Erosion of the Weald, Southeast England

Part I: Uniformitarian Mysteries

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Abstract

The Weald, covering ~10,000 km² (3,900 mi²) of southeast England, is composed of a heavily eroded east-west anticline. It features a surface sometimes capped by gravel called "clay-with-flints," water and wind gaps through the chalk ridges on its flanks, and a local silcrete duricrust with eroded sarsen stones. Although uniformitarian scientists have offered several hypotheses to explain the geomorphology of this classical area, they all have major difficulties. We analyze these explanations and draw the following conclusion: The Weald's geomorphology, like many other areas of the world, remains a uniformitarian mystery. It is better explained by rapid Genesis Flood runoff, not erosion over millions of years.

Introduction

Geomorphology is a "gold mine" for Flood geology. It provides a reasonable explanation for Earth's landforms using the mechanism of Flood runoff, while uniformitarianism/actualism has great difficulty (Oard, 2008, 2013a). Flood runoff can explain large-scale erosion evident from a number of features such as far-transported resistant rocks, tall erosional remnants (inselbergs), coastal Great Escarpments, planation and erosion surfaces, water and wind gaps, submarine canyons, vertically walled canyons, and pediments. The lead author's area of study has been North America, especially in the western United States. However, similar features found worldwide suggest a similar cause—the global Genesis Flood.

Geomorphology first developed in England, especially southeast England. The Weald, as it is called, is a classical area of study dating back to the early 1800s, with a literature spanning over 200 years (Jones, 1980, 1999a, 1999b). In Part I, we will describe this classical region to demonstrate the failure of uniformitarian mechanisms. In Part II, we will provide a Flood geology explanation, suggesting that the Wealden anticline was rapidly uplifted and rapidly eroded during Flood runoff, leaving slightly dipping chalk limbs, very similar to the Colorado Plateau in North America. Channelized Flood runoff then carved water and wind gaps through the North and South Downs.

The Weald

The Weald is an area of southeast England approximately 200 km (125 mi) long from east to west, varying from 30 km (19 mi) wide in the west to 80 km (50 mi) wide in the east (Figure 1). It was once a forest but is now mainly an agricultural area with numerous small towns and only a few large ones. The

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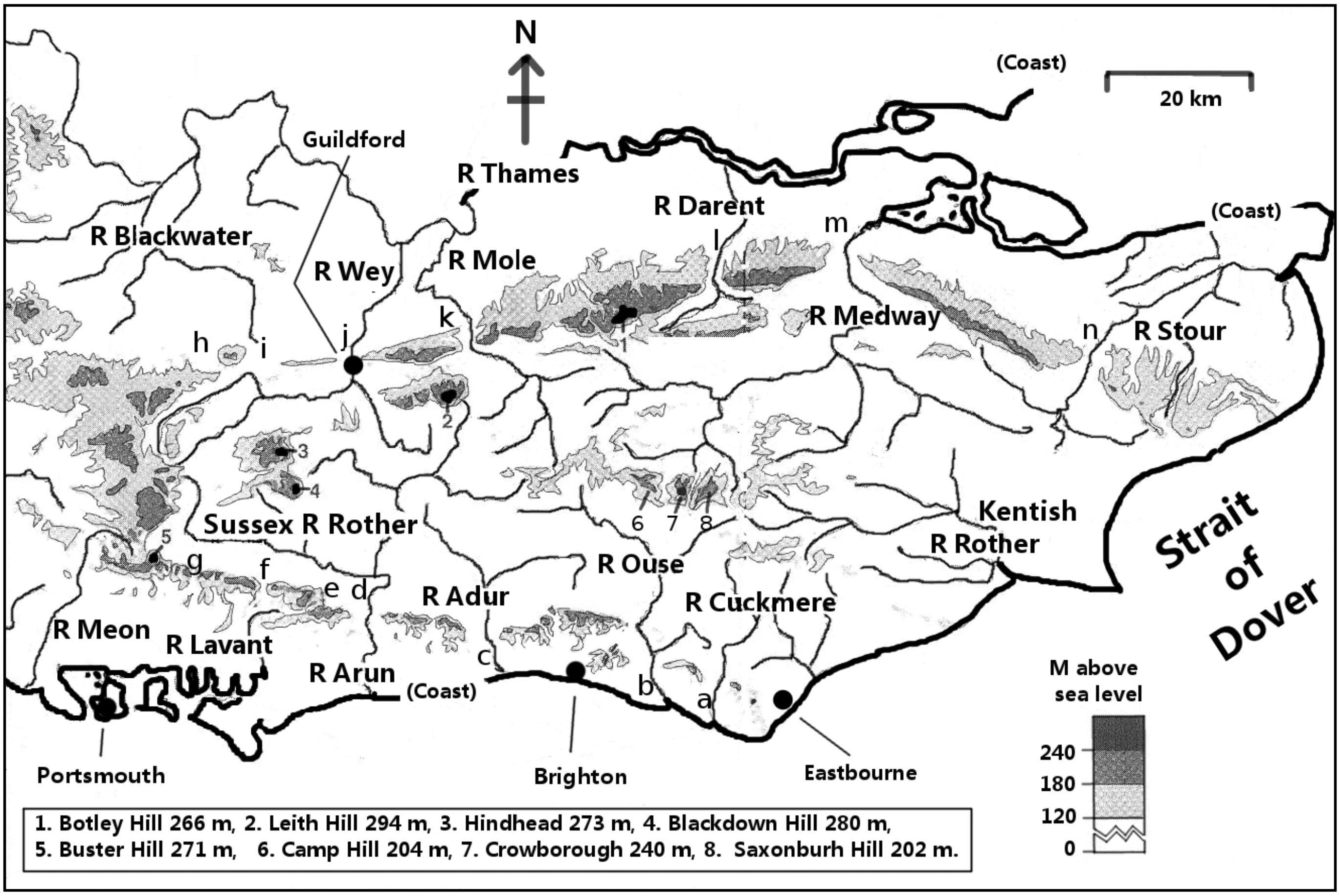


Figure 1. Map of the Weald by grayscale elevation above mean sea level with eight well-known high areas and showing important cities and rivers with water gaps denoted by letters (modified from Jones, 1999b, p. 27).

