a bank of 5½ miles of 1 in 100 on the line between Sheffield and Dronfield.

The principal dimensions are as follows:

PARTICULARS OF BOGIE EXPRESS PASSENGER ENGINE, JOY'S MOTION.

	ft.	in.
Cylinders—		
Diameter of cylinders	1	7
Stroke	2	2
Length of ports	1	1½
Width of steam ports	0	1⅝
Width of exhaust ports	0	4
Distance apart of cylinders center to center	2	0
Lap of slide valve	0	1⅛
Lead of slide valve	0	3/16
Motion—		
Diam. of piston rod (steel)	0	2¾
Length of slide blocks	0	10
Length of connecting rod between centers	6	2¾
Wheels and Axles—		
Diameter of driving wheel on tread	7	0
Diameter of trailing wheel on tread	7	0
Diameter of bogie wheels on tread	3	6
Distance from center of bogie to driving	10	0
Distance from center of driving to trailing	8	6
Distance from driving to front of firebox	1	8½
Distance from center of bogie to front buffer plate	5	3
Distance from trailing to back buffer plate	4	4
Wheel base of bogie	6	0
Crank Axle (Iron)—		
Diameter at wheel seat	0	8½
Diameter at bearings	0	7½
Diameter at center	0	7⅛
Distance between centers of bearings	3	10
Length of wheel seat	0	6⅝
Length of bearings	0	9
Trailing Axle (Steel)—		
Diameter at wheel seat	0	8½
Diameter at bearings	0	7½
Diameter at center	0	7¼
Length of bearings	0	9
Diameter of outside coupling pins	0	3½
Length of ditto	0	3½
Throw of ditto	0	12
Bogie Axles (Iron)—		
Diameter at wheel seat	0	6½
Diameter at bearings	0	5¾
Diameter at center	0	5¾
Length at wheel seat	0	6
Length at bearing	0	9

	ft.	in.
Distance between centers of bearings	3	7
Tires—		
Thickness of all tires on tread	0	2¾
Width of all tires	0	5½
Frames—		
Distance apart at leading end	3	11¾
Ditto at trailing end	4	1½
Thickness of frames (iron)	0	1
Boiler—		
Center of boiler from rail	7	4
Length of barrel	10	6
Diameter of ring next to firebox	4	3
Thickness of plates (iron)	0	½
Thickness of smoke-box tube plate	0	¾
Lap of plates	0	2½
Pitch of rivets	0	1⅞
Diameter of rivets	0	13/16
Thickness of butt strips, outside	0	½
Thickness of butt strips, inside	0	7/16
Width of butt strips	0	7½
Firebox Shell—		
Length outside	5	11
Width outside at center line of boiler	4	4
Ditto at bottom	4	½
Thickness of front plates	0	9/16
Thickness of back plates	0	½
Thickness of side plates	0	½
Distance apart of copper stays	0	4
Diameter of copper stays	0	⅞
Inside Firebox—		
Length at bottom, inside	5	3
Width at bottom, inside	3	4½
Top of box to inside of shell	1	3
Depth of box inside, front	5	11½
Depth of box inside, back	5	4½
Tubes (Copper)—		
175 diam.	0	1¾
30 "	0	1½
Total No. of tubes 205		
Thickness, 11 and 13 B.w.g.		
Diameter of exhaust nozzle	0	4⅝
Height from top of top row of tubes	0	½
Height of chimney from rail	13	1½

Heating Surface—	sq. ft.
Tubes	1011·459
Firebox	110·163
Total	1121·622
Area of grate	17½

