The Proceedings of the International Conference on Creationism

Volume 6
Print Reference: Pages 449-457

Article 36

2008

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Recommended Citation
Whitmore, John H. and Wise, Kurt P. (2008) "Rapid and Early Post-Flood Mammalian Diversification Evidenced in the Green River Formation," *The Proceedings of the International Conference on Creationism*: Vol. 6 , Article 36.
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In A. A. Snelling (Ed.) (2008). Proceedings of the Sixth International Conference on Creationism (pp. 449–457). Pittsburgh, PA: Creation Science Fellowship and Dallas, TX: Institute for Creation Research.

Rapid and Early Post-Flood Mammalian Diversification Evidenced in the Green River Formation

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Abstract

The Eocene Green River Formation (GRF) is a series of basin deposits in Wyoming, Utah, and Colorado (USA), famous for its well-preserved fish and other fossils. The GRF's post-Flood lacustrine status is confirmed by a whole host of geological evidences. Depending on the post-Flood timescale used, the GRF was probably in place between decades to several centuries following the Flood. Its early post-Flood date is confirmed by *Hyracotherium,* the first animals in an intrabaraminic biological trajectory. For having such an early post-Flood date, the rocks of the GRF contain a remarkable disparity of fossils, including a greater mammal disparity than the area currently supports. Present are about 230 families (proxies for baramins) in about 104 orders, representing every kingdom of organisms. Species diversity within baramins seems to have been very low soon after the Flood, suggesting that first-order intrabaraminic diversification may be modeled *following* low diversity biodispersal. This suggests baramins dispersed at low diversity and diversification occurred at the termini of post-Flood dispersion paths.

Keywords
Baraminology, Green River Formation, Wyoming, Diversification, Babel, Eocene, Tertiary, Post-Flood geology, Post-Flood boundary, Post-Flood biogeography, Intrabaraminic diversification

Introduction

The Eocene Green River Formation (GRF) includes a series of laterally discontinuous sedimentary basin deposits in Wyoming, Utah, and Colorado of the USA (Figure 1). It is considered a Lagerstätten and is famous for its well-preserved fish, plants, insects, amphibians, reptiles, birds, mammals and other organisms. Whitcomb and Morris (1961) argued the formation was made during the Flood, primarily because they found it difficult to explain how "varves" (yearly deposited laminated couplets of sediment) and well preserved fossil fish could exist together. They correctly determined that spectacular fish preservation probably meant rapid depositional conditions, assuming that rapid deposition occurred only during the Flood. Recently, the GRF's post-Flood lacustrine origin was debated by creationists (Oard & Whitmore, 2006). We believe its post-Flood lacustrine status is confirmed by a large number of geological evidences (Whitmore, 2006a, 2006c, 2006d; Whitmore & Garner, 2008) and its rapid deposition is confirmed by fish taphonomy (Whitmore, 2003, 2006b).

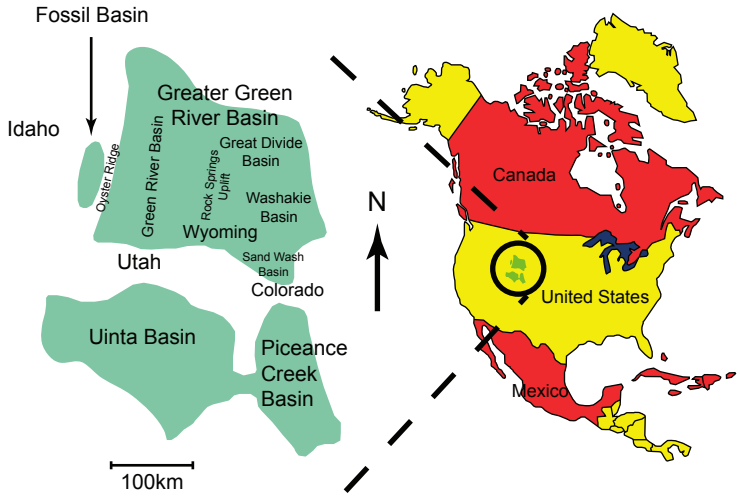

Figure 1. The basins of the Green River Formation in Wyoming, Utah and Colorado. After Buchheim and Eugster (1998).

