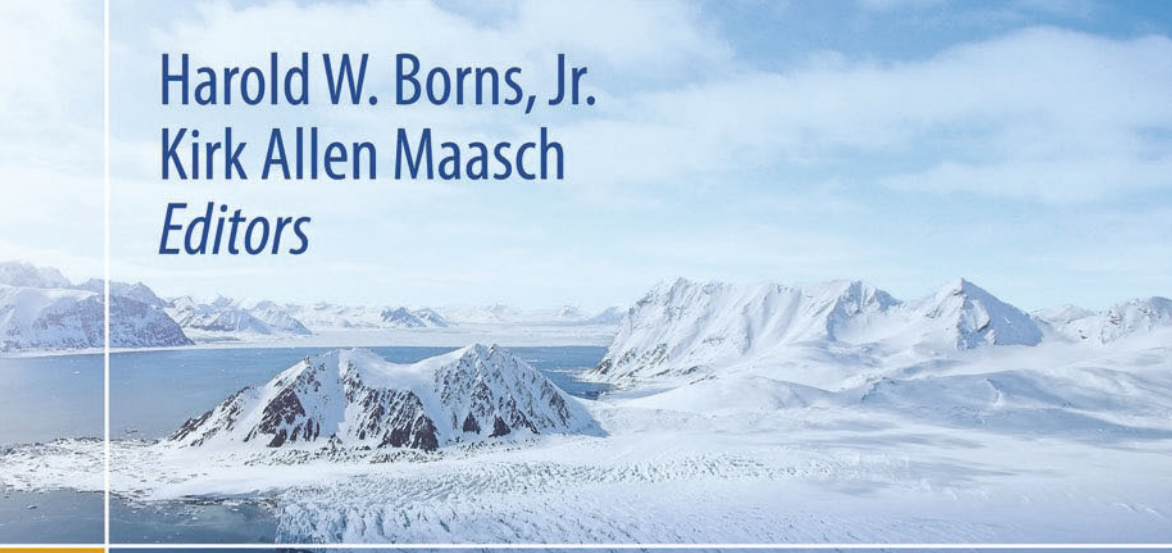
Harold W. Borns, Jr.
Kirk Allen Maasch
Editors



Foot Steps of the Ancient Great Glacier of North America

A Long Lost Document of a Revolution in 19th Century Geological Theory

Springer

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We dedicate this volume to our deceased friend and colleague David Clayton Smith, Emeritus Professor of History at the University of Maine. Many years ago, after browsing DeLaski's handwritten manuscript for the first time David asked "who is this Dr. John K. DeLaski?" That profound question launched a long and ongoing search for the shadowy facts of DeLaski's life, and ultimately an understanding of his scientific research and significance of this manuscript.

Foreword

The publication of this book, written by John Kimball DeLaski, has been a long time in coming, about 140 years too long! The story is one well known today, but in mid-19th century it was very much ahead of its time. A master of reading the incredible geologic record indelibly imprinted upon the landscape of Maine, he was among the first to recognize the scale of the immense continental ice sheet that covered North America at the height of the last ice age. Over his lifetime, Dr. DeLaski made careful observations of surface features across Maine coming to the inescapable conclusion that only the action of glaciers could have created this landscape. At the time of his investigations the prevailing belief was that the biblical deluge and icebergs were the primary agencies responsible for sculpting the land. In this volume we present the synthesis of DeLaski's scientific work as of 1869 with a transcription of the handwritten manuscript that he presented to the Portland Society of Natural History of which he was a member.

Orono, Maine
July 2014

Harold W. Borns, Jr.
Kirk Allen Maasch

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Part I
John Kimball DeLaski

John Kimball DeLaski, M.D.

Chapter 1
Biographical Sketch

John Kimball DeLaski, M.D. was born June 9, 1814 in St. John, New Brunswick. He emigrated to Bangor, Maine on June 9, 1833 and was naturalized in Portland, Maine on January 4, 1868. He married Anne Vaughn Wise in Eastport, Maine on July 27, 1839, and together they had eight children. In the early 1850's the family moved to Iron Point on the island of Vinalhaven, Maine and later, to Carver's Harbor, the village on the island. Dr. DeLaski practiced medicine for nearly 30 years, but where and when he received his medical training is unknown. It has been suggested that he may have apprenticed to a medical doctor. In addition to practicing medicine he also carefully observed the Maine landscape as a geological naturalist. He meticulously described, often in minute detail, the evidence on the ground that he attributed to former extensive glaciations of the Penobscot Bay region. Through the decade of the 1860's he complied his observations into a handwritten book manuscript entitled "Foot Steps of the Ancient Great Glacier of North America" dated 1869, that was not published until now. However, parts of the manuscript were previously published as articles in the local Rockland Gazette and as scientific papers in the American Journal of Science and other places. He was also a published poet. It is apparent from these early observations and descriptions that DeLaski had a real appreciation for the immensity of the ice sheet that he determined had covered this region of Maine and New Brunswick and much of North America in the past. Note that in the preface of his book DeLaski wrote "In presenting the following pages to the public, I am actuated by the conviction that the views hitherto had of the ancient great glacier of North America, by scientific men as well as by geological readers generally, have not come to the magnitude of the mass, nor to the gigantic work which it has preformed upon the floor of our continent." Among these scientific men were Louis Agassiz and James Dwight Dana, both of whom we know he interacted and corresponded with over the years.

Louis Agassiz, while a professor at Neuchâtel and president of the Natural History Society of Switzerland announced in his presidential address of 1837 and ultimately to the broad scientific community, that Earth had experienced an ice age in the recent past during which a great glacier had flowed south from the arctic covering most of northern Europe and the Alps. This was in direct contrast to the devines who

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believed that the landscape features, described by Agassiz and others as glacial, were really the product of the biblical deluge. Professor Agassiz was invited to Boston and Harvard College in 1846 to present a series of natural history lectures in the prestigious Lowell Institute, all of which were extremely well received. He stayed in Boston after being appointed to the faculty of Harvard College in 1849. Agassiz was charged with developing the natural sciences. Harvard up to that time had been primarily a divinity school. He oversaw the building of Harvard's Museum of Comparative Zoology, which came to be known colloquially as the "Agassiz Museum" that today houses the famous Glass Flowers.

Once ensconced as a professor at Harvard he started a series of long and short distance travels to look for evidence of wide spread glaciation in North America and even to the Amazon basin of South America. In this search he visited Maine on several occasions, where he met, traveled and consulted with local naturalists making observations of the landscape. Literature shows that Agassiz met and traveled in central and coastal Maine with his "naturalist friend". Research of DeLaski's papers has shown that this unnamed friend was actually DeLaski. Agassiz was shown many glacial features on their excursions that DeLaski had previously found and interpreted and certainly together they observed more, especially in coastal and central Maine. Most of DeLaski's observations had already been published in several of his long articles in the Rockland Gazette in July and October1862 as well as in the American Journal of Science in April 1864, 6 months prior to Agassiz's trip to Maine. It appears that many features both previously published on, and those seen anew by both on their excursions, were published by Agassiz in his "Glacial Phenomena in Maine", The Atlantic Monthly, 1867. In a manner typical of Agassiz he made no mention of DeLaski nor gave him credit for his observations.

DeLaski also befriended Benjamin Silliman and James D. Dana at Yale College. These relationships developed through exchanges of letters on glacial features of common interest, and through DeLaski's publications in Yale's American Journal of Science on glacial age fossil marine shells from the glaciomarine mud on North Haven Island, Maine, and on his 1847 and 1871 observations of glacially transported boulders on Mt. Katahdin, for example. Clearly John DeLaski was a member of this august team of Silliman, Dana and Agassiz that broadly advocated the glaciation theory in contrast to the biblical deluge interpretation to account for the landscape of the northeast. However, he remained a rather shadowy member of this group of notables.

DeLaski's many publications, especially in the Rockland Gazette, demonstrate his unusual and very critical powers of observation. Good examples of this are his descriptions of and interpretations of glaciated rock outcrop surfaces on Vinalhaven given in a detailed letter to Dr. Charles H. Hitchcock, State Geologist of Maine. This letter is embedded in Hitchcock's General Report on the Geology of Maine, 1861. In the letter DeLaski noted that striae on rock surfaces existed at all levels on Vinalhaven Island and which did not vary in their N-S directions over the entire island regardless of local variations in topography or bedrock type. These could only be interpreted as glacial in origin. Hitchcock, a firm believer in the biblical deluge completely ignored DeLaski's letter. In several of his more extensive publications

John De Laski.

Delaski noted striae continuously present on the upslope over the top and on the downslope of large smoothed hills called “whalebacks”. Advocates of the deluge argued that such features, and in fact all striae, were made by icebergs, in which rock fragments were embedded in their bases, scraping across rock outcrops. This latter example of DeLaski begs the question how does a floating iceberg possibly move upslope and then downslope? DeLaski pointed out that the iceberg theory for these features was impossible, and that the force was actually moving glacial ice. These examples demonstrate the critical observations made by DeLaski that became his proof of glaciations in contrast to the deluge as being responsible for the modification of the pre-existing landscape.

John DeLaski’s early observations were made on Vinalhaven Island, Maine where exposed granite surfaces abound. Here he spent considerable time cogitating and recording glacial erosional features on the island’s bedrock surfaces as well as the generally smooth and rounded glacial shapes of hills in the range behind nearby Rockland and Camden. Based upon these observations he concluded that a very broad glacier had occupied all of the Penobscot Bay in the past.

As he traveled further east and west in coastal Maine and New Brunswick he noted similar glacial features at all elevations. The striae all were generally parallel to those of Penobscot Bay, and indicating glacial flow from northwest to southeast. This consistency lead him to conclude that a very large, regional glacier had flowed through central and coastal Maine and adjacent New Brunswick and not just a smaller one restricted to Penobscot Bay. After climbing Mt. Katahdin in north central Maine in 1847 and 1871, where he noted glacially transported erratic boulders on the slopes

nearly to the top and perhaps some on top as well, he decided that the glacier had been at least 5000 ft thick. After several years of more regional observations he again concluded that this thick glacier, not only covered central and coastal Maine and New Brunswick but that it could only be part of a far greater glacier that covered the northeast and was of continental proportions.

DeLaski was an extensive reader of geological publications and articles in general, but especially those related to glaciers and glaciation. He was an avid reader from the time of his youth and over his life compiled a very notable personal library. Many of the things that he read about in geological publications he used to understand and develop a greater view of glaciation. For example he understood that the material called the "boulder drift" by the advocates of the biblical deluge, was not a material "drifted" over the landscape by deep ocean currents, but in reality was a material composed of an unsorted mix of particle sizes from boulders to clay, which clearly was derived, carried, and deposited at the base of glaciers, a material called basal or ablation till today. This material had already been described from the study of modern glaciers in the Alps by Jean de Charpentier, Louis Agassiz, and others. DeLaski observed this material all over New England but not south of it, and in areas he visited in New Brunswick. In his readings he observed that "boulder drift" had also been described by others from localities all of New England, the Great Lakes Region as far south as the Ohio River and west, down to the Missouri River. From all of this he concluded that the entire area of the boulder drift had been covered by a glacier of continental proportions that flowed southward terminating on a line marked by Long Island, New York, and the valleys of the Ohio and Missouri Rivers. This conclusion became the focal point of his later book manuscript.

In his later life John DeLaski felt that the general public should be more widely exposed to the concept of continental glaciation and as a result he produced this hand written book manuscript. This book manuscript is dated 1869 and we feel that it was basically completed at that time. However, before he submitted it to the Portland Society of Natural History, presumably for publication, he inserted his notes on appropriate scientific matters, along with short statements by others that he clipped from newspapers, between the hand written pages. The last of these newspaper clippings was dated 1871. We can only assume that he was going to tweak what he had

Cover of DeLaski's handwritten book manuscript of 1869.

originally written with this added information. However, he died in 1874 and either he had submitted the manuscript with the note papers still in it, after 1871, to the Portland Society of Natural History or it was given to the Society after his death. We will never know. In his words "It has been my purpose to elucidate the progress and completion of this great physical change in the aspect of the north, and to bring it as a panorama of life before the reader, that he might see his connection with the past, the present and the future of the country". It is clear that he did not want to write the book in the style of a scientist, but in his words "to leave the old past reverent with age and the voices of sages, and to strike out with my companions, at once into the green fields and forests of the earth into the overgrown bye ways leading to the hill, lake side and the shore of the ocean, where the presence of nature was free and joyous, and the human ear and eye more open to the tongue of instruction".

As to the book itself, the strong, factual core is devoted to DeLaski's own observations and interpretations, made over many years, of both the large and small features of the landscape of New England and New Brunswick, all of which he carefully interpreted and attributed to wide spread glaciation. He also included what he deemed to be critical observations of striae and "boulder drift" from the lower provinces of Canada, Labrador the northwestern Canada and along the Ohio and Missouri Rivers made by himself and other scientists at different times. It was the geographic distribution of these features that led to his conclusion that the courses of the rivers along with Long Island, N.Y. mark the southern border of the Laurentide Ice Sheet. In addition, he reviewed his published conclusions on the motion of glaciers that had been responsible for the basal erosion and deposition of sediments.

These conclusions were a mix of his own interpretations of landscape features, as well as published observations of modern glaciers in the Alps by European scientists.

On either side of this core work he reviewed pertinent aspects of the long held biblical deluge theory as being the responsible force that shaped the landscape. He dismissed the theory as impossible and explained his position through his analyses of erosional landscape features primarily from Maine. For example, he demonstrated that the ubiquitous striated and rounded bedrock hills could not possibly been caused by icebergs drifting in currents flowing from the northwest to southeast across Maine in a 5000 ft deep very cold ocean by occasionally scraping over and along bedrock hills and valleys. This flood theory and results had been advocated, for example, by the Maine state geologist as recently as in his 1861 report on the geology of Maine.

All of these observations and conclusions logically led DeLaski to review possible origins of a glacial age in the recent past. In passing, he briefly reviewed the merits of the many aspects of past astronomical shifts proposed to account for major long-term temperature change which could have caused glaciations. He did not reach any conclusions that were suitable to him. He then considered that many scientists of the time were also advocating that entire continents or large parts of them throughout time, could rise up vertically, or sink down. Given this theory DeLaski felt that if the idea had merit then conceivably, a rising continent under the right conditions could become colder and glaciated and, conversely, a sinking continent could get warmer and cause deglaciation. He concluded that this seemed a plausible scenario for this region especially since coastal and central Maine became submerged leaving fossiliferous marine sediments on the landscape during late glacial time.

In his discussion of possible causes of a glacial age he briefly pointed out the problems and need to develop new methods of determining the duration of the glacial age beyond the existing less exact methods. Such methods were largely based on determining of rates of modern physical changes on the landscape such as bluff retreat and changes in beaches and river courses. Finally, he considered the role of glaciations in preparing the landscapes of the northern latitudes for the advent of man and for the development of civilization. He felt that glaciations prepared the landscape in ways that enabled both people and civilizations to be able to develop more rapidly and to a more superior level in the northern glaciated areas as contrasted to those of the tropical areas Figs. 1.1 and 1.2.

With the exception of the direct observations by DeLaski in Maine and elsewhere in the surrounding region, nearly all of the subjects in the book have been at least partially discussed as individual topics in the literature by the scientists over of his time. However, DeLaski in writing this book put them all together with his own observations and ideas in an integrated manner to present, for the first time in book form, a holistic view of an ice age for the educated public as well as for the scientific community. To our knowledge, if this book had been published when written, it would have been the first book to do this in a contemporary world that still largely believed in landscape alteration by the biblical deluge theory, which definitely did not consider ice sheet glaciation.

"Foot-Steps of the Ancient Great Glacier of North America" was not published (until now) for reasons which are not clear. Those who read this book today will

Fig. 1.1 Map of Maine showing the location of primary rivers and lakes along with some of the key places where DeLaski made observations

clearly see that in the mid-nineteenth century it had the potential of elucidating a global paradigm shift in scientific thinking of that time. Clearly, because of the scientific culture of his day, both he and his work were not widely known or appreciated and both remained in the intellectual shadows until recently, when a series of fortuitous events came together and exposed John K. DeLaski and his work to the light of modern ice age science! Fig. 1.3

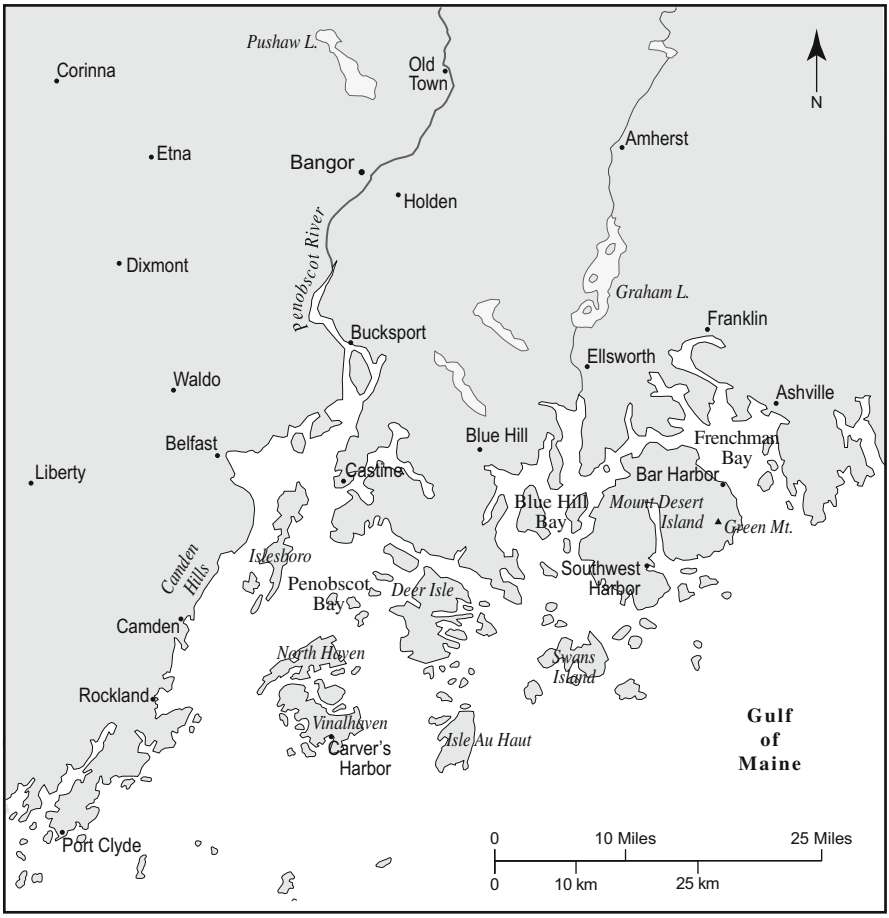

Fig. 1.2 Map of Penobscot Bay region (marked by the box on the map of Maine) showing the location of islands and other places where DeLaski made observations

Fig. 1.3 Title page of DeLaski's handwritten book manuscript of 1869

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Chapter 2
The Manuscript

This hand written, bound book manuscript, dated 1869, was written by John K. DeLaski, M. D. and presented to The Portland Society of Natural History in Portland, Maine, probably between 1871 and his death in 1874, presumably for publication by the Society. Sometime in 1923 the manuscript was typed and submitted for review by Dr. Arthur Norton, Secretary of the Society. At that time it was deemed to be out of date and of very little scientific value. The original book manuscript and the typed version were returned to the Society's collection, and were not seen again until 1972.

In 1972 the trustees of the Portland Society of Natural History voted themselves out of existence. Subsequently, the Maine Audubon Society presided over the disposal of the museum building and its contents; the rather unorganized dispersal of its eclectic collections and an exceptionally large and valuable library. The building, on Elm Street in Portland was sold, then demolished and replaced by a paved parking lot.

The University of Maine in Presque Isle was the recipient of a wide assortment of items from the collection , including some books. Professor William Forbes, since deceased, transferred several truck loads of material to Presque Isle. Subsequently, several books dealing with glaciers were given by Professor Forbes to Professor Harold W. Borns, Jr., a glacial geologist at the University of Maine in Orono, for his interest and disposal. Included in the books given to Professor Borns was the handwritten and bound 700 page book manuscript, dated 1869, entitled "Foot Steps of the Ancient Great Glacier of North America" by a member of the Portland Natural History Society (John K. DeLaski). The manuscript currently resides with Professor Emeritus Harold W. Borns Jr. and Professor Kirk Allen Maasch of the University of Maine.

H. W. Borns, Jr., K. A. Maasch, *Foot Steps of the Ancient Great Glacier of North America,*
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PHILIP W. MESERVE
BRUNSWICK, MAINE

September 8,1923.

Mr. Arthur H. Norton,
Portland Society of Natural History,
22 Elm Street,
Portland, Maine.

Dear Mr. Norton:-

I am returning to you by American Express the manuscript of " Foot-Steps of the Ancient Great Glacier of North America" by John DeLaski. I have gone over the manuscript thoroughly and it seems to me that expense of publishing such a book greatly out of proportion to its value. The manuscript contains some interesting and valuable data:I doubt if much of it could be called an important contribution to our present day knowledge of the geology of Maine. The manuscript is of more interest as an historical than a scientific document.

Yours very truly,

Philip W. Meserve

Part II
Foot Steps of the Ancient Great Glacier of North America

Chapter 3
Preface

In presenting the following pages to the public, I am actuated by the conviction that the views hitherto had of the ancient great glacier of North America, by scientific men as well as by geological readers generally, have not come up to the magnitude of the mass, nor to the gigantic work which it has performed upon the floor of our continent. It is indeed extremely difficult, even for an intelligent man more or less conversant with the phenomena attendant upon the superficial drift covering the country, to imagine that New England and the northern states have been essentially changed in aspect since the latter part of the Tertiary ages. But the great facts everywhere before our eyes when properly generalized, assure us that this has been the case to a most extraordinary degree. The peculiar shape of the mountains of the north, the multiplicity and symmetry of its lakes, the deep indentation of its coast line into the crystalline formations, all assure us that some great change has passed over the country in a time geologically not very remote. But this mutation has not occurred since man came to occupy it. Of this event his intellect has treasured no recollection whatever.

It has been left to the researches of modern times, to men of the Old World and the New, sagacious by a life-long study of the facts, to unveil this mystery of the past infinitely greater than the "riddle" of the Nile. It has been my purpose to elucidate the progress and completion of this great physical change in the aspect of the north, and to bring it as a panorama of life before the reader that he might see his connection with the past, the present and the future of the country. The manner of this exhibition has not indeed been strictly in accordance with the style of the scientist. The aim has been to leave the old past reverent with age and the voices of sages, and to strike out with my companions, at once into the green fields and forests of the earth into the overgrown byways leading to hill, lakeside and the shore of the ocean, where the presence of nature was fresh and joyous, and the human ear and eye more open to the tongue of instruction. And this explanation will I trust, spare me the censure of my grave superiors in the lore which I have thus attempted to impart to my fellows.

Maine
1869

John K. DeLaski
A member of the Portland Natural History Society

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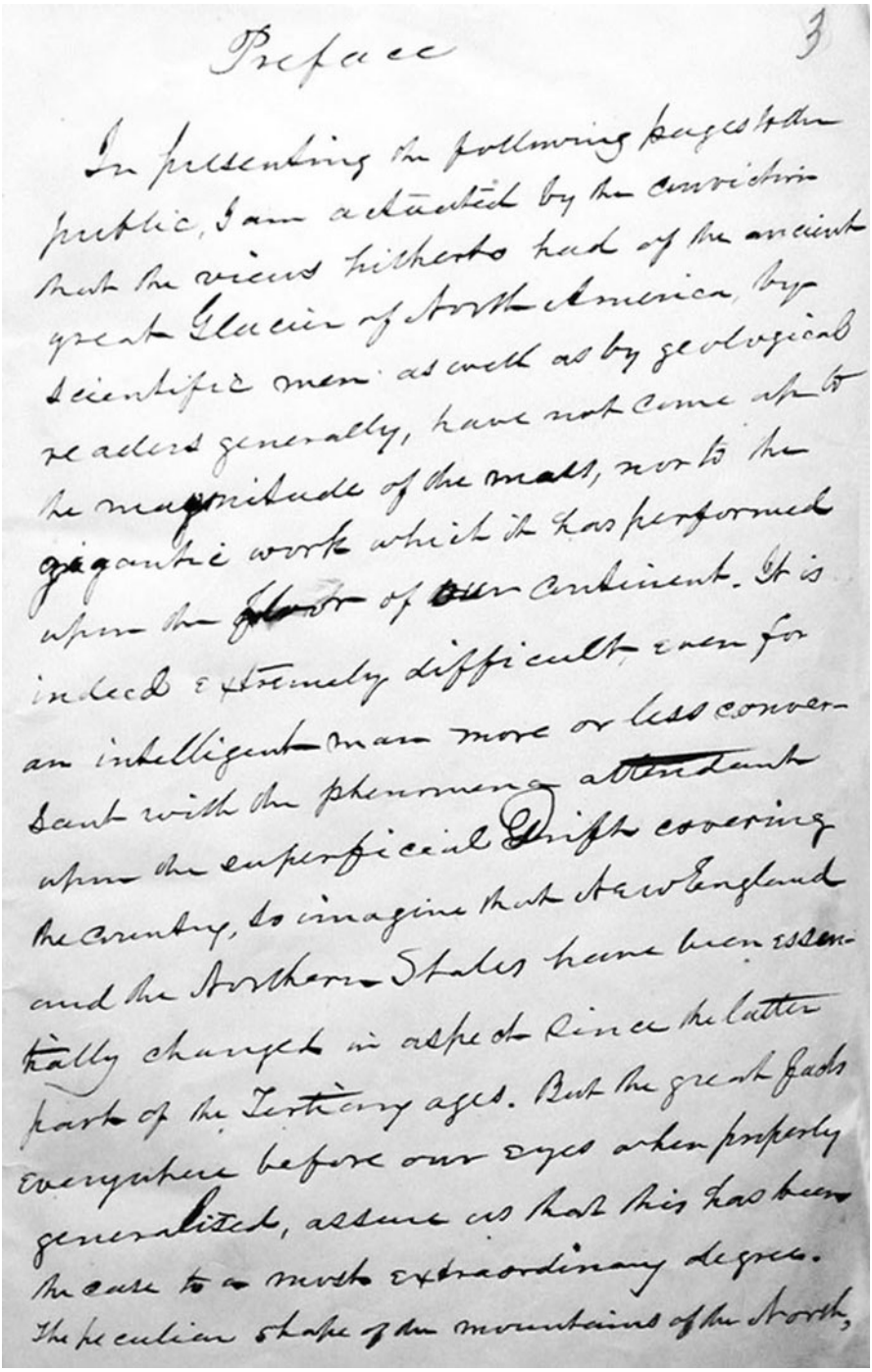

Preface 3

In presenting the following pages to the public, I am actuated by the conviction that the views hitherto held of the ancient great Glacier of North America, by scientific men as well as by geological readers generally, have not come up to the magnitude of the mass, nor to the gigantic work which it has performed upon the surface of our Continent. It is indeed extremely difficult even for an intelligent man more or less conversant with the phenomena attendant upon the superficial drift covering the country, to imagine that New England and the Northern States have been essentially changed in aspect since the latter part of the Tertiary ages. But the great facts everywhere before our eyes when properly generalized, assure us that this has been the case to a most extraordinary degree. The peculiar shape of the mountains of the North,

Chapter 4
The Phenomena of Boulder Drift

Attention first called to the phenomena of the boulder drift—The iceberg theory preferred up to the year 1860—Objection to the opinions that the drift owes its origin to Noah's flood—Hugh Miller's views of the drift in his work on popular geology—Nature of the scratched rocks—Their abundance in Maine—the locality of some scratches irreconcilable with the theory of iceberg action—Decision that the drift phenomena were wholly due to glacial action—Original communications to the "Rockland Gazette" on the "Ancient Great Glacier of Penobscot Bay"—Original paper for the Second Scientific Report of Maine—Geoogical explorations in the interior of the state—Boulder phenomena as exhibited on Vinalhaven—Fascinating interest which they inspired. The history of the past not voluminously written, but rather fragmentary and in a strange stenography—"Sermons in Stones"—Reflections on this stone writing—Impressions made upon the minds of children often indelible, and sometimes matures into great practical results.

During the summer of 1859, I first became directly interested in the drift phenomena of Maine. I had for many years acquiesced in the generally received opinion advanced in elementary books on geology, that the superficial covering of the floor rocks of the middle portion of North America, composed of clay, sand, gravel and loose rocks; as well as the singular aspect of the hills, and the mysterious scratchings of the rocks on which this boulder drift reposes were the work in times anterior to the introduction of man upon the globe, of drifting icebergs from the arctic regions while New England was beneath the sea.

It is apparent enough that the denudation of the rocks which are in their natural places, and the mineral soil which covers them, have an intimate family relation, that in fact, this soil was directly derived from the rocks on which it rests. Aside from any geological catastrophe however, the generality of readers of the Bible, and many scientific as well as theological writers, have supposed, and some yet insist, that this diversified soil spread over the dry land of the northern part of the globe, is nothing more or less than the result of Noah's flood. But it is evident that these soils with the wearing and scratching in one general direction of the floor rock of North America, were *not* the result of the great flood; for one reason among many may be given, that had these unconsolidated clays, sands, gravels and loose rocks of various sizes, been deposited by that flood, the diluvial waves which transported them, would

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have mixed them into a general likeness, and would never have left boulders often of immense volume, perched upon the brow of hills, where the supposed current evidently could have lost nothing of its normal force. Nor would the deluge of Noah after it had reached the North American Continent, let us suppose, have been likely in its passage towards the south, to have halted about the parallel of the fourtieth degree of north latitude, and then mysteriously disappear leaving no signs whatever of its path beyond towards the torrid zone, as it had done beyond towards the north. Indeed I may say here *en passant* that there is no evidence on this continent of Noah's flood, more than there is that the garden of Eden was located here, or that the Ophir of Solomon was located in California or Australia. About this time Hugh Miller's "Popular Geology" appeared in the country I became interested in his ingenious treatment of the subject of the boulder drift of Scotland. He argues that at the close of the Tertiary period, Great Britain along with much of the coast of Europe, was undergoing a process of submersion; that as it went down into the sea, the icefloes and icebergs of high northern latitudes yet dry land, and subjected to intense frost, drifted southerly as at the present day, and were met by the Gulf Stream then as now flowing northeasterly, or in the latitude of Scotland, *easterly* over the collapsed country; and that as the land continued to sink deeper into the sea, those floating masses of ice having rocks frozen into their bottoms as they are presumed to have at the present time, were able to surmount the highest hills of the country during the subsiding process of the land, and denude and scratch the rocky bottom of the sea as we now find it scored upon the dry land; and that the *debris*, or denuded material of this iceberg action, in addition to what the bergs carried as rocks &c; torn from their native beds, and discharged as they grounded and broke up, constitute the leading phenomena of the boulder drift of Scotland.

And there is no doubt but that the phenomena and cause of this drift of Scotland are identical with the phenomena and cause of the boulder drift of the middle and upper part of the North American continent, whether the two cases be of the same year or not. Up to this year of 1859, I had not seen any notice whatever by observers, nor to the day of publication of my articles upon the subject of the former existence of glaciers in the State of Maine.[1] The Geological Report for 1861 under the superintendence of Mr. Charles H. Hitchcock, gave us but little information of evidence of ancient glaciers in the *state*. It mentions the traces of glacial action in the northern border of Maine, and suggests that within that part of it near the White Mountains, traces of old glaciers may be found. The report adheres to the theory that glacial action "occurs only in valleys forming moraines" and that glacial "striae descend from higher to lower levels." This view of glacial action is taken upon page 268 of that report. In a letter to Mr. Hitchcock written by me while beginning my observations upon the drift of Maine, a month or two after reading Miller's work, I mentioned some of the singular phenomena of this action, as the polishing and scratching of the rocky floor both *up* and *down* hill, and that the boulder grooves were seen close up to the hills on their southern side. In reply to my observations, Mr. Hitchcock

[1] In the "Rockland Gazette", 1862 for July 12, 19 26; and October 4, 11.

gave his opinion that ancient glaciers of New England existed in inclined valleys, and that the general phenomena of denudation and striation of the surface of the country, were referred to the action of icebergs. Mr. Hitchcock was by no means unacquainted with the phenomena of striation as witnessed upon the rock surfaces of New England. He began the hunt quite early in life, I take it; for his father had preeminently distinguished himself in this geological striatic chase. He had hunted hill and valley of the mountainous States for this interesting game; and therefore the efficient son boldly entered the State of Maine armed and equipped with his eyes thoroughly open.

But in sooth, all the phenomena of denudation and striation everywhere seen by Mr. Hitchcock as by myself and others, from the northern borders of Maine to the coast, are referable to one agent only, that of the glaciers, though he from educated bias, had taken as remarked, a different view of their origin. It occurred to me that the evidence of polish and scratch of the rock surface in front of a hill facing the south, is conclusive that such action was not caused by icebergs floating over a submerged country; for it is apparent enough to all, that after an iceberg had passed the summit of a submerged hill, it could not touch the bottom of deeper water about its southern base. An iceberg has no vertical motion when exposed to the severest gales of wind, because its volume is principally beneath the influence of the waves; Neither are larger bergs turned aside by occasional currents cause by long continued winds from a part of the horizon opposed to their course. I shall refer to their movements again when reviewing the iceberg theory.

There is nothing surprising therefore, that I who made geology an occasional study only, should fail to comprehend fully the import of the drift phenomena thus early, when my attention was first called practically to the subject. I could see indeed that the phenomena exhibited in some localities, could not well tally with the teaching I had had from books. A small evidence in a great matter is sometimes indeed, as brisk and convincing as a multitude; but no prudent man builds up a theory upon a few facts. Important truths are not generally snatched up by mortals from these profound depths. They come to the surface very slowly, like a sulky fish on the hook, surging this way and that. Coy and very nervous, they must be handled with extreme circumspection, and weighed in the balance of judgement with the nicest care before they will afford us much reward. To what conclusion then, should I arrive? I saw how matters stood. Research and care, observation and comparison alone could finally lead me out of the labyrinth of doubt concerning the cause of the denudation and scoring of the surface rocks of the locality where I resided. I pursued this line of investigation for nearly 2 years, before I made a final decision upon the origin of the phenomena of the boulder drift of Penobscot Bay; and in the summer of 1862, I announced to my friend Dr. George L. Goodale, chemist of the Geological Survey, that my convictions were that over suppressed iceberg denudation and striation, were wholly referable to the action of glaciers—one great icecap that overspread the country; and showed him some examples of what I considered strong evidence in support of this opinion. At the same time I had sent a communication to the "Rockland Gazette" headed "The Ancient Great Glacier of the Penobscot Bay", deferring a judgement of a more general action to the supposed ice mass, till I had had an opportunity of examining the

country far to the north, and elsewhere upon the east and west beyond the supposed bounds of a glacier apparently limited to the Penobscot Valley. At the request of Dr. Goodale, I drew up a short paper upon my boulder observations, which appeared in the Second Report of the State for 1862, p. 382. At the time of my full decision upon the question of glacial origin of the drift of Penobscot Bay, I knew not the name of any American who advanced such a theory as I had now found myself compelled to adopt. I supposed that geologists were much divided in their opinion regarding the cause of that phenomena, as were the Messrs Hitchcock's, who adopted the view that the boulder materials are due to the union of the action of icebergs and glaciers. Having therefore fully matured my observations during the month of August 1862, upon the question of the extent of the supposed Penobscot Valley glacier, by visiting far distant localities in the neighborhood of Moosehead Lake, and to the east of it, I decided that the entire superficial denudation of Maine, and therefore of New England and North America wherever observed, was due to glacial action, and not to that of icebergs. A few of my earlier or July papers on the drift of the Penobscot Bay, were sent by the suggestion of a friend, to Prof. James D. Dana of Yale College, New Haven, who noticed my researches in his "Manual of Geology" then going to press.[2] I afterwards drew up by his request, a memoir upon the subject for the *American Journal of Science*, which appeared in the May number for the year 1864.

At Carver's Harbor where I was living, I saw upon the ledges at low water, almost acres of rock smoothed and scratched in one general direction, often with the most delicate parallel lines. The bedrock of the town is eminently fitted for exhibitions of this kind. There are about 25 square miles of syenite in the town, principally of a course texture, very tough and admirably adapted for fortifications and ordinary building purposes. The aspect of this granitic region is that of numerous hills, abrupt valleys, abundant and excellent harbors, a multitude of coves and creeks, with basins of salt and fresh water. This island of Vinalhaven in shape somewhat resembles a five finger radiate, or rather would, if the animal had a multitude instead of five digits. This divided exterior is a modernism. It is evident that this phase of the island was not that which it wore before the boulder age was introduced. The hills, valleys and water basins are objects of denudation. Wherever the soil is removed and the ledges exposed, about the shore, quarries, or in digging wells or cellars, the rock is always found polished and grooved, and generally exhibits finely scratched lines in a direction magnetically north and south. This direction is maintained though the bedrock be uneven and its dip towards different points of the horizon; and the lines of striation are alike in character upon such uneven surfaces as upon the bed rocks. I noticed that the surfaces had been irregularly planed off, in many cases, and that hollows or depressions were common upon them. Over the bottoms and veins of these, the striating agent had sometimes passed leaving the foot marks as well defined as upon the smooth flat rocks. I was sorely puzzled to explain these facts upon the iceberg theory, seeing that icebergs grating over a submerged country would ground hard upon the bottom, and would be likely to break down the sides or veins of these

[2] "Maunual of Geology" p. 545.

depressions, and would probably not striate the hollows. And if glaciers were formed in elevated valleys only, why here in the southern part of Maine by the seaside, there were not only no alpine valleys, but frequently no valleys at all in which an ice bed could exist with even a small descent towards the south. Furthermore I reasoned, where was the source of this glacier, and whether was it limited or very extensive? Snow falling upon a limited area, and finally passing into ice, and constituting a glacier, is not tenable in regard to Vinalhaven and the islands of Penobscot Bay. No snow could accumulate here to form glaciers. Snow falling for even a few days in succession there would of course fall everywhere in the state, and the result would be a ubiquitous uniform depth of it. If then the denudation and striation of the surface of Vinalhaven originated through the agency of a glacier, the ice sheet must have been very extensive, having vast breadth on the coast, and a far distant source in the country. Of this required amplitude I had no providence whatever. But the conjecture was too unique and vast to be entertained for the present. I was thus often sorely perplexed in my glacier studies, and glad would I have been could anyone have led me out of the confused entanglement. There was no resource left but continued observation and accumulation of facts. What judgement these might render, I dared not then conjecture.