Weald is bounded on the north by the chalk ridges of the North Downs, just south of the London orbital motorway M25, and to the south by chalk ridges of the South Downs, roughly 10 km (6 mi) inland from the South Coast between Portsmouth and Eastbourne. In the east, the Weald terminates against the English Channel. The same eroded anticline continues east into northern France, being separated from the Weald by the 42 to 95 km (26 to 60 mi) expanse of the Dover Straits (Jones, 1999b). In the west, the chalk ridges largely disappear in the Winchester region, although the chalk strata continue well to the west.

The Weald remained unglaciated, which eliminates complications from glaciation in understanding its formation. The maximum southeastern edge of glaciation over the British Isles varies between 30 and 80 km (19 and 50 mi) north of the river Thames (Rayner, 1981). However, there are believed to be isolated permafrost features in the area (Goudie, 1990), but those features do not appear to affect the basic geomorphology of the Weald.

In terms of sedimentary geology, there is a broad similarity between the Wealden area and much of southern England, though its geomorphology is unique, thanks to variations in tectonic activity and erosion. Of particular interest is "the Jurassic Coast," designated a world heritage site in 2001. This area runs along the south-central coast, beginning about 100 km (60 mi) west of the Weald. Like the Weald, it has not been disturbed by glaciation. The stratigraphy of the Jurassic Coast is similar to that of the Wealden area. The Jurassic Coast is claimed to be a 185-million-year walk through earth history. Its visibility from tourism and an emphasis on millions of years and evolution (Figure 2), make the Jurassic Coast an interesting topic for creationist study (Oard et al., 2014).

The Geology of the Weald

The geological layers of the Weald are shown in Table I (Gallois and Edmunds, 1965). The exposed Weald layers start

Figure 2. The Jurassic Coast draws millions of tourists every year and teaches them millions of years and evolution.

from the "Cretaceous" chalk and move across the structure of the eroded anticline, which shows a small area of the Purbeck Beds at its center. Other famous formations include the Upper Greensand, the Gault Beds, the Lower Greensand, the Weald Clay, and the Hastings Beds. Deeper layers, which outcrop farther west, are known only from boreholes but are of no concern for this article. All of these layers of strata were deposited roughly horizontally over a period of approximately 100 million years of the uniformitarian timescale. The chalk is believed to have accumulated at a submarine depth of 300 m (1,000 ft) or more. Near the end of chalk deposition, the anticline started to form.

Weald Strata
Chalk
Upper Greensand
Gault
Lower Greensand
Weald Clay
Hastings Beds
Purbeck Beds

Table I. Strata in the Weald area.

The Geomorphology of the Weald

The subdiscipline of geomorphology was essentially developed at the Weald. It is a classic area with many mysteries. Catt and Hodgson (1976, p. 181) stated:

> Geomorphological studies of the Chalk landscape in south-east England have played an important role in the development of geomorphological thought in Britain. South-east England has been long regarded as a 'type area for British geomorphology.'

The Eroded Anticline

After the east-west anticline developed over this area, it was intensely eroded. A series of chalk ridges, the North and South Downs, are the residual limbs of this anticline. The chalk of the South Downs is orientated generally a little south of east, ~N100°, while the North Downs chalk is oriented a little north of east, ~N80°, as far as the water gap of the river Medway (Figure 1), and then ~N120° to the coast. The chalk ridges are typically 200 m (655 ft) above mean sea level (msl), though there are a few places exceeding 250 m (820 ft) msl. The chalk ridges are in the shape of a "cuesta," with a low slope corresponding to the dip of the sedimentary layers on the outer side and a cliff or steep slope on the inner side. In both the North and South Downs, the dips of the beds are generally between 1° to 5° away from the central area, while the escarpments face the central area. A simplified north-south cross section uses significant vertical exaggeration to show the structure of the anticline and the extent of subsequent erosion (Figure 3).

Within the eroded anticline, the "floor" has a typical height of less than 50 m (165 ft) msl, and nearby rivers may be less than 10 m (33 ft) msl. South of the North Downs, there is a partial secondary set of ridges that is more subdued. These ridges appear to be the result of faulting or local folding during the uplift. There is a narrow set of ridges and elevations in the west. In the east, the Weald is truncated by the English Channel. The precise relationship of this truncation is unknown, but it probably happened after the bulk of erosion of the Weald. Excluding the inner northern ridges, the middle of the Weald consists of a few erosional remnants. In places these can be higher than the North and South Downs, and they include Botley Hill, 266 m (873 ft), Leith Hill 294 m (965 ft), Hindhead 273 m (896 ft), and Blackdown 280 m (919 ft). These heights are numbered 1 to 4, respectively, on Figure 1.

The amount of erosion in the central anticline was roughly 1,300 m (4,260 ft). This estimate is based mainly on the thickness of the formations making up the Weald and the slopes of the anticlinal limbs. However, an unknown amount of chalk, possibly as much as 300 m (1,000 ft), was eroded along with some Tertiary sedimentary rock (Jones,