Creationists have not agreed on a date for the confusion of tongues at Babel because of large differences in the numbers found in the Samaritan, Septuagint, and Masoretic texts of Genesis 11 (for example, Young, 2003). Pleistocene sediments document the oldest post-Flood evidence for wide geographic distribution of humans, even in North America, and thus must post-date Babel. The GRF is near the base of a thick stack of Tertiary sediments in the western United States, all of which must be pre-Babel since they lie below Pleistocene sediments. Depending on the post-Flood timescale used,

we think the GRF may have been in place as early as decades following the Flood. Its early post-Flood date is confirmed by *Hyracotherium,* the first animal in an intrabaraminic biological trajectory (Cavanaugh, Wood, & Wise, 2003). Excellent fossil preservation, low stratigraphic position and great distance from the mountains of Ararat, makes the GRF an incredible window into early post-Flood biogeography and intrabaraminic diversification.

Our GRF study shows that mammal species diversity within baramins seems to have been very low soon after the Flood, suggesting that first-order intrabaraminic diversification may be modeled *following* low diversity biodispersal. This suggests baramins dispersed at low diversity and that diversification occurred at the termini of post-Flood dispersion paths. It seems that soon after the Flood, even at this great distance from Ararat, a tremendous range of terrestrial and fresh-water baramins had been dispersed most of the way around the world.

The Post-Flood Nature of the Green River Formation

The GRF includes a series of lithologically similar basin deposits that outcrop in southwestern Wyoming, northeastern Utah and northwestern Colorado (Figure 1). The GRF represents only a small sample of the dozens of Cenozoic basins throughout the Rocky Mountain region of the west-central United States that formed from rising mountains (Dickinson, Klute, Hayes, Janecke, McKittrick, & Olivares, 1988). Often the GRF occurs as a large lens of sediment within the basins, surrounded by the largely fluvial Eocene Wasatch Formation (Figure 2), making it about the same age as the GRF. Fish and other fossils indicate the basins were primarily filled with freshwater (Grande, 2001), although saline facies occasionally occur as indicated by dolomite and trona (Bradley & Eugster, 1969; Buchheim, 1994; Buchheim & Eugster, 1998). The sediments of the basins are still nearly horizontal, but rest unconformably on folded and thrusted Paleozoic and

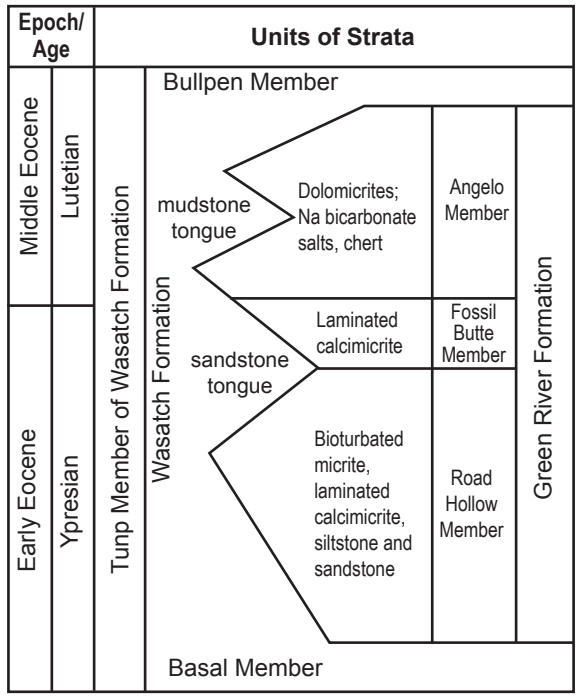

Figure 2. The Green River Formation often occurs as a lens of sediment within the Wasatch Formation, as shown here from Fossil Basin. Adapted and modified from Buchheim and Eugster (1998).

Mesozoic rocks. Figure 3 is representative of this relationship. The geology of the basins is well known because of the rich mineral resources within and surrounding them. These include trona, oil, oil shale, coal and natural gas.

The lacustrine post-Flood origin of the GRF is indicated by a whole host of geological evidences which are detailed in articles by Whitmore (2006a, 2006c, 2006d) and Whitmore and Garner, 2008. Selected evidences will only be summarized here. (1) There is a shift in sedimentation patterns from the Mesozoic to the Cenozoic. Late Mesozoic sediments are, for the most part, extremely widespread and marine, indicating their origin during the Flood. Early Cenozoic deposits are terrestrial and much more localized indicating continental exposure. Cenozoic