So I continued day and night, month after month, to ponder over this singular phenomena of polish and scratches of the rock. What mysterious worker was this whose presence had long ages vanished from the country, but whose footsteps and mighty labors in ruins alone attest its former existence? And these fragments of the former achievements of nature are in keeping with the manner in which she leaves behind her, her history written only in mutable earth. Nor are her witnesses always multitudinous and loquacious. Like the ancient Lacones, their language is addressed rather to the age than the ear. Sound is silent in the august presence of thought. There was no intelligence in the wind nor the earthquake, nor the fire, but in the "small voice" also significantly called *still*, which the prophet heard and saw before Horeb. In strange stenography, in symbols, types, and shadows, in hints and riddles, is all the great past written, and committed not to the careless eye, but to the profounder understanding of men.

There were thus every day around me "sermons in stones", exceedingly well written sermons, embracing a vast range of thought, full of beauty and grandeur, though with a spirit of mystery about them it must be confessed. I, one of the human audience to whom this preaching was addressed felt myself sorrowfully ignorant like the poor benighted wight who listens to displays of oratory very much beyond his comprehension. Nevertheless, I was convinced there must be meaning and method in all this mighty talk; and I fully resolved to master its important teaching. Thus I became "in league with the stones of the field", their devoted friend, ever ready in sunshine or in storm to seek their society, and to study their faces, to read their perchance, some silent and great thought, some marvelous story of the past.

It seems indeed strange how one can become absorbed in matters wholly enigmatical so his senses, when there does not appear the slightest probability that any special benefit can result from such devotion. The interest I felt in these singular

works would not leave me for a day. Like Banco's ghost it would not "down" at the bidding of my ordinary employment.

I was constantly, every day, every hour, as I walked by these hieroglyphics of nature written on the rocks, disposed to halt and gaze intently upon them. If I passed by in haste I promised a protracted communication with them at some future time.

In my leisure I often wandered to the shore of the sea, where I had seen some unusual display of sculpturing, polishing, or writing on the rocks; and there as the day was retiring from the summer sky, I contemplated the the mysterious characters. Though I could not well interpret what nature had here delivered to the world, yet I knew by the manner of her writing, that she had indicted a weighty matter. Upon these smooth tablets of stone, written over with delicate tender lines, there were often here and there a deeper stroke of the pen, as though some particular and more important thought had gushed forth and demanded a bolder dash of the hand. In these missings so hushed and solitary by the ocean's side, disturbed by no sound but the monotonous murmurs of the waves as they ran up and down upon the shores like children at some wild play, I often felt that I was accompanied by superior beings, and imagined that I could discover in the thickening twilight, their august forms pointing with sublime expression of hand and eye, to this wonderful engraving of nature upon the rocks. They constrain I thought to read this her autobiography written on imperishable stone, of her deeds in an empire infinitely grandeur and more remote in the past, than any which man has ever erected.

The corroding touch of time, the winds and the rains of heaven, even the erasing fingers of the sea, had refused to obliterate these sacred glyphics engraved upon the rocks. For ages the waves had wandered over them yet had spared them fresh and beautiful for the age of man. I thought of the frailty of human hopes, of the noblest efforts of the soul in its struggles of success, of the mementos of art, of the memories of the fondest affections of men; how often all these fade from our keeping and all lost forever; that though we have preserved of the king and the hero, the sage, the orator, and the fact, the deeds and the sentiments of ages past for the example of passing generations of men, and though written on monuments erected with care by human hands, or treasured up in the archives of nations and scattered over the broad sublets of our memories, yet a thousand accidents may forever efface them. But upon these granite rocks upon which the waves of the sea have broken for innumerable ages, nature hath engraved with a pen whose lines are indelible, the record of her actions in times so remote, that the genius of man is unable to comprehend the antiquity of the age.

It was always a mystery to me when at home with my father in the dense wilderness of the north, how such multitude of shore rocks, "popple stones" we called them, became strewn over the valley in which our farm was located, and piled on high ridges along its border far away from the bed of the river. Many a time was I perplexed by this query, but it was alike dark to me and all whom I interrogated. There was an abundance of smooth elliptical stones that especially interested us children, having a brownish white color memory's eye, roc's eggs we called them, supposing they resembled in size and complexion the fruit of that celebrated bird of Sinbad the Sailor. I have no doubt but that they were feldspathic water-worn rocks colored probably by

an oxide of iron, and once constituted the bed of an ancient river, many times larger than the one now its little representation, which ran along by the distant border of our valley. I imagine by the recollected forms of the retreating hills, and the shore rocks far away up the sides more than 50 ft above the spring flood marks of the river the scepter of the great ice king once extended there, and that in bygone times a greater amount of cold, vastly more abundant snows, and an enormous volume of spring flood, must have been of yearly occurrence. And that strange sights often leave more than a momentary impression upon the minds of children, and we repeatedly hear them recurring to the subject that so elicited their early attention, till they either mastered the meaning, or their vivacious natures ever anxious for something new, ceased altogether to think of it. Upon the soul of a child we know not but that the spirit of truth ever attends, and follows the young footsteps as a living individual thing, and solemnly speaks to the unfolding mind of the child in a thousand varied and mysterious voices, as if she would forestall and constrain the immaculate soul of the child to observe and learn to read the records of her acts. And who can doubt but that impressions thus made when the mind had but begun to put forth its tender leaves of thought, have often bloomed and borne golden fruit in its mature years, of many who have blessed the earth with their presence?

Chapter 5
Carver's Harbor

Hill of granite on east side of Carver's Harbor—It affords fine opportunity for studying glacial erosion and disruption of the hills and general surface—Original deposits of Maine, rocks principally *clay*, which in time was consolidated into slates, and finally passed into granite and other rocks—Boulders used as rasping, polishing and scratching tools—Terrace-like steps at a quarry west of Carver's Harbor—A huge slab removed 200 or 300 ft, and placed upon its edge—Nature personified—Thoughts on seeing men at work upon a boulder quarried ages before man appeared upon the globe—Moraines of doubtful existence in the State of Maine—Some hills bare of boulders; others covered with them—The motion of the glacier slow.

There were a few localities in Penobscot Bay which interested me more than others. Many hours had I stood among them alone, silent and thoughtful, gazing into the immensity of the past, as the astronomer from his watch tower, into the midnight sky. As oft with the astronomer, so with me; a cloud now and then passed darkly over the field of the minds telescope, or the mist of uncertainty slowly settled down between my understanding and the nature of the objects I was so absorbingly contemplating; and I often unwillingly turned away towards my home hoping that the future might reveal the truth I sought.

On the east side of Carver's Harbor at the village, the hill now occupied as a quarry, is a little over a hundred feet above high tide mark. This hill like all the granite hills in town, has been greatly denuded, and is singularly broken up over the summit. We have little data by which to estimate the actual vertical loss of such masses. Doubtless in many cases, hills have been entirely obliterated; in other respects they have been formed out of the originally level surface. The highest granite hill in town, is not quite 300 ft above the sea. There are several others nearly as high as this. It would seem probable that these hills were once united, constituting a broad granite plain elevated more or less above the sea at the close of the Tertiary period. Its best cleavage line is in a horizontal direction. This is invariably so with the coarse granite but a species of finer texture lying above the other has this cleavage a little inclined to the east This cleavage may have originated from pressure but I suspect it due simply to the laws of crystallization and that the position of the rock has not been disturbed since that action occurred. The syenite then, was not protruded in the form of hills. The fact of great depressions in the granite bed, of harbors, extensive and high walled

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creeks, deep lakes and salt water basins, compel us to infer an enormous denudation, as heretofore remarked.

The summit of this village hill affords a splendid opportunity to study the disrupting forces of the boulder agent. The top is broken up into innumerable masses, generally of considerable magnitude. In the majority of cases, these now erratic boulders lie merely loosened in their native beds, or pushed a little towards the south side piled one upon another, in strange positions, which do not suggest the work of frost though intense like those of the arctic regions. Among these rocks, few of which weigh less than a ton, we find a very small percentage of foreign rocks. The phenomena of the disruption of this hill compared with others where the quality and cleavage of the granite are precisely similar is certainly very surprising. The south side of this hill is steep only in a few places. This peculiarity is exchanged for one of great singularity. There are four or five deep troughs leading from the summit down to the southern base of the hill. A loaded cart and oxen might be driven through two of them at least without being seen by persons standing a few rods to the east or west. One or two of these gigantic grooves are filled with boulders, while the others are quite free of them. I find no grounds for suspecting that the sea was concerned in filling or emptying these gigantic troughs, thus gouged out of the solid granite. Those that contain and that do not contain, boulders, are alike turning towards the south. It appears to me probable that these grooves are very much as they were when the denuding agent passed away. Shore ice for thousands of years, may have deposited boulders along the coast of Maine after the glacial age had disappeared; but as the boulders about this quarry are nearly all alike, the supposition is natural that no material change in the aspect of things about this quarry, has occurred since the cold period passed away.

Upon and around this hill are seen many boulders which have been used as drags, the agents by which the polishing and grooving were effected. Where they have not been disturbed, am quite sure that the boulders generally lie with the scratched side down upon the floor rock. An immense boulder of this description reposes upon the southwest side of the hill not far from the top. As one passes up by the quarry wharf to the hill, he will see one of these boulders a few feet from the road upon his right hand, resting upon the naked rock, an examination of which will satisfy him that it has been used as a denuding instrument and now rests precisely where it was left when last used by the glacier ages ago.

Half a mile from the village towards the west there is a hill of about the same height as the one just described. It is of similar rock, and is also used as a quarry. The north and west sides of the hill are regularly cut away, and the rubbish principally removed. The former extremity being covered with soil the scratches on the rock cannot be seen, but on the west, the floor rock is here and there well exposed, and the scratches are visible. There was one boulder lying here of the same kind of rock as the hill, and would weigh 15 or 20 t. It rested flatly upon the granite ledge. One end was slightly raised so that I could thrust my fingers beneath it. It had evidently been dragged along over the underlying ledge, as I could feel the polished surfaces distinctly. It had been at the bottom of the glacier when it ceased to move, and had remained in that position ever since. Surely if rocks had life, it was a long time to

wait for a change of circumstance. But it came at last. In 1863 I saw a man perched upon its back with hammer and drill in hand with vile intent to remove this ancient inhabitant out of the land. Had it been the only relic of the kind in the town, I should have vociferously protested against the wickedness of its destruction.

At the southern end of the hill ere the quarrymen had commenced operations, the extremity was broken down into long and nearly regular terraces. Its width east and west was about 600 ft. There was here one perfect step over 300 ft long, 9 ft high perpendicularly, and averaging about 11 ft wide. There were four or five of these steps one above another, and at a distance they seemed to be regular running quite across the brow of the hill. The ocean's waves had had no agency whatever in this breaking up the brow of the hill, nor in removing the quarried masses. I apprehend such detachments could not be identified in front of the hill. But in this direction at the distance of 15 or 20 rods was an abundance of large boulders, degraded more or less by the glacier and the elements since the great ice age passed away. Upon the eastern side of the hill, there is an exhibition of rock rendering of a different character altogether. Great masses have been born away from this side, and lie in contact with each other in a curious manner. Some of these boulders have been removed to a distance of several rods, and are piled up together as if done by the hands of giants. It is absurd to refer this effort to the agency of frost independent of that of glaciers. One of these boulders would weigh 500 t. A huge slab regular in length, breadth, and thickness, as if quarried by human workmen instead of those of ice forms, reposes here upon its edge at an angle or 60° or 70°; and at first view it would seem that it had been thus emplaced for the convenience of the cutter. On this eastern side of the hill the smaller boulders are so closely packed that one might walk over the area of several acres without being obliged to step between the rocks. Among these boulders little and big which pave the ground, you discover as you turn them out of their bed, the chisels, gouges, planes, and polishing tools with which nature performed her wonderful work of transforming the face of the country cutting down high hills, and excavating in the solid rock valleys 200 and 300 ft deep making safe and capacious harbors, enlarging the beds of rivers, and making basins for the deposit of fresh water.

Though this was the *stone-age* of nature, it by no means betokens that she was *savage* like man on the stone-age of his race. We have ocular evidence that she was a *polishing* matron, but whether she herself were polished and policyised up to the notions of this refined artistic age of ours, is a matter of uncertainty. For my part I admire her manners throughout her existence, even in her *infancy*, so far as I can get a glimpse of them by tradition, or otherwise. We can safely infer that her skill and wisdom were of a very high order during the great by-past now under consideration, and infinitely exalt her genius. Indeed the tendency of the human mind to personify the leading ideas of experience, has been common to all mankind savage and civilized. The conviction that there were "gods mercy" upon the earth and among the stars performing all the wonders which ever are around us, could not escape a thinking mind, unless instructed directly by the Supreme Creator of all. And now if we personify what is commonly understood as nature, and follow up closely her footsteps, and examine her labors here among the wild retreats of Maine by the side of the never resting sea, we get not only an insight into the manner of her working,

but we now and then seem to catch the very thought which lay shining within her soul. We are told by the ancients who pretended to understand celestial matters right well, and were polytheists, that the gods the representation of majesty, justice, and propriety, had their fits of fiery indignation, and displays of wonton powers frequently originating in some petty jealously or umbrage, of which even fallable creatures like Solomon and Sacrabes, would have been ashamed; but nature had no compeers to bicker with in this mighty work of engineering among the hills and valleys of the ancient earth. Forethinking and irresistably strong in her resources, she works after her own profound system, with none to molest or suggest. We are enabled to get now and then, a glance of her earnestness through the dim vistas of the past. We see her impulsive and potential thoughts, as she orders her laborers to remove a frowning hill, and the wave of her mighty hand, as she gives commands for the solid rocks to be uprooted, and a place to be made for the waters of the sea. Again we see her in moods of meditative thought and prudential rest. At a nod and sign of her staff, troop down her lusty laborers to do her will. Varied they are in aspect and of a vast multitude. Her eye sweeps the horizon around, and seeth everything under the whole heavens. She looks on with unerring glance, as she beholds everything progressing according to her wish. She takes no note of time, a thousand years are as one day, and one day as a thousand years with her. At length the moment of the completion of her labors, arrives. Nature cries *enough*! and the sound of the vast machinery of those mysterious laborers, is heard no more in the land. Every workman in an instant disappears from mortal vision to return no more forever. Long ages must pass away, before the grand achievement shall appear in their beauty and order They are to be sealed up for the examination of her future child, with the signet of her own hand, and the word *perfection* legibly written upon the work.

It did indeed seem strange to me, and the fact was full of serious reflection, as I saw the quarrymen at work upon a large boulder which had been wrenched from its bed perhaps at a little distance to the north, that it should have been suffered to remain unmolested, on the brow of a hill, for a period of time far beyond all human history, to repose near its own birthplace, silent, yet a mighty witness of wonderful events. Approach son of the earth, and come into the regal presence of this mighty one, with reverence, doing obeisance, thy feet unsandaled. What is the span of thy life compared with the multitude of years of the sublime face of this sphinx, ever gazing into futurity? Ages on ages before Adam appeared in the midst of the abundance and glories of Eden, this boulder stood where it does now, left perchance, as employed in denuding the hills, in making the soils of the earth, or in engraving the wondrous history thereof upon the rocks, left in the midst of a mighty event like the half finished plastering on the walls, and the un-removed bread from the oven, in the cities of Pompeii and Herculanium where they remained entombed and unknown for more than 1500 years after the ancient tradesmen had been overtaken by the fatal lava of Vesuvius.

The ruins of the works of man, the noblest cities of his hands, scattered over the face of the earth, empires transformed into desolate graves, these indeed create in man the most profound and humiliating contemplation, because we ourselves are intimately connected with their fate; and we know their past, their rise, their progress,

and when was quenched forever their brilliant light. But who knows the history of this lonely rock? It has not been disturbed for innumerable ages. The waves of the sea did not drive it from its throne; the storms of heaven could not move it. The earthquake that shook the hills, but woke it from its profound revery. It was seated there when Egypt was the home of wild beasts, and not of men; it was old, moss grown and gray, when the Kings of Atlantis flourished, it has seen the bright stars of heaven change their places, it has seen comets flame along the pathway of night, whose return perhaps the human eye has never yet beheld, and may never see. All that is recorded of the earliest deeds of the human race, is as a matter of yesterday, before the face of this sublime relic of the past; and could it speak to us, and tell us what it has witnessed since its separation from its home among the mountains the human heart would indeed thrill with the most profound emotions.

The boulders lay about this hill in such remarkable abundance, that I had supposed it possible that they had constituted a local moraine; and so in fact it may be said they did, a mass of rocks thousands and tens of thousands in number from 90 to 95 % of which was similar in composition to the rocky bed on which they were resting. They were erratic rocks, excepting the large boulders in the neighborhood and had been transferred how far we know not, perhaps a 100 rods, perhaps 5 miles. The bed rock on which they rest is smoothed wherever we get a glimpse of it. It is possible furthermore, that when this hill was within reach of the sea, the dirt may have been partly washed from among the rocks, and carried away into other localities. But we have no true moraines, nothing that we can identify as such, as seen at the foot of mountain glaciers, anywhere in the State of Maine, certainly not till a height of many 100 ft above the sea, is reached. It is impossible that they should exist. The waves of the ocean, which covered much of Maine in past glacial times as well as terrific storms immediately after the glacial age, have swept away all such relics. As a general thing, the gravel, sand and clay all have been rewashed in the State of Maine.

There are no boulders lying upon the top of this latter hill, nor are there any singular indentations, as upon the former hill at the east of the village. This great contrast in the aspect of the two elevations, without doubt furnishes us with a specimen of the progress of the glacier from time to time. Now one hill and now another perhaps, was covered with massive ruins. Change, revolution the renewal of fashions and forms in the complexion of the surface of the earth was the order of the age. So the second hill may have worn at one time, the aspect of the first; and the first that of the other. The surface of the rocks over which the glacier was moving, was constantly changing as regards a uniform level. Where there are now hills there may have been depressions or valleys. A change has occurred in the features of New England as great as though the whole country had been convulsed by the mightiest earthquake. Every mountain in Maine has a rounded aspect. The giants of the Aroostook seen from the east, declare in no equivocal speech, that they have passed through a mighty battle, long, fierce and *frigid* instead of hot. Rocks innumerable and magnitudinous were hurled upon their heads and at their brawny bodies. Bruises and wounds took hold of them; and though they came out of the strife alive, they were nevertheless, exceedingly *humbled* rather than exalted. So of the White Mountain chain. Everywhere the foot

of the mighty leader has left its signs and wonders along its path. In a word, the destiny of humiliation is most signally stamped upon the mountains of New England, notwithstanding a grand old form here and there rears itself aloft above the clouds. And if the mountains have thus been degraded, what shall we say of the common surface or the country?

Chapter 6
Research on Rocks

Highest granite hill in Penobscot Bay—North and south terraces on west side of a valley—A singular ridge forming the east side of a dell, 475 yards long, cut out of the solid granite—Evidence that 10,000 t of rock have been removed from the western rim of the dell, towards its northern point—A perpendicular wall of granite facing the south, 24 ft east and west and 20 ft above the rubbish—Tremendous force necessary to disrupt this wall—Largest boulder in town—A large wedge shaped boulder—Polishing and scratching of south side of hills—View from the top of a high hill—Evident enormous denudation within sight—Surface of granite broken up into sheets or "platforms"; how it was probably done—*Lunoid furrows*[1], their utility and how made—Some granite boulders foreign to the place or time, where they rest.

As we leave these hills and pass along towards the north, we immediately begin to ascend another, the highest hill in the town, 260 ft high. There commences here at the foot of the hill, upon the left hand as we follow the road, at a height of about 50 ft above the tide, a series of terraces running north and south, and facing the east, in full view of the road which runs parallel with them. They are altogether irregular in their lines of fracture, compared with those of the last hill described. They preserve no uniformity as regards horizontality and width of step. The top of the highest terrace is rounded off and resembles a "horse back" on a small scale, a singular ridge of assorted boulder material, common in Maine. This wall extends 700 yards north and south, and is fairly unbroken except in one place, where there is a breach 50 yards wide. Above this opening for nearly 600 yards, one might lead a well trained horse quite safely along this elevated ridge. The wall falls off towards the east at different heights from three to 10 ft, and at angles of 30, 60 and 90°. There are several terraces below this towards the road on the east, till a descent of 50 ft is obtained near the lower end of the dell, and 75 ft perhaps, at the northern end, where a space between the lower wall or terrace and the road occurs, occupied with boulder dirt and granite debris. Between this highest terrace or ridge described, and one still more elevated on the west, there is a dell 50 yards wide, and 475 yards long trending of course, north and south. This great trough has been liberally gouged out of the granite floor, chip

[1] *lunoid fractures.*

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by chip. There are no boulders of considerable size now remaining in this dell. This unique depression inclines towards the south at an angle of about 10°. If we mount the highest ridge on the west overlooking the dell, and pass along towards the north, we are at length brought to a halt by a strange discontinuity of the uniform regularity of the ridge below. A portion of this wall has been removed not less than 24 ft wide, and 75 high, and 200 ft long. There is thus nearly 10,000 t of granite broken out of this wall, and nothing now remains of the fragments thus disrupted, but on one or two boulders situated at the lower end of this oblong indentation the side of the ridge, and these may have been brought from a distance. As we pass along towards the northern or upper end of this open space, the impressions of astonishment culminates as we see before us a perpendicular wall towering up 20 ft above the rubbish at its base, and 24 ft wide east and west. This wall is broken at right angles to the course of the dell, and the trend of the glacial striae in the vicinity. No blasting by art however carefully conducted, could perform a smoother operation in separating a mass of this kind of granite from its native bed. This perpendicular wall looking south, forms a part properly, of the high ridge. There is a fissure commencing from the point where the 24 ft terminate on the west, and running northerly perhaps 30 ft or more, and curving thence towards the east. This fissure is now about 6 in. wide. The mass of rock thus demarked and isolated whose southern wall is probably 25 ft high above its horizontal bed or seam, but 20 ft above the rubbish, and 24 ft wide, is then a now erratic boulder, removed from its original site by only about 6 in. The exact length of this mass I have forgotten, but think it about 35 or 40 ft. Dr. George L. Goodale roughly estimated with me its weight to be about 600 t.

This perpendicular wall of naked white granite looking south, is seen from the village three fourths of a mile away, as a prominent object. Its blank front and projection towards the east, gives it apparently a greater altitude than other points of the ledge; and it seems thus, seen from the south to lift its head like Saul the Israelitish King, far above its fellows. We have here an example of a smooth vertical wall of no inconsiderable dimensions, the most positive assurance that neither icebergs, nor terrific flood waves sweeping over the country from the north a mile in depth, as one suggested by Dr. Jackson[2] was capable of rupturing this wall and removing the consequent fragments. The fact of the mural fracture in a direction east and west, while the best vertical cleavage line runs nearly northeast and southwest, is suggestive that the fracture must have been effected through some agent which had seized the rock firmly at the points of rupture, and gradually increasing its force from a direction north, finally rent the mass asunder and carried it before it. We can imagine that the moving force of the disrupting agent must have been very great, which was brought to bear upon the area of about 600 ft^2. A cubic inch of the hardest Penobscot Bay granite, that of Dix Island, at the Washington Navy Yard, resisted the force of 30,000 pounds before being crushed. A surface then of 600 ft^2 and 1 in. thick, of such granite, would sustain a weight equally distributed over it, of 1 million, 296,000 t. But the separation of a mass of rock of a broken surface of the

[2] Second Geological Report of Maine for 1838, p 149.

extent of 600 ft^2, would doubtless require a greater force than this. The amount of the crushing weight required, however, would materially depend upon the direction of its application in regard to the plane of cleavage of the rock. The cleft surface of the granite under consideration was effected in a line nearly due east and west, whereas its best vertical cleavage line is nearly southwest and northeast requiring a greater force in the former case than in the latter, to produce a separation of the rock. I would observe however, that the syenite of Vinalhaven, is not so hard as that of Dix Island. But this imagined force of more than a million and a quarter of tons, was by no means the measure of the dynamic energy of the agent which effected the separation of the surface of 600 ft^2. In a general sense, any amount of force was available in the glacier through which this fracture was effected.

The apparently perfect separation of the non-erratic boulder from the ledge, was a post glacial act; because had the fissures now several inches wide, been effected at the time of the fracture of the vertical wall, this mass would have been carried away along with that portion of the rock removed south of it for 200 ft. When the great denuding and disrupting agent had disappeared from the country, the climate was for a long time as cold as northern Labrador. Intense winter frosts had doubtless an incredibly great effect upon our granites, splitting them into fragments in many cases, and completing the separation of large masses wherever a fracture had bee produced by the force of the glacier; but the isolated portions have never been removed to considerable distances.

There is an erratic boulder standing near the southern extremity of the ridge from which those vast masses have been broken, of great dimensions. It rests upon the eastern side of the hill, about a 100 ft above the sea. It is 20 ft high, and is the highest erratic boulder in the town, I believe though we cannot identify its original locality, it was doubtless derived from the granitic area on which it rests. A little farther south is another of wedge shaped form, resting upon the brow of the hill, with its base or large end *head on* towards the south, as a glacier would probably carry it, moving in that direction. Its base is 9 ft high, and 15 ft wide east and west. I have forgotten its length; but think its weight about 300 t, perhaps more. There are four or five other examples of this form of boulder within a half a mile of it, all having the large end pointing southward. From the great boulder *in situ* with the immense front looking towards the south, one passes along to the head of the dell and turns off to the left, and proceeding a few rods, comes to an open plain of bare rock, slightly inclining towards the south about 150 ft above the sea, and within a 100 ft or thereabouts, of the top of the hill towards the north, the greatest granitic elevation in the town. Here and there over this plain of rock, one sees a few small boulders. A mere glance over the surface affords proof that it was once well polished and grooved, even upon the uncovered rock in many places the polish and scratch are well developed. Upon ascending the hill top towards the north, a fine view of the island and adjacent islands is afforded, as well as of the mainland, including the Camden Hills on the northwest and those of Mount Desert on the northeast. The distant islands of granite to the south and southwest gleam in the sunshine like the white sails of vessels at sea. Some of them are high, one called Hurricane, is not less than a 150 ft above the ocean. Large vessels heavily laded, can sail among them. On every hand you also get a glimpse

of a broad deep valley. Hills and great crags everywhere stand out in bold relief. The impression gradually unfolds itself and settles down upon your mind, that those neighboring islands must once have been united with each other and with the main island, that this isolation and desolate condition of the prospect, is not as nature once formed the landscape in this locality. The granitic floor of the region has been plowed up. Some terrible revolution has been enacted, some mighty hand has been laid upon the rocks in an age before man appeared upon the globe. Earthquake action as in Italy, has sometimes tossed and ridged the surface of the earth as the face of the sea is often tormented by a mighty wind; but not in the later ages of the world has such action existed in Penobscot Bay. No imprisoned Enceladus has shaken the subterranean walls of his dungeon with his giant hands, deforming its external aspect as we now behold.

Towards the north, after the hill top has been descended to the fall of 75 ft perhaps, the plane gradually dips in this direction for a mile nearly to the level of the sea. Wherever the soil has been removed by the road side the polish and scratches appear. Within a few feet of the highest part of the hill, in a depression of the surface, there is a collection of boulders to the amount of several tons, none of which is perhaps, larger than a water pail. They are granitic rocks, and are not so angular or rough as the ordinary rocks buried up in the soil. This Saxetum appears to have been brought together by the waves of the sea, long after the glacial age had passed away, when the summit of the hill was merely a tide covered shoal, or just out of water at an ordinary full sea. That the waves of the ocean were once within reach of this hill top, we have a further proof in the fact of small stones frequently well rounded, being impacted between the horizontal fissures of the rock. I have seen them wedged in so closely and tenaciously, that they could be detached only by considerable force. These horizontal fissures form another singular and important feature in the granitic rocks of Vinalhaven. Wherever the surface is exposed, the rock presents itself in sheets, often running quite across a hill. It is a strange fact, and has been unnoticed, so far as I am aware of. This horizontal fracturing is not always in parallel lines. Sometimes a sheet will be of a certain thickness at one end, and thinner at the other. The thinnest sheets lie near the surface. The thickness of these strata is from a few inches to 70 ft or more. At the quarry at the east side of Carver's Harbor, the lines of fracture can be seen is here described, running quite across the hill, at depths more than 50 ft below the summit. And very convenient indeed, are these fractures. A vertical split is made in the direction of the best vertical cleavage line, down to the horizontal seam, when the sheet or block as the case may be, is removed.

It is evident that water and frost have not originated these seams, because they are formed at all depths from the surface yet penetrated by the workmen. This phenomenon is a condition of the origin of the terraces described in this and the preceding chapter, so frequently occurring upon the south sides of the hills, and occasionally present upon their other sides, though always showing rounded edges or degraded corners. These horizontal seams existed before the formation of the steps otherwise a step would not present one side vertical and the other flat, or level. In fact, we occasionally see where a seam terminates, a step running perpendicularly down for a certain distance, and then striking off obliquely at an angle of 30, 40 or 50°. These

fissures exist in all the granitic quarries of Maine which I have seen, and in those about which I have made inquiries. I think these horizontal seams are the result of the slow passage over the granite, of a solid structure of immense thickness, rather than to the influence of percolating and congealing waters.

Another phenomenon of considerable interest, is the *lunoid furrows*, first observed by me in 1860, upon the rocks of Vinalhaven.[3] I pointed out the utility of these transverse furrows in my paper in the Second Scientific Report of Maine for 1862, already alluded to. These *lunoid furrows* show at a glance where the striae are faded the direction which the denuding agent traveled, and are thus a guide in foggy or cloudy weather, to one who wishes to know the cardinal points of the horizon, without a compass. The steep side of these furrows are always directed towards the *north*, when made upon a level surface. The right horn therefore, when one turns his face in that direction points towards the northeast, and the other of course, towards the northwest. The horns then, are bent like a drawn bow. Midway between these points of the furrow following the line of fracture, the wall is highest, that is, the furrow is deepest. These walls are generally perpendicular, but often lean towards the north. If the furrows are made upon a ledge descending towards the south, the horns are more contracted as well as the width of the furrow, though the height of the wall by this circumstance, is by no means diminished. If the furrow be made upon a ledge dipping to the east, the northwest horn is turned more towards the north, and the other towards the southeast, but if the ledge dips towards the west, the northeast terminus of the furrow points more towards the north, and its other end to the southwest. The furrows in these cases, are more elongated than when made upon the level rock, or when it dips either towards the north or south If the furrow be made upon the top of a ledge dipping both towards the east and west, which may thus be said to be semi-cylindrical in form, the horns are then invariably turned towards the south, namely, the northwest point is directed towards the southwest, and the northeast one towards the southeast, and in this case also, is the face of the wall in its highest part, directed towards the north.[4]

I have observed these peculiarities of the *lunoid furrows* with much care, and should be able to recognize the natural position they had in the rock, if detached specimens were presented to me. These facts prove that the furrows were made by some agent moving invariably in one direction, and that the stylus or boulder by which they were effected, was pressed with great force upon the underlying rock, sufficiently so to destroy the molecular union of the particles of granite. It is furthermore evident that the movement of the stylus was slow, and was directed upon the rock at an angle of about 45°, and that the boulder was firmly set in its matrix, so that its movement was controlled by the moving mass, otherwise the boulder in passing over the wall which its pressure had made, would have broken it down. Over

[3] From *luna* the Latin for moon, and *eidos* the Greek for likeness or form—meaning a furrow shaped like a crescent or new moon.

[4] In the State Report heretofore mentioned an error occurring in my article probably by the correction of the proof reader, of south for north.

some of these furrows we see where sand and gravel were afterwards pushed towards the south, scratching the bed of the furrow in beautiful parallel lines, yet leaving the wall more or less perfect. These furrows are from a few inches in length towards the east and west, to several feet. There is a furrow of this kind in Vinalhaven 30 ft long and 2 ft wide, with a wall 6 in. high. To the north of it a few rods there is a high terrace wall from 30 to 50 ft, looking south. When I first saw this furrow, ere I had well studied the lunoid fractures in their character of uniformly pointing their horns and walls in certain directions as just described, I imagined that its owed its origin to the action of the sea, but further observation unconvinced me. Thus cool evidence which obstinately pits itself against us, generally shows more musele than a favorite conceit, and so the battle often goes to our discomfiture.

There is yet another circumstance connected with granite boulders, of which I have never seen notice in print. The larger granite boulders of Vinalhaven, identifiable in composition with the granites on or near, which they repose, are cleavable in the same directions as the granitic ledges. This fact which no doubt is persistent in other towns, does not favor the iceberg theory. There are however a few granite boulders in that town, not traceable to beds of granite in the Penobscot Bay. These have their lines of cleavage in directions different from those of the former. Quarrymen or citizens when using these find it difficult to hit the best cleavage lines. This trouble can be avoided only by close attention given to the manner in which the different crystals are set.

Chapter 7
Vinalhaven and North Haven

The great denuding agent scratched the north as well as the south sides of the hills—No *bridging over* of the hills by the glacier—Remarkable scratches at lower end of Liedbetter's Island—Wished to convert his scratched wall into a statue holding a slab—Specimen of the Ice King's work—The ledges like the mountains, steeper on their southern sides, and have north-south trends like the ponds, creeks and harbors—Cleavage lines of the granite—Slates of Vinalhaven highly altered—Embossed rocks—Their resemblance to windrows of hay in the farmer's field—View of the Camden and Mount Desert Hills—East and west sides of the Hills denuded and scratched—Scratched walls in Vinalhaven—A creek a mile long with high walls on each side wholly gouged out of the granite rock—No local glacier on Vinalhaven in ancient times—Scratches immediately south of the trap hill on North Haven, at the Thoroughfare—A remarkable fissure in a granite ledge on Vinalhaven, thoroughly polished.

Thus the hills exhibit the fact that the denuding and scratching agent which passed over them from the north, left also the impress of its power upon their southern sides. I do not hesitate to give it as a general fact, that in every locality where the grooving is found running north-south, or in a direction varying from this, upon the northern sides of the hills, precisely the same direction of the grooving may be found about their bases to the south. If the southern brow of a hill is not very abrupt, we are able to trace the scratching here and there from base to summit. But even upon some of the most abrupt hills of Maine, we occasionally get a glimpse of a portrait of the denuding agent as it passed over the hill.

It has been remarked by Prof. Agassiz that the hills during the glacial period, were "bridged over".[1] A glacier of the thickness of 6000 ft as estimated by him, for New England, would not probably bridge such enormous inequalities of the surface of the country over which it was slowly passing, as the brow of a *hill*. We have reason to believe that there was no space at the southern sides of our mountains or hills, left untouched by the presence of the denuding agent. There is an overhanging wall or cliff about 20 ft high facing the south, at the lower end of Liedbetter's Island, at the

[1] "Atlantic Monthly" for July 1864, p 89.

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southwest end of Vinalhaven, where the polish and scratch are seen within 2 or 3 ft of the base of the southern wall upon horizontal rock. If any part of the face of this granite wall has been denuded by the sea since these scratches were made, of course these markings once must have been nearer the wall than at the present time.

This smoothed and striated locality is about 10 ft above the sea, and once was exposed to its utmost fury. It is an exact counterpart of the polish and scratch elsewhere seen. To the west a few rods from the face of a wall, which is in fact a part of the former cliff, there is a splendid specimen of under scratching in a horizontal seam a few feet above the reach of the highest tides. No sketch could give a definite idea of its wonderful grooving. The last time I saw it, I left it unwillingly, but in hope that some day I should have a camera view of it. I upbraided the hoodwinked and fickle vixen, whom her favorites call "Fortune", and some gallant but graceless madcaps no doubt *Miss*-fortune, who would not show me where "Kidd" buried his golden treasure among these islands according to tradition, that I might have the prerequisite to remove this wall with its glorious hieroglyphics and set it up in *New York*, no *Boston*, the northern Athens of art and Science, where this pre-Adamite relic would be appreciated with enthusiasm. I think Diocrates might have exercised his wits to better advantage in transforming this hill into a statute of the ancient Ice King of the north, presenting his slab of glyphics in his left hand to the world, with the right pointing to the inscription, than in thinking of converting mount Athos into a statute of Alexander, holding in one hand a basin, and in the other a city.