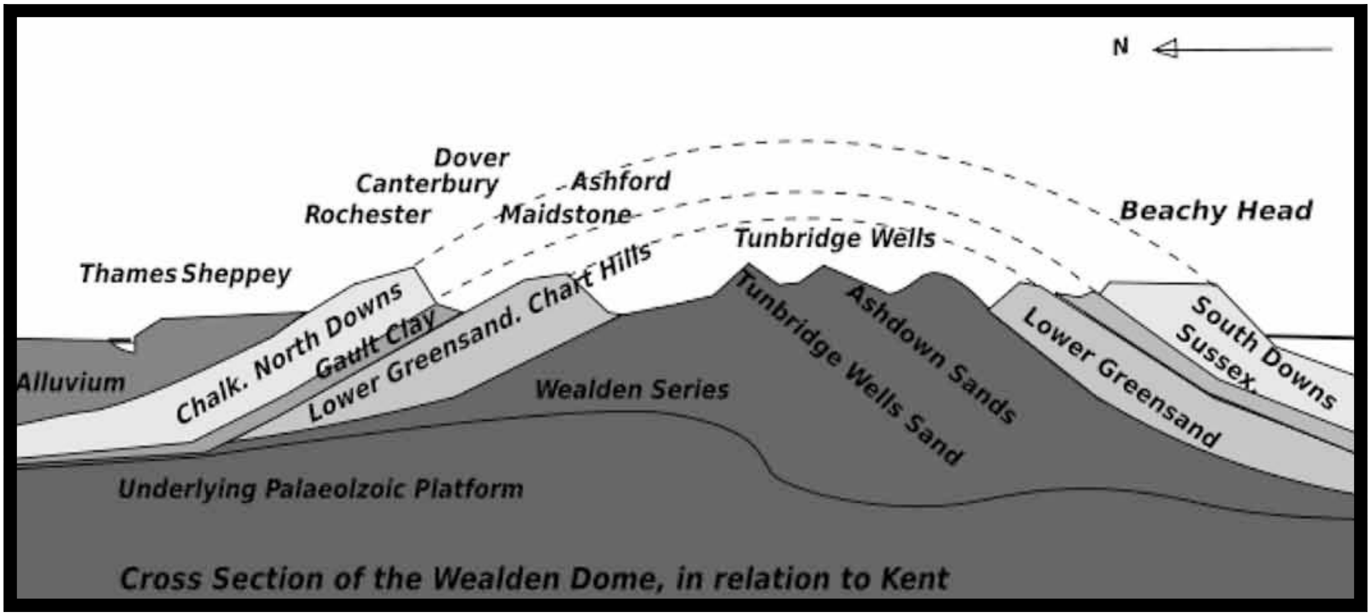


Figure 3. Uplifted, eroded Wealden Dome of southeast England (from Wikipedia). Total erosion in the center of the dome is more than 1,300 m (4,260 ft).

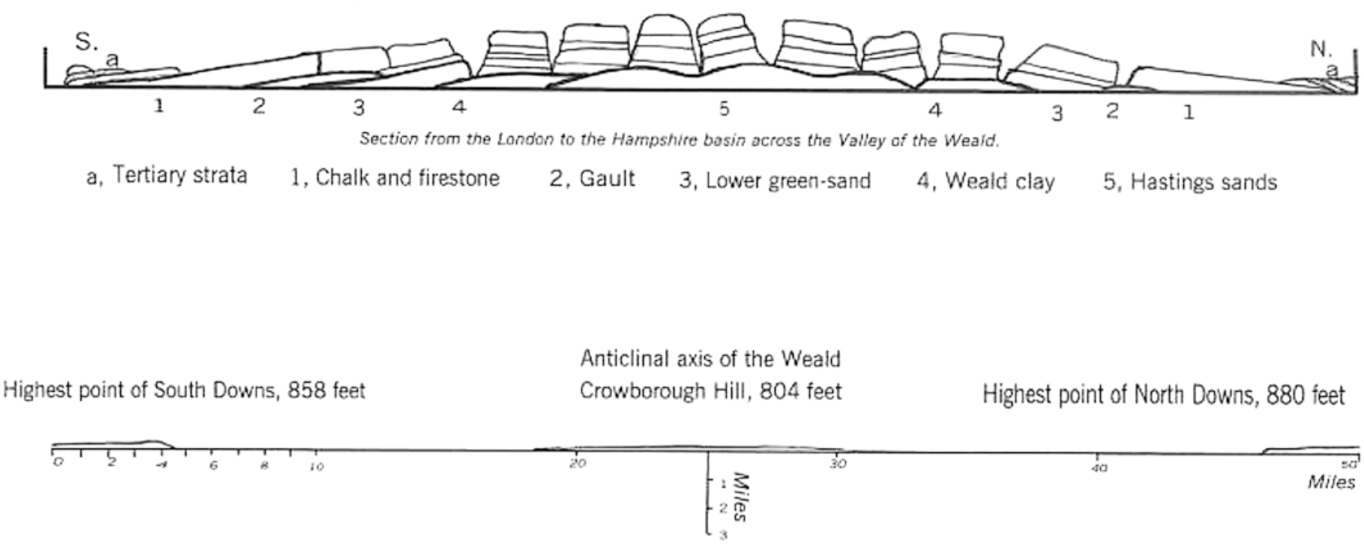


Figure 4. Charles Lyell's drawings of the Weald with high vertical exaggeration (top) and to scale (bottom) (from Lyell, 1991, p. 288).

1999b), suggesting that total erosion may have reached ~ 1,600 m (5,250 ft).

At ground level, the extent of erosion is barely detectible because of the distance and low slopes and the fact that the layers bow up in the middle of the anticline (Figure 3). The difficulty of seeing the extent of erosion is shown in the bottom panel of the north-south profile across the Weald in Figure 4 from Charles Lyell's (1991) *Principles of Geology*. The cross section shows a spatially

