Creation Research Society Quarterly 2015. 51:286–298.

The Hell Creek Formation: The Last Gasp of the Pre-Flood Dinosaurs

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Abstract

According to secularists, the top of the Hell Creek Formation records the last of five great extinctions. It has gained further fame as a unit that documents the disappearance of dinosaurs in the Western United States. The so-called Cretaceous-Paleogene (K-Pg) extinction is more complicated than many are led to believe, and is probably just the last appearance of many organisms in Flood-deposited strata. The Hell Creek Formation extends across eastern Montana and parts of North and South Dakota, varying from 170 m to 41 m thick. The base of the formation is picked where the composition of the underlying sandstone layer (Fox Hills Formation) changes to carbonaceous sandstone, marking the lowermost bed of the Hell Creek Formation. The top of the unit is more complicated. In the past, changes in the stratigraphy and/or fossils were used to pick the upper boundary, but now secularists choose the Iridium-rich layer as the top, regardless of other geological data. Limited occurrences of an Iridium anomaly make picking this top problematic in many locations. The type section shows ample evidence of water deposition. Marine fossils, including sharks, bivalves, and gastropods, are prevalent throughout the Hell Creek, not just in isolated lenses as many have claimed. Patterns of dinosaur occurrences in the uppermost Hell Creek show less dinosaur fossils toward the top of the formation and a 2–3 m gap at the very top that is devoid of dinosaur fossils. Dinosaur fossils found in the overlying lowermost Paleocene Fort Union Formation, may indicate some dinosaurs survived until the end of the Zuni Megasequence, slightly above the K-Pg. All geological data observed in the Hell Creek Formation are interpreted as occurring during a worldwide Flood event. Stratigraphic data, such as ripples and cross-bedded sandstones, demonstrate water transport. Marine fossils found throughout the formation imply a strong marine influence during deposition of the entire unit. The observed mixing of land and sea organisms is best explained by tsunami-like waves transporting ocean waters onto the continent, engulfing the terrestrial animals and depositing the Hell Creek Formation.

Introduction

The Hell Creek Formation is probably most famous as the unit that has produced the majority of *Tyrannosaurus rex* specimens. It is now becoming even more famous for its production of dinosaur soft-tissue fossils, which exhibit remarkable preservation, demonstrating that these fossils cannot be millions of years old as claimed by secularists (e.g., see Thomas, 2015). The formation is also extremely important in the secular dinosaur extinction debate. It is one of the only units in the world that secular scientists believe contains significant numbers of dinosaur fossils from rocks from the very end of the Cretaceous

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Accepted for publication March 20, 2015

system (Lucas, 2007). In addition, it is claimed the formation provides the most detailed history of continental biotic changes across the K-Pg (Cretaceous-Paleogene) boundary in the world (Clemens, 2002; Clemens and Hartman, 2014). Yet, the top of the Hell Creek also contains the famous "3 m gap," where no dinosaur specimens have been discovered (Johnson et al., 2002).

The Hell Creek Formation is one of the last deposits of the Zuni megasequence across the northern Great Plains region. Megasequences are defined as packages of sedimentary rock bounded top and bottom by erosional surfaces, with coarse sandstone layers at the bottom (deposited first), followed by shales, and then limestone at the top (deposited last) (Sloss, 1963). The corresponding size of the sedimentary particles is also thought to decrease upwardly in each megasequence. The megasequences are interpreted by secular geologists as representative of the depth of the sea at the particular time each one was deposited. The base sandstone layers of each megasequence are believed to represent the shallowest sea level, the shale representing a little deeper water environment, and the limestone the deepest water environment in each sequence.

Primarily described as a siliciclastic rock unit, the Hell Creek Formation has been labeled by secular geologists as a Late Cretaceous depositional event. Above this unit are Paleogene (Tertiary) system rocks of the Fort Union Formation (Tullock Member), the basal unit of the Tejas megasequence (Blakey, 2010). The Hell Creek Formation extends 700 km across eastern Montana and North Dakota, and an approximately equal distance from northeastern Wyoming (where it is equivalently called the Lance Formation) to the Canadian border (where it is called the Frenchman Formation) (Figure 1). The formation's best exposures are in eastern Montana and North and South Dakota, along the outer margins of the Williston Basin (Figure 1).

K-Pg: Just One of Five Great Extinctions?

Secularists claim to have identified five so-called great extinctions in the Phanerozoic Eon, one each in the Late Ordovician, the Late Devonian, the Permian-Triassic, the Late Triassic, and, finally, the end Cretaceous or K-T (now K-Pg) event. Table 1 summarizes the secular view of these five events by the percent extinction per species and by vertebrate extinction rate. Looking at only vertebrate extinction through time, by families per million years, we see the same five events, but the relative family extinction rates are different from the overall species extinction percent. This demonstrates some of the statistical bias that can be used, depending on whether the focus is on extinctions by species or families or by rates of extinctions versus extinction percent.