It seems that not only the trend of the hills of New England is north-south like the lakes, ponds, rivers, harbors and coves, but the ledges everywhere over the state have this trend more or less. I am quite sure that wherever we find the granitic rocks lying in horizontal beds, there the denuded surface when broken into ridges, shows them running in a direction conformably to that of the striae in the locality. If the beds have a dip to the southeast however, and the strike or principal cleavage line northeast and southwest, the ledges will run more or less in this latter direction. In this instance the denuding agent has cut across the grain, to use a phrase of the worker in wood. The ledges of this trend are rounded and under-worn upon their northwest sides, with a peculiar rounding of the opposite sides, of a different kind. They like the hills, are also steeper in one direction, namely to the southwest, or rather south-southwest, although we often see a perpendicular wall facing the south. All the coast granites of Maine have as far as I am acquainted with them, good cleavage line toward the northeast and southwest. Their dip if they have any, conforms to that of the slates, from which they evidently were derived. If the syenites of Vinalhaven had their origin from the slates, the latter must have been tilted vertically, or have lain in their beds in horizontal strata.

These granite ledges of the coast showing themselves everywhere in our fields and pastures, white in the sunshine and looming in a misty day, have had the term applied to them by the Swiss geologists[2] of "roches moutonnés", *fleecy rocks*, because they resemble at such times a flock of sheep lying down, their heads turned toward the

[2] By Profs. Agassiz, Guiot, and others.

south. But by American geologists these ledges in relief are called *embossed* rocks, a decidedly more appropriate term for them I think, as these ledges protrude above the surface generally in vast proportions resembling more a white *mammoth* than a sheep, besides the plural adjective moutonnés gives the American reader a too *sheepish* idea of the rocks altogether. No! let us Yankees tenaciously hold to the word *embossed* introduced I believe, by that fine writer, and most excellent man and geologist the late Edward Hitchcock, D.D. of Amherst College. These ledges trend off in parallel lines more or less, and have reminded me of a broken windrow of hay in a farmer's field, over which a young hurricane had been capering for a moment. As remarked they are very much steeper on the south sides, and are often cloven vertically in this direction, at right angles to the trend of the ledge, and the isolated parts have been removed beyond recognition.

I extended this kind of observation to higher grounds, to the minor hills and the mountains themselves. I found that all had been finished upon a general plan. Still I could not conjecture how the highest hills could have such gradual and often graceful curves towards the north, and meanwhile present bold fronts to the south. It could be readily seen that a glacier could break down the southern part of a *ledge* and carry the fragments away, but could such an icecap over riding a mountain, crush down its southern extremity? I cannot answer the question here, but will endeavor to do so in its proper place. I had many times both from the upper end of North Haven and the lower end of Islesboro, looked at the Camden Mountains bearing west across the channel. They rise to the height of about 1400 ft. Their southern sides are much steeper than those of the north. If we look from the southern part of Deer Island or from the Camden Hills, towards the east, we see the same contour of outline occurring among that splendid cluster of hills on the eastern border of the great fiord of southern Maine, the hills of Mount Desert 2000 ft high. And all granite hills here on their southern sides an abundance of talus, of boulders little and big, specifically the same as the rock of which the mountains formed. Clay, slate hills sparingly show upon this side debris consisting of rocks of considerable magnitude. The bedrock has been broken off in small pieces generally, which were ground into *clay* ere carried far away.

Following these mysterious tracks impressed upon the rocks, in silence and with absorbing interest, as an Indian does those of an enemy, over field, valley and hill, I learned at last to see them everywhere and to recognize their partially faded forms where a fresh observer would not be able to do it. The eastern and western side of the hills from base to top, have been subjected to the same process of scoring and denudation, as in other parts, and the common surface of the country. Upon Vinalhaven perhaps midway between the house of Mr. Jonathan Calderwood and that of his brother Ezra near Pleasant River, upon the left hand going south towards the house of the latter gentleman, there is a perpendicular wall of granite perhaps 20 ft high. Upon this western wall immediately by the road side, there are plainly visible a large patch of beautiful horizontal striae, 5 ft or thereabouts from the ground. I have no doubt but that the whole face of the wall has been polished and grooved. Upon the other side of the valley to the east perhaps half a mile or more away, there is high land that dips sharply to the east. The extent of this granite ridge is sufficient for two

or three good farms, but it has been severely dealt with by the austere monarch from the distant north, the great Ice King. The greatest height here is about 150 ft above the sea. If we locate ourselves in the denuded valley midway between the scratched wall on the east and the high ridge of land on the west, there rises up to the south of us a granite hill 200 ft high, perhaps a little more. It can be ascended from the north and east sides, but is very steep even in these directions. The south wall is almost perpendicular and a stone can be easily thrown into the midst of a pretty deep tide river washing the base of the hill in this direction. Upon the northeast side of the hill a little above the reach of the tide, the ubiquitous groovings are seen upon the polished wall. A very long creek a famous locality in ancient times for sea fowl that came at early morn to drink from a brook at its head, runs around this hill and up towards its striated wall. Valley, hill, and creek owe their origin to the denuding agent, whatever it was. Beyond the hill perhaps a mile towards the north, is a high ridge of clayslate from which one looks north over the Thoroughfare a ship channel between Vinalhaven and North Haven; and away up the bay over numerous islands, 30 or 40 miles distant. A glacier would be no more likely to form upon the upper end of Vinalhaven, than upon the prairies of the west. A local glacier would no more exist there than in a hundred other places in the town. If such a mass of ice existed there it must have covered the town and all the islands to the north at the same time. Nor could there be a moving ice mass here short of 1500 ft thick at least. The channels between these islands of Vinalhaven and North Haven, and the mainland on the west, is deep, let us suppose 200 ft. The glacier would then be not far from a thousand feet above the highest part of the island and perhaps 200 ft *below* the top of some of the highest hills of Camden, 8 or 10 miles away. But this ice field would have no plane of descent like an alpine glacier. It would everywhere meet with tremendous resistance in an effort at forward movement. It would be just as likely to move towards the southeast or west as towards the south. There would be in the mass a motion of expansion and contraction coincident with the extremes of temperature, which would indeed produce progress in some direction, but unless the mass of the Penobscot Bay were supported by a glacial mass on the east and west its paths would spread out like the ribs of a fan. To cut this matter short, I may say with some degree of propriety, nature could not make a Penobscot Bay glacier under existing configurations of land. A glacier there supposes a glacier everywhere in the state.

Not only upon Vinalhaven I saw the smoothed and scratched surfaces on the south sides of hills and ledges, but also upon other islands in this vicinity. There is a signal display of his character at the location of the old post office in North Haven, at the Thoroughfare. A hill of trap a hundred feet high, or thereabouts, overlooks the old store. Both to the east and west of the building, the out cropping ledges exhibit the polish and furrow in the same direction as at other places on this island and others, towards the south. The hypotenuse carried from these ledges to the top of the hill can not be more than 200, or 250 ft. Between this locality and Iron Point half a mile towards the east, the same thing is seen with high land to the north. On the western face of the trap hill, perhaps 50 rods west of an old stone is a small horizontal fissure, I discovered fine but distinct glacial grooves.

On the eastern side of a level ledge of granite of considerable extent, a few rods nearly south of the home of Mr. David Calderwood, of Vinalhaven, I discovered an example of rock-grooving or rather of *gouging*, altogether different from any thing of the kind I had hitherto witnessed. There is here a fissure running north-south for about 20 ft opening horizontally into the ledge to the extent of 6 or 8 in. The internal roof of this opening is not flat however, but irregular, and dipping to the west at angles of 30, 40, and 50°. The ledge rises from a foot to 18 in. above the floor of the fissure and the outer roof was no doubt, once well polished and scratched. The lips of this aperture are smooth and delicately scratched. On introducing my fingers into the opening I was astonished to find the internal roof or *ceiling*, and the floor beneath thoroughly polished; and as soon as I could drench the fissure with water from the well near by the striae showed themselves distinct and regular on the floor, as upon the ledges elsewhere in the town. There seemed no escape from an accurate conclusion respecting the agent employed in the production of this unique example of denudation and polish. The chafing of an iceberg along the opening, would have broken down the wall, rather than have thrust its foot merely into the existing fissure and enlarged it thereby. On the other hand, a glacier crowding its ice mingled with sand and gravel into the crevasse, with a force equal the force exerted upon the ledge, the enlargement of the fissure with polishing and scratching would follow as a natural consequence, without a breaking down of the shelf. Had the glacier existed much longer, the entire shelf would have been denuded and removed, or converted into small boulders, gravel or sand.

Chapter 8
Camden Hills and Mount Desert

Researches continued—Evidence of glacial action—Galileo's assertion at the conclusion of his recantation before the Inquisition—Supporting our opponents side of the question in dispute—Deep water to the south of Vinalhaven—Examination of Camden Hills—Glacial striation about the village and its nearest mountains—Scratched quartz vein on the summit of Magunticook, 1300 ft high—The mountain broken down upon its south side—Boulders between this mountain and Battie—Denuded condition of Mount Battie—Its bold southern front—Glacial scratches at this side—Great boulders around its base—Battie the oldest mountain of the group, and probably the oldest in the state—Visit to Mount Desert -Ð Reflections—Picturesque effects of the mountains—Glacial phenomena abundant—Splendid passage of Somes Sound between two high mountains—Sometimes a dangerous passage—View from mountain top—Denuded summits of the mountains—No local glaciers ever existing there—Degraded summits afford us some data for estimation of thickness of the great glacier.

My researches on the drift phenomena had hitherto been principally confined to the two large islands at the east entrance into the Penobscot Bay. What I had seen there convinced me that the agent in the matter was logically that of a glacier. Looking at the facts everywhere around me and carrying them every day with me pictured vividly on the mind, though silenced by a few word flashes from some sturdy advocate of the iceberg theory. I should have said with compressed lips as did Galileo *e pur si muove*, the *glacier* moves, or did move.[1] But obstinacy is by no means indicative that the possessor thereof is on the side of truth. To make ourselves, doubly sure of the truth of our opinion of a question, we ought to be familiar with every conceivable argument which our opponent might bring against us. In fact I believe we ought to entrench ourselves with his arguments and cooly, attempt to batter down our own favorite fortification with them. We then become familiar with the strength of our foe, and thereby develop the extent of our own prowess.

[1] It is said that when Galileo had abjured before the Inquisition at Rome, his belief in the motion of the earth, he rose from his knees and whispered to one of his friends, "e pur si mouve"—*it does nevertheless move*.

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My field of observations had indeed been eminently adapted to a critical examination of the subject of the drift, but a neophyte in that department of the earths physical history, might go seriously astray in the proper rendering of the facts observed, nevertheless I now determined to extend my boulder observations to the mainland. I thought it possible as already hinted that in the Penobscot Valley as a basin, there might have been a glacier of limited extent, and that its breadth near the sea might have been enclosed within the space bounded on one side by the Camden Hills and on the other by those of Mount Desert. Its reach southward I had already found, had involved the most remote islands of the coast, as Ragged Island, Matinicus, Wooden Ball and Seal Island, from 12 to 18 miles to the south. Between Seal Island entirely composed of gneiss, and Vinalhaven there is a "hake ground" of deep water, of two lines, on about 60 fathoms. The mud in this basin in all probability, is like that of the coast near our rivers, now dry land, which in remote times was deeply submerged, composed of clay and silt above, with sand and gravel perhaps below, overlying clay, and without doubt is many feet in depth. Upon the rocky bottom beneath all this deposit, I am certain the glacier rested, between 300 and 400 ft now beneath the sea. Over this island the drift agent had passed, leaving the evidence of its passage precisely analogous to that upon the large islands to the north of it.

I had seen the boulder polish and scratch in abundance upon the rocks about the city of Rockland and vicinity. But I wished to know to what height had the glacier reached. For this purpose I turned my attention to the Camden Hills. I commenced the ascent of Magunticook on the eastern side, at a mile or more above the village. Upon the woodside opposite the house of a clergyman I saw a very good example of the polishing and scratching of the sides of the ledges and hills. As I continued to ascend the mountain I encountered the polished surface occasionally though generally the striae had faded out from the micaceous sandstone of which the eastern part of the mountain at least, is composed. At the southern end there is a precipice of about 300 ft. A few steps from this precipice towards the north, there is in this sort of rock, a vein of quartz colored with the oxide of iron. It is of course, harder than the sandstone, and stands out in relief. It is polished like glass, and when wet with the fingers, it exhibited the most delicate striae running in the usual direction. Though I had expected to find this phenomena of scratching upon the summit, I was as much astonished and gratified thereby, as the astronomer on the discovery of an expected comet.

I battered off 2 or 3 pounds of this quartz rock, and carried it home as a great relic. The height of this rock was about 1200 ft above the sea. Directly behind the precipice, the hill begins to rise toward the north; and 50 or 75 rods away, is the highest point, probably 200 ft higher, making about 1400 ft as the height of the mountain. On descending Magunticook and approaching the base of the precipice, we find ourselves in a deep valley between the mountains. Here is an endless profusion of rocks torn from the vertical wall of Magunticook. Many of them have been separated through the agency of rains and frost, aided by their own weight, but this is not the case with all of them. The most distant from the base are mostly glacier removed boulders. But hundreds of thousands of tons of rock have been utterly removed, borne away over the back of Mount Battie, and some have been thoroughly ground to atoms thereon.

As we pass along over the top of this mountain toward the south, we see around us 1000 ft above the sea, the most conclusive evidence that this mountain has been subjected to intense glacial action. This hill is composed of quartzose conglomerate and the top is entirely denuded, almost polished everywhere, naked as the hide of a rhinoceros; and its form reminded me somewhat, of a baker's loaf of white bread. There is the glazed top, the precipitous sides, and the abrupt end presented to the south, while the other end towards the north, seems to have been overlaid by a *larger loaf*, to carry out the comparison. It is probable that Battie was entirely marked by a cap of sandstone, or in other words, was a part of Magunticook ere the glacial set in. On descending the southern brow of the former, falling off at an angle of 60 or 70°, I found a few pitches of glacial striation between the brow and the base. These were on small small horizontal benches jutting out towards the south. The *scratching agent had slid down over the brow of the hill*. The glacier, for so the scratching agent undoubtedly was, was thoroughly acquainted with this sort of rough coasting. It had slid down over many hills and mountains to the north of Battie, and though it had had innumerable bruises by the performance, it was none the worse for them when it came to this remarkable mountain. These scratches on the southern face of Battie, do not all preserve the usual direction elsewhere found; but in one case they were considerably deflexed to the east, and in another a good deal so towards the west. Nor should we look for regularity of direction in such cases. At every forward movement of the glacier as it passes over a hill there was a settling down of the mass crowding itself into all the inequalities of the bed over which it was traveling. Where the angle of descent was not vertical, the weight of the glacier would permit of no unoccupied space. Ice would be as rigidly impacted at the southern base of the hill as elsewhere. The *bridging* of the hills as supposed by Prof. Agassiz, was not therefore what occurred with those of Maine, when covered by the glacier.[2] Hills composed of slates or shales with their dips more or less coincident with the march of the glacier, do not exhibit their southern brows much wrenched or glacier worn. The strata were crowded forward and broken, just as we should crumple the leaves of a book on turning them over somewhat hastily. But upon hills of granite, silicious slate and quartzose rock like Mount Battie, I do not consider that there can be any objection to the expectation of finding their southern faces here and there scarred and scratched from top to base, if the angle of descent is not very great. We should not anticipate the striae to be *dropping*, but rather *horizontal* made upon shelves of rock.

At the southern side of Battie, lie vast boulders torn from the great hill overlooking them. They are of course identical in composition with the rock of the mountain. One of these boulders is 40 ft long, and must weigh 600 t at least. It might be considered an idle endeavor to speculate upon the origin of this mountain. But there is no doubt but that it is infinitely older than Magunticook. It is a growth of long forgotten eternities of past when paradventure, created intelligence was but a thought that lay enshrined within the mind of the Deity. Older than the lower Silurian, away back into ages dim

[2] See the preceding Chapter.

and gray with the mists that forever formed the shores of the unknown. As we look out along these receded and mysterious eons, we see the material of which Battie is composed, a deposit in the sea, and very possible a deep one. In process of time, a time which can be estimated only by millions of years, this material underwent a great change, became consolidated into rock of a flinty nature. It came near the surface of the ocean, and perhaps was a coast line. The locality then became a locality of convulsions, and its shores or the shallow sea, were strewn with broken rocks, on which, or over which, the waves of this old ocean broke with tremendous force. Ages which no man can number go by, and this shore or shallow bottom of fragmentary material, is buried deep in the sea and undergoes a process of cementation, is again united into a solid mass. It again becomes the bottom of a shallow sea, on a coast line as before. Strong currents from a land we wot not of, pass over for ages this bed of flint, and deposit there, a coarse clay mingled with micaceous sand. This process goes on while the bed of flint is once more returning to the sea, till a deposit of great depth perhaps a thousand feet thick, and possibly several, is laid over the primitive bed of rock. That also is at last transformed into stone. In due time which nature never considers long, though the sun of the solar system revolves many times around *his* sun but once in more than a million of years, and all things have "waxed old as doth a garment", these two formations, the very aged Methuselah of the one, and the young lad of the other reposing in his arms, or on his back, appear as dry land during the great coal age; and in long ages thereafter, the old and the juvenile sons of the past, were lifted together and molded into gigantic forms. Before their presence a panorama of wonderful events and aspects passed for for many more long eons of time, of strange and mighty animals upon the land, of gigantic reptiles and birds, of fish in the sea that made the deep to "boil like a pot", of the transformation of landscapes, of the retreat and advance of the ocean in greatly extended periods, while as yet no lordly man had walked the earth; and at last time the great leveler of all terrestrial things, brought a fierce and ambitious youth to the land, who laid *his* leveling hand upon the old rough mountains, and tortured and rent them in pieces, treading the fragments beneath his feet, and throwing them into the yawning sea. This son of Boreas with his mountains of ice and terrible winds, at last passed away into the silent land; and the country once more green and peopled with innumerable forms of life, with man among the multitude.

Having examined the hills of the west side of the Penobscot Bay, and satisfied myself that a glacier not *less* than 1200 or 1500 ft above the common level of the sea, or high enough to cover the Camden Hills, had once occupied the locality, I decided to examine the opposite extremity of the fiord, by visiting the island of Mount Desert. This island is about 40 miles nearly due east from Camden. It is divided into three townships under the names of Tremont, Mount Desert and Eden. It contains the finest cluster of hills on the eastern coast of North America from Labrador to the Isthmus of Darien.[3] The hills are 12–15 in number, and rise to the altitude of 2000 ft.

[3] *Historical name of the Isthmus of Panama.*

If "high mountains are a feeling" as Byron has well expressed it, a feeling of grandeur and divine calmness, falling upon the soul like the gentle dew of heaven upon the earth, surely here upon the border of the ocean under the shadow of these grand old hills, this feeling, this emotion,must be fully comprehended and appreciated. The sea as the sun to our system, is the parent of all terrestrial grandeur. From it came forth the mountain, the desert and the plain. Its voice gentle as the language of affection, or loud as the thunder of heaven, is everywhere heard declaring its superiority over all. The mountains nature has chosen to sit upon the right hand of the sea. It is not its equal, but it is its chief companion. I cannot therefore conceive of any earthly scenery so well adapted to suggest and develop the nobler aspirations of the soul, as a landscape where the mountains and the sea are thus blended into intimate friendship. It is here at the feet of these mountains of Maine standing in familiar associations like noble chieftains in council, where the waves of the ocean display their mighty power, that man may come and drink of the free cup of joy which nature here presents to all who love to contemplate the glory and grandeur of her works.

The blue of heaven and the mists of the sea as sunshine and shadow upon the face of man, settles down upon these watch towers of the ages. No decay, no change touches them which the human eye can perceive. Empires founded by man have risen, have agitated the world for many centuries, and have passed away; but these mountains existed as we see them now, thousands of years before there was a man upon earth. And when he had come, and his descendants after thousands of years more swept over the land and the sea, fierce men clad in skins, with spears and bows, and war clubs, and in primitive canoes, did they reverence these hills as the grand captains by the ocean's side? Did the gods of primitive men reside upon these high places and not in the valleys, like the strong "gods of the hills" of which the prophet spoke to Ahab? Ah! if we *could* but know who first among men beheld these mountains and rejoiced. Did the bearded blue eyed Goth, Saxon, Dane, Irish, Welch, children of the far off northeast see these hills as they coasted along our waters, and were glad, and record in priestly rune or ogham symbols, the auspicious event upon our rocks? As I gazed upon these mountains, I thought of the lively loquacious colonists who under the Baron de Castine, settled here and said their *Ava-Marias* upon these picturesque shores, bright eyed thoughtful women and imaginative men, of the last sad look which they took of these hills when driven away by adverse fortune; of the tearful eyes of *Gabriel* who was separated forever from his lovely *Evangeline*, as so sweetly sung by Mr. Longfellow, when these hills alone remained above the ocean, perhaps as he sailed away from his beloved home.[4] Thoughts too, of others of whom we know not whence they came or whether they went, nor the name by which they were known among men. The vistas of the long ago as I sat by the sea in an evening

[4] In 1755, the French forts of Acadia at the head of Bay of Fundy were taken by the English under General John Winslow. The harmless and happy people were seized in their fields, houses, and churches and conveyed on board of English vessels, and carried away to Louisiana and elsewhere, under the plea that they might aid the French brethren in Canada. Their growing crops were destroyed and in a few weeks the paradise of the colony was completely desolate.

of August gradually opened one after another upon the eyes of the mind, forms wild and fantastic, of men and women and children, passed before me. Others of various aspect came and went. Wild songs and psalms of blessing fell upon my ear, and the sound of the Sabbath bell was heard. White sails dotted the face of the deep blue sea. Great ships passed by from which men and women gazed with serious eyes upon these mountains, and sailed away into unknown seas. Never another mountain of this world saw some of them. The same thoughts which we think today, agitated their souls ere we were born, thoughts of nature's beauties, of the joys of childhood, youth and ripe years, of beloved companions of the holier duties of life. Where are these affectionate eyes, these loving hearts, O where are they? I ask, and the sea and the mountains reply "*where are they*"? *These* know not, but it has been given to *me* to know. Their meditations and deeds are preserved where moth and rust corrupt not, in a clime of pleasant sunshine, of green fields and cooling streams. Thither these men and women went also. I know the shadowy way they took leading from the land of mortal life. From the shore of that land we see them waving their white hands, beckoning us to go to them by the same path by which they went away from us.

Viewed from a southern aspect from the ocean, these mountains seem to rise boldly out from the sea. They are not built up with a broad base like the clay slate hills of Maine, but seem to leap up tall and gigantic from the earth as if awakened at the sound of a trump. As we approach these hills the evidence of ancient glacial action reveals itself around us in no stinted measure. We meet boulders torn from the mountains before us, and their numbers and comparative size increase as we advance towards the hills, the larger rocks lie near the base of the hills, but many are smaller between between it and the shore, and doubtless some are strewn over the bottom of the sea. From Bar Harbor on the northeast in Frenchman's Bay to Bass Harbor in the southeast in Blue Hill Bay, a distance along the coast of 15 or 20 miles, there is a continued exhibition of glacial separation of rocks, of wide and deep plowing up of the floor rock, and smoothing and scratching of it in one general direction.

On entering the "Sound"[5] from Southwest Harbor, that paragon of New England scenery when the sea and the mountains meet each other in everlasting embrace, a picture which reminds one of the great Saguenay of Canada east, the mountains on the west rises abruptly up from the from the south and the marveless waters of the basin, to the height of 1400 ft. The opposite mountain on the east stands a little farther north, but looks down from a very great height also, with nearly a vertical wall. As you float along by the current or the force of the oars of your boat, you feel the hand of silence laid upon you, and a thought of personal safety starts into life. We have many a dark passage in our world, wanderings, and though we hope, we fear also, but fortified with care, let us make this sublime passage between the lofty hills. It is a cloven pathway where the glacier plowed its way toward the sea beyond. Upon its narrow sheet of water, the largest ship in the world may float with a hundred feet of water around her. The wild storms of the sea and the land seldom disturb these profound waters. A gust from the mountain top like an evil spirit, dashes now

[5] *Somes Sound.*

and then down upon the face of the tranquil waters, and sweeps angrily over it for a moment, when all is silent and calm again, as if Earth contained not a living thing. It is this sudden descent from aloft, a kind of "white squall" of the mountains, a secret enemy whose presence is unknown till his hand is fiercely laid upon you, that makes this passage dangerous, a stygian passage to many who have braved the dangers of an ocean storm and a leeward shore. Beneath you many a valuable vessel lies buried, both the laded and the light, having been capsized by those strange gusts of wind, always felt aloft before their presence is known below. The sailor never suspicious when he knows his "reckoning" in fair weather, dreams of no danger here, though he understands well enough, that it is from the mountain tops that the perfidious squalls leap down upon their victim. He is but a few miles from his journey's end. He goes along smoothly with the tide. Perhaps now he smokes his pipe, the sign of peace with the white man, as with the savage; or he whistles, not for the want of thought exactly, but coaxingly for a little wind which he does not precisely need, and getting it does not want it from the direction whence it comes. The sailor's prayer uttered in humility or wrath, in trouble or a calm, is often answered though he offer no sacrifice of a black sheep and a few shillings to Neptune as in the days of Aristophanes and Virgil. So now having sighed out a wish for a gentle breeze, by and by the messenger of Eolus sweeps down in a twinkling, and the stately vessel is suddenly knocked over. She fills with water, and goes to the bottom at once, whence no human aid can redeem her. The Sound terminates about 5 miles north of its mouth, near the northern base of the hills which I have described, at its entrance where there is a little quiet village called Somesville. You imperfectly get a glimpse from the village of the rising land to the east, a part of the mountain which bounds the right hand entrance, otherwise you would not suspect that there towered up around you at the distance of only a few miles, some of the highest mountains on the eastern coast of the Great Republic.

At the southern base of these hills of Mount Desert where the tourist sometimes seeks to ascend, he is confronted with difficulties on every hand. The mightiest rocks torn from the hills impede his path, many being merely loosened from their native places, or turned out of them. Trees taking root within the scanty soil, grow up along the walls and assist the tourists' ascent. The beholder sees everywhere around him, the picture of desolation, or rather desolation itself. The rendering asunder of stupendous masses of granite, as if there had once been the habitation of the earthquake for ages. This mighty boulder before us lying in the mouth of this little dell, has doubtless come from the mountain side, not far away. In every direction the ground is paved with these detached rocks, and the attention is perpetually recurring to the fact that they look as if they had but recently been removed from their native beds by the hands of men, who had left them not many months ago. There is a gorgeous view from the top of the mountain opposite Southwest Harbor. You look down upon the Sound beneath your feet, silent in sunshine and in storm; but now it is glowing like a mirror as the meridian sun covers it with his beams. Yonder to the south, the sea and sky blend into one. To the northeast your eye runs along the shore to the mouth of Pleasant River Bay; and nearly in the opposite direction rise up the Camden Hills, princely members of the same race as now surrounds us, clad in imperial purple

and blue. Every mountain that we see towards the east and west, wears the aspect of steepness at its southern end, with an easy curve towards the north. Many large boulders are scattered over this part of the mountain, which is here nude and scored in every direction. A wretched night would he be, who had such a list of *old scores* to wipe out, as this mountain exhibits.

At the extremity of the sound waters, a short distance to the north of Somesville, there is upon the east side of the creek, a long ledge from 7 to 10 or 15 ft high, facing the west. Upon this wall a few feet from the ground, the polish and scratch are very finely executed in several places. Here as upon the northeast part of Vinalhaven you see no local source for a glacier. If you have come to the island by the way of Trenton, you have not yet approached the mountains. The foot-marks of the glacier along this road all assure you that it came from the *north*. On the road towards Bar Harbor the scratch and polish are everywhere abundant. From the village to the summit of Green Mountain[6] 2000 ft high, we see around us the evidence of a tremendous wearing and grinding of the surface rock in some remote period. The aspect of the surface is vastly more corrugated than in the region of those hills of Camden which I have described. It is no less so as we pass around to the south of this mountain. Wherever we can get a view of the recently uncovered floor rock there, we find it smoothed and grooved. Standing upon the highest hill of this group and having everywhere seen the tremendous denudation to which it has evidently been subjected, I cannot perceive how it is possible for an intelligent man to attribute this destruction to any other agency than that of a glacier, which once overrode these mountains. And all the evidence witnessed by me in the valleys of the Island of Mount Desert, goes to show that when glacial action ceased there, it was centered in, and controlled by, a single stream, moving towards the south. The last rock quarried by the glacier from the summit of the hills, and the last below, struck upon the ledges below around the base, and in the bottoms of the valleys, were I believe, events that occurred simultaneously. It is impossible for me to believe that Mount Desert "must have been a miniature Spitzbergen, and colossal icebergs floated off from Somes Sound into the Atlantic Ocean"[7]

Any glaciologist would justify me in saying that no geologist can restore upon evidence now within his reach, the aspect of the country just ere the great glacial age began. An approximate profile of the country may be given to some extent, but nothing can be relied on, as an accurate description of it. The Mount Desert Hills may have been very much higher at the commencement of the glacial age, or they may be hills of denudation to a great extent. Now at the close of that age, supposing the bed rock of the Sound was barely above the level of the sea, or 2000 ft above it, the snow filling that gorge from the tops of neighboring mountains, would certainly imply the accumulation of snow in all the vicinity, as well as allover the surface of the state. The tops of the mountains would be no more in all probability than 2100 or 2200 ft above the bottom of the Sound. How then could a glacier accumulate there,

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[6] *In 1918 Green Mountain was renamed Cadillac Mountain.*

[7] Prof. Agassiz in Atlantic Monthly for March 1867, p 287.

more than to the north, or east or west of that locality, or in other directions from it? No "*colossal icebergs*" ever "floated off from Somes Sound into the Atlantic Ocean" I *know*.

If therefore the hills of Mount Desert and Camden bear evidence that their summits have been swept and broken up by some power independent of that which raised them to their present altitude, exhibiting a degradation which is only commensurate with the action of a glacier, we have some data though imperfect, by which to estimate the thickness of the great ice sheet. Had the glacier not been of a thickness greatly overtopping these hills, it could not have been pushed forward over their summits with regularity, in consequence of the flexure of the ice cap in its upward march and its tendency to stumble back towards the north, as well as to be pushed aside towards the east and west. For although the dynamic energy of the glacier was doubtless very great, one must bear in mind that its motion over the hilly surface of Maine was *indisputably* slow. Ice moving over the summit of a hill 2000 ft high could have no steadiness of motion unless supported at a distance east and west by a volume of the material of a thickness greater than the height of the hill. Taking into consideration these facts I was therefore compelled to infer that the glacier which swept the Mount Desert Hills was not *less* than 4000 ft in thickness.

Chapter 9
Mount Desert to Holden

Route from Mount Desert to Ellsworth—Slate formation—Few boulders along this route—The glacier did not generally transport the broken rocks to a considerable distance—Granite boulders in west Ellsworth—These should be preserved as memorials of an ancient revolution of the earth—Remarks—Dedham boulders white in the distance like arab tents—Farrington Hill in Holden—Denuded state of the Rider Hill which caps the former—The ancient story of the battle of the giants against the celestial deities—Milton's description of the battle between the good and rebellious angels—Passage of the glacier down the Penobscot Valley—Morning scene—Mount Katahdin—Prospect from Farrington Hill—No Penobscot Valley glacier, as an independent ice stream – Passage of the glacier over Farrington Hill—Its decrease and disappearance, in a vision of the past.

As we leave the island of Mount Desert and pursue our way over the slate formation of Trenton towards Ellsworth, we are surprised at meeting with so few boulders. The route is not very hilly and is covered with a soil principally of brick clay. Only here and there a boulder larger than a man's head can be seen, and they are akin in comparison to the formation on which they rest. The glacial striae I found wherever the slates cropped out by the wayside. The fact of the general absence of boulders over the plain of Trenton, though everywhere the slates are seen protruding above the clay deposit confirms my conjecture that the glacier did not generally tear large masses of this rock from the surface of the country, unless when in a highly altered condition; and that the fragments were mostly ground to clay by the glacier, and by no means transported to considerable distances. These slates underlie the village of Ellsworth, and extend west for 3 or 4 miles beyond it, when the granite formation appears, of a white and course texture. In several places in the village, the polish and scratch upon the rock were beautifully developed, as they are always upon metamorphic slates. Upon the left hand side of the road leading to Bangor just above the western bank of the Union River, within sight of the village there is a splendid example of rounding, polishing and scoring of the surface rock.[1]

[1]*This rock was described by Louis Agassiz in his 1867 Atlantic Monthly article "Glacial Phenomena of Maine". It is now listed on the National Register of Historic Places as the Agassiz Rock Outcrop.*

H. W. Borns, Jr., K. A. Maasch, *Foot Steps of the Ancient Great Glacier of North America,*
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As we approach the granite formation, we meet boulders of this rock in abundance. There are here at three, possibly at 5 miles from Ellsworth village, a train of enormous boulders weighing individually from 300 to 1500 t. There is a passage between them sufficiently wide for the county road. Those upon the north, or right hand side going west, stretch along in a line north-south far into the forest. Upon the opposite side were three large boulders near together. They were all probably derived from the granite hills visible at no great distance towards the north. One of these rocks had been partly split into fragments, perhaps for building purpose, possibly to make a stone coffin for the sapient individual who ordered or executed the transaction. In the name of the Sacred *Past*, I protest against such profane vandalism. A man born in the sunrise state with an ordinary share of mother-wit, should not be guilty of so mean a trick. If a man can hear any noise below that of thunder, he certainly ought to hear nature shout "hands off!", to every attempt to mangle and destroy those grand old waymarks between the human age and the one which just preceded it. I was angry enough when I first beheld the transaction, to wish that at the first blow of the hammer, the pirate had been frightened into a protracted syncopy by the icicled ghost of the glacier that has set up this sublime monument.

Farmers of Maine, if you desire to be remembered in the present and coming time as men of good sense and intelligence, do not suffer these gigantic monuments of nature to be removed from your estates. Day and night have many of us pored over the history of extinct nations of men *dulce et decorum* it is to know that they once lived, and that we have brains to reverence their memory; but here around us born sons of North America, nature has set up monuments to perpetuate the grandest event in the story of the earth's mutations, and tell us by what means she has given us a country rich in mineral soils; and shall we indiscriminately overturn them, and forever remove the sacred relics from our sight? I trust not. I believe that a proper appreciation of the matter will speedily be manifested by the citizens of Maine.

As I stopped my carriage to visit those boulders and gaze upon their majestic forms hat in hand reverently, as I approached them, I bethought me of the great sights and sounds with which our mortal existence is associated. Never in multitudes are great things of mortal life consorted, whether of fruits, trees, rocks, or men. The mighty mammals of the earth go not in crowds like weaker quadrupeds, that seek protection in the magnitude of their numbers; and the noblest birds are solitary or few in number when they show themselves in the dwelling place of the clouds. The great trees which have lived for many centuries, are scattered but sparingly over the surface of the Earth. Mighty men whether of body or mind are in the ages, "few and far between". These are the real princes and lords of the land and air. In this individuality there is grandeur and protection. Thus nature has preferred to distribute sparingly her mighty works over the face of the earth, upon the lonely plains, the mountainside, and in the bosom of the valley, that they may arrest the attention of the thinking man, and bear witness of her methods with the ages. Though "there is no speech nor language where *their* voice is not heard" they have notwithstanding a most charming and comprehensive speech. It does not indeed abound with the declinable nouns and conjugatable verbs, nor is it copious and rich in synonyms. It is addressed more to the eye than the ear, and thus shows its correspondence with the

first languages used among men. We once looked upon these individuals as solitary aliens in our midst, of whose history we knew nothing, as of our fellow beings whose language to us is totally unknown. But we have by our intimacy with these strangers, wormed out of them a precious bit of personal biography. The enigma of their birthplace is unriddled, and their mythism has disappeared. We and they thereby are united in abiding friendship, separated only by death.

The granitic formation of west Ellsworth is continued into Dedham, and is prolonged west as far as George's Corner in Holden. In the former town there is a profusion of boulders. The fields and woods are freely sown with them. Many are of gigantic proportions. Their white forms as I stopped to gaze upon them, reminded me of the white tents of Arabs pitched among the Idumean hills, picturesque and silent aloft from the great world of thought and of strife. A little way from George's Corner I turned aside to the left, from the direct road to Bangor. After passing through a beautiful grove of hardwood upon the old homestead farm of Deacon John Farrington I commenced the ascent of Rider's Hill, a barren elevation of clay-slate 300 ft higher than the main hill, and 700 ft above the Penobscot River at Bangor. I believe there was not a bush upon the top of this hill. A single boulder lay near the summit. The naked hill has been subjected to rough handling by the glacier. The entire top of several acres is rounded, polished and deeply scratched.

