A DILUVIAL INTERPRETATION OF THE CYPRUS HILLS FORMATION, FLAXVILLE GRAVEL, AND RELATED DEPOSITS

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KEYWORDS
Cypress Hills, Flaxville, erosion surfaces, gravel, biostratigraphy

ABSTRACT

Much of the Northern Plains Physiographic Province is characterized by extensive, planar erosion surfaces. Many of these surfaces are capped by gravel showing evidence of fluvial transport. This paper provides a description of the Cypress Hills Formation, Flaxville gravel, and related deposits. These deposits are very difficult to explain within uniformitarian geomorphological theory. A diluvial interpretation provides a superior explanation for the origin of these deposits. Implications of this interpretation are summarized, including problems with traditional age dating, likely formative processes for similar features found throughout the world, and the probable location of the Flood/post-Flood boundary in the geologic record.

INTRODUCTION

Planar erosion surfaces cover large portions of Montana, U.S.A., and adjacent areas. According to Bates and Jackson, an erosion surface is: "A land surface shaped and subdued by the action of erosion, esp. by running water. The term is generally applied to a level or nearly level surface" [9, p.170]. Notice in this definition that the surface is generally believed to have been eroded by running water, and that the surface has to be either level or nearly level. The surface, therefore, can be gently tilted. It is important to remember that an erosion surface is cut into hard rock or sometimes into unconsolidated sediments by some erosive mechanism. It is not a planar surface of deposition or aggradation, such as terraces, flood plains, or alluvial fans. Erosion surfaces are recognized within a sedimentary sequence by an angular unconformity, but in this paper, we will concentrate on generally planar surficial erosion surfaces. There are several geomorphological signatures for the recognition of surficial erosion surfaces [26, 65]. The best signature is a planar surface that is indifferent to structure, bevelling both hard and soft rocks evenly. These surfaces should be unequivocal to both geologists and laymen. Erosion surfaces can sometimes be recognized by the accordancy of the summits of mountains in an area. This accordancy may represent a dissected erosion surface. However, this geomorphological signature is equivocal unless remnants of the flat surface can be identified at the tops of the mountains. Erosion surfaces can also be parallel to the strata, such as the tops of some buttes and mesas. An interesting erosion surface is the type that planes soft rocks:

It may, therefore, astonish some persons to note that certain of the stripped plains are made in part on very unresistant formations, such as the Mancos shale. Evidently, the process of making the flat land is not in the least influenced by local unresistance [26, p.207].

Erosion surfaces were first observed and reported in Montana late in the last century and culminated in the descriptive work of William C. Alden [1,2]. In general, the erosion surfaces are remarkably flat and truncate subjacent rock units. In most cases, bedrock consists of gently dipping sedimentary strata, though other structures, including plutons, have also been sheared by erosion. The erosion surfaces are typically covered with a deposit of coarse gravel, from a veneer a few centimeters thick to a cap many meters thick. They commonly occur as topographic highs in the Northern Plains Physiographic Province. Erosion surfaces also extend westward into the intermontane basins at the northern edge of the Basin and Range Province. These erosion surfaces are normally called pediments, outcropping at the foot of mountains or mountain ranges. Small planar erosion surfaces are also present on the tops of high mountains in several Montana mountain ranges. These erosion surfaces have been locally dissected and eroded by subsequent processes. Establishment geologists have long puzzled over these features, and myriad attempts have been made to explain them. This study emphasizes the two highest erosions surfaces on the high plains: the Cypress Hills and the Flaxville Plain. The data presented in Figure 1 were derived from our field observations and from several published sources [1, 18, 35, 44, 57, 76, 77, 83, 84, 101].
Paleocurrent Rose Diagram for Cypress Hills Formation from Vonhof

Cypress Hills Formation
Flaxville Gravels; in vicinity of Swift Current, Saskatchewan. Undifferentiated Swift Current Creek Beds and Cypress Hills Formation/Reworked Cypress Hills Formation
Related Deposits: Reworked Cypress Hills Formation, Wood Mountain Gravel, Minor Deposits (undifferentiated)

Map of Study Area
FIGURE 1
CYPRESS HILLS EROSION SURFACE

The Cypress Hills are large erosional remnants located in southeastern Alberta and southwestern Saskatchewan, Canada (Figure 1). They extend approximately 130 km east-west and in plan view are wedge shaped, being about 5 km wide at the western edge and about 30 km wide at the eastern edge. The Cypress Hills are coarse-gravel-capped plateaus (Figure 2) that are "remarkably flat-topped" [16, p.75]. The structure is a broad, eastward plunging anticline [35, pp.125,126]. The elevation of the Cypress Hills is 1466 meters ASL at the western end, sloping eastward at about 2.7 m per km [101, p.145], to 1070 meters ASL at its eastern end. The western end is about 300 meters above the surrounding plains and more than 600 meters higher than the Milk River to the south and the South Saskatchewan River to the north. The eastern end is about 100 meters above the plains and 215 meters above the rivers.