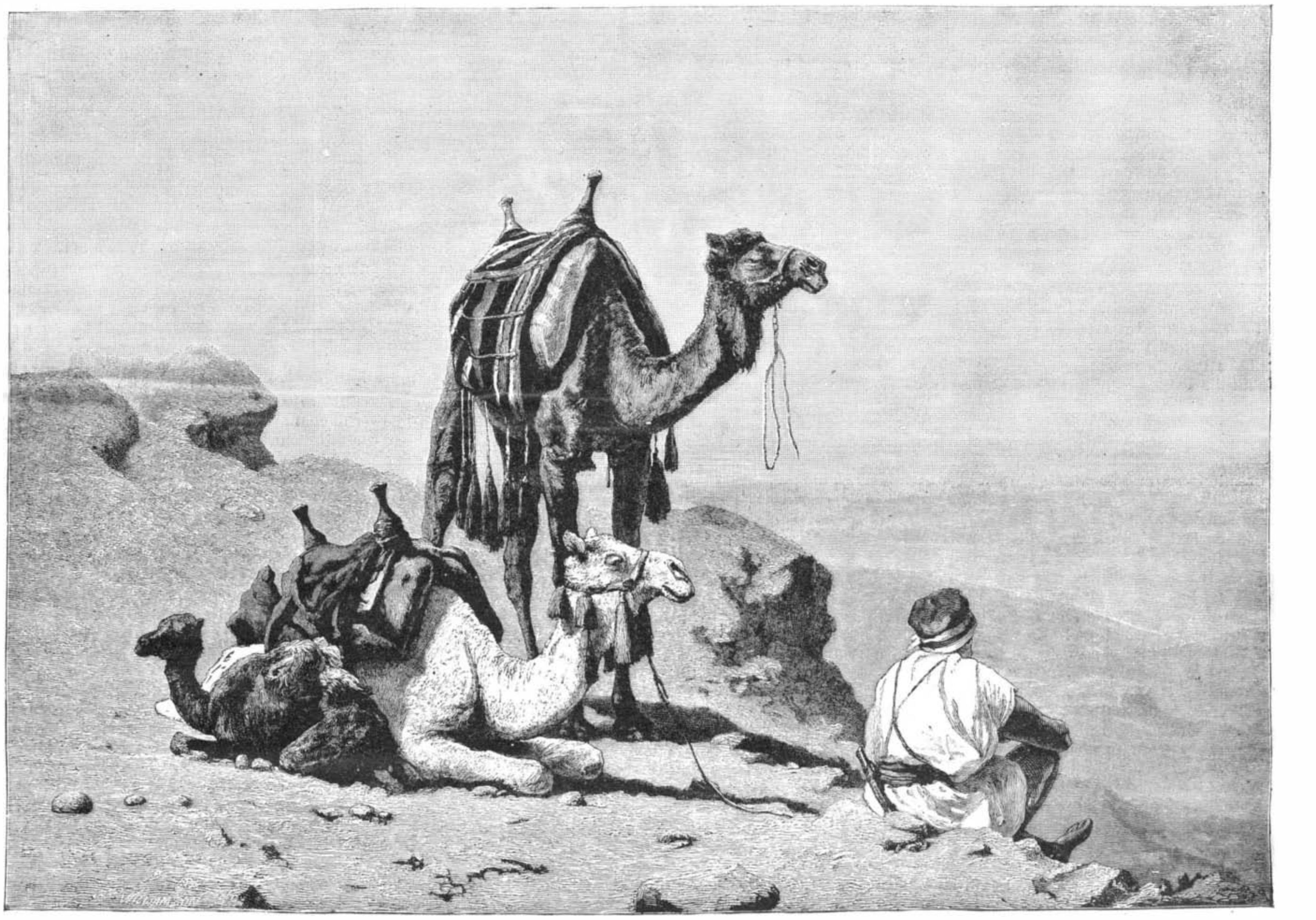
	tons.	cwt.	qr.
Engine Empty—			
Bogie	13	14	2
Driving	13	12	2
Trailing	12	4	1
Total	39	11	1
Engine in Working Order—			
Bogie	14	16	3
Driving	15	0	3
Trailing	12	18	3
Total	42	16	1
Tender Empty—			
Leading	6	10	0
Middle	6	6	2
Trailing	6	0	2
Total	18	17	0
Tender in Working Order—			
Leading	10	17	3
Middle	12	5	1
Trailing	12	0	0
Total	35	3	0

	lb.
Adhesion	12,544
Tractive power at 100 lb. mean pressure	11,173

THE EGYPTIAN CAMEL SERVICE.