One of the great secular mysteries of all time concerns the extinction of dinosaurs at the end of the Cretaceous System, of which the Hell Creek Formation plays a major part. This extinction

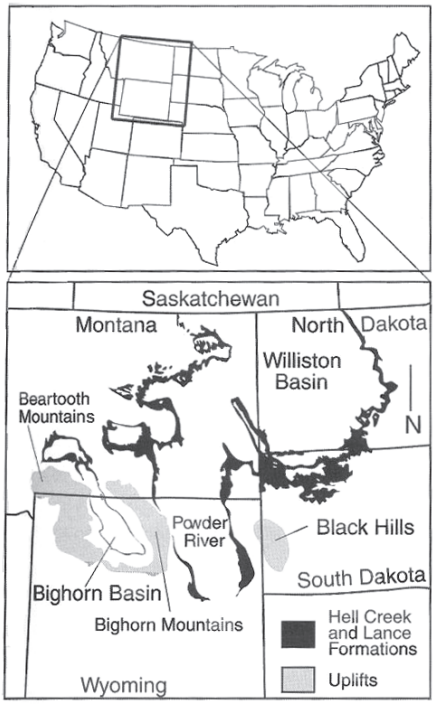


Figure 1. Location map of the Hell Creek Formation and the equivalent Lance Formation. Outcrop area is shown in black. The Hell Creek Formation extends under the Williston Basin in eastern Montana and North Dakota. In the Powder River and Bighorn Basins, it is known as the Lance Formation. Modified from Hicks et al. (2002).

Extinction Event	Species Extinction (%)	Vertebrate Extinction Rate (Families per Million Years)	Secular Age (Ma)
Cretaceous-Paleogene	70	16	65.9
Upper Triassic	76	10	206
Permian-Triassic	96	15	248
Upper Devonian	82	10	354
Upper Ordovician	85	20	443

Table 1. The so-called five great extinctions in the sedimentary record, showing purported extinctions by species and vertebrate extinction rate, assuming the secular ages listed. All ages are listed in millions of years.

is commonly called the "K-T" or "K-Pg" event because it occurred at the Cretaceous-Tertiary (Paleogene) boundary. The general secular consensus on the date of the K-Pg extinction event was approximately 65 million years before present. However, this date has been recently revised to 65.95 million years (Kuiper et al., 2008).

There have been over 65 serious published ideas attempting to explain this extinction (Benton, 1990). Some of these ideas, as summarized by Powell (1998), include medical problems, overspecialization, competition with mammals, plant changes, climate changes, sea-level changes, increased volcanism, and extraterrestrial events. The most popular theory currently appears to be the asteroid impact.

The asteroid theory is based on the "accidental" discovery of higher-than-expected levels of iridium (Ir) within the K-Pg boundary layer at Gubbio, Italy (Alvarez et al., 1980). Similarly high levels of Ir were subsequently found at many sites worldwide at the K-Pg boundary. Iridium is an element found in meteorites but is not very common on Earth, and so it is thought to have come from space. Many have concluded that this Ir-rich layer was deposited after an asteroidlike body struck Earth, scattering Ir-rich dust all over the globe.

Further study of the K-Pg boundary layer found tiny crystals of "shocked" quartz at many of these same locations (Bohor et al., 1984). Shocked quartz can form only under extremely high-pressure conditions, like impact sites, further strengthening the evidence for an impact at the K-Pg. In 1992, microscopic diamonds were reported from the K-T layer in Alberta, Canada (Carlisle, 1992). It is thought that the diamonds are fragments of impacts, as they are "cleaner" and contain less nitrogen than traditional mantle-derived diamonds.

The presumed site of the K-Pg impact was located near the northwestern edge of the Yucatan Peninsula, Mexico (Hildebrand et al., 1991). The site consists of a large, circular gravity anomaly known as the Chicxulub Crater. It is 110 miles (180 km) in diameter, allowing room for a 6-mile (10 km) wide asteroid to have created the dimensions of the crater. There is, however, disagreement on the exact size of the crater.

However, many dinosaur paleontologists do not feel an asteroid impact is the answer to this mystery (Keller et al., 2007; Keller and Adatte, 2007). They believe an impact happened but that it had only a minimal extinction effect. Dr. Robert Bakker (one of America's leading dinosaur paleontologists and author of *The Dinosaur Heresies*) believes dinosaurs went extinct from an epidemic brought on by a rapid drop in sea level. He thinks dinosaurs were killed by foreign diseases carried from continent to continent across land bridges.

Mr. Jack (John R.) Horner, noted dinosaur specialist and professor of paleontology at Montana State University, spoke about extinction at a lecture at Central Michigan University in April 2001. He stated that the meteor or asteroid theory of extinction is a "good example of taking an idea too far," noting that this theory is all based on negative evidence. He pointed out that "just a few dinosaur taxa (3–4) were living at the end, or close to the K-T [Pg] boundary," and that there is "no record of any catastrophic event that correlates with the last of the dinosaurs." Horner frequently reminds his audiences that no dinosaur bones have ever been found within 3 m of the K-Pg boundary, supporting the idea that dinosaurs were extinct prior to the deposition of the Tertiary System. He believes that dinosaurs went extinct from simultaneous sea-level changes and climatic shifts. He readily admitted, "I don't care. I'm just glad they're gone. I want to go out for walks at night."

Many "extinctions" seem to coincide with simultaneous rapid change in rock type and/or depositional pattern at or near a particular rock boundary. These rapid changes in rock type would seem to indicate condition changes that could rapidly "finish off" a population, like the dinosaurs in the Hell Creek Formation and elsewhere. Rapid shifts in depositional patterns are an expected consequence of a global Flood.

A review of 110 secular research papers on the K-Pg extinction, examining all organisms, showed that a sudden extinction was noted in only 50% of the papers, and that 72% of those sudden extinctions were associated with a corresponding rapid shift in rock type (Clarey and Heim, 2012). This strong correlation demonstrated that the perceived abruptness of the K-Pg extinction may be enhanced by observable changes in the rocks. This would be predicted as Flood sediments were being piled on top of one another, accumulating new sediments in rapid succession, with new organisms appearing and disappearing just as abruptly. Clarey and Heim (2012) also found that 28% of the so-called extinctions occurred prior to the K-Pg boundary, 55% occurred at the K-Pg boundary, and 17% occurred just after the K-Pg boundary, in the Early Tertiary system. Rather surprisingly, only 57% of the papers reported an iridium anomaly present in the boundary layer. So, it appears there is no definitive stratigraphic boundary where all organisms, including the dinosaurs, went extinct. Organisms merely stopped being deposited at those locations.