The Cypress Hills likely were continuous before dissection by subsequent (probably glaciofluvial) processes [102, 103]. The top 100 meters of the western Cypress Hills were never glaciated [20]. One north-south gap 10 km wide and about 100 m deep separates the western Cypress Hills from the central Cypress Hills. Within this gap, hummocky till and large crystalline erratic boulders are common. The eastern Cypress Hills are covered with a thin veneer of hummocky till with little evidence of glacial erosion of the plateau. Taking into account the meltwater channels, the Cypress Hills once covered an area of about 4000 km² [24].

The most striking feature of the Cypress Hills plateau is the coarse gravel cap (locally cemented to conglomerate), which averages 40 meters thick, called the Cypress Hills Formation (Figure 3) [101, p.143]. The coarse gravel or conglomerate is massive, poorly sorted, imbricated, and clast supported with few fine-grained interbeds in the western and central Cypress Hills [58, p.1920; 80, pp.110-111; 81; 107].

The average thickness of the gravel in this area varies from 15 to 30 m on the Ravenscrag Formation (locally Frenchman Formation), which consists mostly of soft silt and clay with minor cross-bedded sandstone [35]. The gravel rests on a slightly uneven erosion surface with a relief of less than 15 meters that has an eastward slope of 3.8 m/km [58, p.1919]. In the eastern Cypress Hills, the coarse gravel is estimated at up to 75 m thick [101, p.143], although some investigators estimate the maximum thickness at 150 m [24, p.66].

The eastern area contains many more sandy interbeds with local deposits of unstratified mixed sediments interpreted by some as debris flow (bank collapse) deposits [58, 90]. The presence of fine-grained interbeds may explain the greater thickness of the eastern Cypress Hills Formation. In a few locations, the erosion surface bevels steeply dipping sedimentary rocks [109, p.69]. Steep slopes separate the plateau from "pediment-like" erosional surfaces that slope more gently away from the plateau [8; 49, p.218; 103] to the level of the plains, which is also a generally flat erosional surface that bevels the sedimentary rocks [22, p.186].
A distinctive suite of gravel lithologies forms the gravel cap on the Cypress Hills. The predominant rock type is quartzite, ranging in color from tan to red, sometimes mottled or banded. At all of the outcrops observed, the quartzite constituted over half of the mass. Nearly all of the largest clasts are quartzite, and 90% of the clasts in the western Cypress Hills are quartzite [58, p. 1920]. The quartzite is very hard, well rounded, and about 50% of them exhibit percussion marks, which are circular to semicircular cracks about 3 cm wide and 5 mm deep [58, p.1925]. The largest clast observed by the authors has an a-axis of 39 cm and a b-axis of 24 cm and weighed 26 kg. Hard, siliceous sandstone; maroon argillite; gray to tan chert; and igneous rocks form most of the remaining lithologies. The igneous lithologies are varied, but are mostly phaneritic and often porphyritic. Syenite is probably the most common igneous lithology, which could have been transported from the mountains to the south or southwest [58]. Clasts composed of minor lithologies are also well rounded. Nearly all of the rocks exhibit a uniform patina of iron oxide with the exception of sandstone concretions. The concretions consist of moderately soft, buff to light brown sandstone with parting lineation commonly perpendicular to the short or long diameters (c-axis or a-axis) of the concretion. They are identical to concretions observed in the subjacent Ravenscrag Formation or Frenchman Formation [35, p.94] and were observed in the western Cypress Hills. In many of the outcrops observed, the gravel forms an unconsolidated surficial deposit; elsewhere, it is lime cemented and forms a limestone conglomerate, usually matrix-supported. Kupsch and Vonhof [56] suggest this cement is of post-depositional origin, but personal observation of pockets of gravel devoid of matrix within matrix-supported conglomerate suggests the calcite cement is primary.

