "pump-up model"

and the water theory, the "run-down model." The second half gives the evidence and explanatory powers of the run-down model. The book includes a six-page glossary clarifying terms and also copious references.

Two paragraphs in the preface are of particular interest:

There also doesn't appear to be a requirement for God to have created the earth's magnetic field supernaturally. Contrary to creationist folklore, Earth's magnetic field doesn't protect us from cosmic rays and other particles from space. Instead, the field scoops up such particles arriving at all latitudes and dumps them into the atmosphere above Eskimos near the Earth's magnetic poles, often making spectacular auroral displays (Northern lights) as they arrive. Yet the intensified cosmic radiation at polar latitudes is still far too low to cause problems for living creatures there. Instead it is the thick blanket of air above the Earth that is our primary protection from cosmic rays. If the magnetic field were to disappear tomorrow, only a few birds

and bacteria who depend on the field for navigation might miss it. The rest of us might not notice its absence.

Instead, I think God created the magnetic fields of the Earth and the heavenly bodies as clues for us to better understand how and when He created them. Their magnetic fields are strong evidence for a recent and obviously supernatural origin (p. xii).

This book is an excellent treatment of the magnetic field subject. Some specifics are difficult to grasp, but the overall themes and points are easily understood. Those interested in the Dynamo theory and its weaknesses will enjoy the first half of the book, and readers interested in God's creation of the universe starting with water will find the second half enjoyable.

This book takes Humphreys' groundbreaking and foundational creation science work out of the realm of the scientist and into the realm of the general population, a must have for any serious biblical creationist.

Richard Overman
Richard@coreprinciplesllc.com

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

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

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

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

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

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

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

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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 Glendale, Arizona.

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

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

1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.

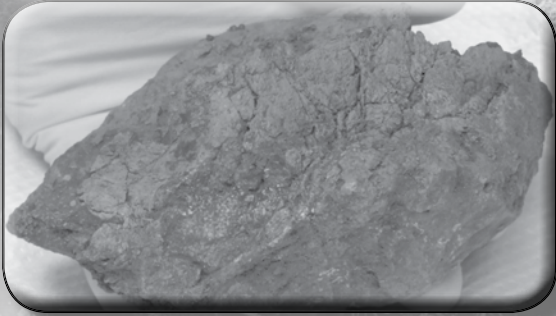
2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.

3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.

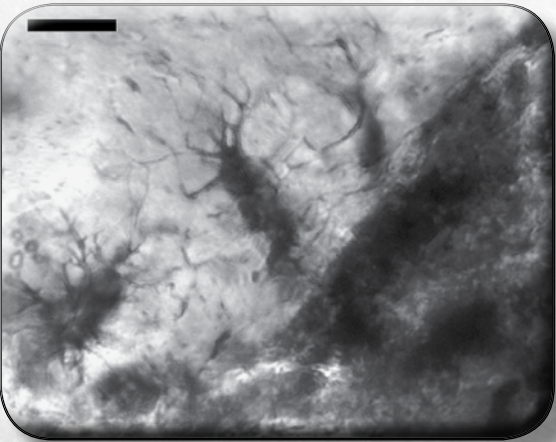
4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.

iDINO II

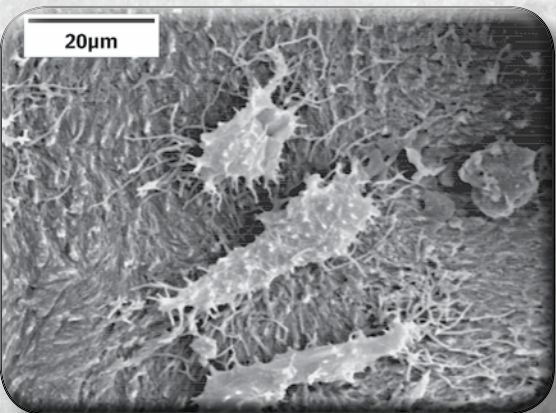
Investigation of Dinosaur Intact Natural Osteo-tissue



A fragment of the *Triceratops* brow horn.
Fragments, such as this one,
still contain tissue and cells.



Microscopic examination of tissue
extracted from a *Triceratops* horn
reveals bone cells still present.



Electron microscope picture of
intact bone cells still in tissue
extracted from a *Triceratops* horn.

How can pliable, stretchable tissue survive inside dinosaur fossils for over 65 million years?

How can this tissue still contain intact cells and even dinosaur proteins?

How can this fragile biological material survive for so long?

The answer to these questions directly challenges the current, evolutionary-biased, geologic timescale.

The Creation Research Society began its iDINO research initiative for the purpose of studying soft tissue in dinosaur fossils. The first phase of the project detected pliable, unfossilized tissue in a brow horn of a *Triceratops*. Within this tissue were intact osteocytes (bone cells). Some results from the iDINO project have been published in a technical microscopy journal and presented at an international microscopy conference. The Spring 2015 issue of the *Creation Research Society Quarterly* also features a special report of the iDINO project. Plus, to further spread the important information about soft tissue, the Society is developing a video (Echoes of the Jurassic).

The **second phase** of the project (iDINO II) will look more extensively at the process of tissue preservation. Evolutionists have offered various theories of how this tissue could survive for millions of years. iDINO II will methodically investigate these preservation claims, assessing their plausibility.

The iDINO results have already provided a strong challenge to the evolutionary worldview. More extensive and detailed examination may provide even stronger evidence that the age of dinosaur fossils is far less than 65 million years. To this end, the Society continues to seek those willing to fund this project with either one-time gifts or monthly donations.

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

Also visit <http://tinyurl.com/nphm2c4> for project updates and details.



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