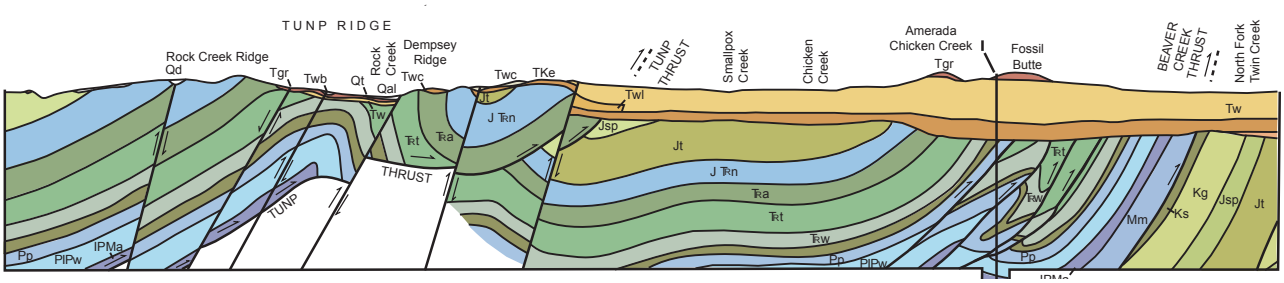

Figure 3. The Wasatch (Tw) and the Green River (Tgr) lie unconformably and nearly undeformed and horizontal on folded and thrusted Paleozoic and Mesozoic Rocks. The structural geology indicates the Laramide uplift and faulting which formed the Rocky Mountains must have occurred mostly before the sediments of the GRF were deposited, since they remain primarily undeformed. This cross section is representative of what lies below the Green River basins. Note the location of Fossil Butte which is near Kemmerer, Wyoming. Part of a west-east cross section (D-D') from Fossil Basin (Rubey, Oriel, & Tracey, 1975).

sediments (including the GRF) contain continental flora and fauna which overlie the marine sediments (Dickinson et al., 1988; Roehler, 1993a) which in part formed as the interior Cretaceous Seaway regressed from the continent (Roehler, 1993c). (2) The Cenozoic basins, and in particular the GRF basins are "basins" because they were formed by various uplifts that surround them. For example, the Greater Green River Basin and Fossil Basin are surrounded by the topographic highs of the Uinta Mountains (south), Wind River Mountains (north), Wasatch Range (west) and various structural highs to the east (Roehler, 1992b). (3) A regional unconformity exists on the top of Paleozoic and Mesozoic rocks (Johnson, 1985), probably formed by retreating Flood waters and erosion of the freshly exposed post-Flood surface. (4) Current directions obtained from cross beds and ripples show sediment transportation toward basin centers within these closed basins, exactly as predicted within a lacustrine model. For example the deltaic facies of Farson Sandstone (Roehler, 1992a) or the Wasatch Formation (Petersen, 1987) show such current directions. (5) All of the GRF basins have sediment characteristics of lacustrine deposition. Modern lakes ideally have a "bull's-eye" pattern of concentric sediments, with coarse sediments along the edges grading to finer sediments in the middle. The GRF basins contain such patterns (Buchheim & Eugster, 1998; Picard & High, 1972). (6) Paleontology indicates a post-Flood lacustrine origin for the GRF. Bird tracks, bird nests, large stromatolites, bioturbated sediments, and large caddis fly mounds only occur around basin margins. The GRF fauna is freshwater (Grande, 1984, 2001) with abundant

Figure 4. An exploded fish from Fossil Basin. Decay gases build up within the fish causing it to explode. In experiments by Whitmore (2003), this phenomenon occurred at depths of 3 m or less. In deeper water, water pressure is sufficient to keep decay gases from erupting. In Fossil Basin, exploded fish are mostly found along the basin's edges, in shallow water. In the deeper water deposits, the phenomenon is less common.

Figure 5. A fossil fish from Fossil Basin, Wyoming. Note the scales that have sloughed off before the fish was buried. Experiments by Whitmore (2003) have shown that this fossil specimen probably lay on the lake bottom for several days before it was entombed by sediments. Specimens like this indicate sedimentation in the GRF was slow enough for specimens like this to form, but fast enough for many fish to be preserved.