All the lithologies observed, with the exception of the relatively soft Ravenscrag/Frenchman concretions, are exotic. Paleocurrent analysis, based on cross-bedded sands and clast imbrication, indicates a general northeast to east-northeast flow (average direction 078° or N78E according to Vonhof [101, p.146]) for the Cypress Hills Formation (Figure 1). The bimodal distribution is typical of planar cross-bedding and is not indicative of a bimodal current system [38]. Leckie and Cheel [58] studied paleocurrent indicators at greater detail; their observations differ little from Vonhof [101]. The clasts also decrease in average size from west to east. Vonhof [101, p.154] has measured the b-axis of clasts decreasing eastward from 70% greater than 3.2 cm to 20% greater than 3.2 cm in 100 km. The nearest upcurrent source for the exotic rocks, based on inferred paleocurrent direction and distinctive igneous lithologies, is either the northern Rocky Mountains of Montana [101], 300 km distance from the western edge of the Cypress Hills, or central Idaho, 500 km away [58, p.1926].

**FLAXVILLE EROSION SURFACE**

The Flaxville erosion surface crops out as a belt of large plateaus within an area 300 km east-west by 80 km north-south in north central and northeastern Montana (Figure 1). The plateaus correlated as the Flaxville erosion surface [1] likely were once continuous as indicated by concordant surfaces and by similar clasts on the plateaus and within the soils in the valleys that dissect them. The elevation of the western edge of the plateau surface is 975 m ASL, approximately 100 m lower than the eastern edge of the Cypress Hills 100 km to the north. The eastern end of the Flaxville erosion surface lies at an elevation of 800 m ASL, which results in an average east-west slope of 0.7 m/km [46]. The surfaces of the plateaus are remarkably...
flat. The erosion surface is capped by gravel that varies in thickness from about 1 m to as much as 30 m [19, 21, 47, 96].

The gravel observed by the authors on the Flaxville plain is identical to that described for the Cypress Hills with the exception of additional crystalline lithologies and the absence of Ravenscrag/Frenchman concretions [89]. Some of the observed exposures of Flaxville gravel appeared to have a larger percentage of small pebbles and more common sand interbeds than were observed in the Cypress Hills Formation. The nearest source for the predominant lithologies making up the Flaxville gravel is the Rocky Mountains 400 km away. This indicates that the gravel has been transported approximately 700 km to the eastern edge of the Flaxville erosion surface!

RELATED DEPOSITS

Gravel indistinguishable from that of the Cypress Hills is commonly found on the plains of southern Alberta and Saskatchewan and may be what has been called either the "Saskatchewan Gravels" [109, p.71] or the "redeposited Cypress Hills formation" [101] or both (Figure 1). Smaller hills and plateaus capped with a veneer of similar gravel are also located east and south of the Cypress Hills [109, p.69; 105]. These plateaus include the Swift Current Plateau, about 70 km east-northeast, and the Wood Mountain Plateau, approximately 170 km east-southeast of the Cypress Hills [78, 79, 86].

The Flaxville gravel is very much like the Cartwright gravel, exposed around Williston, North Dakota, and the Crane Creek gravel, found at lower elevations of northeast Montana [46]. Cypress-Flaxville type rocks (well-rounded quartzite with percussion marks, chert, etc.) can also be found capping mesas along the edge of the Missouri Coteau in northwest North Dakota [45]. Alden [1, p.8] claims that these distinctive rocks can be traced as much as 230 km east of the northeast corner of Montana along the 49th parallel. These rocks have thus been transported at least 1000 km from their nearest source in the Rocky Mountains!

UNIFORMITARIAN GEOMORPHOLOGICAL HYPOTHESES

The problem of explaining the Cypress Hills and Flaxville erosion surfaces boils down to explaining the remarkably flat erosional remnants with their gravel cap composed of pebbles and cobbles transported many hundreds of kilometers over a low slope. Many geomorphological hypotheses have been proffered in an attempt to explain these features. Perhaps the most popular hypothesis was the one developed by William Morris Davis around the turn of the 20th century. Based on his observations of the flat plains of eastern Montana [26, p.171], he visualized the "cycle of erosion," or "geographical cycle" in which a landscape is tectonically uplifted, dissected by rivers and streams, and then flattened to a "peneplain" [29]. Davis strongly believed in the theory of evolution and held that the doctrine of the Flood had to be overthrown first before landforms could be understood: "The emancipation of geology from the doctrine of catastrophism was a necessary step before progress could be made towards an understanding of the lands" [29, p.77]. Davis's hypothesis was widely accepted and taught in America (and still is), but it is vague, qualitative, and based on a number of unreasonable assumptions [93]. Other than observations of planar erosion surfaces, it was not based on field work, and Davis could not give any current examples of peneplains at base level or sea level [64]. When pressed on these points, Davis [29] simply pointed out the innumerable flat surfaces that grace the landscape of the earth - a logical fallacy of begging the question. It is important to understand that Davis actually envisioned the peneplain as a "rolling surface of low relief, and not a flat surface" [93, pp.458-459]. Achieving flatness is at least an order of magnitude more difficult and time consuming than eroding mountains down to a rolling plain, and some geologists also have pointed out that a generally flat plain could not be achieved in the "cycle of erosion" [23]. Besides, renewed uplift would likely commence before the old age cycle would even begin. Davis's hypothesis especially falters in attempting to explain multiple erosion surfaces at different levels in an area [26, pp.176-178; 27, p.107], as observed in northern Montana and southern Canada, because the higher "peneplains" should be destroyed during the development of the lower ones.