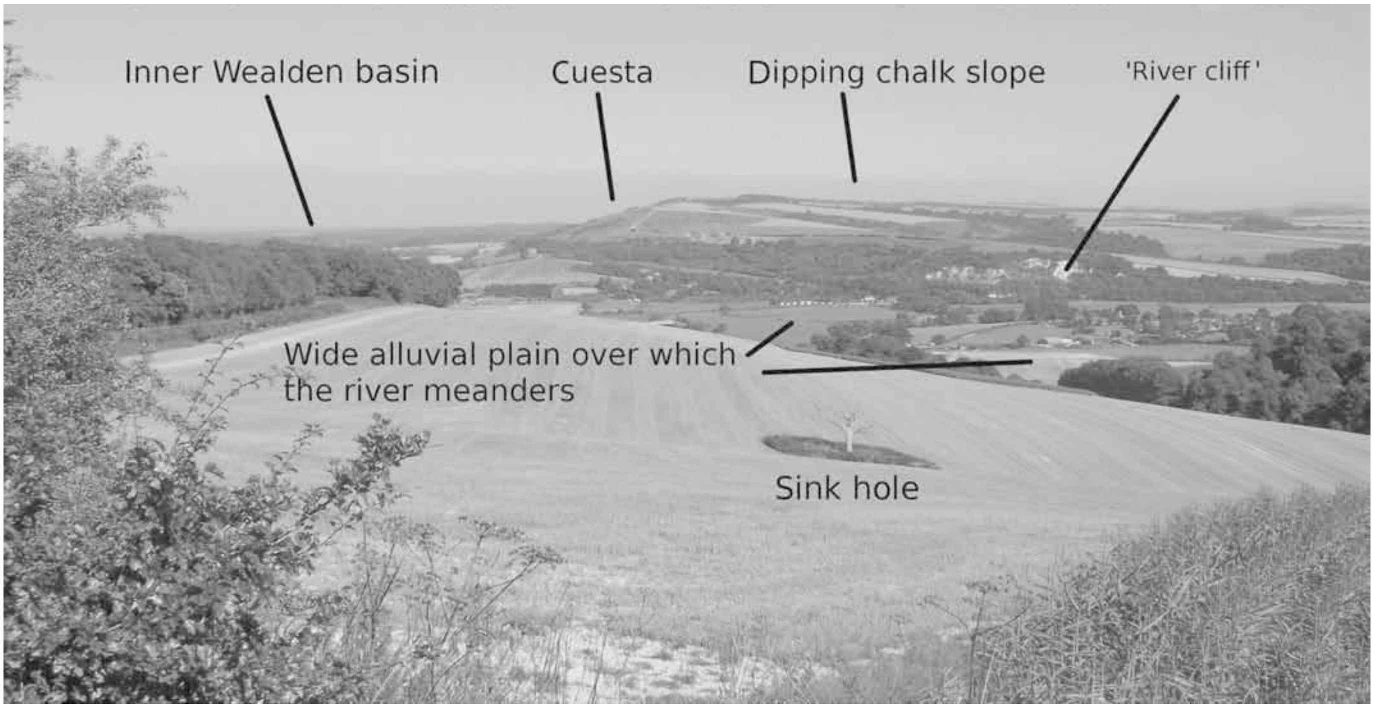


Figure 5. Erosion surface on the top of the South Downs on the dipping chalk slope. View east across the Arun water gap. Notice the shape of the South Downs on the other side of the water gap, showing the cuesta (steep slope) on the north side and the gently southward dipping erosion surface towards the south.

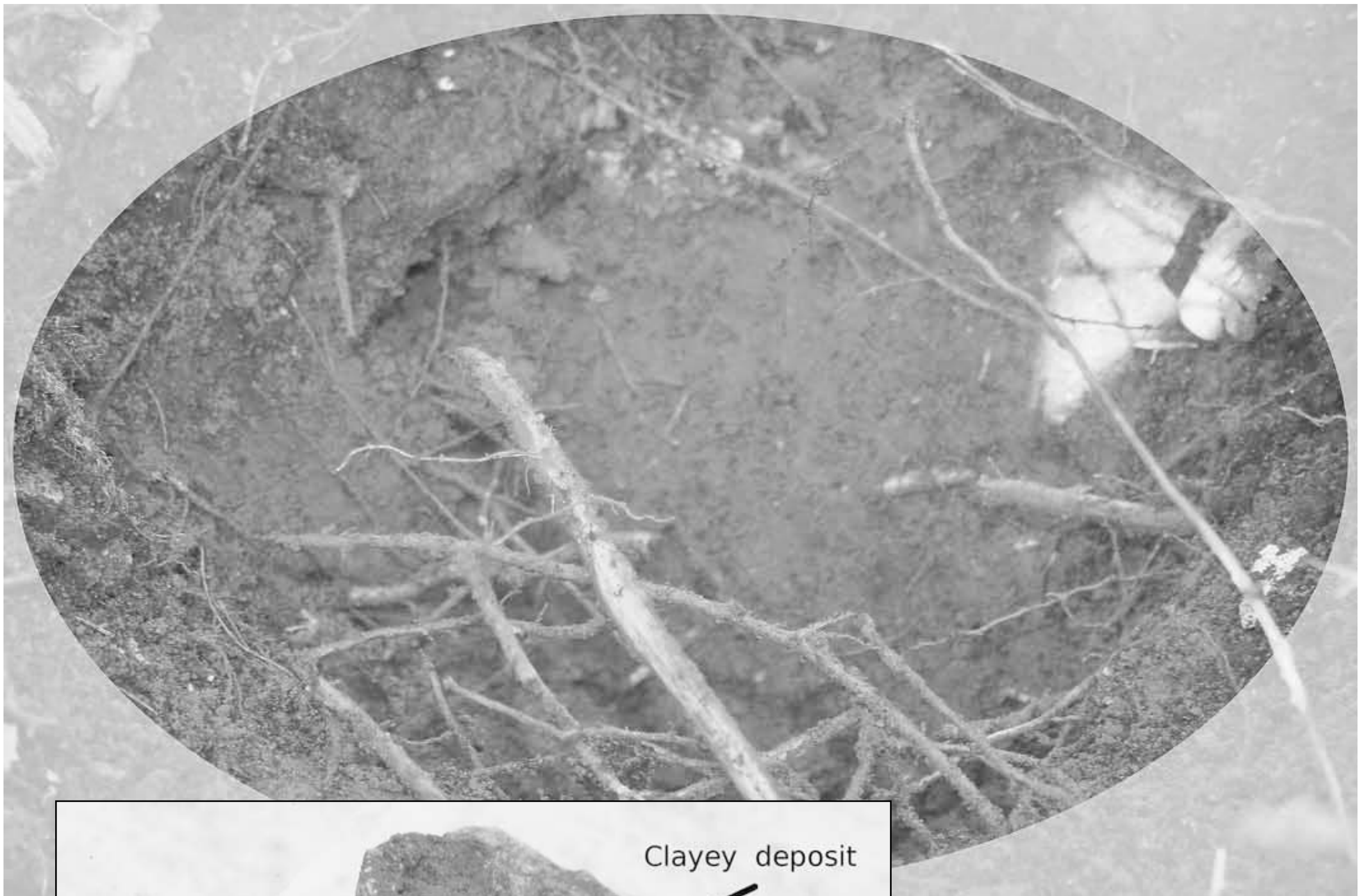
accurate cross section on the bottom, and one with vertical exaggeration that better shows the strata (top).