fossils disappearing when saline sedimentary phases appear (Buchheim, 1994). Explanation of these paleontological patterns seems impossible unless the basins were centers of active lacustrine deposition following the Flood. (7) Large caddis fly mounds (Leggitt & Cushman, 2001) and stromatolites occur around the perimeters of some basins, especially the Greater Green River Basin (Roehler, 1993b). These in situ features would not have had time to form during the Flood. (8) Patterns of fish taphonomy (Whitmore, 2003) show the margins of Fossil Basin were shallow and the center was deeper. Whitmore demonstrated that some fish along the basin margin exploded due to decay gases erupting in shallow water (Figure 4). The same pattern is not seen in deeper water. Again, the pattern demonstrates a lacustrine setting, not a catastrophic one, having the deposition of the entire GRF within days. Fish decay patterns also demonstrate the passage of time within the sediments. Whitmore (2003) demonstrated that in order for fish to be well preserved, they must be buried soon after death. This is true of the GRF fish. However, contrary to popular belief, most GRF fish are not perfect specimens. Many show various stages of decay indicating some passage of time (days) before entombment (Figure 5).

The Green River Formation in Biblical Time

Although not yet quantified, there is a sense in which the first four post-Flood evidences for the Green River Formation listed above are true world-wide for sediments on either side of the Cretaceous/Tertiary (K/T) boundary: (1 & 2) Austin, Baumgardner, Humphreys, Snelling, Vardiman, & Wise (1994) accepted a K/T boundary for the Flood/post-Flood boundary because of their sense that K/T sediments

worldwide tend to be inter-regional to trans-continental, whereas Tertiary sediments above that boundary tend to be basinal. (3) The most significant unconformity in seismic profiles worldwide, at least in offshore sediments, is one between Cretaceous sediments below and Tertiary sediments above. The K/T boundary very often shows up as a strong reflective boundary because of a substantial decrease in consolidation and deformation across the boundary. (4) Chadwick's paleocurrent data (http://origins.swau.edu/projects/research/geologic/paleocurrent.html) (Chadwick, 2005) suggests trans-continental currents which dominate throughout the Paleozoic and Mesozoic worldwide, break up in the Tertiary. Whereas currents converge on the center of basins in the Tertiary, they cross *through* basins below the K/T. This suggests that the K/T boundary corresponds to the end of the Flood—at least in the Green River Basins, and possibly worldwide.

If we accept the assignment of Lubenow (1992, 2004) and Wise (2002, 2005), *Homo erectus* fossils are the oldest known humans in the fossil record. Since the oldest *Homo erectus* specimens are in Lower Pleistocene deposits, all known human fossils are post-Flood, and thus remains of descendants of Noah. *Homo erectus* is found in such places as the East African Rift valley, China, and Java. This means erectines are dying thousands of miles away from potential ark landing sites and tower of Babel sites. Since man probably did not disperse to such distances until after Babel (compare Genesis 9:7 & 11:4 & 11:8–9), *Homo erectus* fossils should be post-Babel in age. Since the oldest *Homo erectus* fossils are found in the Lower Pleistocene, the youngest stratigraphic position for the Babel dispersion would be the Pliocene/Pleistocene (T/Q) boundary. If the beginning of the Tertiary corresponds to the Flood/post-Flood boundary as argued in the last paragraph, then the Tertiary sediments (worldwide) were deposited in the period between the Flood and the Babel dispersion.

Although the chronogenealogy of Genesis 11:10–32 (Wise, 2002) offers a chronology for post-Flood times, that chronology is only directly connected to the lineage between Shem and Abram, not to the Babel event. Several evidences, however, suggests that the Babel dispersion occurs sometime in the lifetime of Peleg, a great, great grandson of Shem: (1) Because Hebrew historical narratives are often introduced with genealogies (for example, Genesis 5 in the Flood account; Genesis 11:10–32 in the Abraham account; Matthew 1 in the Jesus account), the genealogy of Genesis 10 can be understood to be an introduction to the Babel account of Genesis 11:1–9. This is confirmed by the fact that the genealogy is a list of the people by whom the earth was divided into nations after the Flood (verse 32). This suggests that the Babel dispersion occurred subsequent to the last births recorded in the Genesis 10 genealogy. The Shem genealogy (Genesis 10:10–31) terminates with the births of Peleg's nephews. (2) Whereas before the Babel dispersion "the earth was of one language" (Genesis 11:1), in the days of Peleg 'the earth was divided' (Genesis 10:25; 1 Chronicles 1:19). (3) Until recent centuries, the traditional understanding of the church has been that Peleg's division corresponds to Babel dispersion. (4) If Genesis 10:25 and 1 Chronicles 1:19 do not refer to Babel, then Babel would be one of the few major events in Genesis not directly linked to biblical chronology. Although it is most likely it occurred in Peleg's prime, the Babel dispersion could have occurred at any time during the life of Peleg. The naming of Peleg (Genesis 10:25) could have been prophetic of an event anytime during the life of Peleg, such as was the naming of Noah was prophetic of an event 600 years after his birth (compare Genesis 5:28–29 and 7:6). Furthermore, Peleg's brother Joktan—and even Joktan's sons—could have been born before Peleg, just as Haran was most probably a much older brother of Abram (Genesis 11:27–28), in spite of being listed second among Terah's sons (Genesis 11:26–27).