Since the time of Davis, many other geomorphological hypotheses have been developed to explain erosion surfaces. All of them have serious problems [26, 93]. Crickmay [26] recognizes many of the unsolved problems explaining flat landforms; for instance, any kind of wasting roughens a surface, and precipitation tends to form rills and coulees on flat land, rather than preserve the flatness. He admits the difficulty for present processes to explain the abundance of flat land, especially since the past erosional process planed both hard and soft rocks equally. He realized that only water can produce flat land [26, p.217]. In fact, processes that cause flat land do not appear to be occurring today [26, p.140]. Consequently, Crickmay...
[26,27] has developed his "hypothesis of unequal activity" in which a stream or river erodes laterally over a low-relief flood plain of tens to hundreds of kilometers wide. The river deposits coarse gravel on a wide plain, then due to a lowering of base level, the rivers subsequently cut down to a new plain, leaving behind erosional remnants of the depositional surface. These erosional remnants are then eroded little over millions of years. Crickmay admits his idea is simply an hypothesis based on his observation of gravel-capped erosional plateaus. Thus, his hypothesis is not so much a mechanism as an explanation, like punctuated equilibrium is an explanation of small gaps in the fossil record rather than a demonstrated mechanism.

There is another problem with Crickmay's hypothesis and similar hypotheses of other workers: how the gravel was transported many hundreds of kilometers from its probable source in the Rocky Mountains over a low slope. The problem of spreading gravel on erosion surfaces has been little reported or addressed. Torrential streams that swept back and forth over a flood plain hundreds of kilometers wide are envisioned [1]. But how can this occur over a low slope? Besides the basic problem of transporting all this gravel far, the problem is compounded by the sinuosity of the "river." So, the slope would be even lower. Deposits characteristic of observed fluvial processes differ markedly from the vast gravel caps in the study area.

All mainstream geological hypotheses attempting to explain generally flat, gravel-capped erosion surfaces fall considerably short because they have numerous weaknesses:

The difficulty that now confronts the student is that, though there are plenty of hypotheses of geomorphic evolution, there is not one that would not be rejected by any majority vote for all competent minds. This situation is in itself remarkable in a respectable department of science in the latter half of the 20th Century [26, p.192].

Crickmay goes on to state:

A century and a half of literature bearing on scenery and its meaning shows primarily the inspired innovations that carried understanding forward; followed in every case by diversion from sound thinking into inaccuracy and error [26, p.201].

In view of the failure of mainstream geology over the past 100 years to explain large, surficial erosion surfaces, perhaps it is time to bring back the "doctrine of catastrophism" that was rejected by Davis.

CATASTROPHIC EROSION BY WIDESPREAD SHEET FLOW FOLLOWED BY CHANNELIZED FLOW

About 1000 m of sedimentary rocks have been eroded from the plains of Montana and the surrounding regions [68, pp.261-262]. This is inferred from many plutons protruding well above the surface, such as Devils Tower in northeast Wyoming, and many remnant sedimentary plateaus, such as the Cypress Hills and Flaxville erosion surfaces. It is possible that the Cypress Hills erosion surface once extended from Canada southward into northern Wyoming. Alden [1] correlated the Cypress Hills erosion surface, Bench Number 0, to gravel-capped erosional surface remnants on Sheep Mountain, east-central Montana (105°W, 47°N), 425 m above the Yellowstone River; on Pine Ridge, south-central Montana (108°W, 46°N), 335 m above the Big Horn River; and on Tatman Mountain, in the middle of the Bighorn Basin, north-central Wyoming (109°W, 44°N), 375 m above the Greybull River. Therefore, it is likely the Cypress Hills represents a remnant of a surface about 500 km east-west and more than 1000 km north-south with a gentle eastward slope extending from the Rocky Mountains.