As we look around us, the hill has a *cut off* contour as if it had been pared down by the slashes of a giants sword. Paradventure some giant *had* sharpened his instrument of his, upon this argillaceous whetstone. We have a strange inkling of many a bold deed done in this forest country of New England, many thousands of years before the Mayflower cast anchor in Plymouth harbor; but the antique record is so tattered and time-soiled that we must fain consent ourselves with that which is fairly legible and legitimately deducible. It is pretty well established historically and traditionally, that the world *has* had its human giants. Passing over the brief allusion of the Bible to such monster men, the classic poets tell us how they once warred with the deities of the celestial world, and piled mountains upon mountains to climb that abode; and the Irish story tellers assure us that their giants, general fionn macCamhall and his compeers, built the Giant's Causeway between the northern part of Ireland and Scotland, that they might the better fight with the giants of the latter country by carrying the war thither, and beard those human lions in their own dens, and how they brick-batted those foreigners with huge boulders, throwing many a rock from a dozen to a score of miles. Looking around upon the boulder country of Maine over which I had recently traveled, I suggested to myself that though this land of ours has no classic record of the doings of demigods in the matter of piling mountains upon each other in attempt to scale the dominion of the celestial gods, and that though we have no Yankee traditions running back into the past concerning the bridging of the new world with the old one by ancient American giants, paradventure now the State of Maine and the great North to boot, may have been the theatre of old gigantic strife notwithstanding the whole continent might not have been too large for a bellicose exhibition of this kind. The puny battles fought among men often beat over half a country before the fight is closed; we ought therefore to give an abundance of elbow room for the display of super human prowess. I suggested to myself I say, that

among the hills of Maine the famous battles may have come off between the great seceder, Satan, on the one side, and the Union generals, Michael and Gabriel, on the other, described by the good blind poet of our language, true enough the author of "Paradise Lost" tells us that this great battle was fought in heaven; but the wise-acres of a popular theology, have wonderfully improved upon the opinions of our ancestors in sacred matters and have now located the celestial world upon the terrestrial one; and if their spiritual decision be infallible, all the better for our sincere suggestion.

As it regards this divine episodes, matters of general misunderstanding had climaxed in a brisk? Mad battle, the rebellious cavaliers so far have carried matters with a high hand, and have had things generally after the pleasant fashion of their own wills. They had suddenly opened upon the Federal forces with a new weapon, and had scattered them far and wide, *hors de combat* for the moment at least. Those fire-eaters had not like ours in the beginning of the late war between the North and South, *stolen* their cannon, but had like "cute" yankees, invented them; and an admirable piece of mechanical strategy it proved to be, at least for a brief half hour or so. The celestial generals to preserve their honor intact from this unexpected rebuff, had now to resort to more effectual measures. No profound mining of forts or Dutch Gap canalling, would avail them anything. Nothing but a magnificent open fight would bring those villainous rebels to their senses. Since their late success general Satan and his chief captains are having a delightful colloquial barbecue. They are as the poetical narrator expresses it, in "a gamesome mood" miscellaneously. Their rascally boasting naturally tingled the ears of the Union Army, and excited their deep indignation. They speedily rallied and reformed their ranks. At word given by the two great federal commanders, the battle again began; and now I must let the historian tell his own story. Speaking of the national army he says:

> Rage prompted them at length, and found them arms Against such hellish mischief fit to oppose forthwith Their arms they threw away, and *to the hills* Light as the lighting glimpse they ran, they flew. *From their foundation loosening to and fro, They plucked the sealed hills with all their load, Rocks, waters, woods, and by their shaggy tops, Uplifting bore them in her hands*. Amaze Besure, and terror seized the rebel host, When coming towards them so dread they saw *The bottoms of the mountains upward turned*; And on their heads *Main promentories flung, which in the air Came shadowing and oppressed whole legions armed*, Which wrought them pain Implacable, and many a devious grave Long struggling underneath, ere they could wind Out of such prison. The rest in imitation to Eitle arms Betook them, and the neighboring hills uptore; So hills amid the air confronted hills, Hurled to and fro with jaculation dire, That underground they fought with disimal shade; Infernal noise-war seemed a civil game To this uproar; horrid confusion heaped Upon confusion.

As I stood upon this hill that set like a dome upon the Farrington Hill, and surveyed the prospect around me, and reviewed at the same time, all that I had witnessed south of me towards the coast, it really seemed as if the besom of destruction, the embodied spirit of wrath, had reveled for a season over this domain of the earth. I had minutely examined all the islands of the great fiord of southern Maine; had visited the towns bordering the western side of the Penobscot River to Bangor; had passed over from Belfast through Blue Hill and Surry, to the Island of Mount Desert, and thence north within sight of Bangor, embracing an area of nearly 2000 square miles. One and the same agent of destruction had visited all these localities, had laid its hand upon

the rocks and the hills, and had overturned them, in the language just quoted had emphatically "plucked the sealed hills with all their load, rocks, waters, woods". One of the most extensive inland prospects of the state was before me. I was standing about 700 ft above the great valley of the Penobscot. Towards the north 80 miles distant Mount Katahdin towered up without a cloud upon his brow. I had passed the night in the puritanic homestead of deacon John Farrington, the worthy son of deacon John Farrington, deceased, who had made the farm from the wild rugged forest, and whose good wife had heard Whitefield preach. In that very house I had often been refreshed in body and mind when a youth. It was the home of cultivated minds and of christian principles.

The mountains within sight of this hill, had been to me of yore, as well the "mountains round about Jerusalem" to the great psalmist, a source of never failing joy hidden from the common eye. Katahdin was the grand chief, whose form I always loved to contemplate. I had not seen the mighty monarch of the forests of Maine, for more than a dozen years before this morning. I rose at dawn on this day, to see the light break in on this great valley. There was not a cloud in the sky. A blue ribbon of mist hung over the river, and was lost in the distant north. His majesty "the great mountain" as the Indian word Katahdin implies, was not visible at so unseasonable an hour. I was uninitiated into the etiquette of the royal chamber, or having once understood it, did not bethink me of the rigid code. *His majesty never rises before the sun!* The mist of the great waters by which he is surrounded, cover him as a garment at night, during the summer. I watched for the movement of the purple curtains which overshadowed the royal couch. Meantime, another monarch greater than Katahdin, was seen in the east. His head was clothed with a crown of burning rays as he glanced over the habitations of men. The glory of his countenance illuminated the heavens and the earth. Clouds of dazzling gold tipped the hills over which his chariot passed. By and by I looked towards Katahdin, and lo! he stood forth clothed in his royal robes of blue and purple, grand and glorious greeting the monarch of the east. At the right hand along the airline road between Calais and Bangor, turned up many mountains, among which was "Peaked" mountain in Clifton, a dozen miles distant, cloven from top to bottom, apparently perpendicularly, on the southern side. On the left, the Dixmont Hills stretched away towards the north. Towards the northwest the Ebeemee Hills bounded the extensive prospect.

Surveying this wide sweep of country with the great facts of glacial denudation before me, the mind naturally enough ran back over the path of the past. I saw that no glacier could have filled the valley of the Penobscot as an independent ice stream, and have climbed the hills between me and the coast. When the first ice movement reached this Farrington Hill, the whole country was covered with ice and snow to a great depth. This conclusion forced itself upon me though I calmly considered what objections might possibly be brought against this view. I saw in imagination, and I trust not altogether fallaciously, the unrolling of the scroll of the past containing a part of its modern history from the close of the Tertiary times forward. I saw hills which had existed millions of years, invested with the strong arms of this giant of the north, and finally swept away, old plains and valleys obliterated, rivers which had grown mighty with the march of time, still and frozen under the feet of the

conquerer, and the land no longer visible to the eye. As I listened with a silence as hushed as the sky which overspread the scene, I heard the tread of the invader filling the soul with a performed sense of destruction. I saw also a figure pass slowly by, of commanding presence, with symbols of death and the renewal of life in his hands, very old yet always young, “having neither beginning of days nor end of life,” upon whose forehead was written in dazzling letters “Time”. I asked how long should his dominions of ice continue, and it was told me, for a time of times. I saw also his kingdom pass away, and many other wonderful scenes written upon the scroll of the past, and at last the tread of wild beasts and men, and finally the gleam of a great empire in the bright glow of a summer’s sun.

Chapter 10
Bangor to the Piscataquis Valley

Researches in Piscataquis Valley—Glaciation in the region of Bangor—Scratches in front of the Dwinal House—Mount Hope—Glacier came down the Penobscot Valley from the north—It crossed the river where it runs towards the southwest—Levant and Corinth "horse back"—Rounded features of the hills in Charleston—Glacial groovings there—The same thing in Sebec, south and north of the Corner—A hill in Bowerbank—Ebeemee Hills north of the Piscataquis River 1500 or 2000 ft high—Elliotsville Mountain—Its steepness—Pond on the top of it—Buker mountain in Guilford—Lunoid furrows there—Evidence that the glacier came over the Ebeemee Hills—The town of Abbot; glacial scratchings there on a wall referred to by Mr. Charles H. Hitchcock—No local glacier there.

Along the banks of the Penobscot River both above and below Bangor, I found the rocks polished and occasionally scratched. To what extent running water and river ice had been concerned in this work, I could not fully judge. Only here and there the river banks elevated at various heights above the summer stream, showed the old glacial scratches. In front of the Dwinal House, between it and the stable, I found these markings in a good state of preservation. Upon the ledges just above the bridge near the Parsons homestead, at Mount Hope, I saw them again. In a field below the railroad depot south of the city, I noticed another patch of them. I was satisfied with the conclusion, that since the glacial age passed away, the Penobscot River has not very much enlarged its rocky channel.

But on getting away from the river banks to the high lands, within the bounds both of Bangor and Veazie, where the river deflexes toward the southwest, the glacial striation was found running in the same general direction which I have seen in other localities towards the south. North and south most assuredly is the prevailing trend of glacial scratches east of the Penobscot River, and I may add, east of the Kennebec. The persistent march of the glacier in one direction over river, hill and valley, reminded me of the curious habits of the violet land crabs of the windward islands of the tropics. Once a year they visit the ocean where they deposit their eggs along its shores. They eschew all opposing obstacles in their path, that they may attain a mathematically straight line for the sea, from their mountain homes. Over rubbish, rocks and even houses if it were possible, they clamber where they can.

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The last motion which the glacier manifested here, in the region of Bangor, indicated that its direction was very nearly due south. It had descended the northwest bank of the river which sweeps here towards the southwest, and had climbed the opposite one, steep enough surely in North Brewer. The glacier therefore of but a thousand feet in thickness, would be totally incommensurate to ascend a steep river bank of any considerable height.

To dispose or confirm, the supposition that the glacier may have been a limited one, a kind of Penobscot Valley glacier, I purposed to visit the region towards Moosehead Lake, the most of which is higher than the land of the Penobscot Valley. I noticed the scratches in the town of Glenburn west of Bangor, by the roadside, as the passengers left the stage coach to walk up a long hill. The trend of their markings had the usual direction. I saw some boulders by the roadside there, that showed that they had been *dragged* as they were polished and scratched. Beyond this town we entered upon the boulder clay, the rewashed or modified past-glacial deposit which covers so much of marine margin of the state. Here and there only a ledge was exposed. This clay continued through Levant to Charleston, where the land rises again, and we get a view once more of the scratched surfaces, and where also upon the top of the hill ere we descended into the valley of the Dead Stream, we get a glimpse of Katahdin bearing about north 50 or 60 miles away. I would not omit to mention here, the "horse back" between Levant and Corinth, over which the county road to Moosehead Lake passes. This is no glacial moraine, nothing more or less than an old lake or sea beach, made when the great plain of the Penobscot valley, of which this region is a part, was within reach of the sea, or when it was a shoal lake region, and was swept by the winds. I shall refer to this subject again in a future chapter. The slate hills of Charleston have a rounded aspect.

In going towards the Brownville slate quarries, we crossed the Piscataquis River and entered the town of Sebec. About a mile and a half, or 2 miles from the bridge, we began the ascent of a long hill, elevated from 300 to 500 ft above the river. At the foot of this hill, upon a ledge near the woods I noticed the glacial polish and scratch. The glacier had slid down the hill from the north, like an alpine ice river. But the *slide* was not a rapid one, precisely coincident with its march *up* the hill on it northern side. The broad plain between the southern foot of this hill and the river, was once occupied by the Piscataquis. From its mouth as far as Guilford and Abbot, traces of its old channel are everywhere seen. Immediately after the glacial age, when probably but a few glaciers of very limited extent were yet hanging upon the upper valleys of our high mountains, the condition of the country was very similar to that of the region around the upper part of Hudson's Bay, where terrible snow storms prevail in winter, and the ground is covered in March to the depth of 12 or 20 ft. The warm weather of May and June dissipates this enormous mantle of snow, and the rivers are filled with rushing waters. As this state of excessive winters passed away and the land became more depressed these broad surfaces of our rivers became more contracted, and passed here and there into lake basins, of which we have many examples in the State of Maine.

At south Sebec upon the top of the hill in front of the west shore, I saw the grooving again upon the slates. About a mile or more to the north, off towards the west, I saw

upon the face of a high ledge upon the farm of one of the proctors, a large patch of glacial scratching, of a most admirable character. The hill dipped strictly toward the east, and was covered on this side with these grooves both fine and very coarse. The glacier had come up, or crossed a deep valley immediately to the north. About Sebec village wherever the ledges cropped out, this characteristic phenomenon of the surface rocks of Maine was witnessed.

In Bowerbank the granites show themselves again, and exhibit the usual denudation of this formation. A granite hill in this town was completely denuded. It looked altogether too airy, too much "ventilated" even for the warm weather of mid-summer. It seemed perfectly stripped for contention with the elements of this world, without so much as a shirt upon its back. A few blueberry bushes growing here and there at random, looked like hairs growing out of its naked hide.

From Bowerbank there is a lumber road used in winter, running northwest along the southern border of Ship Pond northwest to Elliotsville, one of the most northern towns in the county. There is a singular mountain there, that may be seen from almost any of the highlands about Foxcroft and Dover. It is a very good type of the contour system of the mountains of Maine. It is composed of highly altered clay slate, the rocks upon the southern side exhibiting the appearance of having been submitted to great heat, and have the appearance of trap. I should judge the mountain to be 2000 ft above the Piscataquis River. It has a gradual descent towards the north, from which direction it is of ascent. Its east and west sides are steep, but its southern extremity falls off almost perpendicularly. At this part of the mountains lie vast quantities of boulders piled on each other in sad confusion, extending to the edge of a pond not far away. The summit of the hill is divided into two elevations between which there is a basin of very cold water throughout the summer season. This mountain lakelet has one outlet down over the southern brow making music by its fall not inappropriate to the wildness of the forest. I suppose the water is supplied by the abundant condensation of aqueous vapor in the atmosphere, rather than from having a distant head higher than itself, percolating through the slates; for indeed this strata or cleavage lines, are almost everywhere as it regards the mountain itself, nearly of quite obliterated. After crossing a broad valley around the head of Ship Pond, there is another mountain towards the north, much higher than the one just described. Its south side is a vertical wall 2000 ft high. I did not go near enough to examine its mineralogical structure but from the abundance of micaceous sands in a brook that ran from the direction, I supposed that its composition was micaceous sandstone or gneiss. These mountains are offshoots of, or are a part of, the Ebeemee Hills.

On returning down the Wilson Stream to Buker Mountain one of the highest hills in the northeastern part of Guilford, I determined to visit that elevation, and see what I could find there of interest in the boulder drift researches. This mountain is entirely composed of gneiss, and I should judge it to be about 1000 ft above the bed of Piscataquis, or Sebec Lake near the southwestern extremity of which it is situated. The slates in an open field near the eastern side of the hill, appeared to be a metamorphosis midway between clay slates and the gneiss. The top of the hill is flat, ridged here and there, and occasionally showing the polish and scratch. I observed the lunoid furrows in variety and great abundance. Boulders torn from the

top and the northern side, are scattered over the summit. The south side of the hill is very precipitous, and one could throw a stone from the brow down into the plain below. It was evident enough to me that the denudation of this mountain and that of the town of Bowerbank, as well as the characteristic form of that of the Elliotsville mountain, were not due to the agency of icebergs, or floe ice. The circular chain of hills by which they are surrounded, known by the name of Ebeemee Mountains, are very much higher, and afford no broad passes for the ingress of floating ice into the imagined submerged valley of the Piscataquis River. This chain of hills begins near the southeast extremity of Moosehead Lake, and running along to the northeast and the east, upon the northern border of the great azoic slate formation, form an arc of a circle, of more than 75 miles in length.

The general direction of the glacial groovings on the rocks was towards the south. The scratching agent had climbed three high Ebeemee Hills, some of which must be from 2000 to 3000 ft high. It is true indeed, that in some localities, I saw a deflection from a north-south trend of the glacial striae, which was printed more to the southeast; but then in the same neighborhood I found it running in the other direction.

Mr. Charles H. Hitchcock remarks in the report for 1860, p. 380, that he saw upon the "perpendicular face of a ledge" in the town of Abbot, adjoining Guilford on the west, indications of the presence of an ancient glacier. If a glacier existed in the town of Abbot, it must have been of the thickness sufficient to reach the tops of the mountains in the vicinity, for there was no valley for a limited glacier, nor a source of supply as with the alpine ice river. The course of the river from Guilford to its mouth is east; and though the town of Abbot, southeast. But all the glacial markings with few exceptions which I saw in the towns on both sides of the river, run north and south. It is evident from examination of the glacial striae, that there was no glacier confined to the Piscataquis Valley at any time, either at the beginning or close of the glacial period. For if there was none there at the close of the ice period, the presumption is legitimate that no local glacier existed there before the general movement of the mass occurred, which covered the entire surface of the state. The glacier of the Piscataquis Valley then, was a part of the Penobscot Valley glacier, and both were a part of the great glacier of Maine never having in either of the former cases, an individuality as an ice stream.

Beyond these towns in a direction northwest, the country does not favor the supposition of local glaciers till the White Mountains are approached, and what the evidence is among those hills of diverse ice streams, I know not. It strikes me however, with a good show of reason I think, that local glaciers could not exist there to any extent, because those mountains at the close of the ice period, were elevated but a few thousand feet above the country at their base, where snow must have lain in great depths at the same time that the summits of the mountains were hooded with it.

Chapter 11
Mount Katahdin

Boulder drift phenomena above Bangor—Glacial evidence not so decided as in the Piscataquis Valley and south of Bangor—Town of Molunkus and Golden Ridge and their boulders—Road to Mount Katahdin—Boulders of great size in Wassataquoik River—Course of Glacier south—Katahdin, its steepness—Remarks—*Southward* is the course of northern life—Botany of the mountain—Summit of Katahdin—Its great extent—Precipice on south side 3000 ft perpendicularly—Pamola, or highest peak of Katahdin—Immense quantities of boulders on the summit—The top of the mountain swept by the glacier—Height of the mountain—Vast extent of territory covered by the base of the mountain—*Pamola* an Indian deity—Legend of the Indians in regard to this—The place of winds and storms—Lake in the side of the mountain—Cascade Brook from this mountain pond—A Yosemite Valley—Katahdin surrounded by great lakes—Condensation of vapor therefrom, by the mountain—Thunder and lightning in consequence—Superstition of the Indians—The little flower of the mountain top—Reflections thereon—Influence of mountains upon the mind and body of man—Physical influence of mountains upon climates—Origin of mountains geologically considered—A splendid day upon the summit of Katahdin—View of forest and lakes below, and of distant mountains—A splendid sunset—Night scene—Impression on the mind.

As we leave Bangor and ascend the Penobscot River, the evidence of the presence of an ancient glacier is not of so decided a cast, as between that city and Moosehead Lake, or towards the southern coast. Above Bangor for about 10 miles, the aspect of the river banks corresponds to that below the city; and here and there upon both sides of the river as we drive along the road, glacial erosion is evidenced by the rocks. But after crossing the river at Old Town, we come at once upon the stratified clay deposits, rewashed from glacial deposits by the sea, in a subsequent period. The ledges are generally hidden by this material, except upon uplands, where they occasionally crop out. On turning off a few miles beyond Madawamkeag by taking the left hand Aroostook Road leading upward towards the north, we encounter all the way to Golden Ridge boulders and coarse drift material in abundance. In Molunkus and the Catholic town of Benedicta, south of Golden Ridge, I saw boulders that shined by their polished faces, that they had been dragged or pushed forward, in a manner as a laundress does her smoothing iron.

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The visitor to Katahdin turns off from the Aroostook Road at Golden Ridge, and passes through a forest 10 miles in extent to the east branch of the Penobscot River. Ten miles farther towards the northwest, the road to Katahdin divides into two paths, one leading directly west to the southern base of the mountain, and the other up the Wassataquoik Stream. A few miles from this division of the roads, we encountered the granite boulders in profusion. There was nothing in this saxetum that betokened littleness in nature's work. The chips of her workshop were magnificent. The bed of the stream was literally choked with them. Many of these rocks were from 10 to 15 ft high. I think these boulders came from the Traveler Mountains towards the north.

After crossing the Wassataquoik well up towards its source, and climbing Katahdin to the height of 2000 ft above its base, I saw upon its walls the marks of the great ice stream. The north side of this mountain is an enlarged representation of some of the granite hills of the state. Its descent in this direction is not easy like that of the clay-slate hills nor of many of the granite mountains, but is rough with precipitous steps, stossed and rounded like the north side of the hill at the right hand entrance to Carver's Harbor. Nor is this an anomaly in the contour of the northern face of our hills. Katahdin is a magnified type of form of the hills of Maine, and as a natural consequence we should expect its northern side to be more or less steep.

During the ascent I encountered large patches of the maple, beech, birch, with an occasional mountain ash or round wood (Sorbus americana) which grew a great tree. Firs and spruces of good size took root and thrived upon the mountain side. As the top was approached, the arboreal growth became more and more stinted, and finally merged into a belt of black spruce, called Abies nigra. This belt doubtless girdles the mountain at a height of about 4000 ft above the sea. The zone formed almost an impenetrable opposition to farther progress. Its height was from 1 to 15 ft or thereabouts. It was so scrubby, dense and interwoven that a dog could hardly have forced his way through without a bussy scratching of roots and dirt here and there. But the ax speedily, no *slowly*, opened up a way and ingress into the mysteries of bruinism and hibernation generally, according to that charming voyageur, Mr. Henry D. Thoreau.[1] I did not walk upon the tops of these black spruces as he did, but think had I fairly mounted hither at their highest part, that I could have slid down over them with more speed than comfort. Above this spruce growth is encountered the dwarf birch (Betula nana), only a few inches high. I should have liked to see how this brother of the huge canoe birch (Betula papyrifera) frequently 75 ft high and more than 3 ft in diameter would flourish up the low lands of the state. There are runts in our race, mere manikins, who look hale and hearty, and have as much tact and wisdom as men, aye, more caution and wit than Goliath manifested; and little dogs, mere microscopic brutes are now and then attached to the persons of ladies of the household of Dives, as canine jewels; and there are also miniature monkeys, and why not miniature trees? But this going aloft where the air is bracing and the sunshine more abundant, to be *dwarfed* is not according to my taste.

[1] "Maine Woods" p. 60 and 61.

Above this birchen habitat, I found the arctic willow (Salix repens, or Salix herbacea) from 1 to 2 in. high. These willows from the force of the terrific winds which sweep the summit of Katahdin, are twisted into forms beyond the humors of the imagination of man to conjure up. Here we see them wrung into the spiral whorls of a cork screw, and there woven into hollow balls resembling in form a child's willow rattle. Now we light upon a Lillipution basket half finished, the workman which we suppose was carried into heaven by a gust, or frozen to death ere he could finish the job. Here is a little fellow that started in life with a first rate ambition of being something, but one day the lovely branches that overshadowed its trunk, were by the commands of destiny suddenly gathered about the body, and strangulation was the result. Now we encounter an active little fellow in the side of life apparently, with his body gracefully bent towards the south, making obeisance to the sun or Paloma, doubtless with his branches twirled with a turn or two upon their own axis, and then shaken out nearly straight like the curls of a pet miss, or New York dandy.

Wandering along towards the south over the summit of Katahdin, the great flat-topped hill of the north, 4 or 5 miles in extent, we at length came to the table rock overlooking the precipice on the south side, or rather the southeast side, of 3000 perpendicular feet according to Mr. Hitchcock.[2] This level spot upon the level top of the mountain has an area it is supposed, of many 100 acres. From this platform we gradually rise toward the south over innumerable boulders towards Paloma the highest peak.

This ridge runs northeast and southwest, and is probably, 2 or 3 miles long. The table rock there, is the bottom of a valley with Paloma on the extreme south side, near the vertical wall. The ridge, or southeast valley side, is piled with boulders. It is the most singular feature of the mountain, the precipice excepted. I am of the opinion that those boulders are all transported rocks carried from distant parts of the mountain, and possibly from the distant north. There is no indication upon the floor of the ridge, that they have been quarried from it through the agency of frost. They are piled upon one another in the wildest confusion, so much so, that it is difficult to get over or around them. Some of these boulders would weigh more than a 100 t. The manner in which they are accumulated, excludes the supposition that they have been broken from the bed of the ridge on which they repose. There are millions upon millions of tons of these boulders in this locality. They are all angular but not more so than those about the southern sides of the hills of the state. If intense frosts just before or immediately after the crisis of the glacier age, quarried these boulders from the bed-rock on which they rest, would they not have been split up and disintegrated to a greater extent than they are, and have been carried farther down into the valley by the sliding of the snows and ice accumulating there?

Beyond this evidence the top of Katahdin does not show such marks of degradation as the hills of Maine of lesser heights. However, as we wander over the top, here and there we meet localities where the flow has been broken up and the debris removed. These inequalities are sometimes several feet deep. Around some of the peaks the

[2] Scientific Report for 1861, p. 398.

granite ruins are strewn in great profusion, the materials being usually small, but not disintegrated enough to constitute gravel. This is doubtless the work of frost. I think therefore the evidence is strong that the top of Katahdin has been swept by the glacier. If we suppose that this mass was about 4000 ft thick, as I conjectured it must have been, from the examination of the hills of Mount Desert, or 6000 ft as Prof. Agassiz supposed, a part of it must have gone directly over Katahdin. The top has not the general contour of the hills of the coast, but we must remember that it is more than twice the height of them, above its base, and that it covers nearly or quite as much territory as all the hills of Mount Desert.[3] Indeed it is difficult to find two hills in the country though composed of the same kind of rock, precisely alike in this respect. There is as much comparative difference as in the form and look of the faces of men.

The probability is that Katahdin ere the glacial age set in, was an immense *dome* of granite more or less flat on top and that it is in part a large part I imagine, a hill of denudation. For many thousands of years the glacier swept by it, plowing up the floor of the country, and denuding its sides, before it reached the top. Then the ice by its increasing thickness was pushed along over the summit, as in the case of the mountains of the coast, and the same arguments made use of to show that this was the condition of the Mount Desert Hills, in Chap. 5, hold equally good in regard to the top of Katahdin.

I have said that the highest part of this mountain is called Pamola. The Indians called this pinnacle by the name, supposing that a destroying deity resided there, and manifested his presence by clouds, rain, and sudden gusts of wind. They have a tradition that he once carried off a young and beautiful squaw, and now keeps her confined in his airy palace upon this point of the mountain, and that he manifests his anger at the approach of the red men by thunder, lightning and fierce gusts of wind. The great vertical wall of which I have spoken, forms the north side of a deep indentation much in the form of a horseshoe. In the bottom of this basin there are two or three lakelets, one of which is supposed to be very deep. Peter Covly, an indian doctor of the Penobscot tribe, assured me that the waters of the basin, were the best in the state, and icy cold in the summer. He observed that if he had money enough to build a hotel there, "I get rich very fast." But knowing his drunken habits, I thought it extremely doubtful. This basin is one of the lurking places of Eolus. Out of it the *cheeky* deity sends forth his winds which, according to the Rev. Marcus Keep of Aroostook County, the best cicerone of Katahdin, may be heard several miles.[4] This basin and pond, for I consider that originally there was but one, since obstructed by modern slides of great quantities of rock detached by rains and frosts from the

[3] Mr. Hitchcock calculates the height of Katahdin.

[4] "The basin is the birth-place of storms, and I have myself heard the roar of its winds for several miles. But on the 15th of October when I entered it, all was still as the home of nymphs, except when we ourselves spoke, when the thousand echoes were like the responses of spirits bidding us welcome. In this way a voice singing aloud, would find itself in the midst of a murmuring choir singing a round"—Bangor Democrat, Nov. 20, 1847.

sides of the mountain are about 3000 ft below the table land of the summit, and two above the base, or the bed of the Wassataquoik River. A large brook runs from the greater pond, and finds its way to this river, between the wall of the mountain and probably a spur of it. The water has a fall there, of 2000 ft in 6 or 8 miles, the length of the stream. It is a Yosemite upon a New England scale. The granite walls I should judge to be in some places, 1500 ft perpendicularly. This valley has a twilight cast at midday. Over its ledges the stream rushes in cascades; and in spring when the dell is flood, it must be a fearful place, aye, of joy too. If the swollen stream dashes by you, if the thunders of heaven roar, and the earthquake too, and winds rush madly along the land and sea, rejoice son of man, if thy eye is not a witness of human distress caused thereby. When the heavens are rent and the earth openeth her mouth, and the ocean in frenzy dasheth his waves upon the land, let *me* look upon this good work of nature. Over all I see her enthroned, her eye glowing with divine thought, with goodness like a crown encircling her brow. What if *I* should suffer by this display of her forces? A man is but a mote in the great empire of nature, which she heeds not to work out her great designs.

Katahdin is surrounded by a chain of lakes. It stands in the midst of great waters. About 200 lakes in all are said to be seen from its summit. It is a condenser in the summer season of the vast evaporation carried on from their surface. In calm weather it is often veiled in mists while the distant hills are unclouded. Sudden and severe thunder showers are the consequence of great diffusion of electricity in the atmosphere by this immoderate evaporation. A long narrow cloud perhaps, conceals Pamola or shows nothing of him but his head; *black*, let us suppose, like that of Satan. Other clouds luff up under the lea of this pavilion, and cast anchor. Anon a troop, or fleet, of small fry scud along and join their fortunes to the crowd. By and by out looks a red eye flashing with fire. That is Pamola's. Then his war whoop is heard upon the mountain's side, and the forest by the blast of the breath of his nostrils, is shaken.

An ignorant and superstitious people whose home was the dense forest of a mountain country, would naturally invest a locality like Katahdin, with such crude mythology, as the ancient classic nations invested their mountains and famous places with presiding deities. There is indeed a wide difference between the mind of the savage and that of the civilized man; but his fears and the hopes of mere human reason in both cases, are precisely of a character, in regard to this vital matter of religion. The deities of one were fierce and revengeful and unappeasable as a wild beast; of the other, of great thought and action, but generally contemptible in their interference in the affairs of mortals. A Yankee with a stick in one hand and a jack-knife in the other, would be likely to strike the balance of the moral value between the two mythologies, in favor of that of the Indian.

Upon this pinnacle of Pamola, I saw the Greenland Sandwort, a pretty little flower that appeared to be nearer heaven than any other life in the state! It grew in tufts about 3 in. high, with small numerous stems, crowned with white flowers. A charming life it lived on the very top of Katahdin, where it could catch the first sunbeams of the morning and the last at night, and gaze upon the stars while the flowers below in the forest, were obscured by mists and darkness. Thus the mountain top as well as the

field and the forest, is clothed with life. Nothing is overlooked and unadorned by the Great Presence. All things are perfect in his eye, in their never ceasing circle of change. Whatever man nay do to unman himself, and forget his sovereign duty to the world as its great national lord, nature can never unnature herself by the loss of a single opportunity to plant a life where it can grow and rejoice. Upon the mountain top or in the deep solitary forest, her hand is ever watchful over the vital form, though she may never tell us how or for what end. There her wild flowers spring forth, and shed their sweetness on the silent air, and she cares not whether a soft human hand gathers or not a single blossom from the wild garden. To her they are as sweet and beautiful as if they grew in the conservatory of a queen.

From the earliest historical ages, and we may not doubt that from the period of his introduction upon the globe, the aspect of mountains has always claimed profound attention from man. This reverence for the magnitude in form, springs from his organization in relation to the globe which he inhabits. The principle compels him to take cognizance of the extraordinary forms of nature, whether it be the restless ocean, the boundless forest, the barren desert, the mighty river, the never silent cataract, or the lofty hill whose summit soars into the clouds of heaven. But the mountain is the most sky-grasping thing upon the earth. Full of awful grandeur and sublime silence beyond the power of human comprehension, the high hills are gazing forever into the mysterious depths of space. Monuments erected by nature, cloudy palaces of unknown beings, temples of the sky whose priests and vestals, and worshippers, are invisible to mortal men, these high places of the earth never cease to enchant the human eye.

From that perpetual sense of weakness and instability which everywhere attends him, man has in all ages, made them towers of refuge, and dwelling places of thought where the Great Presence ever exists. Nor can we climb their steep and rugged sides, and place his feet upon their cloud-reaching pinnacle without an overwhelming conviction of his own apparent insignificance in the creation. This thought is not born of the earth where his foot firmly treads, but of the sky; and its greatness overshadows him like a garment. It is upon the mountain top, the home of the thunder and the tempest, where the pavilion of clouds is set up, where man may talk face to face with angels, and the grosser senses of life may be transfigured. No, nature does not say to man "get thee down, my child; I know thee not here".[5] Rather she ever cries "get thee up into the high mountains! There I will commune with thee, and as I pass by, I will show myself to thee as thou liest in the cleft of the rock."

It is only by the familiar contemplation of mountains, that their sublime beauty is unfolded to the eye. No single glance takes in their multitudinious graces and aspects. As we thus behold them, the apparent asymmetry and rude boldness of their forms are softened and blended into beauty and strength. Nothing is then beheld crude and rude. This harmony of proportion and loftiness of air fascinate the human mind. Thus they have inspired the sublimest thoughts of the poet, and the most beautiful conceptions of the painter's soul. Barren indeed would have been the genius of ancient Greece,

[5] Thoreau's "Maine Woods", p. 64.

had there not soared from the plains into the clouds her grand old mountains. Ossa, Pelion and Olympus; and Parnassus and Helicon the home of the muses and that sacred fountain whose waters inspired all who drank them. Glorious is the memory of the mountains of the patriarchs and prophets, and of the Just One. To these lonely places of nature, to these altars of the sky, did those gifted minds often retire from the haunts of men to have holier communion with the ideal world. They took from the hills and the ever ranging aspect of the scenes around them, the glowing conceptions of their noble souls, which have in all ages since, charmed mankind and exerted wonderful influence in shaping the destinies of individual men and of nations.

And the home of the hills have always produced the finest specimens of the human form and mind Our nature gathers symmetry, and beauty, strength and nobleness from constant communion with these mighty works of the creator. The man of the rugged hills becomes in bearing calm, and heroic and impregnable. No vain excitement moves him. Manhood, freedom, and religion, alone stir up his soul and bring forth its sublime strength. This high development of mind has more vigorously flourished among the mountainous portions of the earth, and has longer withstood opposition, than upon the plains however vast or rich they may have been. In Judea, Greece and Italy; among the Alps; in Scotland and New England, there have been some noble men of nature, sturdy soldiers of a spiritual warfare, all conquering heroes in the varied battles of life. Thus it becomes a great nation to spring from men of the hills, who have breathed the mountain air, and braved the rigor of the mountain snows. Vastly different indeed would have been the destiny of the nations of the earth, had there existed no mountains as we now find them distributed over the face of the earth, nay, we can even more than conjecture that if they were depressed to the common level of the surface of the globe, man would become extinct. There can not be a doubt but that the present arrangement of the earth's features, was expressly devised for the advent of man, and that therefore, he was physically and mentally organized for the order of things around him.

Mountains vary the temperature of the atmosphere, and arrest and condense the evaporation of distant lakes and seas, producing rain and thus diffusing over the countries around them forests and animal life; and giving far distant plains perpetual and overflowing streams. The great mountains border the broad plains, and bound the margin of the deeper seas; and their heights are proportionable to the breadth and depth of these. If the mountains of any continent should be elevated or depressed, its maritime cities corresponding to this movement, would recede from the sea, or be engulfed by its waters. It is the mountains that chiefly originate the climate of a country, and the direction of their trend has controlled the destiny of many nations, both of men and brutes.

But it is not the intervention alone of the lofty hills between the human eye and the distant horizon beyond which inspires us with the profoundest regard for them. The question of their remote origin, and of the innumerable changes in the earth's surface which they have witnessed, forever forces itself upon the mind. The traditions of nations are of no consequence connected with the origin of mountains. Only a very few of such elevations, comparatively have appeared or disappeared, upon or from the face of the earth since the commencement of the human period. It has been

reserved for our age to explore the story records of the past, and to read aright the history of the birth and growth of the mountains of the globe. They had their origin in ages when the earth's surface was totally different from its present aspect. There are very few *modern* mountains upon the globe, and the birth and growth of these were completed millions of years ago, excepting those of volcanic origin.

As it regards the origin of Katahdin and the mountains of Maine, we must it is evident enough, run back for it into the remote ages. The constituents of its forms we can hardly doubt, were deposited in the sea as sands and clays, from a crust possibly, vastly older than the Silurian times. In process of the ages, this deposit became transformed while chiefly under the sea perhaps, and was gradually folded or ridged into the form of a hill. As early at least as the great cool period, it became dry land. The opinion of some eminent men is however, that it was out of water before the commencement of the Carboniferous age; but my convictions are however that the denudation of the country has been so great, that we have no data from which to form a correct judgement in the matter of the mountains age. I may say however, that I believe the farther we get from the equator, the older we find the mountains, at least a large part of them.