Because of different numbers in the Masoretic, Samaritan, and Septuagint manuscript traditions, calculations vary on the times of Peleg (see Table 1). The likelihood that Kainan II was not original to the Septuagint text (see, for example, Fetter, 1956; Freeman, 1998; Ray, 1985), combined with the limited attestation of the larger variants in the Septuagint text (see Ray, 1985), suggests that the largest likely numbers are those derived from the accepted version of the Septuagint, less Kainan II. This means that the time between the Flood and the birth and death of Peleg is 101 and 340 years, respectively, in the short chronology, and 401 and 870 years, respectively, in the long chronology. Using similar reasoning, and assuming that Abram enters Canaan immediately after the death of Terah, the time from the Flood to Abram entering Canaan is between 427 and 1077 years, respectively.

Using this logic, it appears that the end of the Tertiary should date between 101 to 870 years following the Flood. The GRF occurs stratigraphically early during Tertiary time, so it would appear that the GRF represents a snapshot in time not more than a few decades or centuries following the Flood. Even though we are certain our lacustrine interpretation of the GRF is secure, additional geological work will have to be completed to see if this short amount of time can be reconciled within the rocks of the Green River strata. However, our current understanding of biblical chronological data seems to lead in this direction.

Table 1. Post-Flood chronology according to different textual traditions.

	Masoretic Text	Samaritan Pentateuch	Septuagint	Septuagint variants	Maximum
Flood to birth of Arphaxad	2	2	2	2	2
birth of Arphaxad to birth of Kainan II	35	135	135	135, 35	135
birth of Kainan II to birth of Salah	0	0	130	139, 135, 130	139
birth of Salah to birth of Eber	30	130	130	130, 30	130
birth of Eber to birth of Peleg	34	134	134	170, 140, 135, 134, 104, 34	170
birth of Peleg to birth of Reu	30	130	130	170, 140, 135, 134, 130, 30	170
birth of Reu to death of Peleg	209	109	209	250, 209, 208, 207	250
birth of Reu to birth of Serug	32	132	132	132, 32	132
birth of Serug to birth of Nahor	30	130	130	135, 130, 30	135
birth of Nahor to birth of Terah	29	79	79	209, 179, 79, 70, 29	209
birth of Terah to death of Terah	205	145	205	250, 205, 75, 5	250
Flood to birth of Peleg	101	401	531		576
Flood to birth of Peleg (w/o Kainan II)	101	401	401		437
Flood to death of Peleg	340	640	870		996
Flood to Abram entering Canaan	427	1017	1077		1333

Mammalian Diversity in the Green River Formation

The Flood narrowed the diversity of unclean terrestrial animals to one pair per kind and clean animal diversity to seven or seven pairs per kind (Genesis 7:2–3). By the end of the Flood this diversity and any of its progeny were geographically restricted to the ark's landing site in the mountains of Ararat. Terrestrial animals in the Green River sediments would be descendants of ark survivors and would allow minimum estimates of biological dispersion rates from the ark. Any species diversity within created kinds beyond that possible on the ark would represent post-Flood intrabaraminic diversification and would allow calculation of minimum intrabaraminic diversification rates.

Probably because it is primarily a lake deposit (other facies besides lacustrine are recognized within the GRF), terrestrial animals are extremely rare in the Green River Formation (Grande, 1984). In spite of that, between 120 and 154 terrestrial mammal species are currently known as fossils in the GRF (see Table 2), representing 85 genera in 41 families in 16 orders (an average of 2.6 families/order, 2.1 genera/family, 1.4–1.8 species/genus). Interestingly enough, this is just a greater disparity and a bit smaller diversity than is currently known among extant mammals in the state of Wyoming (117 species in 61 genera in 21 families in 7 orders, for an average of 3.0 families/order, 2.9 genera/family, 1.9 species/genus) (http://www.mammalsociety.statelists/wyoming.html).