The Flaxville erosion surface is Alden's Number 1 bench and lies one to two hundred meters below the Cypress Hills erosion surface. Alden [1] extrapolated the Flaxville surface westward across a gap of about 300 km to several small plateaus east of Glacier National Park (Figure 1). Alden also correlated the Flaxville erosion surface to many other benches and plateaus, mostly gravel-capped, across a wide area of Montana and northern Wyoming east of the Rocky Mountains. The Flaxville surface is claimed to have extended northward up into central Alberta, remnants of which cap uplands [56, p.769]. The Hand Hills, about 300 meters above the plains east of Drumheller, Alberta, are capped by 8 m of coarse gravel [109]. Hills west and northwest of Calgary, Alberta, are also a partially gravel-veneered erosion surface that is correlated to the Flaxville plain [79, 105].

The Flaxville erosion surface is also about 100 to 200 meters higher than the next lower erosion surface, the Missouri Plateau erosion surface or Alden's Number 2 bench [1; 46, p.9]. There is even a lower Number
3 bench on the high plains of Montana that usually is not far above the river valley bottoms. The Number 2 and 3 benches are extensive over Montana east of the Rocky Mountains and are often capped by water-transported gravel. This series of erosional surfaces make up most of the vast high plains of Montana and surrounding areas.

Based on these erosional remnants, the volume of sediments removed from the northern Great Plains would have required enormous volumes of water flowing over a wide area. Field data and paleohydrologic estimates indicate that the erosion of the high plains and the deposition of the gravels capping the Cypress Hills, Flaxville Plain, and lower erosion surfaces required discharges and current velocities far in excess of those observed in historic floods [53, 54]. The evidence adds up to a watery catastrophe eroding the Rocky Mountains and high plains from at least central Alberta southeastward into northern Wyoming. Erosional processes were so energetic that about 1000 m of high plains strata were stripped off, leaving behind at least four levels of large-scale erosion surfaces, commonly capped by resistant clast-supported gravel transported many hundreds of kilometers across a gentle slope from the Rocky Mountains. The characteristics of the deposits are indicative of sheet flow by water for the higher level erosion surfaces. The lower erosion surfaces must have been eroded by more channelized flow, or else the higher remnant erosion surfaces would have been destroyed. The eroded debris has completely disappeared downstream; there is no trace of it in the U.S. Midwest. Thus, the gigantic torrent that formed the multiple-storied erosion surfaces in the process of eroding 1000 meters of sediments swept the debris thousands of kilometers away, probably into the Lower Mississippi River Valley and the Gulf of Mexico.

TERTIARY FAUNAL SUCCESSION AND OLD AGE DATING ILLUSORY

The sand and debris flow interbeds within the eastern Cypress Hills Formation have yielded abundant fossils, such as horses, camels, rabbits, saber-toothed cats, rhinoceroses, giant pigs, titanotheres, oreodonts, multituberculates, marsupials, and rodents [55, 80, 87, 91, 92]. Reptiles and amphibians, including crocodiles, have also been excavated that indicate a tropical to subtropical paleoclimate [42]. Certain mammal fossils dated the Cypress Hills Formation as "early Oligocene": "Now that we recognize the formation as mostly, if not entirely, of Early Oligocene age, a more critical attitude is in order" [82, p. 636]. Russell meant a critical attitude towards the fossil horses in the Cypress Hills Formation, and he reclassified some of them. Then in 1975, Storer discovered "mid to early Miocene" fossils, mainly horses, near the top of the Cypress Hills Formation [89, 90]. There was much opposition to this discovery, but it is now generally accepted [102]. Recently, "middle Eocene" fossils have been discovered [92], which now can be compared to the "upper Eocene" fossils known for a long time on the Swift Current Plateau near Lac Pelletier, Saskatchewan (Figure 1) [79, p.54]. Regarding the earlier failure to observe fossils of different ages in the Cypress Hills Formation, Storer and Bryant [87, p.667] remonstrate:

How could we fail to see such a major difference in more than a hundred years of research on the Cypress Hills Formation? The answer is probably a combination of incremental discovery, willingness to accept assumptions, and bad luck.

The latest uniformitarian dating suggests that the bottom of the Cypress Hills Formation is about 45 million years (Ma) old [Leckie and Cheel, 1989], while the top of the formation is around 15 Ma. One gets the distinct impression that subjective elements of faunal succession, especially in regard to the horse series, have led to the different dating schemes. For instance, Storer and Bryant [87, p.667] state:

The nature of Archaeohippus stenolophus represents the factor of bad luck: Archaeohippus retains many primitive features, and superficially looks a lot like Miohippus, especially if the investigator has no additional clues in the form of associated fauna.