Those who have an idea that the desert regions of Upper Egypt and the Soudan are simply a dead level, a sort of ocean of sand, have greatly mistaken the actual physical configuration of the country. The artist in the accompanying illustration, for which we are indebted to the London *Graphic*, has sought to give us a view of the desert as it really is, the rocks and hills alternating with sandy plains to make a country rugged of aspect, where the absence of water precludes all vegetation, and the naked, glaring surface seems to almost equally forbid animal life. And this is the character of the country for hundreds of miles along both banks of the Nile, up to the great central African plateau. Long before the First Cataract is reached, at Assouan, five hundred miles above Cairo, these sterile wastes approach quite up to the river banks, and all travel over them is fraught with great labor and hardship.

The difficulty of sending soldiers through such a region was the most serious matter which presented itself to the British Government in organizing its expedition for the relief of Khartoum, and the idea of utilizing the service of camels therefor was promptly adopted by General Lord Wolseley. In the SCIENTIFIC AMERICAN of December 20 we gave an illustration and description of the equipment of this unique cavalry service, without whose aid it would hardly have been possible for the divisions of Gen. Earle and Gen. Stewart to have made their forced marches from Korti across the desert, the former toward Berber and the latter to the Nile near Shendy. In these marches and the subsequent retreat even the endurance of the camel has been severely tried, as it is quite a different thing to take a modern army over the Nubian or the Libyan desert from what it is for an Arab caravan to traverse these dreary wastes. The English soldiers have now become familiar with the characteristics of their uncouth steeds, but it is said that the closer acquaintance has not increased their estimation of his character, and he is declared to be a sulky and troublesome beast, whose use is a most disagreeable necessity.



A REST IN THE DESERT.—FROM A PICTURE BY C. RUD. HUBER.

Rhigolene.—A Local Anæsthetic.

The use of cocaine as a local anæsthetic has directed attention to the value of petroleum naphtha for similar purposes. The name rhigolene was given by Dr. H. J. Bigelow, of Boston, to a light inflammable liquid obtained by the repeated distillation of petroleum. It is probable that it is not a definite chemical compound, but it is said to be one of the most volatile bodies in existence. By using it in the form of a spray with a common atomizer, it produces a degree of cold sufficient to freeze any tissue with which it may come in contact. Dr. W. Chapman Jarvis, of New York, finds that its action is more decided than that of cocaine, although of shorter duration. Skin and mucous membranes may be divided deeply and freely without fear of pain or hæmorrhage. Its effects pass off quickly, so that the operator has to act with promptness. It is a good plan to employ it in conjunction with cocaine. When not in use, it should be kept on ice or in a cool room, tightly corked. In a warm place it would probably burst the bottle or blow out the cork. It has been accused of possessing explosive properties, but probably it is safe if not brought in contact with an open flame. It should not be used for cases which require artificial light. Very little is known about it as yet, although its properties were cursorily investigated some years ago.

Casehardening Axles.

Here, says the *Carriage Monthly*, is a brief description of the process of steel-converting axle spindles. The axles are first forged and then machined or finished in the lathe. The threaded portion is then incased in a ball of fire clay. The axles are next stood (points down) in metal boxes; the space between the axles is then filled with animal carbon, usually calcined "bone dust," to a point one inch or more above the collar. A fire is then made about the metal boxes, and kept up until the carbon ignites and penetrates the iron, the whole being at a red heat. When thoroughly charged with the carbon, and while red hot, the axles are removed and placed in the cooling vat, the water of which is most usually charged with salt, and sometimes with prussiate of potash. When cold, the spindles are straightened and riveted to the boxes, and the spindle and the inside of the box polished.

The Age of the World.