There are no extinctions as described by secular science. Extinction in the rock record is defined as the highest stratigraphic occurrence of a fossilized organism. During the Flood, layers of animal and plant communities were rapidly piled on top of one another, from various directions and in seemingly a global order, according to the tectonic activity taking place at that moment. Viewed in this manner, these last occurrences are not extinctions. Instead, they are merely the last record of various

organisms trapped by the Floodwaters. Some creation scientists think the "K-Pg" was about the high point of the Floodwaters, when all land animals finally succumbed and drowned. That may be why at this point so many organisms seemed to simultaneously go "extinct." It was a major juncture in the Flood record, and the Hell Creek Formation has recorded it.

Stratigraphy of the Hell Creek Formation

The Hell Creek Formation was first named and described by Brown (1907), who separated it from the underlying Fox Hills Formation and the overlying Fort Union Formation, although he failed to identify a type section in his description (Hartman, 2002). Thickness varies from 170 m in Garfield County, Montana, to only 41 m in McCone County, Montana (Johnson et al., 2002). More commonly, the unit varies between 60–100 m in thickness (Johnson et al., 2002).

Base of the Formation

Some authors claim the base of the formation to be a regional unconformity surface, as it contains cobbles up to 10 cm in diameter (Bauer, 1925; Jensen and Varnes, 1964) and lacks lignite beds, which are thought to represent a sea-level regression sequence (Johnson et al., 2002). However, there is no physical evidence of erosion at the basal boundary. It merely changes from white sandstone at the top of the underlying Fox Hills Formation (Colgate Member) to a 0.3–1 m carbonaceous sandstone that is remarkably persistent across southern North Dakota (Murphy et al., 2002). Because of the thin nature of this bed, most well logs pick the base of the Hell Creek Formation at the top of a 5- to 15-m-thick clean sandstone, representing the uppermost Colgate Member of the Fox Hills Formation (Murphy et al., 2002).

Secularists have tried to date the base of the Hell Creek Formation using argon-argon dates from volcanic ash along the North Dakota-South Dakota boundary but have not obtained a tight cluster, finding a range of values that varied as much as 1.32 my (Hicks et al., 2002), almost the entire 1.36-my interval claimed for deposition of the complete Hell Creek Formation (Hicks et al., 2002). Because of these age discrepancies, the base of the unit is thought to be significantly diachronous (Johnson et al., 2002). The base of the Hell Creek Formation is thought to be older in western North Dakota and progressively younger to the east (Johnson and Hickey, 1990).

Top of the Formation

The top of the Hell Creek Formation also can be difficult to identify in the field (Nichols and Johnson, 2002). Most geologists pick it at the base of a lignite or coal bed in the overlying Ludlow Member of the Fort Union Formation called the "Z" coal (Murphy et al., 2002; see Figure 2). However, this lignite bed is not always present (Nichols and Johnson, 2002). Where absent, the upper limit of the Hell Creek Formation is chosen where the sediments change from a smectite-rich, "popcorn"-weathering, gray mudstone to a carbonaceous shale, yellowish mudstone, or yellowish sandstone (Nichols and Johnson, 2002).

The contact between the Fort Union and the Hell Creek formations is believed to be nearly isochronous over more than 500 km, in contrast to the base of the formation (Johnson et al., 2002). According to Johnson et al. (2002), this implies a rapid transgression of the Paleocene seaway across the Hell Creek Formation, which deposited the Cannonball Member of the Fort Union Formation. This likely marks the onset of the Tejas Megasequence across western North America.

Figure 2. Photograph of the boundary between the Hell Creek Formation and the overlying Fort Union Formation near Glendive, Montana, showing the "Z coal complex" at the base of the Fort Union (Tullock Member). Photo courtesy of Brian Thomas.

The age of the top of the unit is, however, poorly constrained. Geologists admit that the top of the Hell Creek Formation does not necessarily coincide with the K-Pg (K-T) boundary (Johnson, 1992; Murphy et al., 2002). The K-Pg has been found to be as much as 2.6 m above the top of the Hell Creek Formation (Murphy et al., 2002). The K-Pg boundary used to be designated directly above the uppermost occurrence of dinosaur bones, but that idea has fallen from favor (Clemens and Hartman, 2014). Geologists now rely primarily on the Ir anomaly found in many marine sections throughout the world (Alvarez et al., 1980). But the presence of an Ir anomaly is not ubiquitous across the top of the Hell Creek Formation, as discussed below.

The presence of an Ir anomaly was found in samples from the Z coal (and above) at two sites in Garfield County, Montana, between 1980 and 1982, one near Brownie Butte in the Hell Creek valley, and the other at a location called Ir Hill on the southwestern margin of Hauso Flats (Clemens and Hartman, 2014). This iridium-rich layer has been labeled the IrZ. The sample from near Brownie Butte was collected from a thin clay layer identified by palynology as the K-Pg boundary. However, subsequent samples taken from Brownie Butte and adjacent hills did not contain the same IrZ layer and did not have high levels of Ir at the base of the Z coal (Clemens and Hartman, 2014).