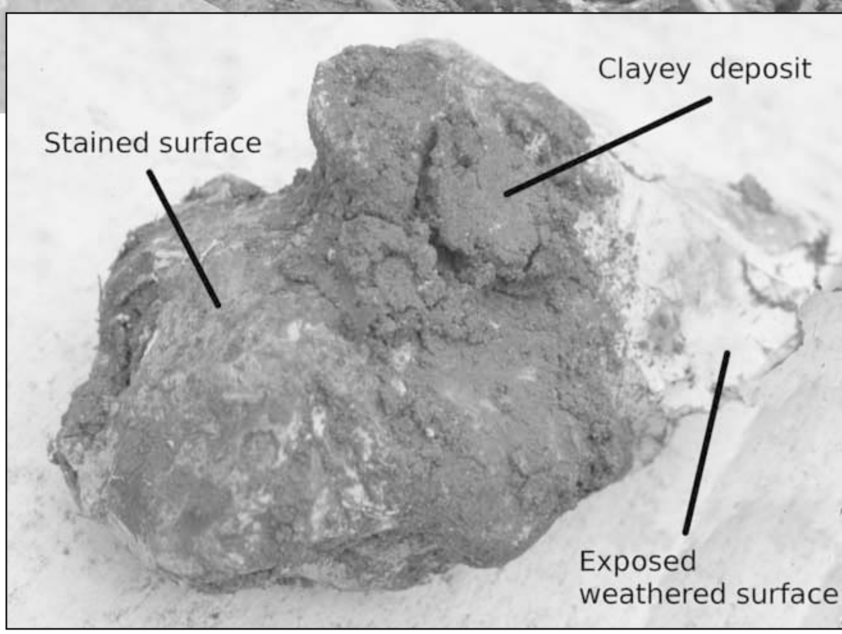
Gravel-Capped Erosion Surfaces

According to the *Glossary of Geology*, 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" (Neuendorf et al., 2005, p. 217). An *erosion surface* is generally synonymous with a *planation surface*, except that an erosion surface is generally regarded as a rolling surface of low relief, while a planation surface is flat to nearly flat. The reason "running water" is in the definition is rocks rounded by running water commonly cap planation and erosion surfaces.

During the erosion of the Weald, planation surfaces were likely formed on the highest terrain, occasionally beveling the chalk ridges. Further erosion roughened and dissected these planation surfaces into erosion surfaces (Figure 5), leaving erosional remnants called *inselbergs*, *monadnocks*, or *bornhardts*. The erosion surface mainly forms an accordant summit on the Weald (Goudie, 1990, p. 22). According to uniformitarian geologists, this erosion surface is considered to be the same found in east Devon and west Dorset, about 190 km (120 mi) west of the western edge of the Weald (Jones, 1999a, p. 10). In fact, some uniformitarians think that most of southern England is one large, uplifted, dissected, and partially eroded planation surface (Jones, 1999a, p. 11). We shall return to this issue in a subsequent paper.

Gravel or conglomerate (cemented gravel) sometimes lies on top of the erosion surfaces and is more significant west of the Weald. The gravel is unlike that seen on planation surfaces in the western United States, which includes well-rounded quartzite cobbles and boulders. The coarse gravel on the Weald and elsewhere in south-central England is commonly angular and is generally called "clay-with-flints" (Figures 6a and b). This term, however, applies to a wide variety of deposits, including water-rounded flints and a matrix of sand (Loveday, 1962). The flints come from the erosion of the underlying soft chalk, which contains hard flint nodules, layers, and lenses, and so the clasts were not transported very far before being deposited. The matrix can be clay or sand, as Jones states, "To the west occur recognizable 'Clay-with-Flints,' angular chert rubble in a sandy matrix" (Jones, 1999a, p. 11). The differences between the sedimentary cover of the Weald and erosion surfaces in the western United States is due to the longer transport distances and possibly larger currents in





above: Figure 6a. "Clay-with-flints" from a pit dug on top of the North Downs east of Guildford.

left: Figure 6b. A flint from pit in Figure 6a.

the western United States, as well as the rock types. Shorter transport distances and possibly smaller currents led to the deposition of a fine-grained matrix on the Weald. But the differences between the "clay-with-flints" and the chalk suggest some distance of transport.

Water and Wind Gaps

One would expect that slow erosion over millions of years would cause tributaries from the North and South Downs to converge into one or two large trunk streams flowing east down the center of the Weald into the English Channel. This is because the anticline is both aligned and slopes slightly from west to east within the Weald basin formed by the North and South Downs.

However, many of the rivers and streams flow perpendicular to that expected direction: north through the