The Rev. L. J. Templin contributes to our excellent contemporary, the *Kansas City Review of Science*, the following interesting paper on the "Age of the World," a theme which has occupied the attention of students, has been a pregnant subject for theologians to discuss, and is of interest to all intelligent persons:

Scarce a generation has passed away since it was the almost universal belief among the common people that the earth, in both its material and form, was only about 6,000 years old. When geology began to teach that the age of the world was to be reckoned by not only thousands and tens of thousands, but by millions of years, it was arraigned as being in opposition to the word of God, being infidel if not atheistic in its tendencies. But now, few if any persons, who have any just claims to be considered intelligent, question the great antiquity of the earth. But only those who have given special attention to the subject are aware of the vast amount of evidence in favor of this view that is presented by the present condition of the rocks composing the solid crust of the earth.

To give even an abstract of all the proofs that exist in favor of this doctrine would require a large volume; much less can it be compressed within the narrow limits of a magazine article. A cursory view of a few representative facts and general principles is all that can be attempted in the present discussion.

There was doubtless a period in the earth's history when its whole mass was in a state of igneous fusion. When it had become sufficiently cooled to permit the existence of water on its surface, currents would be formed, and erosion would begin. The eroded material would be deposited in still water, and form sedimentary rocks. These would be laid down in horizontal, or nearly horizontal, strata. The cooling of the earth would cause contraction, and this would produce subsidence in places and upheavals in others. By these means the strata already laid down would be broken, contorted, and tilted at various angles, leaving the edges exposed. As erosion would go on, new strata would be deposited on the upturned edges of the older strata, but unconformable with them. These co-ordinate processes would go on as long as the vertical oscillations in the crust of the earth should occur. And they have been in operation from those early times when all the water on the earth was probably kept at a boiling temperature till the present, and we find them still in operation, and still producing the same results. In studying the sedimentary rocks, it should be always kept before the mind that they have been formed by the double process spoken of above, and that these have exactly balanced each other, denudation being commensurate with deposition. The amount of this sedimentary matter, in the aggregate, is enormous.

The various formations vary greatly, being thicker in places, thinner in others, and entirely wanting in still others; but taken altogether, they constitute a thickness of about 72,000 feet, or 13½ miles. In considering these rocks in relation to time, the mind should divest itself of all idea of reducing it to any statement in years. But there are numerous facts connected with their formation that indicate an enormous lapse of time. The enormous depth and vast extent of some of these formations, with certain attendant facts and conditions, impress the mind, almost with the force of a demonstration, that the lapse of time during their formation must have been inconceivably great. Let us begin with the Laurentian, the oldest fossil-bearing rock known to exist. These are found to exist over a wide extent of country in both America and Europe. They attain their greatest known development in Canada, where they exist to the thickness of 40,000 feet. Supposing that they were formed by the gradual detrition of older rocks, and the deposition of the debris at the bottom of the ocean, the time required for the accumulation of such vast quantities of rock material must have been very great. This fact seems further evident from the presence in these rocks of certain substances that were accumulated in them during their formation. Interstratified with the rocks, and sometimes existing in pure beds, are found large quantities of graphite. This is doubtless the result of the perfect carbonization of vegetable matter.

The growth of this vegetation would require long lapse of time, after which it would probably pass slowly through the various grades of lignite, brown coal, and anthracite, before reaching the stage of graphite. Another fact that seems to demand the same interpretation in its relation to time is the vast deposits of iron ore during the Laurentian period. It is in the rocks of this period that we find the rich iron beds of Missouri, New Jersey, Lake Superior, and Sweden. This ore is supposed to have accumulated by the leaching of the oxides and carbonates of iron from the rocks, and its precipitation under the influence of decaying vegetation.