The most recent baraminogical research (for example, Wood, 2005) continues to suggest that the baramin is roughly equivalent to the family of modern biosystematics. Some baramins (for example, Chelonia baramins) appear to include multiple families and some families may contain multiple baramins, but to a first approximation the family should be useful as a proxy for the created kind. Using the family as a proxy, the Green River Formation has preserved specimens from 41 terrestrial mammal baramins. The average baramin contains 2.1 genera and 2.9–3.8 species. Since no Ruminantia are known from the Green River Formation, all Green River mammals seem to be unclean animals. This means that intrabaraminic diversity evidenced in the Green River Formation had to have been generated from just two animals which entered the ark not very many years before.

Discussion

The Green River Formation is located half way around the world from where the ark landed. Furthermore, given that it is primarily a lacustrine deposit, the Green River Formation is biased against and thus almost certainly under-represents the true diversity of terrestrial animals. Yet, preserved within it are more than twice as many mammal orders and nearly twice as many mammal baramins (using the

Table 2. Mammal species in the Green River Formation. References: 1: Paleodatabase (http://paleodb.org); 2: Krishtalka & Stucky (1984); 3: Grande (1984); 4: Zonneveld, Gunnell, & Bartels (2000); 5: Unpublished data from A. Aase; 6: Honey (1988); 7: Grande & Buchheim (1994); 8: Froehlich & Breithaupt (1998); 9: Nelson, Madsen, & Stokes (1980).