The day that I passed upon the summit of Katahdin, was so beautifully clear and calm, that the many waters by which the mountain is surrounded, lay apparently at my feet, and seemed as I gazed upon them, fragments of a gigantic mirror wildly scattered over the grass of a field, and reflecting the full blaze of the sun.[6] No winds ruffled the face of these lovely and spacious lakes. They reposed in their sublime solitude glowing under the brilliant light of a cloudless meridian sun. The immense and unbroken forest around me, appeared in the distance below like fields of grass. The tallest trees of the forest, the mighty pines that had braved the blasts of a thousand winters upon the borders of the wild stream or lake, were as indistinguishable as the smallest trees in the vicinity. The glowing sunlight without a cloud to soften the vision and shadow the earth, rested upon the landscape and the mountain top, like the presence of an angel. Silently and joyfully I gazed upon the wondrous scene. Hour after hour I wandered over the summit, everywhere feasting upon the beauties and glories around me. The distant hills at the north that I had gazed on when a boy, the White Hills upon the west, the innumerable lofty forms on every side standing out in their glory and strength, the great lakes spread out like molten silver, all formed a picture of transcendent beauty. The display of the setting sun and the approach of night, were also on the most magnificent scale. As the king of day approached the horizon, clouds like royal guards gathered around his chariot. The sheen of their purple and gold filled the sky. Nature as if still desirous that mortals should behold the monarch's face, parked the clouds that the royal presence might gaze again upon his empire of earth. A mellow glow of light like the faint flickering of a thousand tapers, shot up into the blue of the sky and gradually faded away. But soon a few stars like brilliant points, appeared in the east; and anon troop after troop was poured in upon the vast concave of night.

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[6] Mr. Thoreau quotes this similitude of mine, from an article upon Katahdin written years ago. Vide "Maine Woods," p. 66.

I had watched the landscape below with intense interest. I saw lake after lake gradually loosing the glow of its face. A dimness interspersed with gray streaks of light yet lingered upon hill top, gradually settled down upon the forest, and at last all was invested with darkness. The transcendent panorama of forest, lake and hill, had now passed away, and I was left alone with the hosts of heaven. There now came over the mind the conviction, and overwhelmed it with its power, that I was occupying a position seldom accorded to man, to be elevated in the solitude of the night, above the scenes of earth, to the home of the clouds, far away from the habitations of men, in a vast forest, where human footsteps seldom intrude, upon the summit of one of the oldest mountains of the globe.

The glory and grandeur of this display of the day and night, can not fully be described by tongue or pen. All that is of man, the grosser life and the wearing spirit, was captivated and transported to the realms of thought. Nor think that these pictures can fade away from the soul and be lost. No! she keepeth them in her most secret chamber to be conned over and looked at, when the grosser things of life shall have passed away forever.

Chapter 12
The Inescapable Conclusion—A Large Glacier

Glacial action west of the Kennebec—Transformation of the slates into granitoid rocks—The lake states essentially those of great boulder denudations—The principle applied to other continents—Africa and Australia in their pre-glacial age—The true negro of those countries, the modern counterpart of the pre-historic races—Conclusions as to the cause of the general denudation of the surface rocks of the state—Truth as a revelation to man in physical things—Little by little it dawns upon the mind—Obtaining it second handed—Now the truth of the former presence of a great glacier in the country grew upon the mind.

Let us now see what evidence there is of ancient glacial action to the west of the regions I have examined. If one should consult a good map of Maine, he would see that if a line be drawn obliquely across the state in a northwest and southeast direction from Castine to the great bend of the Kennebec river at Skowhegan, and thence towards the border of Maine in latitude about 45.5°, on the right hand of this line including all the islands of the Penobscot Bay and to the east of it, the trend of the terragraphic and hydrographic features is more or less parallel to this line, but upon the left hand, these characteristics of the country are at right angles to this line, some of the rivers excepted. The former phenomena is continued into New Brunswick from Passamaquoddy Bay to the great bend of the St. John between Woodstock and Fredericton. Beyond this line in New Brunswick and Nova Scotia, this peculiar aspect of the land and water of the coast and the interior, has a trend similar to that in the western part of Maine. The Bay of Fundy is probably a Precambrian fault or valley widened by glacial denudation. All the various fossiliferous formations from the Laurentian upwards in New Brunswick, are laid down in old flexures conformable more or less to the strike of the Atlantic coast. But this process of plication or folding of the earth's crust, or the deposits, has never ceased at any time. The slates of Maine which are very old and probably pre-Silurian, have all partaken of this movement, whatever its cause, whether deepening of the Atlantic bed and consequent folding of the land, or due to chemical action slowly going on in the deposited materials. In the southwestern part of the state, the metamorphism of the slates and shales has been of a different cast to that of other sections. The transformation has resulted in granitoid gneiss of imperfect cleavage planes. But having a dip and strike like the slates generally. Large masses of slates and shales are often seen in Casco Bay

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enclosed in this granite both having the same dip and strike. The granites as they are called, of Penobscot Bay and vicinity, as far as I have observed are not tilted, but lay as I have heretofore observed, in horizontal beds. Those of Vinalhaven are surrounded by metamorphic slates on the northwest, which *apparently* have not had their original strata disturbed, so far as a general position is concerned, but have been subjected to singular local plications notwithstanding. In the northeastern part of the town, there is a patch of slates about three miles long, and averaging half a mile wide. On the east these slates are tilted in the usual direction, but at the other extreme they are more or less horizontal; and the granite which impinges upon them from the south is tilted or horizontal as they are. Upon a comparison of these crystalline beds about the Saco and Penobscot Bays, it would be interesting to know whether the syenites of the latter locality are derived from slates of the same age as the other, and of a corresponding dip. In both these cases we must utterly ignore the idea of these rocks being plutonic or igneous in character. The evidence is *direct* in both cases, that they are altered rocks. Furthermore, the slates of Lincoln, Sagadahoc and Cumberland counties are chloritic to some extent, and may yet show indication of containing some of the more precious metals.

It is the result of the dip and I think of the crystalline rocks of some of the southwestern counties, to which is due the trend of the lakes, harbors, coves, and islands. The ice movement over these rocks was to a disadvantage; it worked *across the grain*, and thus left the country ridged in a direction nearly southwest and northeast. This phenomena is not however exhibited in the form of the hills.

We see that the lake states are essentially those above the parallel of 40°; and that the farther we advance towards the north, the more abundant these basins become. Pennsylvania though more mountainous than New York, is very deficient in lakes; it has none of a notable size. The lakes of New York are gouged out of formations lying in horizontal planes. Connecticut has fewer lakes than Massachusetts, and the latter than Vermont and New Hampshire. The relative size of each state considered, Maine has more than all the New England states. South of this latitude, lakes are strangely absent. This kind of observation may be extended over other countries. Wherever we see an extensive lake region, we may be sure that it has been a glacial country. The tropics show no abundant lakes, nor glacial fiords; neither do Africa and Australia. These continents and comparatively riverless countries, and more left out in the *heat*, instead of the *cold*. The former, and perhaps the latter had a few local glaciers, but none that descended into the sea. They are now in their pre-glacial age in that condition I imagine, in which North America was during the Pliocene epoch. The lakes of Africa are large, like the great ones of North America, but are few in number, and are miasmatic. Her surface is barren and sandy, with broad alluvial valleys along the rivers, which run largely through a lazy country. She is higher in the scale of progress of continents than Australia, and vastly lower than Asia, notwithstanding she had a civilization of unknown antiquity.

The real negroes of these desert continents are the modern counterparts of our prehistoric races of older continents. The question of "one blood," for Africa and Australia in common with the white man, that is of no import to me. If the black man has genius in the germ lying dormant among the debris of human nature, please

gentlemen, let it be evolved and blossom. The great Swedish seer gives us to understand that his incubus of American politics *has* a soul, and a very respectable spark of immortality too, it is. That authority is high in the United States of America with a certain class of very intelligent and blameless people. The wise man says "*the Africans are most beloved (by the angels,) for they receive the goods and truths of heaven more easily than others*"[1] I am thankful that I never was an African slaveholder. The idea that my bond man should supplant me in the affections of celestial beings, would make me wretched, even in paradise.

Let us now take a retrospect of that which we have seen of the boulder phenomena in Maine. The islands of Penobscot Bay, the mountains of Camden and Mount Desert, the northern towns of Piscataquis county, the region of Katahdin, and the country southwest of the capital of the state, have been in most instances minutely examined. In these explorations nearly, 10,000 square miles of the surface of the state of Maine have been scrutinized. Every locality has given its testimony.

We have seen everywhere, the rocky floor of the country broken up, and its crystalline rocks embossed and ridged in long parallel lines generally in the same trend as the hills. The entire floor of the state has been transformed. The border of the coast has been remolded and rendered accessible to ships. Many hills have been created in the overthrow of the old order of things, and some have doubtless been uprooted and obliterated. The tops of the highest existing mountains of the country have been reached, stormed and shattered in a manner as man could render; and the ruins have been scattered along the path of the destroyer. This widespread agent has traveled in one general direction. Its footsteps are yet visible on the tops of the hills, along their sides, about their southern bases, and in the deepest valleys. Now what are the legitimate conclusions to be drawn from these phenomena? Most assuredly they manifest the presence in remote times, of a glacier of extraordinary magnitude. All other causes were incompetent to the work, a labor dictated by consummate wisdom and executed by a wonder-working hand, that a country should be prepared as a home for a race that should be great thinkers and doers of every good and perfect work.

After studying the boulder phenomena of the great fiord of southern Maine for a couple of years, I stood one day upon the top of one of the hills in the region surveying the prospect around me. The mighty facts of drift erosion everywhere uncovered their faces and looked boldly upon me. Little by little the great truth shone upon my mind, as we see in a landscape when the mists are lifted from the face of the earth, and the unclouded sunlight is poured upon it, till at last I saw clearly as did Saul of Tarsus when the scales had dropped from his eyes. I closed my notebook complacently perhaps, as a preacher with a good will shuts his bible after a "sound" discourse, and said to myself this riddle of the boulder drift is solved now and forever in my mind, the fossil ichnolites which I have witnessed are surely the footprints of a glacier, one that overrode all prospect of land and water around and capped the highest hills.

[1] "Heaven and Hell" by Emanuel Swedenborg.

In our moments of calm reflection, truth appears to us like a living thing, wandering about in the universe forever seeking some soul into whose sensorium it can cast forth its light. A divine aroma attends its presence. Sometimes we feel it in weakness, or are impressed and hear her celestial voice in our strength; and paradventure the indistinct form passes before our mental eye, though we cannot say what is the nature thereof. Truth looks through us, and sees as past, present, and to come; knocks softly but audibly at the door of our souls to enter. She will not go in without bidding this mannerly truth. Amiable and wise, she waits to be invited. If she enter and find the house swept and garnished, she abides in peace and joy. She then purges the mental vision and we perceive who is for us, as the eyes of Elisha's servant saw the friendly hosts of men and the chariots of fire. It appears to me that the coming of great men, aye, and bad ones too, all eras, inventions and discoveries that bless mankind, the rise and decline of empires, are controlled by some psychological law, the finger of truth eroding all things. When the condition of man becomes compatible with further knowledge, he will without doubt, receive it.

Thus was unfolded my comprehension of the glacial phenomena so abundant and unnoticed for years around me. I saw without seeing. That was in more than one sense, *stone* blindness. Good it is to see aright, and to catch the first beams of the sun ourselves. But not to all is it so given. We have generally to see second handed, a method infinitely better than blindness. The words which we thus get through other men's eyes, sometimes fall upon our ears with wonderful acuteness. Every word chimes most sweetly there in nature's private cathedral. It is the essence of music that we hear there. The words that are so lightly spoken, sit upon our hearts "like apples of gold in pictures of silver."

I may say that from the time my attention was called directly to the glacial phenomena of Maine by the publication of Mr. Miller's book, they haunted me day and night, like a ghost. Dark was the vision and doubtful oftentimes. Now it took a shape ill-defined and obscure, as the land through the fog of a summer's day; and perhaps on the morrow a gleam of pure sunlight occasionally streamed through the perplexing mist. Or I might liken my comprehension of the matter to the unfolding of the germ of an insect, first it went forth groveling along the ground seeking food hither and thither, often in doubt and weakness; then in silence committed to the cell of repose, that it might undergo there by nature's gracious keeping, a greater change; but at last it began to awaken to a newer and higher existence, to breath a celestial life, to take wings and soar aloft over all the land, the psyche of a nobler, a divine life.

Chapter 13
Evidence From All Over North America

Some of the prominent localities of glacial striae in Maine—On the islands of the Penobscot Bay, and to the east of them; in Rockland, Camden, Lincolnville, Bucksport, Orrington, Belmont, Liberty; in the towns between Penobscot and Piscataquis rivers, and the Kennebec; In the towns between Augusta & Portland—Great boulders in Massachusetts and Vermont—Boulders in New York and the western states—No evidence of the former presence of a general glacier overriding the Rocky Mountains—The distance west along the Missouri Valley which the glacier reached—Its extension south in the western and Atlantic states—Glacial action in Canada, the lower provinces, Labrador and the region beyond to the northwest.

Beginning at the localities where I first observed the glacial scratchings, I would enumerate some of the more prominent places which I have examined in different sections of the state, exclusive of those already mentioned. There is a very marked result of glacial denudation about the Thoroughfare of Deer Island; and the same thing is witnessed in a prominent degree upon the islands to the east, and also upon those lying south towards Isle au Haut; and likewise in many places upon Swan's Island, particularly about the eastern side of Old Harbor. In Rockland the glacial groovings are found along the shore rocks; in Camden on the southeast shore and about the harbor; at Duck Harbor, Lincolnville, on the north side of the stream, near the road; in Northport at Saturday Cove; in North Bucksport on the middle road to Orrington; in Belmont just before arriving at the Corner; in Liberty village, and upon a hill overlooking it. The hill has been broken down on the south side. Perhaps as a field for these phenomena as any, is a route from Foxcroft to Norridgewock, and west into the southern part of Franklin County. In Winthrop, Monmouth, Wales and Brunswick I saw on the naked rocks by the wayside the scratches running north and south. In the turns in the vicinity of Portland, the glacial striation is in the same general direction. Just west of the lower covered bridge at the mouth of the Presumpscot River, where the soil has been removed for the erection of the Canal Dam, the polishing, scratching, lunoid furrows, and breaking down of the southern termini of ledges, are plainly visible. It is seen at a glance that this result must have been caused by a glacier, as the denuding agent had descended the hill towards the north, the descent amounting in the course of half a mile, to a 100 ft, and had crossed

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the river nearly at right angles to its course. The striation of the rocks is seen by the roadside between this place and Grave's Hill, halfway to Tewkey's Bridge.

There is a singular example of polished ledge a mile up the Presumpscot River, by the roadside, immediately in front of the woodhouse of Captain Leonard Merrill. The formation in the vicinity is granite, a metamorphosis of the common slates. The trend of the ledges is towards the southwest, or nearly, as I have previously observed. The end of the ledge under consideration, is broken with a dip of 70° or more, showing a face above ground 3 or 4 ft long, and 1 ft and a half wide in the broadest part. This wall looks towards the *south-southwest*. As it did not exactly stand facing the south, but having its right hand border retreating somewhat toward the northwest, the glacier could evidently crowd its ice mingled with gravel and sand, along the face of the wall towards the east-southeast, in which direction the striae run horizontally along the face of the ledge.

Along the section of the Grand Trunk a little way from the depot in Portland, wherever the boulder materials have been removed, the polishing and scratching are admirably seen on the chloritic slates. In fact the entire face of the bedrock of Munjoy Hill, and no doubt the vast floor on which the whole city is built, is smoothed, scored and scratched in one direction. It would be a sight to delight the eyes of many a geologist, if a glimpse of this denuded plain could be obtained. I will add for the repose of the scruples of the citizens, not at all at the expense of their physical comfort. There might be for all I know to the contrary, such a phenomena as the lifting of the city, boulders, dirt and houses, men, women and children, sundry merchandise, horses, and chariots, cats, dogs and vermin, bodily up into the air, as tables, pianos,and fiddles are exalted in the circles of the spiritualists, all things clearly and cleanly spirited aloft so that the glowing sunshine might flow in between them, till gentlemen who had symptoms of this unique species of *scratches*, which I have been describing, might look on the nude rocks and be *healed*. I bethink me that a troublesome general excitement and much personal solicitude might be engendered by this display of celestial acrobatics, which would not probably be compensated by a view of the polished and striated surface of the rock on which the Forest City is built; but it would be interesting to know if this ballooning of a city *could* be done.

In the cove immediately east of the ferry at Cape Elizabeth, the rock scratchings occur on the upturned slates. On Bangs (or Cushing's) Island at the baths, they may be seen climbing the rocks at the south side of the cove. From this place towards the northeast head, the peculiar cut-off profile of the ledges shows the former presence of a glacier, though the striation thereby produced, is nearly altogether absent. On House Island on which Fort Scammon stands, this rounding of the ledges and scratching of the surfaces are finely exhibited. All the islands of Casco Bay doubtless furnish the glacial scratch and polish abundantly.

But it is not necessary to travel to any part of Maine particularly to find this phenomena displayed in an unusual degree. Every acre of the surface of the state has been subjected to this strange erosion. We do not indeed find the surface everywhere smoothed and striated, because time has wrought some changes upon it here and there, where the detrital material has been removed. We can readily perceive by the general appearance of the rock, whether level or not, that it was once smoothed

down. Wherever the glacier touched the rocky bottom of the country it most assuredly polished it thoroughly.

And what has been said of these wonderful phenomena connected with the boulder deposits of Maine, maybe seen in many other states of the Union. In the White and Green Mountains, the same peculiarities are witnessed, of abrupt fronts of the hills facing the south, while their northern sides exhibit grades of easier descent. The highest mountains in the southern part of Pennsylvania it is said, reveal the presence of ancient glacial denudation; and it may have reached the extreme end of the Appalachian chain. The loose surface materials are similar in quality throughout the New England states. Transported boulders are seen often of magnificent proportions. The late Dr. Edward Hitchcock mentioned one in Bradford, Massachusetts, whose weight is 2250 t, which if granite in the form of a cube, would have a height of more than 30 ft. If during the future there should be a boulder mania, and some society, or geological Barnum should undertake the removal of such a giant by horsepower, a big crowd of spectators would be likely to be congregated about the rock. I would not object to being merely for the pleasure of witnessing the bahelic confusion of lingo, and the unique but natural gesticulations of those most interested in the operation of removal. There is no situation in which man shows off so strikingly as in a multitude where everyone has an opinion of his own, and lets it freely explode.

In the town of Sandwich, Cape Cod, there are many large erratic boulders some of which are estimated to weigh 700 t a piece. Not far from Fall River city, I saw a wonderful conglomerate boulder which I suppose came from an old Silurian shore in Roxbury, more than 40 miles distant towards the north. Dr. Hitchcock estimated its weight to be about 5000 t. If that were to be transported like the Bradford erratic, it ought to draw a *bigger* crowed I imagine. In South Danvers near the town line, there is a large boulder called the "Phaeton Rock" lying balanced upon the brow of a hill over which it hangs, resting upon four small boulders a foot or more in diameter. One of the great columns of Sais, Egypt, weighing but about 700 t, was three years according to Heroditus, in the process of transportation a 100 miles, though 2000 men were engaged upon the work. The largest column in the world is that of Peter the Great at St. Petersberg. It weighs 1500 t, and was moved 15 miles upon cannon balls rolling on a tramway. But nature with her inorganic forces, in which there was no mind at work but that of her own, marshaled upon the surface of the earth, silent and patient workmen born of the rain of heaven and the frost of winter, quarried those gigantic rocks from their native beds, and transported them without ado and rest, to their present localities.

In New Hampshire and Vermont boulders are also very numerous and of great magnitude. The striae in those states are more or less conformable with those of Maine and Massachusetts. In the State of New York, glacial action was also of an intense character. Boulders are everywhere scattered over that country especially in the northern part, among the Adirondack Mountains. Michigan as a glacier swept the state is similar to New York. In other western states, though the surfaces do not show the glacial striation as in the east, owing to the less tenacity of the rock, there is no doubt but that the glacier reached a very great breadth there. I think that the Missouri River at least, must be put down as the western boundary of the glacier, and that its

reach south was as far as the mouth of the Ohio River. Its western border was shoal in altitude and proportionably weak in action compared with the thickness of the ice cap and its denudation in the east, though its mean annual motion may have been greater there than here. It is certain however, that the Bad Lands on the White Earth River in longitude about 25° from Washington, escaped the reach of the glacier, otherwise the fossil mammals of the Tertiary age found there, along with the columnar rocks towering from 50 to 100 ft high, resembling in the distance the ruined cities and temples of ancient Egypt, would have been swept away and ground to gravel, sand, and clay. If then Nebraska escaped denudation by the glacier the country beyond was not subject to its influence. It is also certain that glacial action has not swept the tops of the North American Andes. Those pinnacles are *saw-toothed*, pointed and covered with snow, and hence their Spanish name "Sierra Nevada." Prof. James D. Whitney says here is "abundant evidence of the former existence of extensive glaciers in the Sierra Nevada" that is, ancient *alpine* glaciers, no doubt contemporaneous with the great glacier under consideration. The remarks in the same paper, that there is no evidence of glacial action along the coast of Russian America, now United States Territory. If the statement is correct, it is a very singular fact, for ancient glacial action on that coast, comparing the present climate there with the isothermal line on the Atlantic border, ought to have preceded as far south as 55°, at least.

According to Dr. John Locke in his Geological Survey of Ohio, the phenomena of rock smoothing and scratching, are found as far south as Dayton, about 50 miles north of Cincinnati. D.C.A. White, one of the Geologists of Iowa, describes glacial action on the southwestern part of that State; and remarks that boulders with glacial scratches upon them, are seen in different parts of Iowa.[1] Prof. Dana speaks of boulders 6 ft in diameter seen in Missouri below St. Louis, whose origin must have been 300 miles north.[2] and Prof E. Andrews of the Chicago Medical College, shows us that the material of glacial drift, occurs abundantly in the northern part of Illinois.[3] But Prof. Whitney in one of his reports, says that the southern part of Wisconsin for 300 square miles, is destitute of boulder drift, and infers I presume, that the section was not subject to the presence of the glacier. If the southern part of Ohio exhibits not only drifted materials often of considerable magnitude, but also glacial striation upon rocks *in situ*; and the state of Missouri as far down as St. Louis, shows the presence of boulders which could not have been transported by ice floes, because *that* part of our continent was not submerged, the supposition can not be credited that the glacier left untouched any part of the State of Wisconsin. This supposition would involve the existence of a deep bay of dry land in the glacial age, with an ice border on the east near the city of Cincinnati, let us suppose and the other not far from St. Louis on the west, 200 miles apart, and running north more then 200 miles to the

[1] Silliman's Journal for May 1867, p. 301 and for July, same year, p 23; also "American Naturalist" for February 1869, p 644.

[2] "Manual of Geology", p. 752.

[3] Silliman's Journal for May 1867, p. 75.

southern part of Wisconsin, leaving the States of Indiana and Illinois comparatively unscathed.

Along the Atlantic coast, glacial action may be set down as touching the hill country of New Jersey, Maryland and Virginia, and running along the elevated valleys of the Alleghenies as far south as has already been suggested. It embraced all Long Island, and the islands to the east of it. The detrital silt was washed by the pollen, or rather glacial current, because here was no polar stream flowing down the North American coast as at present, and was deposited in the sea to the south. In a subsequent age while the country was submerged, this marine material became rewashed and distributed over the southern states.

If we enquire what is the evidence of glacial action on the north and northeast of the United States, we find as reported by the geologists of the British Provinces, that it is of the most marked character, and similar in its various phenomena to that found in New England. Every hill in New Brunswick and Nova Scotia, and Newfoundland has been swept by the glacier. In a word, British America is a hydrographic country, due to glacial action which has been from the north to south. Prof. Silliman of Yale College, has reported his personal observations on glacial action in Nova Scotia.[4] Prof. L. W. Bailey of New Brunswick, in his report on the geology of that province, supports the theory of glacial action to account for the drifts in that region; and the same view is radically taken by Prof. Henry Hind in his "Preliminary Report" on geology there. That pleasant mannered and talented gentleman, Sir William E. Logan, chief of the Canadian Geological Survey, is of the same opinion with regard to the denudation of the surface of Canada. According to Prof. Hind the interior of Labrador is a theater of ancient glacial action upon a stupendous scale.[5] Dr. Packard's testimony is to the same effect.[6] The formation of Labrador is a granitoid rock, and vegetation being scanty, an excellent opportunity is afforded during summer, for glacial research. Both gentlemen remark that boulders are infrequent along the maritime coast, till a height is obtained of six hundred or a thousand feet above the sea. Dr. Packard thinks the erratic rocks have been swept away by floating ice, and in some instances, have been gathered into sea beaches.

In the region west of Labrador, and that lying between Hudson's Bay and the great Slave Lake, there is the same unmistakeable glacier denudation of a former age. This northern country is a low lying land with here and there a mountain, and possesses innumerable lakes and majestic rivers. Upon its boundless plains the snow rests for 8 months in the year, and is of enormous depth. In winter all is desolation. The winds sweep over the plains and frozen lakes in horrible tempests; and in the coldest weather the mercury of the thermometer sinks 45 or 50° below zero. Beyond this region towards the north we pass immediately into the country of perpetual snow and ice, and the region of glaciers. A distance less than that which separates the civilization of St. Paul in Minnesota, from the contented Scotch at Fort York

[4] Silliman's Journal for May 1864, p 417.

[5] "Explorations of the Interior of Labrador."

[6] "Observations on the Glacial Phenomena of Labrador and Maine."

in the southwestern border of the great internal bay of the continent, brings one to the coldest spots in North America, where the thermometer shows a temperature ranging from 70 to 80° below zero. There a cold exists which once came down upon New England and transformed her Tertiary hills, rivers and scattered lakes, into a boundless plain of ice.

Chapter 14
Boulder Drift Theories

Sir Charles Lyell's hypothesis—Supposed action of drift ice on the sandstones of the shore at Cape Blomidon, Nova Scotia—Miller's elucidation of the iceberg theory—The polished and scratched rocks of Maine, not referable to the action of icebergs—The bergs carried forward by the polar current flowing beneath the Gulf Stream—They are not deflected from their common course by counter currents—Icebergs could not scratch the east and west sides of hills, and by no means the base at the south sides—They could not scratch an uphill sea bottom—Example on the Gloucester and Salem Turnpike, Massachusetts—A similar one at "Castle Rock", Nahant—Iceberg theory inadequate to explain the denudation of the floor rock of New England—The supposition that the boulder country was a submerged region, implies a northern ocean free of icebergs—The boulder drift of the western states without marine fossils—The boulder country a dry land region, and greatly more elevated than at present, during the glacial age.

I shall now examine the various theories which have been at different times popular with geologists and geological readers, as explanatory of the origin of the boulder materials and the scratched surfaces of the floor rock on which they repose. The oldest hypothesis is that of iceberg action first proposed by Sir Charles Lyell, I believe, an eminent living writer upon the facts of geological science. He supposed that at the close of the Tertiary period the continent of North America where the drift prevails assumed a movement of subsidence, and became sufficiently submerged to permit the passage over it of icebergs precisely similar to their transit at the present time, over the sea bottom of Baffin's Bay, Davis Strait, Grand Banks of Newfoundland, and other places; that these icebergs carried forward by the arctic current towards the tropics as now, chafed over the marine floor, and being armed with innumerable rocks great and small fastened into their submerged surfaces, with these they rounded, smoothed, scratched and grooved the bottom of the sea; that the rubbish of this friction in connection with the dirt and rocks with which the ice masses were loaded, and which were discharged by the slow or rapid disintegration of the bergs as they came in contact with air and water warmer than their own composition, constituted the material which, in after times when it became dry land, we know denominate the boulder drift.

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Mr. Miller tells us in his "Popular Geology" that he was working out the same theory while Sir Charles Lyell was maturing his views, although independent of the Englishman; but in this country Lyell has the merit of the origination of the theory. Sir Charles seems to have fortified his previous views of the agency of icebergs in the production of the boulder drift, by a phenomena which he observed at Cape Blomidon, at the right hand entrance into the Basin of Minas, the northeastern extreme of the Bay of Fundy. He tells us that as he "was strolling along the beach at the base of a line of basaltic cliffs which rise over ledges of soft sandstone I stopped short at the sight of an unexpected phenomenon. The solitary inhabitant of a desert island could scarcely have been more startled by a human foot print in the sand than I was on beholding some recent furrows on a ledge of sandstone under my feet, the exact counterpart of those grooves of ancient date which I have attributed to glacier action. On a recently formed ledge I saw several strait furrows half an inch broad, some of them very nearly parallel others slightly divergent; and after walking about a quarter of a mile I found another set of similar forms having the same general direction within about five degrees; and I made up my mind that if these grooves could be referred to the modern instrumentality of ice, it would throw no small doubt on the glacial hypothesis. When I asked my guide, a peasant of the neighborhood, whether he had seen much ice upon the spot where he stood, he replied that in the preceding winter he had seen the ice in spite of the tide which ran at the rate of ten miles an hour, extending in one uninterrupted mass from the shore where we stood, to the opposite coast of Parrsboro, and that the ice blocks heaped on each other and frozen together or packed at the foot of Cape Blomidon, were often fifteen feet thick, and were pushed along when the tide rose, over the sandstone ledges. He also stated that fragments of the black stone which fell from the cliff, a pile of which lay at its base, were often frozen into the ice and moved along with it. And I have no doubt but the hardness of these groovers firmly fixed in masses of ice, which only fifteen feet thick, are often of considerable horizontal extent, has furnished sufficient pressure and mechanical power to groove the ledges of the soft sandstone."[1]

It is a curious fact and suggestive of those eras of innovated opinions which have ever marked the progress of mankind, when perhaps a few men here and there over the civilized world, find themselves engaged in similar trains of thought at the same time, without personal knowledge of the fact, inventing something new to the world, or discovering some unknown object or principle in science, that though the general character of the boulder drift had long been familiar to geologists, Sir Charles Lyell, Charles Darwin, Hugh Miller, and a few other intelligent men of Great Britain, set themselves about the same time, to work out the obscure problem of the boulder drift as exhibited in that country. Mr. Miller vivaciously observing and acute, ever ready to battle with the dark and obstinate phases of his favorable science, was a man who would assuredly not be unlikely to give his great mind to the solution of this interesting subject. His elucidation of the origin of the boulder drift of Scotland in his "Popular Geology" by an illustration well known to his countrymen is one

[1] "Travels Through the United States"

of the most ingenious and fascinating efforts of his pen. He has however in my opinion, utterly failed in the true generalization of the great facts connected with this last prominent geological revolution of the earth's surface. I will not omit this specimen of his argumentation. He says "when more than a quarter of a century ago the herring fisheries began to be prosecuted with vigor in the north of Scotland, many of the highland woods of natural birch and alder were cut down for the manufacture of barrels, and floated in rafts along the rivers to the sea. And my opportunities for observing these rafts as they shot along the more rapid reaches of our mountain streams, or swept over their shallow ledges, grazing the bottoms as they passed, naturally led me to enquire into their operations upon the beds of the streams down which they were floated. When a large raft of wood floating down a river, grates heavily over some shallow bank of gravel and pebbles resting on the rock beneath, it communicates motion, not of the *rolling* but of the *lurching* character to the stones with which it comes in contact. It slides ponderously over them; and they with a speed diminished in ratio from that of the moving power in proportion to the degree of friction below or around, slide over the stones or rock immediately beneath. And thus, to borrow my terminology from our Scotch law courts, they are converted at once into *scratchers* and *scratchees*. They are scratched by the grating sand-armed raft, which of course moves quicker than they move; and they scratch in turn, the solid mass or embedded fragments along which they are launched. Farther, if the gravelly shoals of the stream have, as is not uncommon in the shallows of our highland rivers, their thickly set patches of pearl mussels, many of these could scarce miss being crushed and broken; and one would find not a few of their fragments, if much subjected to the friction of the rafting process, rounded at their edges, and many hoops, scratched and polished like the stones. Nor is it difficult to conceive of a yet further consequence of the process. A vast number of rafts dropping down some river from day to day and year to year, and always grating along the same ledges of sandstone, rock, or shale, would at length very considerably wear them down; and the material of the waste more or less argillaceous according to the quality of the rock, would be deposited by the current in the pools and gentle reaches of the stream below."[2]

This picture of raft driving and its effects on the Scottish rivers by Mr. Miller, a Scotchman, is better drawn than that of the driving of ice floes and their effects by Sir Charles Lyell, an Englishman. We must give in as did George Canning premier of England on first hearing Dr. Chalmers preach in London: "the tartan beats the English".[3] I have selected these paragraphs from eminent geologists as the best examples I have seen illustrating the theory of iceberg action. It is readily perceived by these extracts what the iceberg theory teaches. We learn from books and the conversation of those who are familiar with the drift in both countries, that there is no difference in respect to their quantity, quality, and order of their deposition in

[2] "Popular Geology", p 71.

[3] Tartan is checkered woolen cloth, first brought to the notice of Europe by the Scotch, for the manufacture of which they are famous.

Scotland, or Great Britain, and New England. The various facts connected with this phenomenon in Maine as I have minutely described them, speak in no indistinct and obscure language that they are not referable to the action of floe ice or icebergs. The smoothed and scratched inequalities of the floor rock, sometimes of considerable depth, precludes the idea of their origin from an agent in transition floating in a liquid. It could not adapt itself to such depressions in the floor of either the sea or a river. As the cutting tool in the carpenter's plane is prevented from trenching the depressions in the face of the wood upon which he is at work, so would the imagined *scratches* of Mr. Miller fail to reach the depressions in the floor rock of the sea. The general direction of the striation, its uniform character, its obliquity, the smoothing and striation of perpendicular walls facing the east and west, the *under*-wearing and polishing of ledges, the scratching on the south side of hills at their base, all reveal the work of one agent, and certainly not that of floating ice. If the theory of icebergs admitted an east and west deflection from their general course towards the south; and after having become becalmed under the sea of a submerged hill, it might have started off again in the usual direction, and thus might have produced the polishing and grooving which we find at the southern base of the hills, the hypothesis would become of no account whatever. It is seen that if a berg could scratch the marine bottom in a north-south direction, it would be likely to scratch it also in an east-west one; and we should find somewhere within the mountainous territory of New England the result of such abnormal drifting. It could not be possible for a berg to be thus eddied. The polar currents which bear them south, are dense, deep, and slow, compared with those which run in the opposite direction. No counter currents in the ocean effect the course of icebergs, unless the latter be small. The Gulf Stream has no other influence upon these ice mountains, when they approach its remote reaches, than to diminish the volume of the bergs. This tropical current overrides the polar one bearing icebergs towards the south. Severe gales of wind blowing towards the same point as the Gulf Stream is running, have been witnessed upon the outer edge of the Grand Banks; and both combined had no apparent influence upon the progress of the greater bergs. The waves have been seen to dash with tremendous fury against the fronts of these icy giants, leaping in their wild energy a 100 ft high; yet straight forward without halt or oscillation, like veterans commanded by a consummate general, they marched impelled by the fathomless cold current of waters flowing below the warm waters of the gulf Stream. The greatest waves ever observed, have been rarely reckoned over 50 ft above the trough of the sea; and 10 ft below their base, would reach the depth of the wind-moved waters, having a motion perhaps, of half a mile a minute. Such waves have been supposed to be about 2000 ft long. It is not difficult to conjecture that a volume of water moving with this velocity, would have a tremendous effect upon the broad front of an iceberg; yet this resistance of wind and wave does not apparently, impede the progress of the bergs.

Nor could icebergs scratch the east and west sides of hills. A berg striking bottom on the side of a submerged hill, would swing round as does a raft in a stream when it strikes the side of a rock or bank. In hills of soft sandstone an impression might be made by a boulder fastened into the side or foot of an iceberg striking it in this manner; but no systematic polishing and striation could take place therefrom. Nor

could an iceberg possibly scratch and score the northern side of a hill, in other words it could not *climb* it. The supposition that the country was undergoing a process of subsidence, thus permitting bergs to ascend in a certain sense, the hills, is a very uncomely demand of the iceberg theory.

We should in this case see some evidence of breakage in these upward paths of the polishing and scratching agent. On some of the northern sides of the hills of Maine, as those of Mount Desert, and the granite hills of Vinahaven, I have traced a single groove for many feet. In one case I traced a glacial scratch 30 ft, where the hill dipped to the north nearly 40°, on an average. This would give the iceberg a rise while making this furrow, of nearly 20 ft, a very laudable performance for a dignified call for-nobody-iceberg. It would certainly be of great consideration to know whether the berg held fast to the hill side while the warm water of the surface of the sea in connection with a mild atmosphere, gradually lessened the volume of the berg, to enable it to groove this long furrow, or whether the land sunk during the passage, to the amount of these 20 ft. I imagine that probability takes as deep a hold on one case as the other; and I who am no icebergist, though I grant they are very cool and pleasant companions in a warm summer's day, shall take leave of the question without any opinion thereon.

These upward furrows are common in the hills of Maine. I have already alluded to two examples of the kind in Massachusetts. If a geologist should after examining the deep groovings up the north side of "Castle Rock" at Nahant, take it into his head to lecture in favor of the theory of icebergs, and against that of glacier, as agents in the production of the boulder polish and scratch I should most devoutly wish to hear him give his opinion of the *modus operandi* of making those grooves. The result would certainly be the conviction that he should be sent to the madhouse, or that I myself had for a long time been insane. On a ledge between Swampscot and Salem, I saw on the left hand by the roadside impressions on the south, or southeast side of a hill, where the glacier had slid down, a natural though not a very common method of progression with animals and men.