Based on fossils, the Flaxville gravels are dated as upper "Miocene" and lower "Pliocene," but an "upper Pliocene" horse fossil has also been discovered [88]. Thus, the Flaxville gravel is dated about 5 to 10 Ma, though there is little or no lithologic difference between Cypress Hills and Flaxville gravels. In fact, the "early Pleistocene and Pliocene" Saskatchewan gravels are predominantly quartzites that are similar to the Cypress Hills gravel [107].

The Wood Mountain gravel is also similar to the Cypress Hills gravel [56] and indistinguishable from the Flaxville gravel [90, p.599]. This similarity of the Wood Mountain gravel to the Cypress Hills Formation was accepted as correlative until "Miocene" fossils of the "wrong age" were discovered in the Wood Mountain gravel [78, 79, 90]. Now the problem has been "solved" with the discovery of Miocene fossils in the Cypress
Hills. It is interesting to note that reptile fauna discovered in the Wood Mountain Formation suggest a much warmer winter climate than today with only a few days of frost [41].

A number of investigators have noted that the Cypress Hills erosion surface is fresh, but actively eroding. The surface is little dissected and has the appearance of youth - not long exposed to erosion [22]. Crickmay exclaims that the upland surface is perfectly preserved "...as a geologically old surface almost untouched by the erosion that has isolated it...the plateau that shouldn't be" [24, p.66]. Yet, the plateau supposedly ranges in age from 45 to 15 million years old! In this amount of time, the Cypress Hills, even with its resistant gravel cap, should have worn away. Summerfield [93, p.396] estimates that for a landscape of moderate relief in a temperate climate, the denudation rate is 3 to 11 cm/1000 years. At this rate, the Cypress Hills would have been almost totally eroded in 3 to 15 million years, yet the top is barely touched by erosion, and the quartzite and chert gravel is hardly weathered. While the Cypress Hills were somehow untouched by erosion, the surrounding plains were worn down 215 to 500 meters to a flat surface [27, p.68].

Lithologic data, gravel fabrics, and paleohydrologic reconstructions indicate that the Cypress Hills Formation and Flaxville gravel were formed rapidly, energetically, and relatively contemporaneously. This implies that deposits dated as middle and upper Eocene, lower Oligocene, middle Miocene, and lower to upper Pliocene were likely contemporary in their formation, possibly from a single event. This calls into question the concept of Tertiary faunal succession and age dating for these fossil suites.

SIMILAR EROSION SURFACES WORLDWIDE FROM THE DELUGE

Similar erosion surfaces - on plains, mountaintops, and pediments - and similar long-runout gravel, as observed on erosion surfaces and elsewhere, are preserved north and south of our study area. It must be remembered that many erosion surfaces have been largely removed by subsequent fluvial, tectonic, and other processes, most often leaving only erosional remnants. Some mountaintop erosion surfaces may have been formed before tectonic uplift.

South of our study area, we discover many mountaintop erosion surfaces, as well as surfaces at lower elevations, in Wyoming and Colorado. These include the Beartooth, Absaroka, Wind River, Hoback, Gros Ventre, Laramie, and Colorado Front Range Mountains [12, 31, 32, 60, 64, 85, 97, 99]. There is controversy over the number of surficial erosion surfaces in these areas and their age, but not their existence. Referring to the extensive erosion surfaces in Wyoming, Mears [64, p.615] writes: "Today, well over a century later, there is still no complete agreement as to the number of different surfaces, their age, or how they formed" (emphasis ours). Colorado geologists mostly believe the erosion surfaces were carved in the late Eocene, but geologists from Wyoming mostly favor the late Miocene. In other words the mountains were flattened close to sea level, the valleys filled up with the detritus, the mountains uplifted, and the valleys excavated - all in the mid and late Cenozoic [64]! The high plains from northwest Texas to south central South Dakota, 1300 km long and 500 km wide, are aggraded by the Ogallala Formation that is composed mostly of long runout sand with gravel beds [97, pp.300,301]. Interfluves on the high plains of central and southern Texas are capped by resistant gravel transported from the southern Rocky Mountains, 800 to 1000 km away [7, 17, 59].

To the north of our study area, dissected erosion surfaces are locally present on the eastern foothills and plains from the Richardson Mountains of the Yukon Territory southeast to Montana [11, p.85; 35, pp.120, 132; 36; 62; 75; 95]. Gravel-capped plateaus also grace the plains of central and northern Alberta [90, 94]. Thus, erosion surfaces that are sometimes capped with gravel outcrop on the high plains, on mountain tops, and as pediments in the Rocky Mountains and the high plains from the Yukon Territory to New Mexico.