Now, if all the vast beds named above have been deposited by this process, it must have consumed almost inconceivable time. The great Iron Mountain of Missouri itself is estimated to contain not less than 600,000,000 tons of iron above the level of the surrounding country. Extensive beds of limestone are also found here; and as these are supposed to be composed of the shells of mollusks and protozoans, the time for them to live and die in quantities sufficient to form such extensive beds of their calcareous remains could scarcely be reckoned in years. Next above these Eozoic rocks are the Silurian, aggregating a thickness of over 25,000 feet, and crowded with fossils, both animal and vegetable. More than 10,000 different species of fossil animals are already known to belong to this system. These are not, as we would naturally expect from the age of the rocks, of simple and primitive forms; but they are of widely differentiated and highly specialized forms. Coming in as they do, suddenly, in such great variety, and on such a high plane of organic life, how to account for their origin on the hypothesis of evolution has been a very difficult problem. In order to surmount the difficulty, believers in this doctrine generally take refuge in the assumption that between the close of the Eozoic age and the beginning of the Silurian age, as represented in the rock of the two systems, there must have been an enormous lapse of time, exceeding in extent all the time required for the formation of the rocks composing both these systems. . . .

We next come to the carboniferous age—age of acrogens, or coal age. Here we find the most indisputable evidence of enormous stretches of time. The foot-prints of time are so indelibly impressed on the rocks of this age that in some places some approximation to a calculation may be made. The thickness of the rocks of this system varies from 9,000 feet to 15,000 feet. The coal measures proper vary between 4,500 and 13,000 feet. We here have the most irrefragable proofs of the frequent oscillation of the earth's crust. The seams of coal, which compose but a small portion of the thickness of these rocks, are interstratified with the various strata of sandstones, shale, and limestone composing this formation.

As coal is the product of vegetation, which must have grown at the surface, it is evident that to form the seams of coal found at various depths would require that each of these various horizons should have been at the surface at the time when the material forming the coal was accumulated. Now, we find in different coal fields a considerable number of these seams separated by intervening strata of rock. Thus in Nova Scotia there are 81; in Wales, 100; in Belgium, 100; in Westphalia, 117. These aggregate, in some cases, as much as 150 feet of coal that would be passed through in sinking a shaft from the surface to the lowest coal seam. It is evident that where these different seams are found, the land has been elevated and depressed at least once for each of the seams found.

There would be a long period when the land surface was above the water; immense forests of vegetation would flourish until a huge layer of it was accumulated, when by some convulsion of the crust of the earth, or by a gentle—perhaps to human eyes it would have been imperceptible—subsidence, it would be depressed below the waves and receive, either from fluviatile or marine sediment, a layer of earthy material, covering the layer of organic matter to a depth of many feet. A reversal of the process by which the land was depressed again elevates the surface above the waters, and again a layer of vegetation would be produced, to be in turn buried as the former was. And thus these alternate elevations and depressions continued till, as we have seen in some cases, a hundred or more beds of vegetable matter have successively grown and been buried. The pressure and heat to which this organic matter was subjected after such burial eliminated the greater portion of the volatile gases, and converted it into coal. The time necessary for the accumulation of all the organic matter contained in all these strata, and in the subsidence and elevation, and for the deposition of the sedimentary materials composing the rocky strata interposed between these coal seams, cannot be estimated—even approximately. But we are sure it must have far exceeded all conceptions of duration that we can form from our knowledge of human history. We have no data on which to base any estimate of the rate of the accumulation of sedimentary matter, except the present rate of sedimentary deposition at the mouths of rivers. The present average amount of sediment carried down by the Mississippi amounts to enough to cover one mile square to a depth of 268 feet annually, or about one cubic mile in twenty years. At this rate it is estimated that it would have required about 1,000,000 years to have carried down and deposited the amount of materials that originally composed the rocks of the coal measures in the coal fields noticed above.

The time occupied in the growth of the vegetation that formed the various beds of coal may be more nearly approximated. If we assume the amount of vegetation growing on one acre at 2,000 pounds, this would give in 100 years 100 tons. This compressed into coal and spread over an acre of ground would give a thickness of one-eighth of an inch of coal in a century, or 10,000 years would be consumed in producing one foot of coal. This would require, to produce 150 feet, as found in some regions, no less than 1,500,000 years. But probably the growth of coal plants, with the very high temperature and heavy atmosphere, laden as it was with carbonic acid that prevailed during the coal age, would produce a much larger growth of vegetation than we have estimated, and the time would be accordingly diminished. But making due allowance for this, there is no question but the time required for the growth of all this vegetable matter, the frequent subsidences and elevations, and the accumulation of the sedimentary matter composing the rocks of this formation must have required hundreds of thousands if not millions of years.