The hypothesis, that the country of the boulder drift was a submerged one during the time of that deposit is inadequate to explain the phenomenon of denudation in some parts of New England. As remarked in a former chapter, the hills near the coast show a degradation corresponding to that of the more distant parts of the state. The White Mountains are said by Prof. Agassiz, to have been reached by the denuding agent to the height of 6000 ft above the sea. When these tops were submerged according to the icebergist, of course all the land north of the St. Lawrence and its Gulf, was under water. To the northeast of New England, which would also be immersed there would be no region on which glaciers could grow. What few might be supposed to form along the axis of Greenland could not possibly send their bergs over submerged New England; for they would have been dissolved by the *warm* water of this northern sea ere they got within a thousand miles of Maine. In fact, if such a submersion were to take place by which so much of the continent would be depressed, snow might annually fall upon the mountains of Greenland, but no glaciers to any extent, would there be formed. No polar current would send water along the submerged region of Maine cooler than now flowing south along the coast

of the Carolinas. This North Atlantic sea instead of being a glacial one, would have the climates of the later tertiary times. Yet such a depression of territory would be necessary in order to send icebergs grinding along the top of Mount Washington now 6000 ft above the sea. The supposition that the country was submerged at the close of the Tertiary period, and that regions to the north of us were vastly colder than at present, is to me, a most unnatural conclusion. The giving to the continent a deep soil suitable for the highest development of muscle and brain, could not be obtained beneath the sea. Such a soil must be derived immediately from the subjacent rocks. A fine alluvium in a warm climate, and a soil of clay, sand, and granitic gravel in a cold one, is natures method with the earth.

Had a part of the continent been sunk to a depth sufficient for the passage over it of vast and innumerable icebergs for a great period of time, there would be formed in the drift resulting from this supposed abrasion, and the deposits of their own detrital material, marine fossils intermingled without order throughout the mass. Upon the bottom of seas over which icebergs are yearly passing, mollusks and other marine animals abound. In the drift of New England we find no such disorder as a submerged country for the glacial age implies. The fossils lie in beds generally with great depths of clay above them, sometimes alternating with sand and gravel, barren of organic forms. The story of this life is intelligible enough, that when they lived, no miscellaneous deposit of rocks, gravel, and sand, was cast upon the bottom of the ocean by passing icebergs. Furthermore, we see in the northern states upon the higher elevations of the country, ridges of unassorted material, which have never been under the influence of the sea. Had these high lands been submerged, the clays made in the paths of the strong dense currents, by icebergs, would have been deposited by itself, or arranged as we find it along our coasts. The enormous channels of our rivers now but partially filled with water show that the country was once greatly more elevated than at the present time. These ridges known as “horse backs” common in Maine about her great swamps, are in some cases modified drift by freshwater lakes as well as old marine shores; they were originally lake beaches when the country was higher than now, and subjected to long and severe storms of rain and wind.

Chapter 15
Objection to Iceberg Theory Continued

No marine polar currents flow south in the northern hemisphere, unless enclosed in deep valleys trending in that direction—Description of an iceberg—Hugh Miller's description of the battered brow of a hill near the town of Wick, Scotland—His opinion of the cause of the abruptness, an erroneous one—Reasons for so thinking—All the hills of Maine abrupt on the south—The manner in which this result occurred—The ledges of Maine show no evidence of drift ice—Floe ice inadequate to score them—The *diluvial theory*—Objection to it—Its influence in keeping the attention of geologists to the great facts of superficial geology.

The boulder denudation and striation cannot be due to the action of icebergs. These would have taken a more westerly course than the boulder scratches indicate. If the northeastern border of the continent had been submerged, the general trend of its mountains as at the present time, would have been in a northeast and southwest direction, and consequently the flow of the arctic waters would have been towards the southwest. The supposed iceberg striation of the rocks could not have been north-south, nor northwest and southeast. The laws of motion as respects bodies moving upon the surface of the earth, is that *north* of the equator they naturally deflex to the *right*; and that *south* of the equator they turn to the left.[1] We see that as soon as the polar current is free from the great depression between this continent and Greenland, it unites with the stream of cold water flowing southwest between the latter and Iceland and that thereafter this direction is maintained. And as the polar waters now flow, so in the northern hemisphere have they always flowed, namely, towards the *southwest*.

Prof. Agassiz has stated that rocks from the vicinity of Lake Superior are found in New England.[2] In another place he says that the small hills known as the Laurentian Hills, in Canada, running from Labrador to Lake Superior, about 1500 ft high, have never been under water since the Silurian age.[3] If I understand him aright, he means

[1] "Am. Jour. Sci." for 1861, vol. I, p. 27; also Dana's "Manual of Geology." p. 40.

[2] "Atlantic Monthly" for July 1864, p. 88.

[3] ibid for March 1863, p. 381.

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that the region called the valley of St. Lawrence has not been overflowed as was the now dry land border of the State of Maine, immediately after the great ice period. How could rocks from the region of Lake Superior get into New England, unless transported by drift ice?

The probability of finding rocks in the east from the distant west as suggested, is, I imagine, about as good as finding them there derived from formations in New England. Because we see a boulder in the *east* which we cannot identify with any rocks *in situ* here, we have no authority I think, to say that it must have come from a locality towards the *west*, where such rocks abound, if the glacial grooves on the floor rocks do not point in that direction. There are formations to the north of New England, beyond the St. Lawrence which have not been thoroughly explored. As far as known, they are considered pre-Silurian, like the rocks about Superior. The testimony of observers Prof. Agassiz not excepted is, that glacial striation is uniformly *north-south*, both in the west and east. The variation from a south course of the striae do not extend over a broad territory.

They are *local*, as has been remarked in a previous chapter. Prof. Agassiz does not believe it would seem that floe ice carrying boulders from the vicinity of Lake Superior during the depression of the continent subsequent to the age of glaciers, could drift a thousand miles towards the *east*, across the western branch of the strong arctic current which swept by Vermont and into the Atlantic Ocean over the region now occupied by the Hudson. Boulders never came here from the west, by any other means. The researches made by eminent men in the west which bear upon the decrease of mean annual temperature of the central and higher parts of the continent, show that since the Cretaceous period at least, the west has been warmer than the east. Would such a climate exist in the north, with more than a thousand miles of its border immersed, as to allow drift ice to approach in great masses, and to exist for weeks and probably months in an open sea of such dimensions? This very depression of the region about Lake Superior would inevitably involve the vast extent of low lands to the north and northwest in a like subsidence even to the Arctic Ocean. Again, I think I shall show in another chapter, that at the time of the last submergence of New England, there was no drift ice, comparatively speaking, over the region of the State of Maine. And if this ancient ocean carried no rock-laden ice, over the eastern part of New England, most assuredly it floated none in the region of the Great Lakes.

Nor could icebergs be concerned in breaking down the southern brows of the hills of the boulder country. When those floating masses strike the bottom of the ocean whether it be of mud, sand, or rock, they ground soon thereafter, and so remain till disintegration of part of the berg takes place. It is somewhat with them as with a ship sinking, or aground. The cargo must be thrown overboard to lighten the vessel. This discharge takes place uniquely with the berg. Stranded in the Atlantic Ocean perhaps 2000 miles from land, superficial currents of water warmer than the berg circulate around its upper part. The temperature of the atmosphere though chilled for a great distance around, is nevertheless above the freezing point. An assault by this heat is made upon the berg. Streams leap from its sides; and perhaps the berg splits into pieces of indefinite extent. Some of these icy boulders will weigh thousands of tons, one of which would be a fortune to a poor man, if he could land it without

much diminution of volume and expense of money in the vicinity of New Orleans, or Havana. But alas! fresh and pure as distilled water, the ocean sucks up the icy boulder as an insatiable urchin does a lozenge or a stick of candy. This is the way the berg becomes lightened, or throws overboard its cargo. It then rises from the bottom; and the deep polar current bears it on as before. Otherwise there is no vertical motion to an iceberg, as to a ship upon a troubled sea, no thumping upon the ocean's bottom and tearing up the solid rock, as suggested by one of our eminent geologists. Oscillations from wind and wave are not natural to this class of kingly personages. They are well mannered, of unsuspicious habits, and feel themselves connected altogether too profoundly and loftily with the sea and the sky, to be employed kicking up their heels upon the ocean's bottom like a wild young urchin learning to swim.

The bearing of an iceberg in the ocean is one of the grandest objects in the universe. Onward towards the south it takes its course like a thing of life, calm, radiant, and imperial. Upon the face of this voyager from the climes of eternal frost, one may look as if awakened to a higher life. There the beams of the sun unfold their celestial colors, green, violet and blue. These they blend together like the thoughts of earnest friends in delightful communion. Upon its forehead is a diadem of gold inlaid with gems. An etherial robe garnished as with an immortal hand, clothes its form. Before this sublime vision, the courage and skill of man fade away as a flash of the sky. Like the waves of the sea he has precipitated himself and noble ship in ignorance against this terrible strife of the north, and quickly passed away from the society of the living. What ambitious hopes have thus perished! What schemes of good or ill has prematurely passed away, aye, fleeter than the "early cloud and morning dew!"

Dr. Miller—bah! *Hugh* Miller, forever memorable because he *hewed* his rocky way up to the temple of fame by stone chisel and hammer. Has given us a gossipy opinion, of the cause and its manner of action, of an abrupt hill near the town of Wick in the northeast of Scotland. That the reader may see how easy it is by the force of vivacious logic to degrade a hill of *stone* by an *iceberg*, I transcribe his account of it, and explanation. "Mr. Bremner[4] adverted in the course of our conversation to a singular appearance among the rocks a little to the east and south of the town of Wick, that had not he said, attracted the notice it deserved. The solid rock had been fractured by some tremendous blow dealt to it externally at a considerable height over the sea level, and its detached masses scattered about like the stones of an ill built harbor broken by a storm. The force whatever its nature, had been enormously great. Blocks of stone forty tons weight had been torn out of the solid strata and piled up in ruinous heaps, as if the compact precipice had been a piece of loose brickwork, or had been driven into each other, as if instead of being composed of perhaps, the hardest and toughest sedimentary rock in the country, they had been formed of sun-dried clay. "I brought" continued Mr. Bremner, "one of your itinerant geological lecturers to the spot, to get his opinion; but he could say nothing about the appearance; it was not in his books". I suspect I replied, the phenomenon lies quite as much within your province as within that of the geological lectures. It is in all

[4] A well known civil engineer of England.

probability an illustration on a large scale, of those floating forces with which you operate on your foundered vessels, joined to the forces laterally exerted by which you drag them to the shore. When the sea stood higher or the land lower, in the era of the raised beaches, along what is now Caithness, the abrupt mural precipices by which your coast is here skirted, must have secured a very considerable depth of water up to the very edge of the land; your coast line must have resembled the side of a mole or wharf; and in that glacial period to which the thick deposit of boulder clay immediately over your harbor belongs, icebergs of very considerable size must not infrequently have brushed the brows of your precipices. An iceberg from eighty to one hundred feet in thickness, and perhaps half a mile in area, could not in this old state of things, have come in contact with the cliffs without first catching the ground outside; and such an iceberg propelled by a fierce storm from the northeast, could not fail to lend the cliff with which it came in collision, a tremendous blow. You will find that your shattered precipice marks in all probability, the scene of a collision of this character; some hard headed iceberg must have set itself to run down the land, and got wrecked upon it for its pains."[5]

It might perhaps, be imprudent to say that Mr. Miller's opinion here given was founded in error, yet I have no doubt of, it. If any one can believe that an "iceberg from eighty to a hundred feet in thickness" could form a battering ram formidable enough to break down a submarine hill composed of siliceous sandstone like these of Scotland, I should consider him a happy specimen of those who readily receive without much caution, the emphatic speculations of others. In fact it is utterly impossible that any such an effect could occur as is represented by Mr. Miller. The ice floe or iceberg "catching the ground outside" could add nothing certainly to its momentum. It would then be "wrecked" ere it reached the brow of the hill, and of course by the act would lose much of its dynamic energy. The east and west sides of the hills of Maine show no such result as this supposititious iceberg battering. They still retain the scars of the glacial gravers wherever uncovered by the detrital mass. When under the sea these sides were exposed equally with other sides to this imagined battering of icebergs, or floe ice, if any such mass floated in the last ocean which covered New England just ere man appeared there. It is the south sides of the hills of Maine which have the disrupted broken down feature. I will say without the fear of contradiction, that there are no hills in Maine unless their formation be of a porous nature and their summits lofty, with roughly torn angular ledges and precipices upon their east and west sides. The fallen fragments lying at their bases, may be referred from this detachment, to the action of frost and rain, posterior to the glacial epoch, ere the country had gone down into the sea for the last time. There they accumulated in heaps, and show no transportation. On the contrary the precipitous aspect of the southern sides of the hills is altogether different. There the talus shows removal more or less distant. The examination of the sides of any hill in Maine would not fail to convince I think, one of a marked difference in regard to the talus as here described. The precipitous aspect of the southern sides of the hills of the boulder country, I am compelled to say from

[5] "Cruise of the Betsey", p. 418.

the evidence they furnish are due to the passage of the glacier over them. The glacier was of immense thickness, and crept slowly southwards over the hill. Seizing with its irresistible grasp every prominence of the hill, its progressive motion perpetually jarred the constituent particles of the rock. As the glacier passed over the hill, there would be a fissure more or less perfect from top to bottom, between the brow of the hill and the advancing ice. Pressure would be removed from the brow of the hill where this occurred. The rock having its molecular tenacity disturbed, and being under inconceivable pressure posteriosly, would be liable to be torn asunder by this down hill translation, and this in connection with the falling force of the glacier, the south side of the hill would be degraded more or less in a vertical direction, while the opposite or north side over which the glacier was climbing, would be planed off at an angle much less steep than that of the opposite side of the hill.

As it respects the observations of Sir Charles Lyell near Cape Blomidon upon the movement of floe ice, and of Mr. Miller upon rafts floating down a shoal river, I consider they have no application whatever as illustrating the agent to which was due the degradation and scratching of the floor rock of the boulder country. I will not ignore the supposition that drift ice having boulder fastened to its under side, might leave impressions upon the softer sandstone over which it was chafing; but upon hard rocks like those of Maine and New England generally, no regular marks would be made. Floe ice of moderate thickness, is moved by local currents in any direction of the compass, whether occasioned by the configuration of land or violent winds. The slates of Maine, furnish abundant internal basins opening southerly more or less, and in some cases towards other points of the horizon, where floe ice as at Cape Blomidon, might have frequently swept over the shore, and had an opportunity to polish and scratch the submerged rocks, but I have looked in vain about the deep creeks and coves of Maine, whether within reach of existing tides, or ancient basins elevated more or less above them, for such ice floe scratching. This sort of ice, even of considerable thickness, moved by a strong incoming or outgoing tide, would be compelled to break into fragments the moment it touched bottom, and these cakes would skip here and there aloft over each other, like a flock of frightened sheep when their egress is impeded. It is not possible in such a case, for uniform striation to occur. At the point of arrest, a divergence of the bottom ice would take place both towards the right and left, and consequently there would be a disk of confused striation, of which no geologist has furnished an example. Valleys trending east and west, have their sides and bottoms grooved in a direction north and south; and those in the vicinity of Portland, trending northeast and southwest, have also the glacial striae north and South. It is thus convincing I think, that icebergs and ice floes had no agency in the production of the polish and scratch of the floor of the State of Maine.

Another theory somewhat akin to that of icebergs, was popular in this country for a while. It originated I believe, with the brothers Rogers, Henry D. and William B. professors in our colleges, and eminent geologists. The former died at his post, as professor of geology in Glasgow College, Scotland, having been elected by the segaceous Scotchmen from consideration of his profound scientific attainments, a like courtesy never accorded I believe, to any other American sevant. But America does not care a fig whether Scotland wishes for her wise men, or no. Her great minds

are all needed in the west where the field of discovery lies broad and deep. There the Yankee is not circumscribed, and he owes allegiance to no sovereign in science north of the Tweed, or elsewhere. The other brother, William B. Rogers, is now at the head of the Polytechnic Institute, Boston, which will soon be a renowned school of Science. These gentlemen some 20 years ago, or more, supposed the area of the boulder drift, standing perhaps at its present horizon of elevation, to have been flooded by great waves originating in the polar basin, and passing south over the continent; and that the rocks, gravel, sand, and clay which we find in the country, were deposited thereon by this deluge, or deluges; and that the polish and scratch upon the rock are the work of this drifting material.[6] They imagined those diluvial waves to have been thrown upon the land by earthquake action about the pole, of course, of vastly more intense action than that which destroyed Lisbon in 1755, Jeddo in l856, St. Thomas in 1867; and convulsed Hawaii and the whole South American Continent in 1868. This theory of explaining the drift is more untenable than that of icebergs. It implies the bed of the polar ocean to have been of many thousand feet thick, of unconsolidated materials, and an extent of volcanic action as never existed upon the globe at any time. Most assuredly not since the close of the Cretaceous age. In fact though the gentlemen were habitually cautious, they gave us all together too much earthquake. Had such arctic deluges come down upon New England "at least a mile deep" as Dr. Charles T. Jackson estimated from examination of the top of Katahdin,[7] we should find our deep opposing valleys filled with boulders, and everywhere ice relics of forests and animals both of the land and water. These would have been heterogeneously mixed with the drift materials, whereas, all the organic remains of that time are chiefly marine, and show *method* in their deposit. These diluvial waves could not have marched in one general direction, but would have conformed more or less to the trend of valleys, have been deflexed by the hills, and would have acquired a strong westerly set before it reached the latitude of New York City.

Nor could these diluvial waves possibly account for the orderly scratching of the rock, nor for the perching of boulders upon the brow of hills and in other places, where evidently the current could have lost nothing of its transporting force. No currents of the nature here supposed, could have torn vast rocks from localities near the northern base of mountains, and have lifted them up the steep incline, and have set them down quietly upon the summits. These rock transporting currents could not have originated the lunoid furrows. Upon one of the large glacial slates in the museum of the Port. Nat. Hist. Soc., destroyed in 1866, five of these lunoid impressions were made one after the other, from half an inch to one inch apart. They were not made with a bounding rock, but rather by one moving slowly along in a straight line. If the land stood at its present level above the sea when those imagined polar deluges came down upon the country, they could not have reached the outer islands of the coast of Maine, with a depth of water between them and the mainland of several hundred

[6] "Am. Jour. Sci." 1845, vol. I, p. 274.

[7] Second Report of the Geology of Maine, 1838, p, 149.

feet. The blow received by the ocean would indeed have sent its waters coursing up and down upon the sides of those islands, but would have left no regular marks upon the ledges. As a wave now upon the ocean's shore, plays over a rock, washing the sand this way and that, and not in any particular direction, so those immense waves would have run up and down the land, rolling hither and thither according to the dip of the prominent rocks.

The fossiliferous clay beds it is claimed, were deposited before the period of the drift, and the tenacious matrix resisted the uprooting force of the diluvial wave. This twist of the diluvial theory is altogether too feeble. All the fossiliferous beds of Maine so far as known, overlie the polished and grooved rocks. If the diluvial waves were sufficiently powerful to carry great boulders across valley and up hills, of course they would have stripped the fossiliferous clays, and scattered them here and there throughout the diluvial deposits, along with the organic remains. Nor could the material propelled by these floods have smoothed and marked the southern base of the hills. There as about rocks in a running stream, tali of gravel, sand, and organic matter would have collected in the dead water made in this direction. Furthermore, this theory looses sight of a very remarkable fact, that nearly all the boulder rocks have been derived from the floor on which they rest.

Owing to the limited amount of facts collected at the time of the announcement of this theory of the Messrs. Rogers, the hypothesis appeared natural enough to many minds. Observations had indeed been made over broad acres of country, but in most cases with a lack of rigid scrutiny. But by and by men became more acute in this kind of observation. What was apparently reasonable enough in one locality, was over matched by facts observed in another. As the facts became more and more amassed, they took a different and a truer shape. They kept the attention of scientific men at work more or less in the right direction, till now, especially since the great work of Prof. Dana on general geology,[8] in which he supports only the glacial view of the course of the drift materials and accompanying phenomena, all the facts have taken we think, their legitimate generalization in the glacial hypothesis. The iceberg and diluvial theories have tended to this end. All conflict was of use. Nothing was lost. In the fiery crucible of opposing forces, the genuine gold comes forth in admirable hue.

[8] "Manual of Geology".

Chapter 16
An Astronomical Theory

Suppression of sun heat—The theory implies glacial action to account for the denudation of the country—The views of Mr. Jennings—Laplace's hypothesis of creation—The moon convulsed with volcanic action—Metallic state of meteors – A shriver of gold—Condition of the planets—One system of law has controlled the development of the solar system—Von Mayer's meteoric theory—Variable stars Sun spots, and their periodical character; and are due to the influence of the large planets—They are coexistent with magnetic storms.

An astronomical theory of the boulder drift was I believe suggested by Sir John F. W. Herschel, the distinguished son of the great Sir William Herschel. It supposed the enormous refrigeration of the higher part of the northern hemisphere, to be due to reduced radiation from the surface of the sun. This view involves a glacial theory, the only one which meets the requirements of the case. It supposes an ice sheet of great extent simultaneously upon the polar extremes of the globe. This hypothesis is at fault *prima facie*. The remarkable diminution of solar heat sufficient to cool off such large portions of the earth at once and for a long time, would correspondingly have reduced the evaporation of the ocean, the origin of glacial growth. There would have been a terrific loss of aerial circulation the moment the earth's atmosphere felt the decadence of its heat. Equatorial heat is the grand source of atmospheric currents, as well as an active agent in generating those of the sea.[1] In 1862 in my articles alluded to in Chap. 1, I made objections of this sort in reply to a communication from Mr. J. A. Jennings in the New York Independent, upon this supposed diminution of solar heat, to account for the great glacial period of former times. Mr. Jennings says "the southern limits of the drift is an isothermal line. And as the relative temperature of countries in the same latitude, depends upon arrangement of bodies of land, of mountains, and of oceanic currents, that arrangement must have been the same as now. If the sun be matter like the earth in its nature, and from its temperature, enveloped in an atmosphere of flaming vapors,it must be in the process of cooling by radiation; and in that process the time would come when the surface temperature would be below the point of volatility for the various substances of which that atmosphere is

[1] The trade wind and accompanying current are partially due to the axical revolution of the earth.

H. W. Borns, Jr., K. A. Maasch, *Foot Steps of the Ancient Great Glacier of North America,*
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composed. Let us suppose that point in the sun's atmosphere to have been passed with regard to some substance forming a large part of it. That substance would collect in clouds and fall like rain into the more heated mass below. There it would again become volatile and rise, to be again condensed, and this would be again repeated till the heat of the sun became so reduced as to allow the vapor to remain condensed. Till then the surface of the sun would be obscured by dark spots varying in extent according to the amount of matter thus becoming condensed. Let those cloudy spots on the sun spread, so as to obscure its intense light, and a gloom would gather upon the earth, a night broken by no twilight ray; and the icy breath of winter dispelled by no returning spring, would be charged with death to every creature."

I know not whether Mr. Jennings has here given us an expose of the views of others, or of himself; it is well enough either way, and will answer the purpose of presenting an astronomical theory to account for the boulder drift. In order to understand the source of solar heat and how it is maintained as far as any one can comprehend, I shall give a brief synopsis of the nebular hypothesis of creation. Though this digression may apparently be out of place, I do not so regard it, because some of the important principles which it recognizes, must be kept in view more or less throughout the remaining part of this volume.

Astronomers generally, and I may say the same of geologists, accept the theory suggested by Sir William Herschel, and fully illustrated by the celebrated French mathematician, the Marquis Pierre-Simon Laplace, in his great work "Mécanique Céleste"[2] This hypothesis supposes that all the stars in the heavens, and all the nebulous matter existing in space, originally constituted a single mass in an attenuated form like gas, more or less. It has been supposed that the etherial medium diffused throughout space, is a relic of this original mass. In the process of infinite time, condensation is imagined to have resulted in certain direction or directions, when finally an axical motion would originate; and such a revolving volume would become an isolated one, and finally the substance and source of an individual universe of stars. Its motion would increase as density augmented, and from its equator in consequence of this centrifugal velocity, a ring of nebulous matter would be rejected revolving in the same plane as itself. This rejectamentum would constitute a sun, which in time would condense and throw of masses for planets; and the planets going through similar processes, would form moons and rings; and some of these sun masses might be divided up into two or a number of suns, constituting a system of suns. The original revolving body would cast off one sun mass after another into space perhaps without number till it became so far condensed that rejectmenta could no longer occur. This mass would be greater in density finally, than all the bodies together, which it had thrown off. It would be not only the oldest, but it would be cast the farthest into space. Such it is supposed is the origin of the universe, or system of suns in which we live. The original etherial matter would condense in another point; a similar process would go on, till another universe of suns, planets, rings and moons,

[2] *Celestial Mechanics.*

and perhaps comets, would originate and thus two, or a thousand universes might be formed, but whose globes in all cases might not revolve in one direction.

There is no doubt whatever, that all the hosts of stellar worlds have had a common origin and are related by intimate ties as regards the nature of their matter; and that they are alike subject to common laws. Suns are effected by the motions of suns, as planets are by the motions of planets; and we may reasonably conjecture that the motions of one universe are felt by another however distant it may be. Whether our universe is the oldest or youngest, we know not, nor ever shall know in this life. The Solar system and all the stars that we are able to see with the naked eye, and thousands invisible to it, are a part of the galaxy or great Milky Way cluster, and constitute a single universe. According to the researches of the Russian astronomer Dr. J. H. Mädler, the great center of *our* universe and source of all the suns therein is Alcyone, the brightest of the Pleiades or Seven Stars. After unwearied observations for many years, the astronomer came to this conclusion. At a certain time he suspected that this star might be the great center of our universe as the sun is that of the solar system. Night after night for years, the great man kept this thought locked up in the recesses of his own mind, lest having suggested it to others, he might thereafter be found in error. Magnificent man, rising far above the stature of his fellow men, this mighty prophet of the stars, standing upon his midnight watch tower, and sweeping with his eye the infinite depths of space, sees there a star whose splendor seems less than a multitude of others around him, and pronounces with authority that this body is the grand center around which the hosts of heaven are marching, and our sun along with them at a rate of more than 90,000 miles a day. Marvelous announcement, one of the greatest discoveries of the age! Stand aside, ye traffickers in the things that perish, as this mighty prophet walks abroad, and with bowed heads in silence, do him reverence!

The flaming sun of suns is reckoned, 36 millions of times farther from us than our sun, or 95 millions of miles multiplied by 36 millions. Light speeding at the velocity of 200 miles in a second would occupy 550 years in coming from Alcyone to us. The light which burst from the face of that marvelous sun on the evening of the battle of Bannockburn where Robert Bruce of Scotland vanquished Edward the Second of England, just flashes upon my eye tonight, as I look out upon that star now setting in the west. Carrying his planets with him, our sun sweeps round this center of the universe but once in 1 million eight hundred thousand years. Furthermore, this theory of creation implies that every nebula in the far off recesses of space, possesses a cosmical system with its grand sun, like our universe. And still farther, that there must yet be one sun, the grand center of creation, of greater capacity as a sun, than all the stellar worlds seen and unseen in the dominions of space. No human soul certainly, perhaps no archangel, can comprehend the grandeur of that flaming world. We thus get a glimpse, and I believe a generally correct one, into the manner of the origination of the solar system. Sun, planets, and moons, were once in a gaseous state, and through their motions only, power, and beauty, and life have come forth, as Schiller sings it in his "Song of the Bell:"

it is in fiery motion

That all forces come to light.

Mr. Tennyson has very briefly and prettily expressed the hypothesis in four lines in the "Princess:"

The world was once a fluid haze of light,

Till towards the center set the starry tides

That eddied into suns, which wheeling cast

The planets.

The earth then, must have been a self-luminous globe, a *sun*; and the same thing of course, must be said of the moon, in whose physical history it is possible, we may see the future destiny of our world. This "silver moon" and "queen of heaven"called also by a score of other pensive and pretty names to illustrate her majesty's sweetness, is a daughter of "mother earth". She sent the child away into space at birth, to roam up and down the vast expanse under the guardianship of its grandfather Sol, but still subject to the tether of her mother's apron string. But age comes at last to youth and beauty, whether slowly or with swift foot; and notwithstanding the pleasant face we often behold in the dark sky of night, is that of a *queen*, it is nevertheless that of an *old woman*. To talk less prosaically, the moon has mountains, sharp and high, and some of them are volcanic. The hand of a glacier has never certainly smoothed down the *wrinkles* of her face. Old lava streams have frequently been observed along the sides of some of those mountains. In l867, Mr. William B. Brit of Great Britain, and others, observed what they supposed to be an active volcano 6 miles in diameter. During the total eclipse of 1868 De Créty observed three protruberences on the moon's limb, which he supposed indicated the existence of three volcanoes on the farther side of the satellite. If these observations indicate existing volcanic action upon the lunar globe, there must be water and an atmosphere to some extent there, though none are visible. The moon is a convulsed used up globe, a mighty conflagration, internal or external, having long ago swept her face, and almost demolished her system. She can boast, if she has life enough, of bigger craters than all the earth possesses if collected into one. Some are from 20 to 60 miles across, and several miles deep, and if floored with smoking brimstone, would be no insignificant illustration of the "bottomless pit" of St. John's vision. Such a hole if upon the earth, would be an awful "slough of despond" even for a righteous man, to fall into. It would undoubtedly be the great mistake of his life.[3]

[3] Dr. Mädler the German astronomer to whom allusion has just been made, has recently I believe, measured the heights of more than a thousand mountains on the moon. Twenty of them are higher than Mount Blanc the highest peak of the Alps of Europe, and one is nearly 25,000 ft high, four times as high as Mt. Washington.

It is not probable that the planets of the solar system have maintained individually the same rate of condensation, or cooling. It is not the relative quantity of matter in celestial bodies that effect the cooling rate, but distance from the center of the system. The nearer the planets to the sun, the greater is their orbital velocity and density, and the less their diurnal motion. The rapidity of the diurnal motions of Uranus and Neptune must be inconceivably great, sufficiently so to keep them still in a fluid or liquid state. It is in the system of gigantic forms that revolutions run slowly, and age matures with moderate pace.

Furthermore, the composition of one planet, or sun even, may not be precisely similar in its evolution to that of another. The condition under which the original element, or elements, were evolved, would I imagine, effect the process of condensation and evolution of compound forms. There is one truth however, which modern discovery has brought to light out of the darkness of space, namely, that all celestial bodies are more or less alike in composition.[4] The aerolites that come down to us from orbits interfering with that of the earth, have iron vastly superior in tenacity to that of the earth, better than that passed through the manufacturing process of man's skill. It has never been oxidized like *that* of the earth. Many other metals have been detected in those fallen bodies. Perhaps by and by we shall have a shower of *gold*, and it would be desirable that it should not happen in California or Australia. *Maine* would undoubtedly, be the most suitable locality for a golden shower. The people of this state would delightfully appreciate it beyond all others. What is wonderful too, *organisms* have been said, to be found in those meteoric bodies which are thus cast loose from their orbits in the depths of space.

We know nothing of Vulcan dodging and limping in front of the solar forge, and Mercury is too volatile and swift of foot for the scrutinizing eye of the astronomer; but he is quite sure that the belle Venus, and soldierly Mars have long since passed their teens, and display the characteristics of man- and woman-hood. They have mountains, seas, and clouds; nor should we I think, reject the notion that *life* is there upon those globes on high. There was life upon the earth before there were any mountains, or an atom of snow falling to the ground. Snow is seen in the polar hemispheres of Mars. What is the ultimate purpose of matter, but for the evolution of life, first the simplest form, then progressively up to man, the embodied intelligence and final image of the infinite one, the creator of all?

[4] Astronomers and chemists know nothing about the nature of the original matter from which the universe was formed. They even withhold conjecture whether it was hydrogen, oxygen or some other known gas. The chemist Braconnet raised various plants on glass with no other envelop than a little raw cotton, weighed and its quality analyzed. He fed them in carefully distilled water. They thrived and matured. He submitted the whole to a rigid analysis again. He obtained alkalies, sulphur, phosphorus, carbon, hydrogen, nitrogen and traces of metals. Thus from the seeds of plants fed on water-oxygen and hydrogen, with a carbon of the atmosphere, the plants through the medium of light and heat, obtained some foreign bodies whose source was wholly unknown to the chemist. Thus we see nature a mysterious and perfect manipulator in the great laboratory of the universe, and man though an apt pupil, has not quite rivaled his teacher. J. DeL.

The astronomer gives us to understand much the same of Jupiter as of Venus and Mars, but shakes his head somewhat dubiously when questioned in relation to Saturn. He says he is a light bodied old gentleman, the ghost of time. Planet and rings, and moons, he drinks the system a liquid of some kind. He conjectures that the other planets, which are older, may yet be in a fluid or gaseous state. But when interrogated about the *sun*, he shrugs his shoulders like the Frenchman, and says nothing; and so we wish him a good night, as he passes on to his watch tower of silence and of thought. Notwithstanding the astronomer leaves us to speculation, a method of arriving at truth he generally distrusts, though he sometimes resorts to it, yet if one reasons from analogy, from what we have now seen of the planets, we may suppose that the great luminary is more or less alike in composition to the other bodies which circulate around him. He has gone on condensing and cooling for untold millions of years since he threw off the last planet, Vulcan, from his equator; yet it scarcely seems probable that this surface is in that admissible state of transition in which one find that of the earth. From the fact that the sun greatly outweighs all the other bodies in the solar system, I do not believe that his surface is *solid*, that he has yet cooled down even to the melting point of *iron*.[5] It is admitted that the sun has an atmosphere of great density and height. Above this envelope is now believed to be the true photosphere, where the sun's light and heat are eliminated. Le Verrier the discoverer of Neptune, or the outer planet, thought from observations made during the great eclipse of 1860, that he saw evidence of a gaseous stratum exterior to that of the photosphere.

But it is from the discoveries made during the same year, by two German chemists of Heidelberg, Bunsen and Kirchhoff, that we get the best insight into the composition of the sun. I shall waive for the present, the opinion held by many that the metallic bases which these gentlemen saw and many others have seen since, burning in the sun's rays, are due to meteorolitic fuel. The reception of the refracted solar rays by a prism upon a piece of paper or a screen, produces the seven elementary colors. This is called the *solar spectrum*. Fraunhofer, another German, in 1814, discovered with the microscope, an infinite number of lines of different tints between the natural colors in all parts of the spectrum. These are known as *the lines of Fraunhofer*, and may be called the *solar alphabet*.[6] By examining the rays of combustion of bodies through the prism with a telescope of any size, characteristic colors as of iron, copper, zinc, silver, nickel &c., may be detected. This is called the *spectrum analysis*. Applying this principle to the sun's light, Kirchhoff discovered in it the vapor of iron, chromium, nickel calcium, magnesium, and sodium, all metals. Gold, silver, mercury, and copper have not been discovered in the beams of the sun or any other celestial bodies, I believe. In 1863 Mertz another German, found iron in the light of the bright stars Sirius, Archunes, Alderbaran, Vega, Porcyon, Regulus, Castor, Polux, Capera and other stars. In 1866 a new variable star was seen in the constellation Northern Crown, to be apparently *on fire*, and was observed in this

[5] The mass of all the planets with their satellites, is only 1/27 or that of the sun.

[6] "Youman's Chemistry," p. 154.

country in May of that year by Prof. B. A. Gould of Cambridge. Messrs. Huggins and Miller of England, applying the spectrum analysis to the light, discovered the remarkable brightness to be due to the combustion of hydrogen, over the face of the star. But the same thing goes on continually according to Mr. Huggins of England on the face of Sirius, that beautiful star 12 or 15° to the southeast of Orion. He also found that the position of the hydrogen line differed compared with that of the burning gas in the laboratory. His conclusion was that the star is receding from the earth, or sun, nearly two and a half millions of miles a day. Sirius is about fifty times brighter than our sun, and about a hundred times larger.

The evident conclusion therefore, to be drawn from these data in regard to the matter of the sun is that either the surface of that body is not solid like that of the earth and moon, but is in a molten state, or that the solar surface may be solid, and the colors of the metallic vapors seen by the spectrum are due to the dissipation of meteors fallen upon the surface of the luminary. Dr. Julius R. Mayer of Heilbronn, Germany in his "Celestial Dynamics" has argued with great force, the meteoric origin of the sun's light and heat, and cites the case of the variable stars in support of the theory. It is supposed that these bodies have their maximum and minimum light at regular periods, but nothing is definitely known in regard to the matter. Hipparchus 125 years before the beginning of our era, records the sudden blazing forth of a star where none before was seen, and its gradual disappearance from the locality. Tycho Brahe 300 years ago, witnessed a similar phenomenon, and Kepler about 30 years after still another; but the reappearance of their stars in the localities, have not since been seen, I believe. But in regard to the variable brightness of the sun, no astronomer ancient or modern, has given us any intimation of the kind. I think it may be safely affirmed, that for the last 3000 years, the light and heat of the sun received by the earth, have been apparently the same from year to year. To imagine that there fixed stars in the heavens, with planets and their attendant satellites, whose light is supplied at intervals of centuries, or of thousands of years perhaps, by the plunging of wandering meteoric bodies upon their surfaces, is to conjecture a state of things that will ultimately bring total darkness and death to the hosts of heaven, because an end to this meteoric fuel must come at last. Nor is Dr. Mayer free from error in supposing that the sun's spots or maculæ, owe their existence to the fall of meteors upon the luminary. If this were the case, the light and heat of the sun would be augmented as soon as the atmospheric storm had abated, and normal equilibrium had been restored his photosphere. This meteoric fuel in the nature of the case, could not be regulated to the orderly requirements of the planets and their satellites. At one time the furnace of the sun would be surcharged, giving out unnatural quantities of heat, and again burning slowly with a minimum supply. Not the earth alone would feel these disastrous extremes, but all other worlds within the sun's immediate influence, many of them of great magnitude and grandeur.