Mountaintop and plateau erosion surfaces, long-runout conglomerate, and pediments are common in the intermountain area west of the Rocky Mountains. They are found in southeast Idaho, western Wyoming, and northeast Utah [5, p.1863], central and northern Idaho [4, 39, 98], the Cascade Mountains of Washington [37; 74, p.292; 106], and extensive areas of British Columbia [40]. Extensive erosion surfaces also are found in Arizona, southern Utah and southwest New Mexico [6, pp.77-79; 37]. Gravel-capped erosion surfaces bevelling strata, including the Green River Formation, are excellently preserved on the north side of the Uinta Mountains [14]. Well-rounded quartzite boulders up to 1 meter in diameter with percussion marks have been found at the tops of the Wallowa Mountains, northeastern Oregon, up to 2,658 m elevation [3]. One gravel deposit is 55m thick and contains placer gold. Allen considered that these exotic boulders were deposited by a "torrential paleoriver." Remnants of this quartzite gravel outcrop locally
in southern Washington and northern Oregon on anticlines and in synclines of the Columbia River Basalts, including the Troutdale Formation around Portland, Oregon [68]. The gravel can be traced to the mouth of the Columbia River at Astoria, Oregon [67, p.F11]. The nearest source for the quartzite gravel is west central Idaho, about 100 km to the east of the Wallowa Mountains and about 600 km east of Astoria. Thus there are many erosion surfaces from Mexico to British Columbia west of the continental divide [37 p.145].

In eastern North America, erosion surfaces are common in the Appalachian Mountains [61; 74, pp.224, 225] and the mountains and plateaus of eastern Canada [11, 13, 34]. Erosion surfaces also have sheared uplands in central North America [15, 97]. Thus, erosion surfaces are common over North America, including many mountain tops [74, p.292].

Erosion surfaces are not just observed in North America but are found worldwide [27, pp.108-109; 50; 51]. For instance, they are widespread at all elevations of Australia [28; 50, pp.111-113]. Africa possesses extensive bevelled erosion surfaces [10, 50, 51]. About 60% of Africa is composed of erosion surfaces at several altitudes, many remarkably smooth [51]. Eastern Africa is composed of a series of high plateau erosion surfaces [30]. Large portions of the land bordering the Congo Basin is composed of two erosion surfaces, believed to have been formed in the mid and late Cenozoic [100]. Much of southern Africa was uplifted and planed in the "Cenozoic" [72]. The highlands of eastern South America possess remarkably flat erosion surfaces [51, pp.310-332; 63]. Ollier [70, p.147] points out: "In fact they [planation surfaces] exist as directly observable landforms, and in many of the southern continents are so extensive that they dominate the landscape." Central and eastern Europe have many erosion surfaces preserved at high elevation [51, pp.381-406; 73; 74]. Erosion surfaces outcrop in Asia, including the tops of the Tien Shan Mountains, Mongolia, Siberia, and India [51, 74]. Pediments are common in the former Soviet Union [73].

This plethora of surficial erosion surfaces around the world, inexplicable to mainstream geology, strongly implies a phenomenon that left its mark on the scenery of the whole earth. Based on our study in Montana and southern Canada, powerful currents and enormous discharges of water would have been necessary to generate these features. An enormous quantity of sediment has been completely removed, with erosional remnants virtually the only evidence of their former presence. What better evidence for the recessional stage of the Genesis Flood as water swept off every continent in powerful, erosive currents as the land rose out of the Flood waters? The worldwide distribution of erosion surfaces points strongly to a global event and not a local flood.

Just like the Cypress Hills and Flaxville gravel, erosion surfaces worldwide are little weathered, but of supposed great geological age. As Crickmay concludes:

Again, one finds all over the world, even high above and far distant from existing waterways, smooth-surfaced and level ground - including everything from small terraces to broad, flat plains - much of it still bearing intact a carpet of stream alluvium. Such lands were carved and carpeted, evidently, by running water, even though they are now in places where no stream could possibly run... What is remarkable about them is the perfection with which they have outlasted the attack of 'denudation' for all the time that has passed since they lay at stream level. [25, p.173]

What better evidence that all these erosion surfaces were recently cut? Although dated as many millions of years old, their freshness indicates that the time scale based on faunal succession and radiometric dating schemes is illusory.