Ash taken from the IrZ layer in the valley of Hell Creek was dated by geologists, using $^{40}Ar/^{39}Ar$, giving an age of 65.58 ± 0.04 ma (Wilson, 2005). To the east in McCone County, however, the same basal Z coal, ash-rich layer gave an age of 65.37 ± 0.05 ma (Clemens and Hartman, 2014). Secularists are quick to claim that these are close but admit the differences in dates make it very difficult to explain the top of the Hell Creek Formation as an isochronous surface (Clemens and Hartman, 2014). Although secular geologists would like to see a universal Ir anomaly across the top of the Hell Creek Formation, they do not. They admit that the evidence for an asteroid impact, like the claimed Chicxulub site, is lacking within most of the exposures of the uppermost Hell Creek Formation, finding the IrZ anomaly in only a few isolated sections (Clemens and Hartman, 2014).

It appears that the only reason the K-Pg and the top of the Hell Creek Formation do not always coincide is the sporadic Ir anomaly. When it is present, secular geologists set the K-Pg boundary to match it, not the lithologic formation top. Sometimes, however, they adjust the top of the Hell Creek to match the Ir anomaly, as in Figure 3. The physical top of the Hell Creek should be placed a few meters higher than the Ir anomaly, at the top of their unit 29, in the lectostratotype section (Figure 3). This matches a clearer change in rock type, which normally defines a formational contact. Unfortunately, secular scientists insist on using the Ir anomaly, in spite of its unmappable nature, and choose to ignore the obvious stratigraphic conflict it sometimes creates.

Stratigraphy of the Formation

Detailed stratigraphic studies of the Hell Creek Formation include those by Belt et al. (1997), Butler (1980), Fastovsky (1986), Johnson (1989, 1992), and Murphy et al. (2002). Most of these studies include descriptions of measured sections and formation contact descriptions. Belt et al. (1997) and Fastovsky (1986) found paleocurrent directions in the Hell Creek in Montana and North Dakota to be predominantly to the south-southeast.

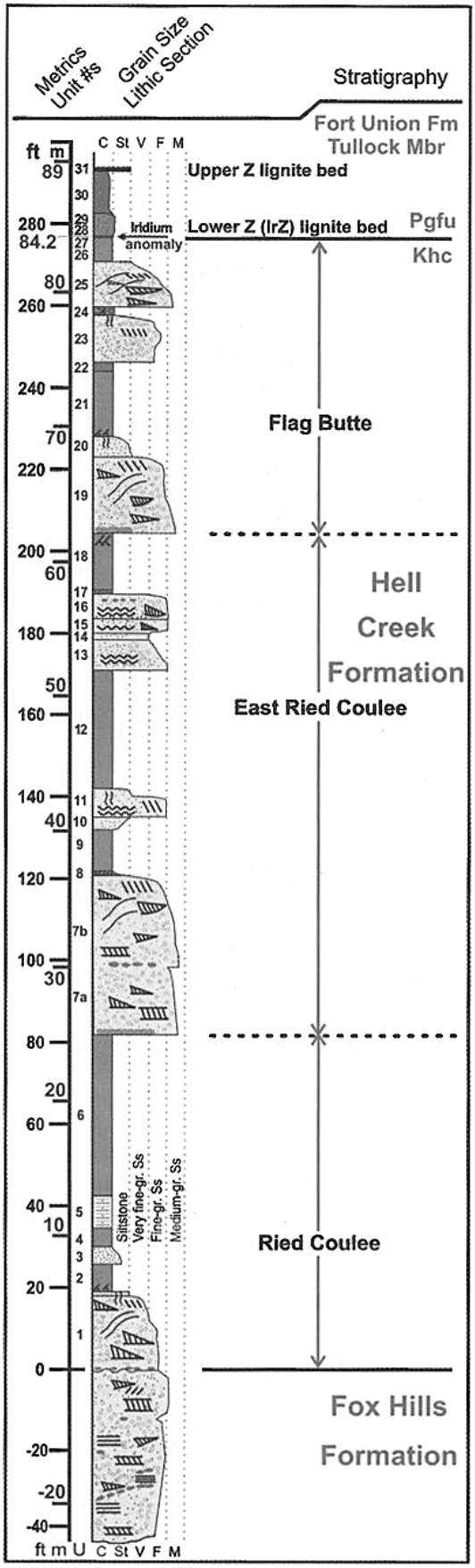
The most recent stratigraphic study was by Hartman et al. (2014), proposing a "type section" for the Hell Creek Formation (Figure 3). They noted that when he named the formation, Brown (1907) did not provide such a top-to-base reference section, as is the convention in modern stratigraphy.

The proposed type section, termed a lectostratotype location, described by Hartman et al. (2014), is located in the Flagg Butte area, just north of Jordan, Montana, near exposures along Ried Coulee in Garfield County. This location is about 26.7 km east of Ir Hill, described above. The type section is actually a composite of two closely spaced locations in the N½ Sec. 29, T. 21 N., R. 38 W. At this location, the Hell Creek Formation was determined to be 84.2 m thick.

Moore et al. (2014) identified an Ir anomaly just below the top of the Hell Creek Formation in a thin pinkish claystone layer near the lowest thin coal bed at the nearby Flagg Butte. Hartman et al. (2014) noted that most of the 4.5-m-thick section above the Ir anomaly layer looked more like Fort Union sediments than Hell Creek sediments. Regardless, the K-Pg boundary picked in their type section was chosen on the basis of the Ir anomaly and not on the observed changes on sedimentology.