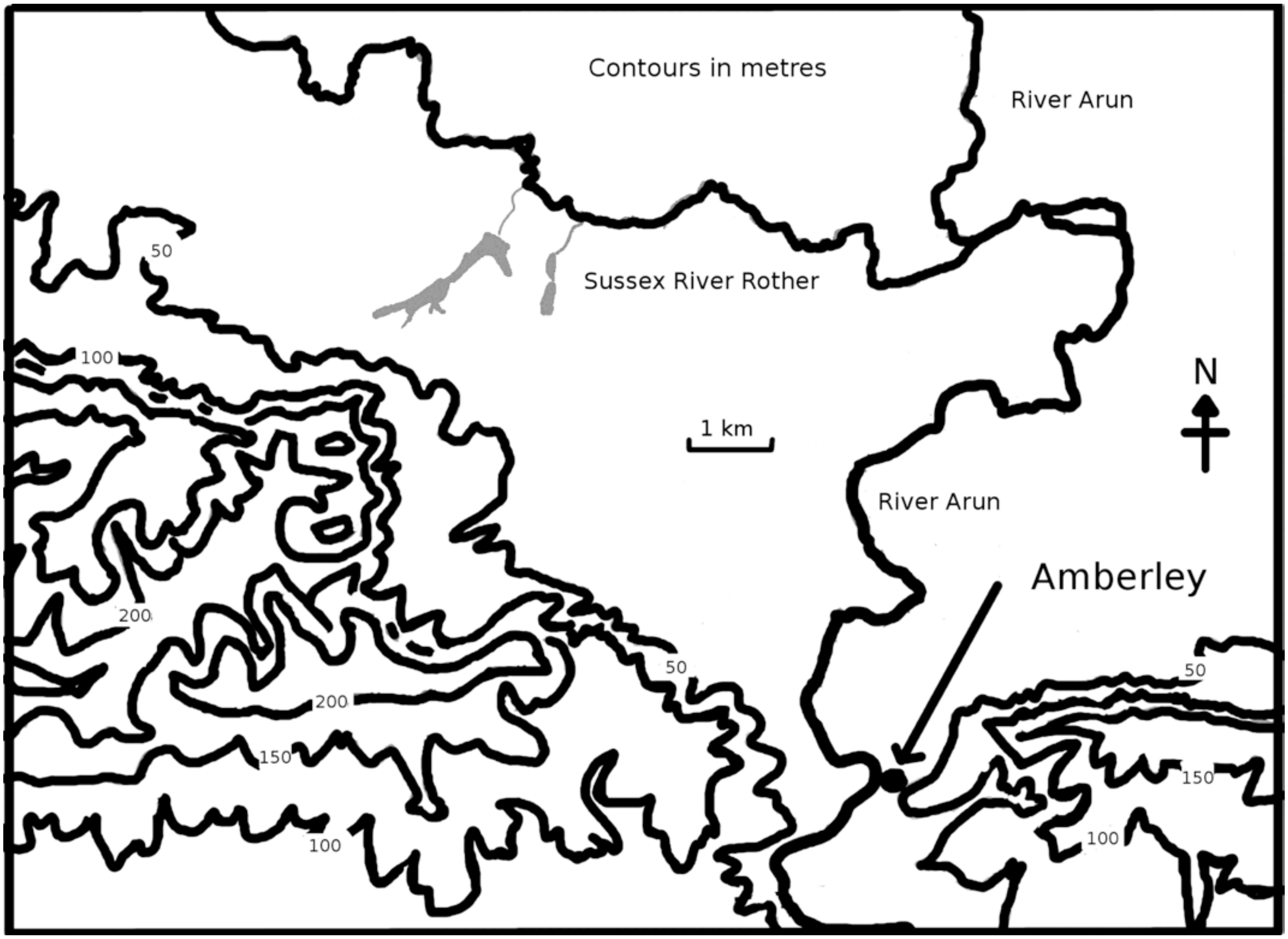


Figure 7. Contour map of the Arun water gap of the South Downs. The Arun River flows through the water gap around 10 m (33 ft) above msl while the top of the South Downs rises up over 200 m (656 ft) above msl.

North Downs and south through the South Downs in water gaps (Figures 5). See Figure 1 for a map of the rivers flowing through water gaps. A water gap is "a deep pass in a mountain ridge, through which a stream flows; esp. a narrow gorge or ravine cut through resistant rocks by an antecedent or superposed stream" (Neuendorf et al., 2005, p. 715). Figures 7 and 8 show contours along the Arun and Adur water gap, respectively, through the South Downs between the major towns of Chichester and Brighton, based on UK Ordnance Survey maps and the authors' supplementary surveying.

However, the *Glossary of Geology* definition is not strictly descriptive; it unfortunately includes two supposed mechanisms: antecedence and superposition. These are two of five possible hypotheses for the origin of water gaps. Ironically these two mechanisms have been largely eliminated as viable explanations for most water gaps. This definition is a case of two uniformitarian hypotheses intruding over strict observation. Also, this definition is too narrow. It states the gorge must cut through a "mountain ridge." But there are gorges that also penetrate ridges, plateaus, or even a series of plateaus. The ones in the Weald are cut through chalk escarpments. Therefore, a water gap should best be understood as a perpendicular cut through any structural barrier. To simplify the discussion, we will define a water gap as a gorge that cuts through any barrier of rock and has a stream or river flowing through it.

Wind gaps are also present across the North and South Downs. A wind gap is "a shallow notch in the crest or the upper part of a mountain ridge. Usually, it is at a higher level than a water gap" (Neuendorf et al., 2005, p. 723). To qualify as a wind gap, the gap has to be a notch *caused by substantial erosion*