THE FLOOD/POST-FLOOD BOUNDARY IS IN THE "LATE CENOZOIC"

Erosion surfaces can be used to help define the Flood/post-Flood boundary, currently a controversial topic. Both Tasman Walker [104] and Carl Froede [33] have proposed a creationist geological timescale or model. The Genesis Flood portion of the model is similar to the 21 weeks of "prevailing" and 31 weeks of "assuaging" in the model of Whitcomb and Morris [108]. During the prevailing or inundatory stage, much sediment is expected to have been eroded and deposited as vast sheets. During the assuaging or recessive stage, the water drained off the land as the continents rose up out of the water. During this latter stage, much erosion is expected of inundatory stage sediments, especially from those continental areas that first arose and which are likely the highest areas of the current landscape. It is during this latter stage that extensive erosion surfaces and their gravel caps could be expected to have formed. Moreover, the draining Flood waters would likely first erode as a sheet, but as mountains and plateaus rose above the water, the
erosion would be more channelized. This would correspond to Walker's abative and dispersive phase of the recessive stage. Mountain top, plateau, and high plains erosion surfaces would be more likely to form during the abative (sheet erosion) phase, while pediments probably would have been cut during both the abative and the dispersive (channelized) stage. Thus, it is reasonable that strata below a surficial erosion surface would be from the Flood.

Assuming that the geological column is a general chronological sequence of the events during the Flood year (an issue that needs to be demonstrated with rigor), these worldwide erosion surfaces imply that the Flood/post-Flood boundary is in the late "Cenozoic." Erosion surfaces worldwide bevel sediments of all Cenozoic ages, including "Pliocene" [52, pp.177-196, 65], and even "Plenistocene" in non-glaciated areas [48, 71]. Practically all these dates are based on fossils, and the Flood/post-Flood boundary must not be defined by the fossils found below an erosion surface, whether they be titanotheres, horses, saber-tooth cats, or mammoths. Such a biostratigraphic approach assumes faunal succession while ignoring the independent, physical evidence of erosion surfaces. For instance, the Flaxville erosion surface is dated by fossils as young as upper Pliocene. Baulig [10, p.925] states: "In middle latitudes there are, however, almost everywhere locally planed surfaces that bevel moderately resistant terrains even as young as Pliocene." Worldwide erosion surfaces that bevel rocks as young as "Pliocene" strongly imply that the Flood/post-Flood boundary is in or above the "Pliocene" in at least these locations. This further supports the location of the Flood/post-Flood boundary in the late "Cenozoic" [43, 66, 68, 69]. For those who believe the Cenozoic is post Flood, some catastrophe would have to erode 1000 m of sediments over a large area of the high plains from at least Alberta south into Wyoming, leaving behind four extensive erosions surfaces. Extant transport mechanism would then be required to remove these sediments from the region, perhaps as far as the Gulf of Mexico. Before such a catastrophe, however, subtropical and tropical amphibians and reptiles would have lived in an area that currently has January average minimum temperatures of about -20°C with yearly extremes to -40°C.

CONCLUSIONS

We have analyzed two extensive erosion surfaces that are relatively high plateaus in southern Canada and northern Montana, U.S.A. These erosion surfaces are capped with mostly massive gravel, and the erosional remnants are correlated from central Alberta to northern Wyoming. Based on the lithologies - mostly well-rounded, iron-stained quartzite and chert with abundant percussion marks - the clasts were transported 300 to 1000 km over a low slope! Mainstream geologists, starting with William Davis, have attempted to explain these features by the principle of uniformitarianism, but to no avail. Based on paleohydrological analysis, the clasts were transported in currents significantly faster and with greater discharges than modern flash floods. We conclude that only a fluvial catastrophic process of regional extent could account for the gravel-capped erosion surfaces. Based on the character of erosion surfaces at multiple elevations, this process apparently consisted of widespread sheet flow that became increasingly channelized. In considering that similar erosion surfaces are found worldwide, it appears evident that these features mark the recessional stage of the global Genesis Flood. Furthermore, the gravels contain fossils from most Tertiary epochs, yet the gravel is similar over the whole region and very little weathered. This challenges Tertiary faunal succession, as well as the radiometric and other old age dating methods used to date these fauna. These erosion surfaces also can be employed to locate the Flood/post-Flood boundary, which, based on the assumption that the geological column is a general Flood chronology, would be in the "late Cenozoic."

ACKNOWLEDGEMENTS

We thank four anonymous reviewers and editor Steve Austin for their helpful comments.

REFERENCES


[76] Regina Sheet Saskatchewan (with supplementary sections), Map 267A, 1935, Canada Department of Mines, Ottawa.