unnamed therian family		*Proviverroides cf. piercei*	1,2	*Cantius venticolus*	6
Aethomylos simplicidens	1,2	*Sinopa major*	1,2	*Copelemur australotutus*	5
Didelphidae		*Sinopa rapax*	1,2,3,5	*Notharctus matthewi*	3,5
Armintodelphys dawsoni	1,2	*Tritemnodon cf. agilis*	1,2	*Notharctus robinsoni*	1,4,5
Copedelphys innominata	1,2,3,4,5	*Tritemnodon gracilis*	2	*Notharctus sp.*	1,3
Herpetotherium knighti	1,3,5	**Viverravidae**		*Notharctus cf. tenebrosus*	1,2
Herpetotherium marsupium	1,2,4,5	*Didymictis protenus*	5	*Smilodectes cf. gracilis*	1
Peradectes chesteri	1,2	*Didymictis sp.*	1	*Smilodectes gracilis*	1,2
Leptictidae		*Viverravus eucristadens*	3,5	*Smilodectes mcgrewi*	1,4,5
Palaeictops bicuspis	4	*Viverravus gracilis*	1,2	**Omomyidae**	
Palaeictops bridgeri	1,2	*Viverravus minutus*	1,2,3,4,5	*Anaptomorphus aemulus*	1,2
Ischyromyidae		*Viverravus sicarius*	1,2	*Omomys carteri*	1,2,4,5
Microparamys minutus	1,2,3	*Viverravus sp.*	5	*Omomys lloydi*	1,2,3
Microparamys sp.	5	**Canidae**		*Omomys pucillus*	3,5
Paramys copei	4,5	*Procynodictis cf. vulpiceps*	1	*Omomys sp.*	1
Paramys delicatus	1,2,3,5	**Miacidae**		*Tetonius nettingi*	3
Paramys cf. delicatus	3	*Miacis gracilis*	3,5	*Tetonius sp.*	1,3,5
Paramys excavatus	5	*Miacis cf. parvivorus*	1	*Tetonius wortmani*	4
Paramys sp.	3	*Miacis sp.*	5	*Uintanius ameghini*	1,2
Pseudotomus sp.	1,2,5	*Oodectes sp.*	1,2	*Utahia kayi*	1,2,3
Pseudotomus cf. robustus	3	*Uintacyon cf. major*	1,2	*cf. Utahia kayi*	3
Tapomys parvus	1,4,5	*Uintacyon sp.*	5	*Washakius insignis*	1,3,4,5
Thisbemys sp.	1,3,5	*Vulpavus australis*	3,5	*Washakius laurae*	1
Sciuravidae		*Vulpavus canavus*	4,5	**Uintatheriidae**	
Knightomys depressus	4,5	*Vulpavus profectus*	1,3,5	*uintatheriid*	6
Pauromys sp.	1,2,3	**unnamed erinaceomorph family**		**Hyopsodontidae**	
Sciuravus eucristadens	1,2,3	*Talpavus nitidus*	1,2,3,5	*Apheliscus insidiosus*	5
Sciuravus nitidus	1,2,5	*Talpavus sp.*	2	*Haplomylus scottianus*	5
Sciuravus sp.	2,3	**Diacodontidae**		*Hyopsodus lepidus*	1
Palaeoryctidae		*Diacodon alticuspis*	5	*Hyopsodus minisculus*	1,2,3,4,5
Eoryctes	2	**Sespedectidae**		*Hyopsodus paulus*	1,2
Apatemyidae		*Crypholestes sp.*	1,2	*Hyopsodus sp.*	5,6
Apatemys cf. bellulus	1,2	*Scenopagus edenensis*	1,2	*Hyopsodus vicarius*	3,5
Apatemys cf. bellus	1,2	*Scenopagus priscus*	1,2	*Hyopsodus wortmani*	4,5
Apatemys chardini	5	**Geolabididae**		**Phenacodontidae**	
Apatemys cf. rodens	1,2	*Centetodon bembicophagus*	1,2	*Ectocion superstes*	5
Stylinodontidae		*Centetodon pulcher*	1,2	*Meniscotherium chamense*	4,5
Ectoganus sp.	5	**Nyctitheriidae**		*Phenacodus trilobatus*	5
Tillotheriidae		*Nyctitherium serotinum*	1,2,3	**Mesonychidae**	
Esthonyx sp.	6	*Nyctitherium sp.*	3,5	*Mesonyx sp.*	1,5
Esthonyx spatularius	5	**undescribed chiroptera family**		*Mesonyx? sp.*	4
Trogosus sp.	1,2,3,5	*nov. gen. nov. sp.*	3,5	**Dichobunidae**	
Coryphodontidae		**unnamed chiroptera family**		*Antiacodon diacodexine*	2
Coryphodon sp.	1,5	*Ageina sp.*	1,2	*Antiacodon homacodontine*	2
Pantolestidae		**Archaeonycteididae**		*Antiacodon pygmaeus*	1,2,3
Palaeosinopa lutreola	5	*Icaronycteris index*	1,3,5	*Bunophorus macropternus*	5
Palaeosinopa sp.	4	**Microsyopidae**		*Diacodexis metsiacus*	5
Pantolestes cf. longicaudus	1,2	*Microsyops cf. elegans*	1	*Diacodexis secans*	4,5
pantolestid?	7	*Microsyops elegans*	1,3,4,5	*Hexacodus uintensis*	5
Epoicotheriidae		*Microsyops latidens*	5	*Microsus cuspidatus*	1
Tetrapassalus sp.	1,5	*Microsyops scottianus*	4,5,6	*nov. gen. nov. sp.*	5
Metacheiromyidae		*Microsyops sp.*	1,2,3,6	**Perissodactyla**	
Metacheiromys sp.	1,4,5	*Uintasorex cf. parvulus*	1	*undescribed perissodactyl*	3
Palaeanodon sp.	4,5	*Uintasorex parvulus*	1,2,3,5	*undescribed perissodactyl*	8
Hyaenodontidae		**Paromomyidae**		**Equidae**	
Limnocyon cf. verus	1,2	*Phenacolemur jepseni*	4	*Hyracotherium vasacciense*	1,2,4,5
Prolimnocyon sp.	5	**Adapidae**		*Hyracotherium sp.*	3
Prolimnocyon? sp.	4	*Cantius frugivorus*	5,6	*Orohippus cf. pumilus*	1,4,5

Table 3 (continued).

Prototomus secundaria	5	*Cantius cf. nunienus*	1,4,5	*Orohippus*	3
Equid	6	*Palaeosyops fontinalis*	1,4,5	*Helaletes nanus*	1,2
Brontotheriidae		*cf. Mesartirhinus*	3	*Helaletes*	6
Duchesneodus uintensis	1,9	**Hyracodontidae**		*Heptodon sp.*	1
Lambdotherium cf. popoagicum	1	*Hyrachyus modestus*	1,2	**Isectolophidae**	
Lambdotherium popoagicum	1,4,6	*Hyrachyus sp.*	1,3,4,5	*Homogalax protapirinus*	5
Lambdotherium sp.	1,3	**Helaletidae**			

family as a proxy for the baramin) as are known from the wide diversity of environments represented today in the entire state of Wyoming. The intrabaraminic diversity is a bit less than that of Wyoming mammals, but even that may be an artifact of preservation bias. The evidence suggests that by the time the Green River Formation was deposited, a wide variety of terrestrial mammals had already made it to the farthest reaches of the world, and had reached a level of intrabaraminic diversity comparable to that seen today.