Another remarkable illustration of alternate elevation and depression, or at least of alternate land and water surface, is found in the Amethyst Mountain, in Yellowstone Park. This mountain is made up of alternate layers of sandstone and conglomerates, and the remains of gigantic forest trees. The stumps and trunks of these trees are found embedded in the rock material of the mountain at various altitudes; the stumps five to six feet in diameter, and the trunks sixty feet long. It would seem that a forest of these gigantic trees would flourish for a time—perhaps for centuries—and then be overwhelmed with a flood, bringing down sand, gravel, and broken stones, completely covering the site of the forest. This would become the soil upon which another forest would spring up and grow, only to be buried up as its predecessor was. And this process of alternate growth and burial has gone on till from one to two score of these gigantic forests have flourished and passed away. Since the last one passed away, the mountain has been elevated 3,000 feet above the river. The time required for all these changes must far exceed all our conceptions of duration.

It is an undoubted fact that the topography of the present surface of the earth has been largely affected by erosion. This process is constantly going on, degrading the eminences, changing the declivities, and gradually wearing away the whole surface of the land. The sum of this erosion, since the last great geological changes, is enormous. The erosion over many portions of England is estimated at 10,000 to 11,000 feet.

In the Appalachian region it is proved that the erosion has amounted in some cases to not less than 20,000 feet in depth. In portions of the Rocky Mountain regions this erosion has been still greater. Professor Powell informs us that in the Uintah region the amount of erosion has exceeded five miles in depth in some places, with an average depth of three and a half miles over 2,000 square miles of country. The time necessary for the removal of so large an amount of material would depend on the agencies employed and the energy with which they operated. It would undoubtedly be vast.

Water, aided by frost, is probably the principal agent operating in producing all the erosion that has taken place on the earth. The power of water to "wear away a stone" is witnessed in the wonderful channels they have cut for themselves during the present geological age. The Niagara River has cut a channel about 200 feet deep a distance of seven miles. Mr. Lyell estimates 36,000 years as the time necessary for the accomplishment of the task; but as we know neither the present nor the past rate of progress the river has made, such estimates are perfectly unreliable.

A very noted example of river erosion is exhibited by the Grand Canon of the Colorado River, which is 300 miles long and from 2,000 to 6,000 feet deep. But we have no data from which to estimate the time required for the river to cut its way through this distance of rock. We do not know the present rate of recession, nor do we know but the river simply followed and enlarged a crevasse that had been formed by some convulsion of nature. As all such data are unreliable, all conclusions drawn from them must be fallacious. . . .

Two facts present themselves for consideration here, that go far to vitiate all such estimates. One is the fact that in the earlier ages of the world the higher temperature that prevailed, and the large per cent of alkaline and acid substances held in solution by the water, would greatly increase its erosive power, thus requiring a far shorter time to produce a definite amount of sediment than is required at the present time. This would require a large reduction of the above estimate. But on the other hand, we have the fact that the erosion that is now taking place is principally operating on sedimentary rocks; and doubtless this has been true during a great portion of geologic time. This same material has been laid down and removed again and again, so that an estimate of the time that it would take to deposit the materials of the sedimentary rocks as we know them gives but a very slight clew to the time since the beginning of their deposition. . . .

Different scholars have attempted a calculation of the age of the earth from the rate of cooling of heated bodies exposed to a cold atmosphere. But the various elements entering into the mathematical analysis of this problem are so numerous and uncertain that there is no agreement in the conclusions arrived at. These conclusions vary from 160,000,000 to 600,000,000 of years as the probable time required to bring the earth from a fluid state to its present condition. . . .

From all the foregoing considerations we are led to the conviction that though the earth has existed for an inconceivable length of time, yet from the data at command it is impossible to reduce it, even approximately, to years; that these unmeasured and unmeasurable years are known only to Him who is from everlasting to everlasting, yesterday, to-day, and forever.