These spots on the sun are never seen nearer his poles than 60°, nor do they approach his equator more than a quarter of that distance. They are then scattered over a space about 15° broad each side of the sun's equator, in a sort of *temperate zone*. Their revolution from west to east indicates the axical revolution of the sun. It would be difficult for Mr. Jennings I imagine, to persuade astronomers that these

spots once extended over the entire face of the sun, and excluded his light and heat for ages. But to cut the matter short, these solar spots are *periodical*, and the astronomer can accurately predict the time of their appearance and disappearance. They are occasioned by the influence of the planets Jupiter and Saturn, but chiefly by that of the former. This Jupiter was a great sovereign in the mythology of ancient Greece and Rome. But through an autocrat ruling in the "extensive heaven in air and clouds", according to Homer, he was a mean symbol of a high toned gentleman, nevertheless. Since his kingdom passed away along with his dynasty he has had a status as an inferior personage in an empire higher up in the sky than the summit of Olympus. He is the first prince in the dominion of Sol. What his cogitations and ulterior designs are there, it may be difficult to truthfully say. But of late he has been found taking unbecoming liberties with the King of Day. The astronomical police, very sharp eyed men, and famous for their superior opera glasses, have detected the jolly prince in the habit of pulling away the aerial veil from the face of his sovereign Sol. After giving his majesty an atom of rest for a few years, Jupiter resumes his tricks again. He now compresses the veil, or pushes it violently back upon the venerable face of the monarch. Thus it is tossed and torn, and whisked about like a cloud in a tornado. The countenance of his majesty is troubled and tormented by these eccentricities of Jupiter, who now and then inveigles some of the other princes of the realm into complicity with him in these misdeeds. The celestial monarch telegraphs his distress through the etherial wires stretched nearly a hundred millions of miles, to mother earth, one of his favorite daughters. She trembles at the news, and has rigors; her pulse falls, and there are decided symptoms of convulsions. Along her atmosphere the electric phenomenon of the aurora borealis, shoots in brilliant scintillations and violent contortions. They hurry to and fro over the earth in confusion like an army taken by surprise.[7]

This phenomenon of sunspots is periodical, as I have stated, and returns once in about 11 years, or a little more. Hofrath Schwabe, of Germany, was first to notice this periodical character; and General Sabine, of England, first called attention to the periodicity of magnetic storms, or unusual displays of aurora borealis, and their contemporainity with the existence of solar spots.[8] Thus magnetism is intimately connected with the light and heat of the sun, and may owe its existence on the face of the earth, to the heated state of its atmosphere, and rotations of the planet.[9]

[7] Am. Jour Sci for 1858, vol. I, p. 295.

[8] Schwabe thinks he sees a relation in time between the period of sun-spots and meteoric showers, Vido Am. Jour. Sci for 1867, vol. II, p. 287.

[9] "The evidence appears irresistible that the earth's magnetism is directly dependent on the terrestrial gravitation of thermally disturbed aerial currents.", Prof. Pliney E. Chase, in Am. Jour. Sci. for 1865, vol. I, p. 166.

Chapter 17
Astronomical Theory Continued

Much of the heat of the sun due to his diurnal motion—The earth generates heat from a similar action—Von Mayer's theory again—Objections to it—Only one great cold period for each polar temperature of the earth—New England had no cool climate till the Tertiary age—The approach of ancient glaciers towards the equator, not an isothermal line of the present arrangement of land and water—The cold period of the northern hemisphere not synchronous with that of the southern one—No astronomical theory which supposes the loss of solar heat available—Variation of the magnetic poles insufficient to account for the cold period—Their duality and locality—Cold winters in Europe 2000 years ago—Iceland and Greenland warmer then than now—Traditions of the Eskimos—Depression of the northern part of the hemisphere would make the temperate zone milder than at present—The glacial ice cap must have commenced at the geographic pole.—The precession of the equinoxes insufficient to account for the cold period— Views of some astronomers upon the changeability of climates in Europe.

But the heat of the sun can be wholly due to the supposed molten state of his mass. His revolution on his axes must originate a vast amount of mechanical heat, the result of friction of his atmosphere against the resisting æther of space, and the mobility of the materials of his composition from the same diurnal movement. There is in this direction independent of this supposed molten matter, or the concussion of falling meteors, a source of light and heat that can never fail as long as a solar atmosphere exists, and this axical motion is continued. Nor is the earth exempt from obtaining a certain amount of heat from a corresponding source. If the earth's diurnal motion could be secured, though the sun and fixed stars should disappear, the surface of the globe would certainly be warmer than it would, if the earth had not this motion. Clashing of her atmosphere with this æther of space with the waters over which it moves, of the waters among themselves and upon continental coasts; and of chemical action upon the surface and beneath in the crust of the earth, must give rise to a great deal of heat. The movement of organic existences innumerable, are never ceasing sources of heat upon the globe. The researches of Pouillet have satisfied physicists that the fixed stars furnish to the earth almost as much light and heat as the sun, without which addition says Dr. Lardner the existence of mineral and vegetable life would not be possible upon the earth. I cannot therefore, accept

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the theory of solar heat of Dr. Mayer. That heat and light would result from the concussion of falling bodies from the depths of space upon the sun, may be true; and so every man who is familiar with the new views of thermal dynamics, must admit, this perpetual showering of meteors would continually increase the solar mass throughout the eternities of the past, and must increase it as long as heat action shall continue. But as has been before remarked, an end of this meteoric showering must come at last. The last atom of this cosmic fuel must be meted out to the solar orb, and then the thermal fountain will be dried up forever. And this will be the fate of all the suns now glowing in the immensity of space. Then everlasting darkness will settle down upon the sun, and death will result to every creature and plant in our universe. But no possible evidence has ever come within the grasp of man, to authorize him to believe that a meteorite or comet has at any time, fallen upon the *sun*. The orbits of such periodic bodies circulating around the sun, in orbits more compressed than that of the earth, interfere with the latter, and drawn aside by the influence of the earth, the train of cometic vapor, or of meteoritic bodies, loses its normal balance when near the earth, and falls upon its surface. And the earth and all the planets which receive such alien bodies must thereby be increased in volume. But this cosmic source has never been the origin of the sun and planets, I imagine, as Dr. James D. Whelpley supposes.[1] If his views have any truth in them, as a nucleus, that of Mayer's is unnecessary as an explanation of the source of solar heat, for the former says "all the great masses of matter gradually advance from the dark to the incandescent condition as they grow by accretion."

Whatever intimation there may be in nature and Divine Revelation of an ultimate change in the present order of terrestrial things, bringing death to the existing system of life upon the earth, that mutation will not come about I think, by the cessation of falling bodies upon the face of the sun. No, the universe is not built upon such a plan as that elaborated by Dr. Mayer or Dr. Whelpley. Not only perpetuity in beauty and the sublimest harmony is secured I believe, but *utility* is written upon the face of the universe with inextinguishable letters of light. If there is any thing of man which can never die, or dying, is received and made immortal, is not that subtile essence imbued or will be endowed, with the capabilities of the universe in which light and heat will play a prominent part?

Amidst all the wonderful revolutions which the surface of the earth has undergone, there appears but one in which any extraordinary cold was manifested. From the time when life first appeared upon the globe, this planet traveled on in the path of the ages comfortably cool from head to foot, up to the Tertiary times. It was during this period that New England first experienced the luxury of cool winds, and an emphatic system of seasons; and these probably were not severe till toward the close of the Pliocene, when a climate existed very much milder than that which Maine now possesses. The floræand faunæof the Tertiary period show throughout a gradual approach from a tropical face to the present aspect of life in the country. There was no sudden change from warmth to cold. Nature had insinuated her purpose all along by the forms of

[1] "Atlantic Monthly" for February 1869, p 21, "Birth of the Solar System."

life which appeared from time to time upon the horizon of existence. Looking into the future she saw that the overwhelming hand of cold was necessary to be laid upon the earth, and not upon other planets of the solar system; and I hope hereafter to show the character of the necessity.

As it regards the statement made by Mr. Jennings in the preceding chapter, that the southern limits of the drift is an isothermal line of the present arrangement of land and water, we shall see that it is not. The line of mean annual temperature of 55°, is the usual limits of glacial action in the central states. It is located near Humboldt City on the Pacific coast, just above the parallel of 40. It curves somewhat south easterly towards the mouth of the Ohio, pursues thence an easterly direction, and escapes from the continent at the Capes of the Chesapeake. This line strikes Europe near the mouth of the Loire on the Bay of Biscay, crosses the middle of France; runs north of the Alps and the Balkans to the Black Sea and the Caspian bisecting both; curves south easterly towards the great desert of Kobi to Beijng, near the head of the Yellow Sea; then a deflexing still more southerly, divides the island of Niphon, and strikes the Pacific waters again about the city of Jedo. Now to the left hand of a line drawn from the city of St Louis to Vancouver Island, the action of the Great Glacier is not any where seen. From Pike's Peak in western Kansas to the base of the Sierra Nevada, the former presence of *alpine* glaciers is seen, but no boulders are everywhere scattered, as over the country to the east of the Mississippi. More than 300 miles north of this line, the country about eastern Nebraska escaped glacial denudation.

In the eastern hemisphere the glacial cap was more irregular in its set than in North America. It covered the greater part of Western Europe. The Pyrenees, southern Alps, Apennines and Balkans sent glaciers into the Mediterranean. Ireland, Great Britain, Scandinavia, northern European Russia must have been covered with a great ice sheet, during the crisis of the cold period. Siberia is a great fiord country, showing the action of the glacier. The French geologists tell us that glaciers came down from the tops of the Atlas Mountains in Algeria, to the low lands, 600 miles south of the isothermal line of 55°. Lebanon sent down glaciers along its western flanks nearly or quite to the present line of the Mediterranean Sea. In northern India glaciers of immense proportions swept down from the sides of the Himalayas and covered the level country far to the south, now a beautiful region of perpetual summer, more than a thousand miles south of this isothermal line. One can hardly doubt that nearly all of eastern Asia was subjected to the action of glaciers.

In the southern hemisphere wherever the land rises high above the sea, glacial action is said to have existed. The boulder phenomena in the higher latitudes correspond to what is observed in the northern hemisphere in the same latitudes. The high mountains have been covered with ice, denuded and rounded like those of New England. The Brazilian Andes were covered with ice. Upon the flanks of the Aracay in Guiana, just north of the equator, old drift remains are said to be visible. I have no doubt but that the material of the greater part of the arid plains, and perhaps of some others, in South America, has been derived from the debris of glacial denudation. The high lands of Australia are said to show evidence of ancient glacial action. New Zealand now possesses alpine glaciers, and no doubt but that anciently they covered

her plains. The southern hemisphere is a partially submerged one. If its oceanic floor were exposed to the extent of the dry area of the northern hemisphere, we should see there the counterpart of glacial denudation and drift as exhibited in the latter region. What evidence there is of former glacial action in Tasmania south of Australia, I know not, but probably the phenomenon exists there also. Thus it is quite certain that ancient glacial action did not approach the lower temperate zones in curves now known as isothermal lines, as Mr. Jennings imagines; and consequently the relative arrangement of land and water in the northern hemisphere during the great cold epoch, was not the same as at present. The relations of land and water are constantly changing, and have been doing so since dry land first appeared out of the primitive ocean.

From considerations of this character the astronomical theory of Mr. Jennings, or of any other which implies the loss of solar heat, must be totally ignored. Such extraordinary diminution of the sun's heat, would be a death stroke to organic existence on the globe. Neither plants or animals could endure this almost total darkness of Mr. Jennings. Instead of continuation of many species which could no more endure this protracted loss of light and heat than a baby or a rose, from the Tertiary period to the present time, there would have been a sad hiatus in the chain of life. As soon as the sun had ceased to give out its heat, the air would become still and cold everywhere over the sea and land. No mild currents would circulate over the earth as now, to carry vapors away from the sea. In consequence of this loss of solar heat, oceanic evaporation would be arrested, the source of rain and snow, and of all the glaciers upon the globe. The oceans in the higher latitudes in both hemispheres would freeze up, but glaciers would not continue to grow there. This condition of frost would descend well nigh to the borders of the torrid zone, at least. The equatorial currents would diminish in temperature and therefore in speed as they flowed toward the poles. The mean annual amount of heat of the tropical belt would be so reduced, that the zone in no sense could be said to have been a torrid one. This circumscribing of the natural areas of terrestrial and marine life within the narrow bounds of a few degrees on each side of the equator, is a woefully unphilosophical conclusion. Neither in the sea or on the land could the zoological forms live in the harmonious exercise of their physical functions as nature had ordained. This huddling together of either of the great classes of life, instead of tending to make a "happy family", would certainly contribute to render animal existence as wretched and finally extinct. The astronomical hypothesis of Mr. Jennings which implies a total, or partial darkness even, upon the face of the sun, to account for the glacial period, involves the inference of the simultaneous existence of a great glacier in both polar hemispheres. This also seems to be the opinion of Prof Agassiz.[2] I would further remark that the immense evaporation from the ocean necessary to build up a great ice cap several thousand feet thick covering both hemispheres at the same time, would have drained the ocean to a very considerable extent, and therefore have rendered its waters altogether too salty for a large majority of its inhabitants. In fact I see no escape from thinking that the marine fauna would

[2] "Atlantic Monthly" for Nov. 1863, p 569.

have emphatically been in a "*pickle*" whether dead or alive.[3] These contemporaneous glaciers covering nearly one fifth of the surface of the globe, extending from the poles towards the equator from 40 to 50°, and pouring upon the tropical belt waters of a greatly reduced temperature from the present isothermal point, would also have materially contributed to the extinction of forms of life both terrestrial and marine. The tropical climates would also have been cool, and wet. Drenching fogs and cold rains, with perpetual excitement by floods swamping the land, would have been the condition of the warmest zone of the earth. But an alternation of the glacial age from one polar hemisphere to the other, would but slightly, and perhaps not at all, disturb the harmony of tropical organization for the isothermal equator would oscillate from north to south, or from south to north, as the glacial age shifted.

Nor can a change of locality of the magnetic poles, which is doubtless an astronomical cause, explain the phenomena of remarkable cold in ancient times. These localities are the regions of maximum cold where they are situated. There are two of these poles in the northern hemisphere. One is the North American continent near a point about 70° latitude, and 97 west longitude from London; and the other is in Siberia near Yakutsk just above the parallel if 60, and about 130° east longitude. In the southern hemisphere one pole is about 70° south and 162° east longitude; and the other is not well made out, but probably is to the west of Terra del Fuego, in the antarctic zone. The Magnetic pole of the North American continent according to Kane, is not stationary, but oscillates from west to east from winter to spring when it returns back to the west.[4] That in Siberia is subject a similar movement; and doubtless those in the southern hemisphere are likewise unstationary. The motion of the latter as far as known, are reverse to those of the north, namely, while the boreal move east, the austral oscillate towards the west, and reversely. And this the reader will recollect, is a principle already announced, that all movements on the surface of the earth, are reversed in the polar hemisphere.

As far as ascertained, these poles all exist on land, or ice, and are located near the polar circles. The course of their movements is not yet well ascertained. They are doubtless connected with the diffusion of heat over the surface of the earth. There is also a mean annual variation of the magnetic poles which may be connected with the movement of the geographical pole in space. The moon disturbs the magnetic needle, and the intensity of the action differs with her position in the heavens.

Half a century before the Christian era the Rhine, Rhone, and Tiber used to freeze over, and the Black Sea was yearly congealed as much as our western lakes are

[3] Col. Charles Whittlesey contributed to the American Association for the Advancement of Science in 1867, a paper on "Depression of the Sea during the Glacial Period". He estimates that one fifth of the surface of the earth was covered with ice, which includes both polar hemispheres in an ice cap. Assuming that this ice sheet was 2000 ft thick, it would equal a mass of water 1800 ft thick,as water is one tenth denser than ice and would depress the ocean 360 ft. But the mean thickness of the glacial mass of the northern hemisphere must have been at least 4000 ft and if but one hemisphere at a time, was loaded with ice, the lowering of the ocean would extend the area of dry land south or north as the case might be, so that the balance of vital forces might not have been disturbed by the alternate loading of the poles with ice. Vide *American Naturalist* for Dec. 1867, p. 55.

[4] "Arctic Explorations", vol. II, p. 427.

at the present time. The Rhine furnished rare sport to the savage Teutons in those days. But now snow is unknown in Rome and on the northern shores of the Black Sea. At that time or soon after, and possibly before, Greenland was discovered to be *green*, and a thousand years ago was settled, and was the seat of a great Scandinavian colony. Their navigators carrying priests with them, coasted along the margin of New England, and engraved what they had to say to posterity, on the rocks at Dighton, Mass., and other places.[5] Iceland was settled at the same time, or centuries before, and was covered with a dense forest, while now it is an inhospitable country of a few contented mortals. But whether the amount of the mean annual temperature of localities on continental Europe has materially changed within the last 2000 years, it is difficult to say. The researches of Arago on the climate of France tend to show that it has been apparently stationary for nearly 2000 years; and those of Dureau on Italy for a bout the same duration, tend to a similar result.[6] Notwithstanding these conclusions it cannot be doubted but that a change is actually in progress towards a temperature colder than that of the present time both in the old world and the new. The traditions of the Eskimos as referred to by Dr. Kane may have gone back to the times when the Scandinavians first settled Greenland, though possibly only to a later period, just before the time of the discovery of America by Columbus.[7]

From what facts are thus thrown together, the query might be raised that if the land in the polar zone were depressed so as to bring the continental extremity down to the parallel of 70 or 60, say, whether these northern magnetic poles would cling to the land; and being poles of the greatest cold, would this movement account for the ancient glacial age of the world? The open water of the arctic regions would contribute to the growth of glaciers along the northern shores of this depression, which would be discharged into the northern unfrozen ocean. Let us suppose that an ice belt surrounded the globe of 20 or 30° breadth south of this coast line; a movement along the southern border undoubtedly would take place, during both summer and winter. But in fact with this polar depression of the land, no such an ice girdle could exist. The continent would be warmer than now. This ice belt would necessarily have a time of no progress, from which glacial motion would advance both towards the north and south, a circumstance utterly impossible to exist unless that line of division were a latitudinal chain of lofty mountains like those of northern India; and as no such mountains now exist, we are certain they never did exist. The glacier commenced at the geographic pole, and this it could not do unless the region of the pole was dry land. This glacial mass would present everywhere around the globe, a front towards the south, imperceptibly moving in that direction as it increased in thickness. We have a dwarfed representation of this ancient ice cap, in the existing glacial covering of the south pole. For further discussion of this subject, the reader is referred to Chap. 24 on the motion of glaciers.

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[5] Profs. Rafn and Magnusson Runic Scholars of the Royal Society of Antiquaries of Copenhagen have made out a part of the inscripture on the Dighton Rock to be “on this spot landed Thorfin with one hundred and thirty-one men”.

[6] Somerville’s Physical Geography, p. 275.

[7] “Arctic Explorations”, vol. II, p 160.

Chapter 18
Theory of Mutable Axis of the Earth

Ichthyosaurus & ammonites from the Liassic beds upon the upper border of the continent—Ancient drift referred to the agency of ice floes – Mr. Evans of England on a change of axis—Objections to it—Prof. Pierce's "discovery" on the outlines of continents—The direction of continents and mountains were molded by current deposits—Granite and syenites of the Atlantic coast indigenous rocks—Newton & Laplace on the stability of the earth's axis—Ichthyosaurus and ammonites inhabited the high arctic waters—Rocks transported by earthquake waves, and land floods—Mount Battie conglomerate—Vegetation in the arctic in ancient times—How it might flourish.

There is another theory now having advocates in Europe and this country, which proposes to explain the cause of the boulder drift by a change in the position of the axis of the earth. In 1856 I think, Prof. Samuel Houghton of Dublin University, Ireland, examining the fossils brought to England from the Arctic regions by Cap. McClintock, among which were a Liassic marine Saurian and an ammonite[1] found upon Prince Patrick's Land in latitude 76 1/2° and longitude 117 1/2 west from London, remarked "I am well aware that the question of light in arctic seas will be disposed of by some geologists who will remind us that saurians and probably ammonites were endowed with a complicated optical apparatus rendering them capable of not only using their eyes, not only for the distinct vision of objects, but also of using them under widely different conditions of light and darkness. The only speculation with which I am acquainted capable of solving this *opprobrium geologicum* is the theory of a change in the axis of rotation of the earth, the admission of which as a geological possibility is mathematically demonstrable, and which has had some singular evidence in its favor advanced by geologists. In 1857, I brought forward at the meeting of the Geol. Soc. Dublin, a case of angular fragments occurring in the Carboniferous limestone of the country of Dublin, and explained the phenomenon by ice transportation. In 1855 Professor Ramsay laid before the Geol. Soc. London, a full and detailed theory of glaciers and ice as agents concerned in the formation of a remarkable breccia of the Permian formation of the central counties of England; and

[1] Other ammonites were found at Exmouth Island 22° farther east.

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still more recently, the same agent has been employed by the geological surveyors of India to account for the transportation of materials in geological ages long antecedent to the drift. The motion of the earth's axis would reconcile all the facts known; and it would be regarded as a geological desideratum to determine its amount and direction and to ascertain the course of such movements. The solution of this problem I regard as quite probable."

In 1867 Mr. John Evans presented before the Royal Geolog. Soc. of Gr. Britain a paper with the chemical illustrations on "Possible Geological Cause of changes in the position of the axis of earth's crust" He says "let us assume the earth instead of being a spheroid, was a perfect sphere consisting of a hardened crust of moderate thickness supported on a fluid nucleus over which the crust could travel freely in any direction, but both impressed with the same original rotary motion, so that without some disturbing cause they would continue to revolve forever upon the same axis, and as if they were one homogenous body. Let us assume, moreover, that this crust, though in perfect equilibrium on its center of revolution, was not evenly spherical externally, but had certain projecting portions, such as would be presented in nature by continents and islands rising above the level of the sea.

It is evident that so long as these continents and islands remain unaltered in this condition and extent, the relative position of the crust to the enclosed fluid nucleus would remain unaltered also. But supposing those projecting masses were either further upheaved from some internal cause, or worn down and ground away by the sea and deposited elsewhere, the axis of rotation of the crust of the sphere would be changed in consequence of its having assumed a fresh position on its fluid nucleus, though the axis of the whole sphere might have retained its original direction, or have altered from it only in the slightest degree. Now if all this is true of a sphere, it will also though subject to certain modifications, be true of a spheroid so slightly oblate as our globe."

Towards the close of his paper Mr. Evans remarks, "Without in the slightest degree undervaluing other causes which may lead to climate changes, I think that possibly we may have here a *vera causa* such as would account for extreme variations from a tropical to an arctic temperature at the same spot in simpler and more satisfactory manner than any other hypothesis."

It appears to me to be a matter of impossibility that a revolving globe whose crust is homogeneous in composition, could change the position of its axis as supposed by Mr. Evans. As has already been shown, a revolving globe with loose materials upon its surface, must give them motion in all respects, unless impeded by bodies opposed to the direction of their path, in a manner directly contrary in the two polar hemispheres. I consider this law to be of the utmost consequence to us in the considerations in the alterations of terrestrial climates. It can not therefore escape our attention that the rotary axis of the globe by the working of this law, must be perpetually to one point upon the surface of the earth. For whatever action goes on in the northern hemisphere tending either to depress the crust of the globe or to build it up into mountainous elevations, a similar process must be going forward at the same time in the opposite hemisphere. The fact that there is more water south of the equator than north of it, does not oppose this notion. The widespread agency of the

sea there is met by the united action of the many seas and innumerable rivers in the north.

In the summer of 1857 Prof. Benjamin Pierce of Harvard College, now Superintendent of the Coast Survey, noticed while turning over a terrestrial globe in his library, that the coast lines of the continents and their tropical mountain ranges were more or less coincident with the horizon in their rising and setting. If the north pole be elevated 23 1/2° to correspond with the inclination of the earth's axis, and the globe be turned, it will be seen that the Pacific coast of America rises and sets everywhere about the same time. This is also true of the Atlantic coast; and the principal is applicable to the eastern hemisphere. The form of the continents Prof. Pierce thought, must have been due to the dividing lines of light and darkness. It should be stated however, that Prof. Richard Owen of *Nashville* not Prof. Richard Owen of *London* in his "Outlines of the Continents" published a few months before Prof. Pierce announced this *discovery* embodied much the same observations.[2]

What great influence the interchangement of daily light and darkness could have upon the crust of the earth in giving outline, it is difficult to see, I imagine. If the earth once had a molten condition and is now a cooled globe externally, its cooling and contracting rate could not have been effected by an alternation from light to darkness. It is the opinion of geologists that the azoic ages during which the outlines of the continents originated, were accompanied with a misty atmosphere, and that the oceanic waters had *nearly* everywhere an equitable temperature. There must have been a heated atmosphere previously to the *third day* of creation, as described in the first chapter of Genesis to account for "waters" being in the "firmament", or atmosphere. On that day "dry land" appeared. But even up to the morning of the *sixth* day, between which and the other period, there being but 48 h, the earth could not have been very *dry* so as to need *rain*, having just come out of the sea, "there went up a mist from the earth and *watered* the whole face of the ground", as described in the next chapter. As soon at least, as dry land appeared, there must have commenced oceanic denudation of its shores from the 3rd to the 4th day whether 24 h or 24 millions of years. On this later day the sun appeared, because it is presumed the "mist" had obscured it. Therefore the alternation of *light* and *darkness*, or *heat* and *cold*, could not have had any effect in expanding and contracting the crust of the earth, so as to give the continents outline, because these must have originated *under* the sea, namely they were crystalized and outlined before they appeared as dry land while the globe was a warm one. If the north pole should gradually approach a parallelism with the plane of the ecliptic, and then dip down below as far as it is now above it, the continents would go on changing their forms during this movement, till at last the south would find its lands everywhere assuming the features of the northern hemisphere, and *vice versa*. Thus it appears to me that influences extraneous to the earth, and independent of light and darkness, have molded the features of the earth. We must look for this cause of the trend of the earth's land features, in the influence of the planetary bodies, including the moon, I am inclined to think.

[2] Am. Jour. Sci. for 1858, v. I, p. 130, & Ib. for 1857, v. II, p. 433.

From this fact of the apparent prominence in the trend of continents, it seems that the axis of the earth has not changed since life first appeared upon the globe. It appears to me that the direction of the flow of tropical and polar waters, has been an active agent also in giving direction to the trend of the continents and the mountain ranges. Prof. Bailey of the New Brunswick University, considers the granite and syenites of that province and eastern Maine to be altered beds of aqueous deposits. I think this view is also taken by the Canadian geologists. I have graphite, of vegetable origin, taken from a well blasted 17 ft into the *solid* rock syenite. The surface as already said must have been denuded hundreds of feet. I need scarcely allude to the opinions held by our ablest geologists, that the White Mountains are metamorphic beds, of the Devonian age, possibly overlying Silurian deposits.[3] They are the result of the great oceanic currents flowing north east and south west, which have never been altered from any other direction, throughout the great geological ages of this globe. Had the north pole been shifted a few degrees towards the south, the direction of the Atlantic mountain ranges and the trend of the eastern coast of our continent would also have been changed. The first nucleus of mountain trends, and the subsequent building up in the same line by marine drift, must decide it seems to me, the question of the prominence of the locality of the poles of the globe. Sir Isaac Newton 200 years ago, declared the axes of the earth to be *stable*; and Laplace sanctioned the conclusion. The observations of Profs. Pierce and Owen, if they have any scientific value, confirm also the immutability of the earth's axis.

If therefore there has been a perpetually stable axis of the earth, how is it possible to account for the presence within 14 or 15° of the north pole, of fossils whose analogues are found in other countries much farther to the south, as in England, where circumstances show that the latter region was very warm during their life time, and exposed to daily polar light? The finding of a marine reptilian fish like the *ichthyosaurus*, within the polar circle where there is 6 months day and 6 months night is no objection to the notion of a permanent terrestrial axis. This enelosaurus of Prof Houghton like the modern shark, was not only a predatory fish, but was doubtless to some extent like them a *migratory* animal; and may thus have a wide range over the warm northern seas of the Triassic age, and could have found a sepulcher for ought I can imagine, within the arctic circle during its illumination, as well as in the vicinity of England. The same may be said in regard to the existence of ammonites in the high polar regions. This mollusk was the ancient type of the modern nautilus, and its habits doubtless were very similar. The cephalopods generally are no mean swimmers. A nautilus was taken by Mr. Bennett the naturalist, in the South Pacific ocean, where the water was very deep, and land far away. These ammonites therefore, may have ranged the polar zone during the time of its emersion from darkness. A journey of 600 or 700 miles even, beyond the polar circle. I should suppose no extraordinary undertaking for a fish, though he sailed like Madam Venus in a shell. But even admitting the ammonite and ichthyosaur to have been caught lagging behind the

[3] Loomis' Elements of Geology, p 135, Am. Jour. Sci. for 1861, vol. I. p. 392, Dana's "Man. Geology", p. 384 and 409.

sun, and were immersed in an unpleasantly long night, does not the White Whale (Beluga caloden) which spends its summers in the estuary of the St. Lawrence, pass its winters in the arctic regions? Shall we say that the open polar sea during winter and the sunless season is deprived of living beings with optical organs? No naturalist I think, would venture such an opinion.

As it regards the transporting agency of ice in ages previous to the great glacial period, I doubt the correctness of the conclusion from the evidence so far obtained. The summits of some of the higher mountains of the Tertiary world may have been occasionally covered in high latitudes during summer but I doubt if the hills were sufficiently high to form alpine glaciers, and produce in consequence drifting icebergs. If the Alps, with all the mountains of southern Europe, and Asia, along with the Andes of North and South America were not out of water till the Tertiary age opened upon the globe, what reason have we to conjecture that the northern regions were ice bearing during the Permian period, the evening of the Carboniferous age? In regard to the matter of: "angular fragments" and "breccia" as mentioned by Prof. Houghton, which are synonymous terms and opposed in definition to that of conglomerate or rounded material of rocks, such masses are by no means exclusively suggestive of transportation by ice. All oceans since dry land first appeared, have doubtless had shores along which some *angular* fragments must have lain, detached from precipitous bluffs by the undermining process of oceans waves. Earthquakes such as have occurred in modern times, have thrown the ocean upon the land, whose *undertow* has swept vast quantities of shingle more or less angular, back into the ocean.

Mount Battie in the town of Camden, affords a remarkable instance of brecciated and water-worn materials. Some of these fragments are angular like the "grout", or rejected rocks near our granite quarries. Was this vast mass of cemented material now a thousand feet thick, and of unknown depth, whose top has been degraded to a great extent, also transported by the instrumentality of drift ice, like the scattered fragments of Prof. Houghton? A local flood indeed, might be an efficient agent in scattering angular fragments far and wide over a country, as occurred a few years ago in the Sacramento Valley, and last year in Italy and Switzerland. I am certainly a believer in the wonder working of ice, and very grateful I am for its achievements, in that it has given us a grand country widening way up in the temperate zone, where we can raise excellent grain, hay, and potatoes, and as a consequence healthy bread, butter and babies; but I must be excused from holding the opinion of Prof. Houghton, that drift ice was common and extensive in ages long anterior to the commencement of the Tertiary period. But this opinion I find, is not the most radical in the same direction of the past. A late writer thinks "the earth began as a small, *cold*, dark body", and that it had a thick cuticle of *ice*, before it began to sweat much, and show signs of life.[4]

The growth of coal plants within the arctic circle, can not be well explained, as transported material through the agency of rivers. But even this phenomenon might

[4] "Atlantic Monthly" for February 1869, p. 226.

occur to some extent, examples of which are given by Sir Charles Lyell.[5] If the forest of Maine ten miles in every direction from Mount Katahdin, was cut down, and could be converted into good bituminous coal, and spread out evenly over the ground on which it grew, it would not make more than 1 in. of coal. The material of all the coal fields grew on the spot, as a general thing. If the vegetation of the coal of Melville Island, a dozen miles from the north pole is absolutely similar in all respects to that of the United States, or Great Britain, a strong point might be made in favor of the shifting of the earth's axis. But if this were ever true, the supposition might not be free from doubt. The spruce and the birch of the summit of Katahdin, are so nearly like the species that growing at the base, that by some they are considered identical. There are plants here with us that endure a mild summer compared with that where similar species grow about Hudson's Bay. All the arctic navigators tell us of species of terrestrial animals, which inhabit that region during the winter months, the time of darkness. If animals are fitted to live for so long a time as well in darkness as light, I see no reason to doubt that plants and trees could do the same, if the temperature were favorable. The tropical forests of Brazil are so luxuriant that the sun *never* shines upon the vegetable forms in some places. The ground is so dark, and the air as mephitic as in a tomb. The tall dense growth of trees overshadows all. Now moisture and warmth are the prerequisites for this state of things, and I presume the coal fields of Melville and Disco Islands enjoyed these agreeable requisites.[6] Furthermore, the vegetation of those northern islands was *not* like that of the coal fields on the United States, just as that of North Carolina is not wholly like that of Arkansas, or Maine. These reasons compel me to dissent from the opinions of Messrs. Houghton and Evans, that the axis of the earth are in all probability unstable, and to this cause we must refer to explain some of the remarkable revolutions which the surface has undergone.

[5] "Principles of Geology".

[6] "Am. Jour. Sci. for 1869, vol II. p. 281.

Chapter 19
Continental Upheaval and Subsidence

The facts of the northern drift imply a country greatly more elevated during the accumulation of the material than the present height of the continent—The phenomenon of rock scratching referable only to the agency of glaciers—Examples given where this agency alone could produce them—Variation in direction of glacial action accounted for—The abruptness of the southern brows of hills, and the rupture of syenitic rocks into horizontal sheets, due to glacial action—Facts connected with the grounding of icebergs adverse to the iceberg theory—Beds of fossil mollusks show no drift ice at the time when the animals existed—The orderly distribution of boulders unfavorable to the iceberg theory—River denudation not due to the action of icebergs—River beds once filled with water—Contrast of arctic and antarctic glacier areas—The arctic islands continental and recently out of the sea—North Greenland rising—The North American continent undergoing a similar movement—Europe and Asia subjected to the same process—The north Pacific free of islands, suggests a sunken continent there—Continental movements of upheaval and subsidence regular and therefore under same great law.

There now remains but one theory by which all the phenomena of the boulder drift can be reached, and that is the theory of glacier action. From what has already been said respecting the characteristics of the drift and the accompanying denudation, it is evident that the position assumed by Messrs. Lyell and Miller is a very assailable one. The present relations of land and water of the North American continent, present the approach of glaciers so far south as the existing line of permanent ground frost, crossing the middle of Labrador, and running nearly west across the lower part of Hudson's Bay. A subsiding country which would increase the area of the north Atlantic and arctic waters, would therefore decrease the tendency to form land ice of any kind, and when New England and the neighboring territories were submerged, this northern sea must have been pretty free of glaciers, and therefore could not have been very cold. An elevated country implies a cool one, and there is a greater probability that glaciers then covered it, than there is that they existed in vast abundance and magnitude upon some unknown land to the north while New England was under the sea.

The boulder phenomena of Maine are *sui genaris* in character, and owe their origin to the presence of one agent and the same period. All the facts in the case, I firmly

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believe, are referable to the action of glaciers, and never to icebergs or floe ice. The variation of the lines of striation from a usual course, is local; and this divergence is sometimes witnessed where it can not possibly have been done by floating ice. On Islesboro one of the largest islands in Penobscot Bay, about 4 miles from the lowest end, and above Dark Harbor on the south east side, the scratches upon the upturned slates course to the south east. There is a wide margin of uncovered slates before the steep bank of boulder clay is approached from the shore. The scratching agent passed down a plane of considerable descent. In a field near by to the north, the lines of striation run north-south. At Sabbady Harbor towards the upper end of the town, the scratches can be seen on the rocks about the store and house of Mr. Benjamin Rider. The glacier came down a rise of land to the north of more than a 100 ft; yet the grooved lines on the shore rocks at the harbor run north-south.

The polish and scratch upon the perpendicular wall on the northern part of Vinalhaven mentioned in Chap. 4, could not have originated with icebergs; nor could the two cases detailed, upon the south west corner of Liedbetter's Island, nor yet the deep grooving in the side of an flat ledge near the house of Mr. David Calderwood in the same town. No glacier could exist upon Vinalhaven as an independent mass. At the time it covered the town it must have filled the whole bay, and must have been a part of an *extensive* glacier. Neither could a glacier originate the grooving on the wall in the town of Abbot observed by Prof. Charles H. Hitchcock, unless it had been part of an extensive one. There were no elevated range of hills near to send down into deep valleys vast masses of snow to feed a large glacier. To the north and northwest, the White Hills could not possibly have sent an ice stream so far away. Furthermore if these hills were high enough to be clothed with perennial snow, the low lying country must have been also covered with it, as has been remarked in a former chapter. Perennial snow upon a low country passes into ice, and thus a nucleus would be formed around which in time a glacial mass would grow.