The upper contact at this location is the base of the IrZ coal bed, directly above an Ir anomaly. Hartman et al. (2014) further divided the type section into three informal units from bottom to top, the Ried Coulee, East Ried Coulee, and Flag Butte units, respectively. The Hell Creek Formation is essentially a repeating series of sandstone layers separated by mudstones. The three subdivisions of the formation are all interpreted by secularists as representing various types of coastal-deltaic environments that thin to the east and northeast in the Williston Basin. However, they do acknowledge that the sea level fluctuated and the Western Interior Sea had a strong influence on the deposition of the Hell Creek (Hartman et al., 2014).

Every sandstone unit within the Hell Creek Formation shows evidence of water transport and deposition (Hartman et al., 2014). The lectostratotype in Figure 3 has multiple examples of planar and wedge cross-bedded sandstones,



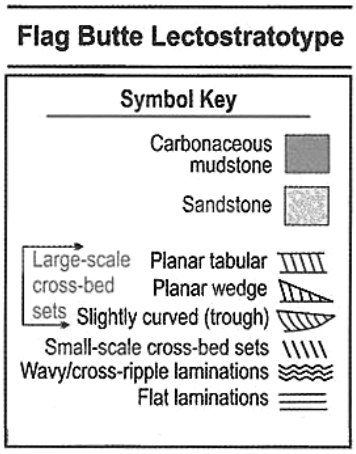


Figure 3 *(left)*. Type section of the Hell Creek Formation (lectostratotype) at Flagg Butte, located north of Jordan, Montana, in Garfield County. Thickness numbers start at the base of the formation. Grain size values: C—clay, St—silt, V—very fine-grained sand, F—fine-grained sand, and M—medium-grained sand. Ripples and cross-bedded sandstones indicative of water transport are found in every sandstone layer. Modified from Hartman et al. (2014).

rippled sandstones, and occasional sandstones with layers of rip-up clasts from higher energy flow. Most secular scientists interpret these sandstone layers as river channels, delta channels and/or overbank deposits (Hartman et al., 2014). However, the presence of marine fossils throughout the Hell Creek (see below discussion) strongly suggests that these sandstone layers were not terrestrial channels but were deposited under a strong marine influence. These sandstones and fossils, and therefore the entire Hell Creek, are best interpreted as forming under Flood conditions, where waves of ocean water washed across the continent, mixing land and sea creatures in water-deposited sands and mudstones.

Breien Member: Evidence of Marine Mixing

Although claimed to be a terrestrial deposit by the secular geologists, the Breien Member of the Hell Creek Formation contains ample evidence of marine influences and mixing throughout (Archibald, 1996; Hartman and Kirkland, 2002).

The Fox Hills Formation directly below the Hell Creek is interpreted as a marine deposit (Hartman, 2002), and the Cannonball Member of the Fort Union Formation above the Hell Creek is thought by secular geologists to be a marine deposit along the eastern side of the Williston Basin (Figure 3). Finally, most geologists admit that the Breien Member, near the base of the Hell Creek in south-central North Dakota, is a marine deposit. This unit covers an area of over 6100 km^2 (Murphy et al., 2002). Frye (1969) noted that the Breien Member is characterized by glauconitic sandstones that contain the marine crustacean trace fossil, *Ophiomorpha major*. He further added that the Breien Member contains marine, brackish water, freshwater, and land fossils. These are just the types of mixed fossils creationists would predict for a Flood deposit. Murphy et al. (2002) described the unit

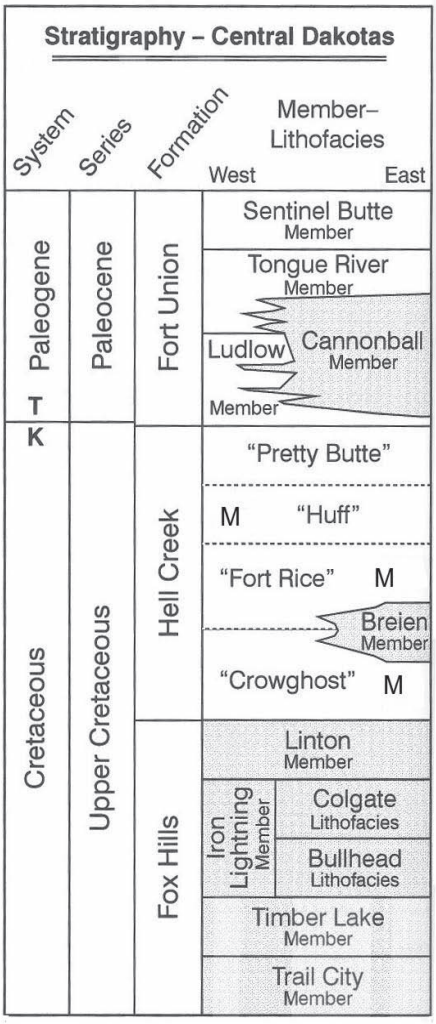


Figure 4. Stratigraphic units in the western and eastern Williston Basin of the Dakotas, showing the formations and members above and below the Hell Creek Formation. The Tullock Member (not shown) is the Ludlow Member equivalent in Montana. The shaded units are secular-accepted marine deposits. The white units are purported to be terrestrial deposits. The stippled boundaries in the Hell Creek Formation represent informal members named by Frye (1969) in North Dakota. The "M" designates layers with fossils providing a positive identification of marine taxon (Hartman and Kirkland, 2002). Modified from Hartman (2002) and Hartman and Kirkland (2002).

as rich in sandstone, mudstone, and occasional thin bentonite layers between 1.5 and 9 m thick near the base of the Hell Creek (Figure 4).

Murphy et al. (2002) also noted that 95% of the dinosaur fossils found throughout the Hell Creek Formation in south-central North Dakota, occur in close association with the Breien Member (within 10 m above or below).