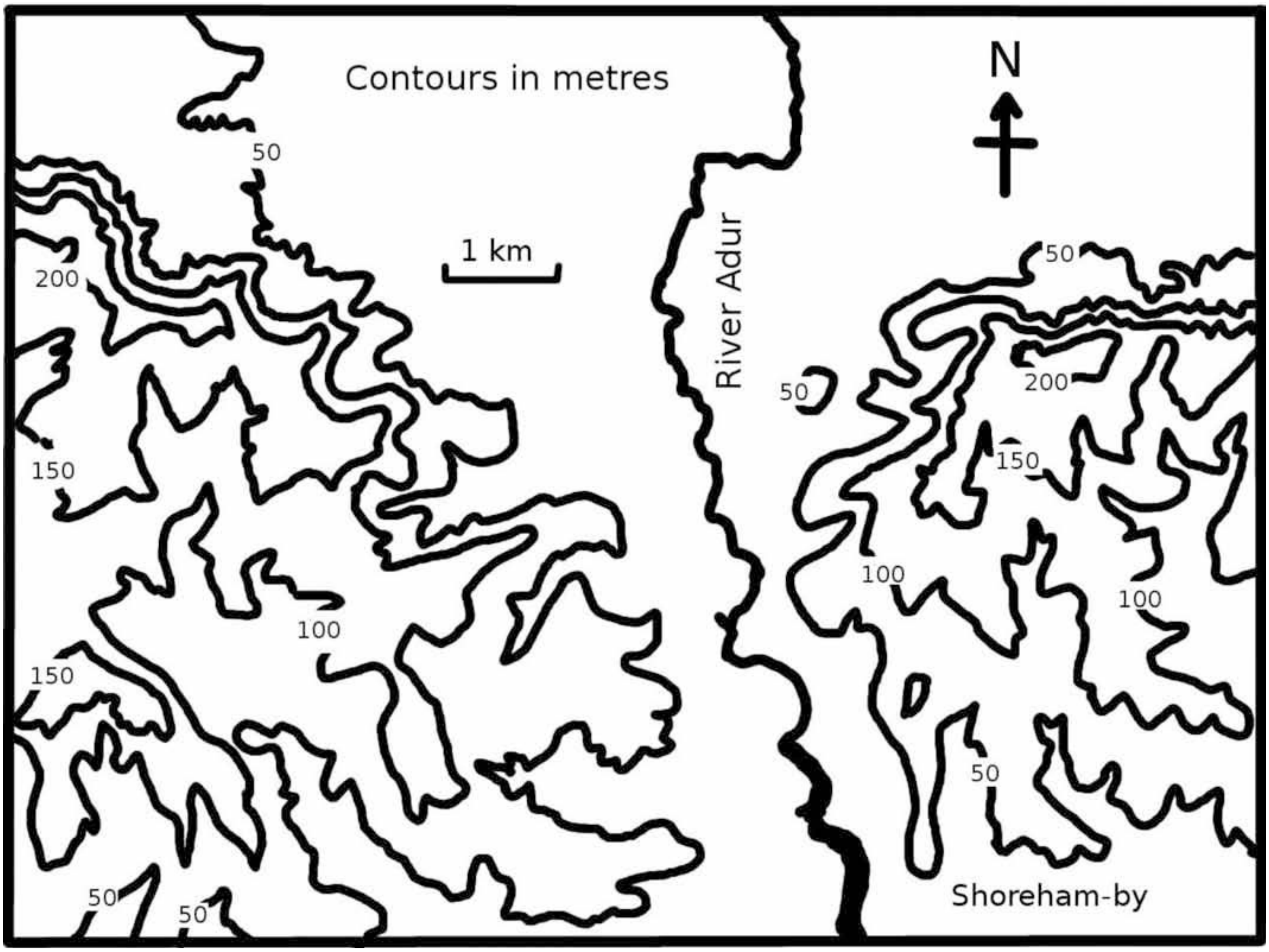


Figure 8. Contour map of the Adur water gap. The Adur River flows through the water gap around 10 m (33 ft) above msl while the top of the South Downs rises up over 200 m (656 ft) above msl.

and not solely by faulting or some other mechanism, as some early investigators thought for the Weald. In other words, the entire ridge was at one time near the same altitude, until the *notch was* eroded, aided possibly by easy removal of either local fault breccia or patches of less consolidated rock. The resulting notch was still perpendicular to the ridge, but erosion was not deep enough to capture a river or stream afterward. Being dry, they are "wind gaps," not "water gaps."

Silcrete and Sarsen Stones

An enigmatic feature on some erosion surfaces in southern England is a duricrust, defined as a hard crust on the surface generally found in a semiarid climate (Neuendorf et al., 2005, p. 197). There are generally four types of duricrusts: (1) ferricrete, an iron oxide crust; (2) silcrete, a silicon dioxide crust; (3) calcrete, a calcium oxide crust; and (4) bauxite, an aluminum oxide crust. The term "laterite" is often used for a crust that has oxides of iron or aluminum or both (Neuendorf et al., 2005, p. 363). Duricrusts are considered chemical sediments.

Duricrusts are found predominately in tropical and subtropical climates. They are common on the African Surface, a planation surface that covers much of Africa (Oard, 2011a), and planation surfaces in Australia but are less common elsewhere. However, they are also found in temperate climates, and an excellent example is the silcrete that sometimes caps erosion surfaces in southern England, including the Weald (McFarlane 1983; Ullyott et al., 2004). Eroded silcrete boulders in southern England are called *sarsen stones*, some of which reach a length of over 4 m (13 ft) (Figure 9). Sarsen stones can be composed of sand (Figure 10) or larger clasts (Figure 11). The clasts are commonly rounded to angular flints. The origin of this once widespread silcrete cap is unknown (Anand et al., 1997; Summerfield, 1983), as is the origin of duricrusts in general.

The formation of duricrusts is not well understood by uniformitarian scientists. They believe duricrusts formed from an as-yet-unknown process.

> Many authors have declared the duricrusting is now in progress only to a slight extent (Walther; Woolnough 1927); others that most duricrust is fossil and assignable to an epoch when the climate was either wetter or drier and the processes more active. (King, 1967, p. 233)

The process remains unknown to this day (Oard, 2013a, chapter 57). Thus, scientists do not know if duricrusts are forming today, since their present-day formation is said to be slight at best. However, duricrusts are being eroded in the present (Woolnough, 1975). The origin of silcretes in particular is not well known: "The environmental parameters which control the formation and distribution of silcretes are poorly understood" (Isaac, 1983, p. 110). Duricrusts are another interesting exception to the principle of actualism. Uniformitarian scientists commonly debate whether duricrusts formed in wetter or drier climates. Perhaps neither is correct.

Many geologists simply believe duricrusts somehow developed chemically within ancient soils (De Swardt, 1964). Since many are found in the tropics, scientists posit similar climates for their formation, although some believe duricrusts are formed by groundwater and not by soil processes (Nash et al., 2004). This is supported by the fact that the chemicals needed to form duricrusts do not appear to come from underlying parent material or by upward migration of the chemicals (De Swardt, 1964; McFarlane, 1983). This problem is also true of the Weald; it is a silcrete formed on a chalk substrate. It appears that the duricrust is a chemical precipitate that collected on the planation surface soon after formation because some of the Weald's silcretes are folded, just like the underlying sedimentary rocks (Twidale and Campbell, 2005), and some duricrusts were found capping a bevelled planation surface cut on tilted sedimentary rocks (De Swardt, 1964; Twidale and Campbell, 2005).