As for the timing, we do not yet know when in the life of Peleg the Babel dispersion occurred. If we choose the midway point in the life of Peleg as the most likely time for the Babel dispersion and we accept the short chronology, merely because of the popularity of the *Textus Receptus*, then the Green River sedimentation began within decades after the Flood and may have been complete as early as several decades following the Flood. This means that worldwide distribution of terrestrial animals may have been achieved in less than a century. Intrabaraminic diversification may have had a generic doubling time on the order of a dozen years or so and a specific doubling time on the order of a decade.

Since we believe there is good geological evidence for the post-Flood origin of the GRF and good biblical evidence to support that it probably was deposited within decades to centuries following the Flood, a few challenges arise. For example, it is not difficult to understand how some of the smaller mammals rapidly diversified and multiplied after the Flood, because many of them have large litters, short gestation times, and reach sexual maturity at a young age. But it is more difficult to understand how larger mammals (like the Equidae) which currently have gestation times of many months and several years to sexual maturity could have multiplied quickly enough to have been preserved in the GRF within decades after the Flood. It may well be that God chose baramin representatives to enter the Ark which multiply much more rapidly than modern representatives. For example, baramins which contain large animals in the present are represented in Lower Tertiary sediments by small species (for example, Hyracotherium in the equid baramin). Such species probably had shorter generation times and larger litters. How this and other factors may have contributed to rapid post-Flood diversification is a fertile area for creationist research.

In order to better define the amount of time which is actually available for diversification, creationists also need to develop reliable dating processes for Tertiary sediments and fossils. For example, the initial conclusions of the RATE project (Vardiman, Snelling, & Chaffin, 2005) suggest that radiometric decay rates have changed through time. This suggests that creationists might be able to develop a radioisotope-based dating method which fits biblical chronology. If we assume, for example, with Vardiman (Austin et al., 1994; Vardiman, 1996), that radioisotope decay rates dropped exponentially following the Flood, approximate translations can be made between radioisotope years in the Tertiary and solar years in Scripture ($y=y_o e^{-rx}$ where y is the radioisotope age (in years) before present [rybf], y_o is the radioisotope age of the end of the Flood [rybf], and x is the biblical age after the Flood [byaf]). Three (x,y) points can allow the calculation of such a curve. In this particular case these three points would be the end of the Flood, Babel, and the time of Solomon—the lattermost being the time when ^{14}C and dendrochronological dates correspond in Bristlecone Pine samples. Using the radiometric dates from McKenna & Bell (1997), the three points would be (65 million rybp, 0 byaf), (1.77 million rybp, Peleg date byaf), and (3000 rybp, Abram date byaf+1,000). Babel's position ranging between the birth and death of Peleg in each of the short and long chronologies allow for the calculation of four curves (Table 3). These curves can then be used to

Table 3. Estimation of decay constants (r) of radioisotope/biblical ages and estimation of the beginning and ending of Wasatchian sedimentation for long and short chronologies and early and late dates for Babel.

Chronology	Babel	Babel (byaf)	Abram (byaf)	r	Beginning of Wasatchian (byaf)	End of Wasatchian (byaf)
short	Peleg's birth	101	427	0.0354	4	7
short	Peleg's death	310	427	0.01159	13	22
long	Peleg's birth	401	1077	0.00897	17	28
short	Peleg' death	870	1077	0.004141	38	61

estimate biblical dating for total time of Green River sedimentation (55.5 to 50.3 rybp: McKenna & Bell, 1997). The results are, that in the short chronology, Green River sedimentation took between 3 and 9 years of time, beginning as early as 4 years to as late as 13 years after the Flood depending upon whether Babel occurred early or late in the life of Peleg. In the long chronology, Green River sedimentation took between 11 and 23 years, beginning as early as 17 years to as late as 38 years after the Flood depending upon when in the life of Peleg Babel occurred. Perhaps this particular method provides too brief an interval for the amount of dispersion observed in the GRF, but approaches like this may eventually give a realistic picture of the timing of the GRF and other early post-Flood events.

Avenues of research suggested by our conclusions would include further exploration of rapid post-Flood dispersal mechanisms, such as Wise and Croxton (2003) have done and further investigation into biblical chronology so as to determine whether the original autographs of Scripture contained the short or the long chronology.

Acknowledgments

The authors would like to thank A. Aase for sharing an unpublished list of Green River taxa and our reviewers for giving helpful suggestions on improving the manuscript.

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