In addition, Murphy et al. (2002) noted marine and/or brackish water fossils in the Cantapeta Tongue near the top of the Hell Creek Formation in south-central North Dakota. They concluded that marine or brackish conditions existed in southwestern North Dakota during much of the deposition of the Hell Creek. Note that the type section in Figure 3 is too far west to identify the Cantapeta Tongue and the Breien Member within the Hell Creek.

Fossil Occurrences and Marine Mixing

Hartman and Kirkland (2002) reported that occurrences of marine invertebrate fossils are more common throughout the Hell Creek Formation than most geologists would readily acknowledge. They argue that an ocean persisted across the Great Plains region throughout the end of the Cretaceous system with, at most, a brief hiatus at the K-Pg boundary. They concluded that the Western Interior Seaway never significantly regressed during deposition of the Hell Creek and that a nonmarine K-Pg interval did not occur in the central interior of North America.

Hartman and Kirkland (2002; see their Figure 3) used the four informal divisions of the Hell Creek Formation of Frye (1967, 1969) and noted the occurrence of marine fossils in three of the four. They also observed the presence of brackish water and marine bivalves *Crassostrea*, *Corbicula*, and gastropod *Pachymelania*, and the crustacean trace fossil *Ophiomorpha* throughout the Hell Creek. They also documented the presence of freshwater mollusks intermixed with the marine fossils in several of their subdivisions. As a conclusion, they suggestion that "the presence of marine waters very near the end of the Cretaceous seems a likely possibility" (Hartman and Kirkland, 2002, p. 272). They further concluded that the rock record in North Dakota does not support a withdrawal of marine conditions in the Western Interior prior to the end of the Cretaceous.

However, the marine influence seen in the Hell Creek Formation is not limited just to North Dakota. Studies in eastern Montana, and even into the equivalent rock units (Lance Formation) in Wyoming, have shown similar results (Archibald, 1996). Other authors have been studying the fauna of the Hell Creek since the 1950s (Lucas, 2007), seeing the same marine and nonmarine faunal mixing. As Hartman and Kirkland (2002, p. 272) have stated, "Although previously reported, knowledge of the continuation of marine conditions above the Fox Hills Formation is not well or widely known." The Fox Hills directly underlies the Hell Creek (Figure 3).

Hartman and Kirkland (2002, p. 276) also discussed the Hell Creek Formation research conducted by C. I Frye (1967, 1969). They pointed out that "Frye's identifications of brackish-water molluscan taxa, although in need of revision, were sufficient to deduce marine-influenced deposition through most of the Hell Creek Formation."

Table 2 shows a sampling of 12 groups of animals from the Hell Creek Formation and the overlying Tertiary (Paleogene) Tullock Member (basal unit of the Fort Union Formation; Figure 4) in Montana (Lucas, 2007). This table is the compilation of work begun in the 1950s by William Clemens and Robert Sloan and their colleagues (Lucas, 2007). The table data was supplemented with data from Archibald (1996), who reported similar findings in eastern Montana. Archibald's database included

Animal Group	Cretaceous Species Present	Paleogene Species Present
Sharks	5	0
Bony Fishes	14	7
Amphibians	8	6
Champosaurs	1	1
Crocodiles	5	3
Bird-hipped Dinosaurs	11	0
Lizard-hipped Dinosaurs	9	0
Lizards	11	3
Turtles	19	14
Placental Mammals	6	6
Marsupials	11	1
Multituberculates	10	5

Table 2. List of animal groups found as fossils in the Hell Creek Formation and in the overlying Tullock Member of the Fort Union Formation, eastern Montana. Note the mixing of marine and terrestrial species in the Hell Creek Formation and in the overlying Tullock Member. This mixing is best explained by Floodwaters transporting ocean animals onto the continent.

more than 150,000 vertebrate specimens housed in the University of California, Berkeley collection from Garfield and McCone counties, Montana.

Table 2 illustrates the many examples of mixed terrestrial and marine influences in the upper Hell Creek Formation in Montana, reinforcing the results of Hartman and Kirkland (2002) in North Dakota. Surprisingly, in two volumes of papers published specifically on the Hell Creek in the last 15 years (Geological Society of America Special Paper 361, 2002, and Special Paper 503, 2014), little is mentioned of the occurrences of the 5 species of sharks and the 14 species of fish that provide evidence of marine influence. Secular scientists either ignore these findings (e.g., Hartman and Kirkland, 2002, pp. 289–293) or dismiss them as freshwater species, in spite of the more likely conclusion that they represent marine organisms.

Formations directly under and over the Hell Creek Formation are accepted as marine, yet the Hell Creek itself is supposed to be terrestrial because it contains dinosaur fossils (Figure 4). Furthermore, the formation is also full of marine fossils—from top to bottom and from Montana to North Dakota. These facts are not best explained by fluctuating sea levels as most secularists claim. Frye (1969, p. 36) recognized that transport was necessary to mix these environments, if even only locally, stating, "These [marine] fossils were found at nearly every location and would lead one to believe that probably all of the terrestrial and most of the fresh-water fossils were washed into a marine or brackish-water environment." An event of tremendous energy was necessary to transport and mix marine and terrestrial animals we observe in the rocks today. The Flood could have provided this energy with its tsunami-like waves crashing across the continent.