Figure 9. Sarsen stones in the Valley of Stones, Dorchester, south-central England.

Figure 10. A sarsen stone of cemented sand at the Nine Stones stone circle 1.6 km (1 mi) west of the village of Winterbourne Abbas, Dorchester, south-central England .

Two Hundred Years of Fruitless Uniformitarian Study

Early studies of the Weald assumed a catastrophic explanation (Jones, 1999b). But during the past 200 years, geologists have attempted to explain the development of the Weald by the principle of uniformi-

Figure 11. Close-up of a sarsen stone with rounded to angular stones at the Nine Stones stone circle. Most stones are rounded to angular flint rocks with the one in the center limestone.

tarianism, and their hypotheses fail with further study. In spite of this, none have reconsidered the catastrophic paradigm.

Lyell's Marine Erosion

Charles Lyell (1991, p. 289), for example, was *certain* that what is now the inner basin of the Weald was eroded by the ocean:

> On the other hand, the quantity of denudation or removal by water of vast masses which are assumed to have once reached continuously from the North to the South Downs is so enormous, that the reader may at first be startled by the boldness of the hypothesis. But he will find the difficulty to vanish when once sufficient time is allowed for the gradual and successive rise of the strata, during which the waves and current of the ocean might slowly accomplish an operation, which no sudden diluvial rush of waters could possibly have effected.

Notice that Lyell rejected the Flood explanation (the sudden diluvial rush of waters) without review, like a lawyer seeking to present only one side in a court case. In his view, the escarpments of the North and South Downs are remnant sea cliffs, similar to the cliffs along large sections of the current south coast of England (Figure 12). The idea of marine erosion, which we will later resurrect in a different form, was finally abandoned in the late 1800s as a result of the work of Whitaker and Topley (Jones, 1999a).

Fluvial Erosion

Soon after Lyell, the fluvial, or river, erosion mechanism gained ascendancy (Jones, 1999b). In spite of several quite different models, all were seriously flawed. Most of these assumed that the Weald rose as an anticline, creating a

Figure 12. The white chalk cliffs of Dover (Wikipedia).

Weathering causes a rough surface, not a planation surface
Weathering will destroy an already existing planation surface
Weathered debris must be stripped from the area
Planation surfaces cut across both unweathered and weathered rock
Cannot account for exotic rounded rocks with percussion marks

Table II. Some problems with the weathering hypothesis and the formation of planation surfaces.

large island, which was later subaerially eroded, mainly by rivers, creating one or more erosion surfaces. The most popular model of the mid-1900s was that of Wooldridge and Linton (1955), who based their work on the "cycle of erosion" developed by William Morris Davis in about 1900. Davis's cycle began with uplift, which was followed by slow erosion over millions of years to a gently rolling surface called a peneplain (Summerfield, 1991).

Wooldridge and Linton's model was abandoned when Davis's cycle fell from favor. Even the term "peneplain" has been abandoned. However, the problem remains. Erosion and planation surfaces are common; workable models are not. One reason Davis's view was controversial was because of his insistence on rapid uplift. Newer models developed in the 1980s depend on pulsed tectonism and Paleogene (early Cenozoic) denudation (Jones, 1999a), but these models have not fared well in the field, either.

The Weathering Hypothesis

Jones (1999a) supports an alternative model: that weathering caused erosion surfaces sometimes capped with clay-with-flints. This idea developed in the early- to mid-1900s and is the most popular explanation today for erosion and planation surfaces (Oard, 2011b). It seems to have survived among geomorphologists because it fills a theoretical void (Thomas, 1994). In the hypothesis, erosion or planation surfaces form as the surface is chemically weathered downward with time. The weathered debris is removed by sheet wash, stream erosion, or other mechanisms. Both stages can occur simultaneously. The mechanism is believed especially effective in the humid tropics, where weathering is sometimes observed deeper than 100 m (330 ft).

There are a number of serious problems with the weathering hypothesis (Table II). The most serious is that weathering does not create planation surfaces but roughens and *destroys* them.

The Weald Is a Uniformitarian Mystery

Hypotheses for the origin of the Weald have come and gone, although the weathering hypothesis is currently popular. But after two centuries of intensive study, the explanation for the Weald's geomorphology remains as remote as ever:

> The evolution of the Weald has been the subject of continuing controversy over nearly two centuries of investigation. … The Weald is one of the best known examples of denuded anticline landscape yet its evolution has remained controversial despite numerous studies. (Jones, 1999b, p. 25)

This is compounded by the lack of robust explanations for water and wind gaps. Uniformitarian geology seems to have failed on both counts.

Summary

The Weald is formed by an erosion surface across an uplifted anticline in southern England. The crest of the anticline was eroded, leaving cuestas, known as the North and South Downs on the northern and southern limbs of the anticline, respectively. During erosion, surfaces were cut on the chalk ridges, sometimes beveling the layers. Erosion surfaces are capped locally by a gravel layer called "clay-with-flints," which consists of flint nodules eroded from the chalk and a fine-grained matrix, commonly sand. Later, water and wind gaps formed perpendicular to the North and South Downs, leaving an anomalous drainage that extends north and south, not east along the sloping axis of the anticline. Finally, a silcrete duricrust formed atop some erosion surfaces and was then eroded into large boulders called sarsen stones.

Although the Weald is a classical area for the origin and study of geomorphology, no satisfactory theory has been found. Many hypotheses have been proposed, but all have serious problems. These include Lyell's marine erosion hypothesis, the fluvial erosion model that mimicked Davis's "cycle of erosion," and today's weathering hypothesis. It is fair to say that the Weald remains a geomorphologic mystery.

In Part II, we will show that runoff from the Genesis Flood offers a reasonable explanation for the origin of the Weald, despite being dismissed from scholarly thinking by secular geologists since the late 1700s.

Acknowledgments

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