The "3 Meter Gap"

Countless studies have argued about the extinction of dinosaurs in the secular literature, and the Hell Creek Formation continues to be at the forefront of this debate. Lucas (2007) reported that there was a steplike decline in the dinosaur diversity near the top of the Hell Creek Formation, with 19 genera near the base, declining to 12 within the top 16 m, and just 7 approximately 3 m from the top. But there have been no genera identified in the uppermost 3 m of the formation. Most of these data came from studies by Robert Sloan and William Clemens, mentioned earlier. Archibald (1998) reported similar findings, citing it as evidence for a "gradual" demise of the dinosaurs. Others disagree, insisting that there was no decline in dinosaur diversity and that dinosaur extinction was the result of a sudden, asteroid-driven extinction event (Fastovsky and Weishampel, 1996; Sheehan et al., 2000).

David Archibald (2000, p. 1150) has written, "A far more important question is the pattern and amount of extinction of all vertebrates, not just dinosaurs." Robert Bakker likes to look at what did not become extinct across the K-Pg boundary. He points out that frogs and turtles showed little, if any, change in population from the Cretaceous system to the Tertiary system (History Channel, 2008; cf. Paleogene, Table 2). He argues that global wildfires, acid rain, toxic dust, and extended global cooling after a large asteroid impact should have wreaked havoc on nearly all living things, especially those in the tropics, like frogs and turtles. As Bakker (History Channel, 2008) has stated, "If you can't freeze a turtle, you can't freeze a *T. rex*. You just can't." Research also has found little change in insect populations across the K-Pg boundary, further adding to the

mystery of what did not go extinct (History Channel, 2008).

Finally, there is the near void of dinosaur skeletal remains in the last 3 m of the Cretaceous; the infamous "3 m gap." Critics of the asteroid hypothesis argue that there should be some skeletal evidence of a mass kill in rocks, like the uppermost Hell Creek Formation, if billions of animals across the globe died simultaneously. All that has been found in this 3-m interval are a few scattered dinosaur bones, with no articulated skeletons at all. Because of these isolated fossil occurrences, Clemens (2002) argued that the "gap" is really only the uppermost 2 m of the Hell Creek Formation. But, he points out that after 30 years of intense study, the 2-m gap remains. And it is not just dinosaurs missing in this 2-m zone; it is all vertebrates and even the "freshwater" invertebrates (Clemens, 2002). So whether it is a 2-m or a 3-m gap, it remains a mystery to the secular geologists. They cannot seem to square it with their asteroid theory.

Dinosaur Bones Found above the K-Pg

Sloan et al. (1986) published evidence of dinosaur fossils found above the Hell Creek Formation in Paleocene series rocks. These results also support the interpretation that dinosaur numbers were declining by the end of Hell Creek deposition. Based on the lack of articulated skeletons found in Paleocene rocks, Lofgren et al. (1990) had previously interpreted these "Paleocene" dinosaur fossils as reworked material, where later erosional events dug up the bones and redeposited them in younger sediments. In contrast, Argast et al. (1987) did experimental studies on fossil reptile and dinosaur teeth and found that very little abrasion occurs with transport (reworking). They concluded that it is impossible to tell whether or not these Paleocene fossils were transported.

The presence of dinosaur bones in rocks above the K-Pg boundary is seen in other formations. Dinosaur fossils in sediments above the K-Pg, mostly isolated teeth and bones, but some egg shells, have been found in many locations across the globe—in the United States, China, Bolivia, India, and Peru (Lucas, 2007). It appears the K-Pg was not a "magic" line in the rock record where dinosaurs suddenly disappeared. Clarey and Heim (2012) came to a similar conclusion in their study of K-Pg extinctions of all types of organisms across the world. Landman et al. (2014) also reported that selected ammonite species were found in lower Paleocene series sediments, demonstrating that they did not all disappear at the K-Pg either.

Zuni Megasequence

Megasequence boundaries appear to be very important in understanding both the history of the Flood and secularist paleontologists' perception of extinctions (Snelling, 2014a). The Flood seems to have buried most of the dinosaurs below the level of the K-Pg, but the Zuni Megasequence extends a bit higher, into lowermost Paleocene series deposits (Blakey, 2010). Unfortunately, a "transposing" error shows the top of the Zuni Megasequence too high stratigraphically in Snelling (2014a) and Morris (2012). It seems likely that the top of the Zuni Megasequence, not the K-Pg, marks the true level of the disappearance of dinosaurs in Flood strata. This interpretation also fits better with assumed tsunami-like waves envisioned for the Flood deposits and for the megasequences.

For Flood geology, the relationship of air-breathing terrestrial fauna, the biblical record of their death within the first 150 days of the Flood, and their stratigraphic location in the geologic column has been of considerable interest (Snelling, 2014a). If the Hell Creek Formation represents a later time during the Flood, then we must explain why dinosaur fossils are found in it. It is possible that dinosaurs were able to survive up to this point in the Flood due to the lower volume of sediment accumulation in the first three megasequences, compared to the later megasequences. In fact, preliminary calculations, based on my unpublished 3-D model of sediment volume across the USA, show only about one-third of the Flood sediments were deposited in the early stages of the Flood (the first three megasequences), and most of this was east of the modern Mississippi River. It was the latter part of the still rising Flood, when the sedimentation volume greatly increased (the last three megasequences), especially in the West, that the dinosaurs were trapped in mud and sand and buried.

Dinosaurs Buried in the Later Flood Strata

There are problems with all proposed Flood models, especially in reconciling the timing of biblical events with the stratigraphic location of fossil evidence. Everything from ecological zonation to the rejection of the chronostratigraphic timescale has been proposed, but no solution has been universally accepted (Coffin, 1983; Froede and Akridge, 2013; Ross, 2013; Snelling, 2014a; Walker, 1994). Catastrophic plate tectonics (CPT) has been proposed as an explanation for the observable geology (Austin et al., 1994; Snelling, 2014b) and as an explanation for the megasequences (Snelling, 2014a). CPT is the working model used for the following discussion and interpretations.

After the early stages of the Flood, and after the deposition of the first three megasequences (Sauk, Tippecanoe, and Kaskaskia), the Flood seems to have increased its fury and energy level, depositing nearly two-thirds of its sediment load onto the North American continent. "And the waters prevailed, and were increased greatly upon the earth; and the ark went upon the face of the waters. And the waters prevailed exceedingly upon the earth; and all the high hills, that were under the whole heaven, were covered" (Genesis 7:18–19 KJV).

It was at this point in the Flood, during deposition of the Absaroka and Zuni Megasequences, that the tectonic plates seem to have undergone their most extensive episode of movement and an entirely new ocean crust began to form globally. The new ocean crust would likely have been hotter and less dense than the old, pre-Flood oceanic crust. This would have raised the level of the ocean floor, especially near the ocean ridges, similar to the way hot air causes a balloon to rise (Austin et al., 1994). Some creation scientists have estimated this action alone could have raised global sea level by as much as 1.6 km, greatly helping to flood the land masses (Snelling, 2014b).

Subduction commenced along the west coast of North America (and other locations around the Pacific) during the deposition of the Absaroka Megasequence, pulling down part of the crust of North America along with it (Baumgardner, 2005). This would have created accommodation space for tremendous volumes of sediment on the former land surface. Huge tsunami-like sand waves likely traversed from west to east across much of the continent. Evidence of these large sand waves is found in the thick, cross-bedded sandstones of the Permian and Jurassic system rocks (part of the Absaroka Megasequence) in the western United States.

In this scenario, the dinosaurs would have been quickly inundated by the accumulating wedge of thousands of meters of sediment rapidly deposited across many Western states. Due to elevation differences (see Dinosaur Peninsula in Clarey, 2015), this sediment incursion would have been initially less intense to the north. Thus, the remaining land refuges of the dinosaurs were systematically buried from south to north. This violent event would have also transported large marine vertebrates onto the continent, depositing them in the same sediments as the dinosaurs, and resulting in the intermixing of marine, terrestrial and freshwater fauna found in the Hell Creek Formation.

Post-Flood erosion, including the effects of the Ice Age (Oard, 1990), has removed any later Flood strata (Tejas Megasequence) that were likely deposited on top of the Hell Creek, leaving it exposed at the surface today.

Discussion and Conclusions

The Hell Creek Formation of Montana, North Dakota, and South Dakota (Figure 1) is one of the most intensely studied sedimentary units in North America. It is used, and possibly overused, in the K-Pg extinction debate over why dinosaurs suddenly disappear in the rock record near the end of the Cretaceous system. The nature of the dinosaur extinction remains one of the biggest mysteries in paleontology for secular scientists. It is likewise a mystery for creationists trying to reconcile the timing of Flood events, including the death of the dinosaurs (those not on the ark) in the first 150 days of the Flood, their stratigraphic position, and their post-Flood extinction.

Disagreement over stratigraphic techniques has caused additional problems. Since the advent of the impact hypothesis, scientists have made the stratigraphic location of the Ir anomaly their primary criterion for picking the K-Pg boundary. However, that anomaly is not geographically continuous; it exists only in some locations near the top of the Hell Creek Formation. This reliance on the Ir anomaly has made picking the top of the Hell Creek Formation nebulous. Instead of the traditional criterion of a mappable change in lithology, many geologists try to map the Ir anomaly. In addition to the increased geographic uncertainty, its location a few meters away from the traditional boundary has created differences in the formation top and the K-Pg boundary of several meters, adding to the confusion.

Two points strongly suggest the secular depositional model for the Hell Creek Formation is in error. First, many marine fossils are found throughout the formation, often mixed with terrestrial fossils. The extent of these occurrences has been largely ignored by secular scientists. Second, sedimentary structures indicative of water transport are ubiquitous to the sandstone layers. Rippled layers and cross-bedded sandstones demonstrate active transport was occurring during deposition of each sandstone bed. Standard models cannot account for both the mixed fossil assemblages and the evidence of water transport. Only a Flood model involving ocean-transported, tsunami-like waves can account for the observed mixing of terrestrial and marine environments in the Hell Creek.

In a Flood model, the debate over a sudden or a gradual extinction to the dinosaurs is immaterial. There are no true extinctions as popular literature likes to describe. "Extinctions" are merely the last occurrence of a particular organism in Flood sediments. The Hell Creek Formation does seem to contain fewer and less diverse dinosaur fossils toward the top, and there is the 2–3-m "gap" at the very top with no dinosaur fossils. However, this does not mean dinosaurs were slowly or rapidly dying out as the Hell Creek was being deposited. It shows the general point in the rock record where the last of the pre-Flood dinosaurs succumbed to the rising Floodwaters. And the isolated discoveries of post-Hell Creek dinosaur fossils may suggest that a few dinosaurs were able to survive a bit longer than even the top of the Hell Creek, becoming buried in the lowermost Paleocene Series sediments. This slightly higher stratigraphic level coincides with the end of the Zuni Megasequence, suggesting this event may be more significant in a Flood model than the top of the Hell Creek Formation.

Acknowledgments

This work was supported, in part, by the Creation Research Society's iDINO

research initiative. I also thank ICR for their logistical support and Mary Smith and Davis J. Werner for assistance with the figures. The paper was greatly improved by the careful reviews of Dr. John Reed and Dr. Kevin Anderson.

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