The broken, abrupt appearance of the south side of the hills of Maine, must be referred to the agency of glaciers, as also must be the product of the syenites of the coast into horizontal sheets, or strata. The gentle sloping of the northern extremity of the hills, and of their scoring and general denudation, and also the phenomena of the scratching of the east and west sides of the hills, must have happened entirely through the action of glaciers. The depressions on the floor rock,whether of the lunoid furrows, or not, imply some action altogether different from that of icebergs. It is argued by the advocates of the drift ice theory, that the denudation of the boulder region was performed analogously to that going on upon the Grand Banks. Facts there observed are at variance with the supposition. Fishermen tell us that as the bergs chafe over the muddy bottom of the sea, the waters are discolored for a long distance to leeward; and that *here* they frequently meet with unusual success in taking cod, as the fish rush to the disturbed bottoms to feed upon the mollusks which the passing berg has turned out of their beds. Had the boulder material been formed under the sea, there must have been shell fish inhabiting the waters at the time. The shells broken by the bergs, and those rejected by the fish, would now be found mingled without order in the clay, sand, and gravel. But we see nothing of the kind in our boulder beds. The fossiliferous beds of Maine indicate a sea free of icebergs, or rock

bearing drift ice. A traveler passing from Houlton to Bangor, or from the latter city to Eastport, or across the state in any direction, will find upon the slate formation, boulders chiefly of that kind of rock, and clay associated with it in great beds; upon granite formation, rocks and gravel abound of similar composition. Upon North Haven in Penobscot Bay, composed principally of trappean rocks, trap boulders are everywhere seen. Crossing the Thoroughfare to Vinalhaven, at the northwest and northeast extremities of the town, is a highly altered slate formation, called in the recent geological survey Taconic rocks, which are non-fossil forms, but which I imagine are pre-Silurian. Upon those areas, boulders are found of this highly altered rock. Going south the syenite is reached embracing about 25 square miles. There from 90 to 95 % of the boulders, is Syenite, derived from the beds on which they rest. Still farther south in the extreme south eastern border of the town, there is a narrow band of hornblendic rock. Here the prevailing boulders are of this formation. Upon one of the small islands at the right hand entrance into Carver's Harbor, we see here and there a few granite boulders, which like very white men in tropical regions, have evidently wandered away from their native homes toward the north. They form a marked contrast to the dark hornblendic rocks among which they have for many thousand years reposed. They came from the granite belt just across the harbor to the north. This overlapping of the debris of one formation upon another, but always to a limited extent, is uniformly to the south, and does not look like the agency of drift ice. During the time when the Fox Islands was submerged more or less, no rocks from one formation were carried north upon an other. Had the locality been at the time, the theatre of drifting ice, there would have been more disorder in the dispersion of the rocks. The movement of a glacier grinding the detached rocks into gravel, sand and clay, and removing but a few boulders to any great distance from their native beds, alone is sufficient to explain all these phenomena. The singular fact that granite boulders resting upon the sides of hills or in valleys, generally split up in the same direction as the granite formation on which they repose favors the glacier theory rather than that of drift ice.

In regard to lake and river denudation which the State of Maine exhibits to an extraordinary degree, there is no probability that icebergs could perform a thousandth part of it. The rivers have not been materially eroded since the drift age. The vast breadth of their old basins show that if they were once filled with water, that water could not have been derived from a country whose elevation above the sea was much the same as, or less than, that at the present time. In our southwestern territories and other countries, river erosions have gone on uninterrupted for millions of years, and there we see canyons or sunken river beds, generally of no great width. In the boulder country all such channels have been obliterated by glacial action, and the time since the great denuding era passed away, has been too short to cut deep channels in glacially eroded beds. Niagara River below the falls, furnishes probably the most marked example of past glacial river erosion. Here is a canyon cut nearly 300 ft deep, into the solid rock, and averaging more than 600 ft in width, and 7 miles in length. This gorge has evidently been cut since the last upheaval of the continent, and as the rise of land increases the volume of the river, and consequently a more rapid erosion the progress made in the excavation has not been uniform, supposing the

strata through which the channel has been cut to be of the same kind of rock, or of the same hardness. Sir Charles Lyell who visited the falls many years ago, concluded from data within reach, that the river has consumed not less than 35,000 years since it fell in a similar torrent, into Lake Ontario, at Lewiston.[1] This estimate may not be far out of the way, it no doubt, is not too large.

In order to bring New England within the action of glaciers, we must suppose it to be greatly more elevated than at the present time. It is the extension of land towards the poles of the globe which would increase the mean annual amount of cold there. Theory and observation prove that there is a perpetually open sea at the north pole, while the land for nearly 15° south of it is encased in perpetual snow and ice. At the other extreme of the globe, facts confirm the suspicion that the region is an elevated one and is covered with solid sheets of ice, extending 73° south. It has an icy coast line encircling the globe of nearly 900 miles. It is a dwarfed representation of the ancient great glacier of North America. The progressive movements of this Antarctic ice cap, are radii extending from the pole towards the north terminating upon the bottom of the sea in some places 2000 or 3000 ft deep. It is this polar ice-hood that makes the southern ocean so much colder during the summer season, than in the same latitude at the north during the summer there. The southern glacier escapes without much loss into the open sea, but the glaciers of the north suffer immense waste by the degradation of the bergs before they reach the great polar streams flowing towards the equator. If the southern frigid zone were a landless region, it would be free of ice. Patagonia would be a delightful clime, and a country without snow, whereas if land extended from that zone to Patagonia the southern extremity of South America would be covered with an icecap of great thickness. The Captain of an English vessel reports having seen in September 1868, off Cape Horn, icebergs 5 or 6 miles long and from 300 to 600 ft high.[2] According to Darwin, glaciers came down to the sea on the coast of Chile in latitude 46°40'S; in North America, nowhere I believe as low as 60°; and in Europe about 67°.[3] Thus it is seen that the extent of existing glacial action is greater in the Antarctic zone than in the Arctic one. No iceberg comes out of Baffin Bay, of a great height above water. An iceberg unlike the common ice of rivers and lakes, is very dense and hard, and floats not more than one tenth of its bulk above water. Hence an iceberg from 300 to 600 ft high must be from 2700 ft to 1 mile or more beneath the sea or, as far *below* its surface as Mount Katahdin is *above* it. We thus get an idea of the enormous thickness of the ancient great glacier of North America, which was doubtless much thicker than the contracted sheet now covering the polar lands of South America.

The islands between Greenland and the continent on the west, show that they are continental, or submerged portions of the northern part of North America. *They have come out of the sea in modern times*. During the arctic voyages of Captain Parry, Sir Robert McClure and Captain McClintock, fossil shells of existing species were

[1] See "Principles of Geology" and "Am. Naturalist" for April 1868, p. 77.

[2] Boston Daily Journal, December 17, 1868.

[3] Lyell's Principles of Geology p. 228.

found as high as 500 ft above the sea. The same kinds are now living in the waters of the coasts of Labrador, Greenland, Iceland, Norway and Scotland.[4] Many of these species are fossil in the clays of Maine. Kane thinks the continent of Greenland is *rising* north of seventy seven, and *sinking* south of it.[5] Thus south Greenland has been growing colder for the last 400 years since the Danes have had possession of it, in consequence of the enormous quantities of drift ice passing south along its borders. When the northern part was more depressed, there was less ice there, because of the extensive open sea, whose mean annual temperature must have been higher than at present. The inhabitants of south Greenland are now timid to build their permanent habitations near the sea. Their old boat moorings gradually recede from the shore. Thus the name of Greenland is a misnomer. From the commencement of the modern elevation of the northern part of Greenland and North America the polar basin has been contracting, and the result is extension of glaciers in the north. Polar currents flowing each side of south Greenland would augment in force as their temperature diminished, and this might have tendency to bring the rapidly flowing waters upon the land, and thus there might be no actual subsidence there. The testimony of Dr. A. S. Packard is, that the coast of Labrador lying to the south west of Greenland, has risen in modern times for the distance of 600 miles, from 400 to 600 ft.[6] Upon the opposite of the continent in the same latitude, or at least as far down as Vancouver Island, the same phenomenon of continental rising, is going forward according to the Messrs. Blake.[7] Fossil shells of living species were found 20 ft above the sea near Victoria City. This deposit of fossils was made subsequent to the glacial denudation of the land there. We thus see that there is in process an extensive rising of land, in the northern part of the western hemisphere.

Let us now see what is going on in the northern part of the eastern hemisphere. The coast of Norway is undergoing a general elevatory movement, and at its northern cape, the progress is said to be about 4 or 5 ft in a century. Several places in the northern part of the Baltic are also partaking in this upheaval. The British Islands are also rising, though the border of the coast here and there is washing away, and consequently apparently sinking, from the rapidly undermining character of the formation. A similar phenomenon exists in northern China and Japan, and future observations will doubtless show that the entire orient is rising.[8]

In the North Pacific ocean, there is a significant blank. A great continent it would seem, has emphatically *gone under*, a few islands here and there remaining to attest the fact. But this depressed continent is rising too, it seems. The volcanoes here and there scattered along its border, indicate this upward movement. Thus the movements of continents are more or less uniform, and no see-saw motion exists in circumscribed areas, as has hitherto been imagined. It will ultimately be found that they are under

[4] McClintock's narrations, p. 370.

[5] Arctic Explorations, vol. 2, p. 278.

[6] "Glacial Phenomena of Labrador and Maine", p. 230.

[7] Am. Jour. Sci. for 1867, vol. I, p. 96 & Ibid. for 1868, vol. I, p. 242.

[8] Am. Jour. Sci. for 1868, vol. I, p. 209 & 219.

the influence of some great law and I doubt not the system of continental oscillation will be eventually well understood. We are thus led to the conclusion that when Maine was depressed 500 ft, more or less, all the British possessions in America partook of the movement and the subsequent rise of the continent to its present status. The northern hemisphere then, must have been warmer while depressed than it now is, and was not a glacial bearing region then to any great extent. Therefore icebergs were not the vehicle by which the boulder phenomena of Maine came into existence. Instead of a depressed continent during the glacial age, the counterpart of this must have existed, a greater elevation than at present and therefore an extended territory towards the north as well as east and west.

Chapter 20
The Changeable Relations of Land and Water

The changeable relations of land and water not a new discovery—Views of the ancients upon the subject—The researches of Mr. Charles Darwin and Prof. James D. Dana in the Pacific ocean—A Continent here of great extent submerged 6000 ft—The West and East India Islands rising—The upheaving and subsiding processes of New Jersey—The submerged old river bed of the Hudson—Coast of Maine evidently rising—Rising of land in Newfoundland—Causes of supposed local subsidence in Maine—How they may be accounted for.

The discovery of the changeability of the relations of land and water is not altogether modern. Allusion is made to it by the classic writers of Greece and Rome. The Egyptians and still more oriental nations maintained that their country had come out of the sea. Much of the cosmology of eminent men of ancient times was founded upon observations as well as tradition. The oral process of communicating knowledge, is never short lived among a people of fixed abode however low may be their intellectual condition. The remembrance of the contour of lands, rivers, lakes and seas, live long upon the mind and is given to the keeping of posterity with great minuteness. Modern archeological travelers have found the ancient and royal city of Ur, or Hur, Chaldeas, the birthplace of Abraham, 150 miles from the sea, on the banks of the Euphrates. It was built on the shore of the Persian Gulf. The sediment brought down by this river along with that of the Tigris, *in connection with the uniform elevatory movement of the continent*, has placed this broad margin of alluvium of a 150 miles wide between the city and the sea.[1] The old abodes of the Castile Ethiopians on the shores of Egypt, have receded in like manner, as far from the sea.[2] These changes show that civilized man has been with the earth for a great period. The facilities which the present age affords of carrying observation unmolested and with dispatch into all lands, have greatly amassed facts relative to the subject of the instability of the crust of the globe, and geology naturally seeks to reduce them to a system.

[1] See Baldwin's Prehistoric Nations recently published by Harpers, pp 191–209.

[2] Ibid. p. 267, *at seq*.

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The researches of Mr. Charles Darwin of England, and Prof. Dana of this country, gentlemen sent as naturalists and geologists with the exploring expeditions of their governments, have shown us the instability of the relation of the islands of the Pacific to the sea. In that ocean a continent nearly 6000 miles long and from 1000 to 2000 wide, has sunk in places to the depth of 6000 ft, or more. Nothing now remains but the summits of its mountains, as islands, around whose tops the coral builders are at work upon their calcareous structures. The atoll islands indicate a subsidence, the polyps building around the hill tops as they subside, in the form of rings, conforming to the circumference of the subsiding land. As the summit disappears there is a lagoon formed where it stood. The *rising* islands are distinguished by their irregular coral reefs.[3] We see in these facts the history of our all mountain limestone deposits, scattered over the world. The calcareous caps in New England and the north, have been removed by glacial denudation.

The West India islands are also rising. There are no atolls there. The coral growth is the reef form. The commencement of this action may have been coeval with that of the present elevatory movement of the North American continent. The shells now living there Prof. C. A. Adams in his "Contributions to Conchology" calls them a harbingers of a future continent. These islands were probably once united, and will be so again in future ages. There seems to be a tendency to upheaval of certain Atlantic islands lying between Europe and Africa, and America, beginning at a point as low down as St. Helena, running through Ascension, Cape Verde, Canaries and Azores to Iceland.[4] Perhaps one may have again the mythical long lost Atlantis.

The East Indian archipelago is notorious as a region of volcanic violence. Such action denotes as has been observed, the existence of an elevating movement wherever it exists. All the islands in this region point to a former union with Asia and Australia. This supposition solves a mystery long a source of perplexity to naturalists, namely, the dissemination of continental animals of large size over islands now far removed from the continent, as Ceylon, Sumatra,and Borneo. It could never have entered into the minds of the ancient inhabitants of the south orient, to colonize Ceylon with the elephant, Java and Sumatra with the rhinoceros, Sumatra and Borneo with the great orangutan, and Sumatra with the tiger.

But to return to our own continent, we have in the behavior of New Jersey, an example of the habitual instability of the dry land, and the history of the process of upheaval and subsidence through which doubtless the entire continent has passed from the earliest geological ages. A line drawn from Amboy near Staten Island, southwest towards Camden, near Philadelphia, divides the state nearly into two equal parts. Upon the right of this line looking south west, in the region of the city of New Brunswick is the free stone of the Triassic period. The materials of this rock were deposited upon the ocean's bed. Much of it afterwards came out of water perhaps transformed into stone, and constituted a shore line. Out upon the sea bottoms beyond, newer beds were laid down for a long time, when the Triassic sandstone

[3] Dana's Manual of Geology, p. 587.

[4] Darwin on Volcanic Islands.

of the dry land went back to the sea from which it had emerged many thousands of years before. There it stayed its time allotted by mother nature, and returned again as dry land with beds of deposited matters which constitute the lower Cretaceous formation. But soon thereafter the state manifested another fit of salt water mania and back she went again into the sea, at least as far as her waist. After splashing and soaking in this marine bath for a while, she went out of it, hale and hearty as ever. This period closed up the Cretaceous age. In its later deposits are remains belonging both to the marine coast and the dry land. There is the grave of the mosasaurus, whale like in habits, 30 ft long, and carnivorous. There too are the remains of a huge land lizard, and vegetarian, the hydrosaurus, a leaper like the kangaroo, 25 ft long, and though hideous, innocent enough to be petted by Dr. Barratt's three toed *man* which he thinks lived about the same time on the banks of the Connecticut, or rather on the *bay* of Connecticut, and manufactured lasts for a living! In the old upper Cretaceous dry land, lived also another jumping kangaroo-progressing animal, but by no means so innocent of mischief as his neighbor. His long sharp teeth and hind feet armed with three immense claws, told how he got a living. He was nearly the size of the hydrosaurus, and could leap 30 ft at a bound. His coming down upon his prey "tooth and nail" would indicate a short struggle with the unsuspicious wight that had made his acquaintance. This loelaps could have gone from the Forest City to Chicago in *less* than 30 days, and have jumped his 100 miles in 24 consecutive hours without blistering his feet. Nor would there have been danger of his *funds* giving out!

But *mirabale dictu*! Madam could not abandon the old habit of an occasional bath, and like a fat duck waddled back to the Kingdom of Neptune again. The land like this domestic fowl, needs a *dive* now and then to compose its externals, and to contribute to its perfect growth and beauty. The duck, though it feels more complacent from a thorough bath, is not rejuvenated thereby, but the land is. It acquires new life from the profound aquatic plunge, and appears glorious again upon the theater of subaerial existence. This is the way the earth is renewed.[5] It is a part of the plan which we can not well see through for the want of perfect eyesight, and which paradventure, may perplex beings who *can* see well, though infinitely older than we. The history of New Jersey after this period merges into the Tertiary age preceding the glacial times. There may have been depressions and uplifts during the Tertiary age; but of the regularity and duration of the periods we know nothing. I think New Jersey came gradually out of the sea during this age, and was several thousand feet higher during the glacial age than she now is. The mouth of the Hudson now is at New York City. It has been ascertained by the Coast Survey, that it once was nearly 200 miles farther to the south, and about 160 miles to the east of New Inlet on the coast of New Jersey. Of course the state was then bounded on the east by the river, and was wider by this 160 miles. It appears evident that the denudation of the river bed could not have been effected while under the sea as now, at least 700 ft deep to its mud, beneath the surface of the ocean. The plain translation of the facts seem to be as above supposed, that the state came out of water at the close of the Tertiary period to a greater extent

[5] Prof. E. D. Cope in Am. Nat. for Dec. 1867, p. 23.

than before, and that the banks of this submerged river were dry land. Whatever width and depth this bed may have had during the Tertiary times, the erosion was about completed during the glacial age. When this age passed away, the land returned again to the sea and has not since fully come out of it. I would say before taking farewell of New Jersey, that evidence is said to exist which indicates another subsidence, though Prof. G.H. Cook of the Geological Survey, has said according to Dr. Dana, that there is a general rising of the land, as on the New England coast.[6]

Our older seamen from Eastport to Cape Cod, tell us that the sunken ledges are "growing" as they understand it, that is, the water over them is *shoaling*. This is their experience since they were boys, and their fathers told the same story. I have had for 20 years, repeated conversations with seamen upon this matter, and their testimony was all to the same purpose, that the sea bottom is rising. The Newfoundland *Times* newspaper a few years ago, made the statement that "the neighborhood of Conception Bay, and very probably the whole island, is rising out of the sea at a rate which promises at no very distant day materially to effect, if not to render useless, many of the best harbors on the coast. At Port de Grave a series of observations have been made which undeniably prove the rapid displacement of the sea level in the vicinity. Several large flat rocks over which schooners might pass some 30 or 40 years ago with facility, are now approaching the surface, the water being scarcely navigable for a skiff. At a place called the Cosh at the head of Robert's Bay, upwards of a mile from the shore, and 17 ft above its level, covered with 5 or 6 ft of vegetable mold or peat, there is a perfect beach, the stones being rounded, of moderate size, and in all respects similar to those found in the adjacent washes". The gentlemen of the geological survey of the island, made since the above article was written, are of the opinion that all the land there is rising, as on the continent.

I do not consider the facts of local sinking of land as effecting the evidence of an existing process of general upheaval of the northeastern border at least, of our continent. There is no probability that these cases of supposed actual subsidence, are deep seated. A grand dynamical action of subsidence or upheaval, effecting a hemisphere, a continent, or a part of a continent, excludes the idea of profound local cavities into which a few acres of the surface of the globe may sink at any time. A continent 3000 miles wide from the eastern shore of Newfoundland to the western shore of Vancouver Island, does not swim on an ebbing and flowing ocean of fire. Nor did the loading up with ice of the northern hemisphere have a tendency to depress the land I imagine, nor could the accumulating materials upon the bed of the ocean, have exerted a corresponding influence there. The crust of the earth ought to be far more stable than is generally admitted; and it seems to me that igneous action as generally understood, cannot extend much below marine deposits, and that where these are actively augmenting there we may look for the nucleus of volcanic force. I can not but adopt the opinion of many astronomers and some geologists, that the crust of the earth is of great thickness. I am less afraid of the internal fire, than of the external water.

[6] Dana's Man. Geol., p. 587; also Cook's Geology of New Jersey.

All the cases of supposed local subsidence existing in Maine so far as I know, are located along the coast, and are peculiar in deposited material. There is a locality of this supposed action at Vinalhaven at the head of Lane's Creek. The place is now overflowed by higher tides. A marine clay rests upon the scratched surfaces of the rocks. Over this is a mass of peat clay, from 1 to 2 ft in thickness. The peat is in process of denudation by the high tides, which never cover more than the fourth of an acre, unless when some extraordinary severe northeast wind drives the sea into the creek in great "bores" 2 or 3 ft higher than usual. This inlet though about half a mile long, is so narrow that a stone can be thrown by the hand across almost any part of it. It is bounded on the west by the first hill described in Chap. 2. I have been told that when the quarry wharf was built on the eastern side, logs were discovered imbedded in the tide mud, and that some of these had the appearance of having been grooved. The conclusion was that there had been a beaver dam at some remote period at the upper end of the creek, into which a small brook empties. Be this as it may, I have no doubt but that a part of the creek was once filled up by fallen trees where now the tide flows freely, and that vegetation finally overspread the locality. It would require a very little more than the denudation of the peat beds to let the high tides into a swamp at the head of the creek, of 2 or 3 acres of surface overspread with bushes and large soft wood trees, as juniper, spruce and fir. The breaking away of the obstruction or dam, giving access to the sea, is the agent I believe, by which the peat interspersed with large sticks, small logs, and stumps, has come within reach of the marine waters.

Upon the northeast corner of Vinalhaven between the residence of Messr's Jesse and Jerry Calderwood, there is a sea wall enclosing a pool of perhaps a third of an acre and 6 or 8 ft deep, without a direct communication with the sea. If this pool of brackish water should be filled up with the wash of the high bank of old land above, and finally be covered with a growth of peat and bushes, and thereafter the sea wall should be washed away, there would then be one of those cases of apparent local sinking of the land.

Upon the western side of North Haven, a mile or so below Pulpit Harbor, during the great storm which carried away the light house upon Minot's Ledge, upon the coast of Massachusetts, the sea threw up an immense beach during 24 h, to the height of 6 or 8 ft above the reach of common tides. Thousands of tons of water worn rocks are there piled together, some of which would weigh 2000 or 3000 pounds a piece. Many years before, I was told, a similar phenomenon occurred, and thereafter a few years another storm entirely demolished the sea wall. Behind the present wall is a small cove, which in time may fill up with peat and be overspread with bushes and trees.

There is a locality of increasing vegetable matter below the level of high tides, in the southern part of the Thoroughfare of Isle au Haut. The mouth of a small cove has been obstructed by a high beach thrown entirely across it, part of which has been built up within my recollection. The material of which it is composed, and the aspect of the wall, resemble the "horse backs" of the state. There is a singular wall at the northern head of Moore's Harbor upon the same island, affording a pool sufficiently large at high water to accommodate quite a fleet of small crafts. The

wall is beyond the reach of common tides, and is I should judge, about 300 yards long. The rocks here are not so large as at the sea wall near the Thoroughfare. At the eastern extremity, the overwashing waves which carried forward the shingle, found an outlet, and a small brook now keeps the passage open, and prevents the rapid growth of terrestrial vegetation within the pool.

There is a wall similar to this upon Gott's Island south of Tremont. It encloses a pool in which I saw a schooner of 50 t lying secure from wind and waves and afloat at low water.

There are examples of apparent subsidence on the north east corner of Jewell's Island in Casco Bay, at Ragged Island off Harpswell, and at the mouth of a tide river in Scarborough, near Portland.[7]

The case cited by Mr. Lewis before the Long Island *Historical Society* indeed looks like existing subsidence. But this depression of the land bearing terrestrial vegetation, may have taken place at the time of the last general submersion of the continent beginning at the close of the glacial period. When farther researches shall be made, geologists will be better able to pronounce upon this case of supposed subsidence of land.

In generalizing the facts of this and preceding chapters we see in process a widespread movement of upheaval of the land in the northern hemisphere, and a subsidence, though not corresponding with it in extent as yet known in the Pacific Ocean near the equator. If this displacement and return of the sea are periodical and regular the facts will be ultimately known and reduced to a system, and we shall see where the axis of oscillation is. It does not seem plausible that the crust of the globe is subjected to periods of irregular convulsions, by which great changes in the relation of land and water are effected. It is to a cause thus hinted at I believe, that we must look for the explanation of the origin of the elevation of land in the polar hemisphere, by which the glacial ages were introduced, and perhaps all the great geological ages of the globe.

[7] See Dana's Manual of Geology, p. 587.

Chapter 21
Supposed Cause of the Cold Period

Compound motions of the earth as a planet—Form of the earth's orbit—Great periods—No perpetual summer—Precession of the equinoxes—The polar star to pass away from its present place and other stars Vega, or Alpha of the Lyre to become pole star—Precession explained—Advance of the line of apsides—Extract from the work of Figuier—The same views as therein given advocated by Sir Richard Phillips over 30 years before—The effects of precession not sufficient to account for the evident duration of the cold period of North America—The cause to be hunted out by astronomers hereafter.

I shall now give the opinions of some mathematicians upon the result of some of the oscillations to which the earth in its movements in space is subject. The ordinary reader probably may not be aware that besides the two common motions of the earth which are familiar to everyone there are motions of perturbations, which it is claimed by those men, may derange the existing order of arrangement of land and water on the globe. The present form of the earth's orbit is nearly that of an egg; but this ellipse is decreasing, and in 500,000 years hence, the orbit will be quite circular; and after that time, it will go on compressing till it becomes flatter than it is at present. This elliptical path in which the earth travels round the sun, has two foci, or points around which the orbit is drawn. The sun is in one of these foci. The passage of the earth around the sun in the southern part of its orbit where the luminary is *now* situated, is called *perihelion*, and the northern point of its orbit is termed *aphelion*. The poles of this oval figure of the Earth's orbit, or its longest diameter are called *apsides*. The perihelion of the earth's orbit, and of all the planets, is moving around the sun, and completes its revolution in 111,000 years. There is a retrograde motion of the point of vernal equinox, called the precession of the equinoxes, which is completed in 26,000 years. The passage of the equinox with the perihelion occurs once in 21,000 years. Five of these revolutions equal one of the perihelion point.[1] Besides these motions of the earth, there are changes going on in respect to the inclinations both of the axis of the earth, and of its orbit. The inclinations are decreasing at the rate of 45 s a year or 1° in 80 years, according to Bessel. Their angles are always

[1] The first is 109,830 years; the second is 20,984 years; the third is 25,920 years.

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the same. This motion is chiefly effected through the influence of the planet Venus; but no doubt the phenomena is complicated, and that not only Venus but all the other planets mutually effect each other according to their masses and position in their orbits. But the axis of our earth it is said, can never become perpendicular like that of Jupiter's, which if this could be the case, would confer on the earth perpetual summer everywhere over its surface.

The precession of the equinoctial points, is occasioned by the influence of the sun and moon upon the equatorial matter of the earth, but chiefly by that of the latter, whose force in this respect is two and a half times that of the sun, and the action of this united force, is to draw away the pole of the earth from the north star, and finally to carry it far off. The peculiar motion which the axis of the earth make during his progress is called *nutation*, or nodding, because the pole in making this great revolution, has an undulatory action like the handle of a top, just before it ceases to spin. This unequal influence of the sun and moon, is balanced every 19 years. There are therefore, about 1364 of these nodding curves made by the terrestrial pole while completing its revolution. The polar star, or north star, as it is generally called, is now about one degree and a half from the point where the geographical pole pierces the heavens. The pole will go on pointing nearer and nearer to the north star till it comes within half a degree of it. It will then begin to recede from it, and will have pole stars till it gets within 5° of Vega, the Alpha of the constellation Lyre. This will happen somewhere not far from the year of our era, 15,000. If we should about the middle of September, and half past six in the evening, turn our eyes to the heavens, we should in the neighborhood of Portland, see this beautiful constellation over our head, but a little to the south. Its brightest star Vega, is nearly fifty one and half degrees from the real place of the north pole, or 38° and 38 s declination north. It is a burning sun 55,000 times larger than our luminary of the solar system. This cluster of stars, the Lyre, furnishes some remarkable phenomena. Beta, about 9° to the southwest, is a variable star, changing its brilliancy from the third to the fifth magnitude in 6 days and three eighths. There are also four suns in the constellation which revolve around each other in pairs. The revolution of one around the other is completed in 1000 years, and in the other case, in 2000 years, while one pair revolve around the other in a million of years. Seven degrees south of Vega, is the great ring nebula, a universe of stars, larger perhaps than the milky way. Its light does not reach us in less than 20,000 or 30,000 years. This procession of the equinoxes, as the name implies, is the falling to the west, or going forward periodically, by a small annual amount of the points where the sun crosses the equator. It is about 50 s a year, or a degree in 72 years, and the space of one whole sign in 2160 years. Thus the stars that rise and set to us in certain seasons of the year, in a thousand years will not do so, but will fall far behind or towards the east. If we retain our months, the seasons even will not be appropriate to their signification. Once the sun crossed the equator in passing from the southern to the northern hemisphere on the first day of March; now it is the 20th, or properly the 21st day. In a little less than 2000 years the spring will commence with the middle of April, and so on, till the first day of January opens with the spring; and in process of time the fourth of July will happen in winter, which on the whole, will be considered a good *move* as young America will find it more

difficult to set fire to a great city in winter than in summer, as was the case with Portland in 1866. With some writers it is the precession of the equinoxes, and with others it is the progression of the line of apsides and the diminution of the obliquity of the earth's orbit, which is to bring about the return of the waters upon the northern hemisphere, or a cold period, according to their fancy.

Having premised thus far, I shall now introduce some extracts from a French work by Luis Figuier, on popular geology. It has not been printed in this country I believe. The design of the article is to prove that there will eventually be another flood like Noah's; which was a natural event with the writer, and whether a miracle or not, to speak after the style of some of the sons of the Emerald Isle. The great changes of dry land to immersed countries, are attributed to this slow working of the pole of the earth away from the commonly supposed fixed point in space. This movement is presumed by the writer to explain the glacial period. The entire article was written by a Monsieur Mangin and copied into Figuier's work:

> A learned French mathematician Adhémar, seeks to explain the deluges by the laws of gravitation and celestial mechanics, and his theory has been sustained by many competent writers. It is this, we know that our planet is actuated by two essential movements, one of rotation on its axis, which it accomplishes in twenty four hours, the other of translation which it accomplishes in a year. But besides these great and perceptible movements, the earth has a third, and even a fourth movement, with one of which we need not occupy ourselves, it is that designated *nutation* by astronomers. It changes periodically but within very restricted limits, the inclination of the terrestrial axis to the plane of the ecliptic by a slight oscillation. The other movement is that on which Adhémar's theory is founded.
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> We know that the curve described by the earth in its annual revolution around the sun, is not a circle, but an ellipse, that is, a circle slightly elongated, sometimes called a circle of two centers, one of which is occupied by the sun. This curve is called the ecliptic. We know also that in its movement of translation the earth preserves such a position that its axis of rotation is intersected at its center by the plane of the ecliptic. But in place of being perpendicular, or at right angles with this plane, it crosses it obliquely in such a manner as to form on one side, an angle of one fourth, and on the other, an angle of three fourths, of a right angle. This inclination is only altered in an insignificant degree by the movement of nutation. I need scarcely add that the earth in its annual revolution, occupies periodically four principle positions on the ecliptic, which mark the limits of the four seasons. When its center is at the extremity most remote from the sun, or in the points of aphelia, it is the summer solstice for the northern hemisphere. When its center is at the other extremity, or points of perihelia the same hemisphere is at its winter solstice. The two intermediate points mark the equinoxes of spring and autumn. The great circle of light and shade passes, then, precisely through the poles, the day and night are equal, and the line of intersection of the plane of the equator and that of the ecliptic, makes part of the vector ray from the center of the sun to the center of the earth, what is called the equinoctial line.
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> Thus placed, it is evident that if the terrestrial axis remained always parallel to itself, the equinoctial line would always pass through the point on the surface of the globe. But it is not absolutely thus. The parallelism of the axis of the earth is destroyed slowly by a movement called *nutation*. This movement has the effect of making the equinoctial points on the surface of the earth, retrograde so that at the end of more than twenty five thousand years, they will have made the tour of the globe. This has been called the Great Year.
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> Now we know that the consequence of the inclination of the terrestrial axis upon the plane of the ecliptic, is *first*, that the seasons are inverse to the two hemispheres, that is to say, the northern hemisphere enjoys its spring and summer, while the southern hemisphere passes through autumn and winter. *Second*, it is when the earth approaches nearest to the sun, that

> our hemisphere has its autumn and winter and the northern polar regions are plunged into darkness during six months. *Third*, it is when the earth is most distant from the sun, when much the greater half of the ecliptic intervenes between it and the focus of light and heat, that the pole being now turned towards this focus, constantly receives its rays, and when the rest of the northern hemisphere enjoys its long days of spring and summer.
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> Bearing in mind that in going from the equinox of spring to that of autumn of our hemisphere, the earth traverses a much larger curve than it does on its return; bearing in mind also, the accelerated movement it experiences in its approach to the sun from the attraction which increases in inverse proportion to the square of its distance, we arrive at the conclusion that our summer should be longer and our winter shorter than the winter and summer of the southern hemisphere, and this is actually the case by about eight days.
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> I say *actually*, because if we now look at the effect of the precession of the equinoxes, we shall see that in a time equal to one half of the Great Year, the conditions will be reversed, the terrestrial axis will have accomplished the half of their bi-conical revolution of the center of the earth. It will be the northern hemisphere which will have the summers shorter and the winters longer, and in the southern hemisphere the reverse. In the year 1248 before the christian era according to Mons. Adhémar, the north pole attained its maximum summer duration. Since then, it has begun to decrease, and this will continue till the year 7388 of our era, before it attains its maximum winter duration.
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> But the reader may ask, fatigued perhaps, by these abstract considerations, *what is there here in common with the deluge*? The Grand Year is here divided for each hemisphere into two great seasons, a great summer and a great winter, each ten thousand five hundred years long.
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> During the whole of this period one of the poles has constantly had shorter winters and longer summers than the other. It follows that the pole which submits to the long winter undergoes a gradual and continuous cooling, in consequence of which the quantities of ice and snow which melt during the summer, are more than compensated by that which is again produced in winter. The ice and snow go on accumulating from year to year, and finish at the end of the period by forming at the coldest pole, a sort of crust or cap, vo1umnious, thick, and heavy enough to modify the spheroidal form of the earth. This modification as a necessary consequence, produces a notable displacement of the center of gravity, or for it amounts to the same thing, of the center of attraction, around which all the heavy masses tend to restore it. The south pole finished its great winter in the year 1248 B.C. The accumulated ice there added itself to the snow, and the snow to the ice, at the south pole towards which the watery masses all tended until they covered nearly the whole of the southern hemisphere. But since that date of 1248 before our era, our great winter has been in progress. Our pole in its turn goes on getting cooler continually; ice is being heaped upon snow, and snow upon ice, and in 7397 years (from 1855) the center of gravity of the earth will return to it normal position, which is the geometrical center of the spheroid. Following the immutable laws of central attraction, the southern waters accruing from the melted ice and snow of the south pole, will return to invade and overwhelm once more the continents of the northern hemisphere, giving birth to new continents in all probability, in the southern hemisphere.

The inference drawn from this elucidation of our precessional movements of the earth's equinoctial points, seems to be that the hemisphere which contains the most water derived from melting ice is the winter hemisphere for the time being, namely for l0,500 years; that by and by, our northern hemisphere will be deluged with water, and will then have its grand boreal season somewhere about the year of the Christian epoch, 9252. In a work lying before me published by Sir Richard Phillips in London in 1832, he says speaking of the earth's perihelion, "it crossed the solstice of Capricorn in 1295 and the equator in 3938 B.C., causing the flood of Moses, and it will cross it again in the year 6528." He makes use of the number 20,93l,

and Adhémar of 21,000 for the sake of convenience. So the progression of the seas from one hemisphere to another, is not a *new* conjecture or theory, it would seem, as Figuier would apparently have us believe. Indeed, I consider it an absolutely absurd conception, that the accumulation of waters in the northern or southern hemisphere could make the region *cold*, and consequently ice bearing, in proportion to its load of waters. I conjecture the very reverse of this circumstance to have taken place. Whether a tropical revolution of the earth's major axis would produce the effect above imagined, that is, of rocking the waters of the globe alternately upon each hemisphere. I am unable to pronounce an opinion, but I have no doubt but that some important effect upon the aqueous and aerial envelopes of the earth would follow from this cause. But this period is not sufficiently long to account for grand ice ages of the world. The known distances of the transportation of boulder drift material in the Penobscot Bay, is a 150 miles. If the glacier moved 100 ft a year, it would require about 8000 years for the transportation.[2] In the west, drift rocks are known to have been moved 6000 miles. One fourth of the 21,000 years of Adhémar for the real winter of the Great Year, would give but 5250 years. Or if we add the coldest part of autumn and spring to the winter, and divide the whole into a cold winter and hot summer, we cannot get a duration commensurate with the demands of facts connected with the great glacier ages of the globe. Prof Dana thinks the islands, or the submerged mountains of the Pacific, have subsided 6000 ft. His conclusion is that the rate of subsidence, or elevation, is only about one eighth of an inch yearly.[3] But if 1 in. were allowed 72,000 years would be consumed in the movement of the subsidence, completing but *half* of a great revolution, of subsidence and upheaval. The evidence is conclusive, that the general movements of the terrestrial crust in this respect, or rise and fall of oceanic waters, have been *uniform* and very *slow*. No! no revolution of the earth's oscillation as given by Monsieur Adhémar can explain the advent and departure of the Great Cold Period of the northern and southern hemispheres. That the cause of the coming of this epoch was an astronomical one, somewhat akin to that of Mon. Adhémar, I have but little doubt. By and by the question will be taken up by the geological astronomer and will I firmly believe be completely solved.

[2] 7920 years.

[3] Manual of Geology, p. 591.

Chapter 22
Geologic Record Since the Devonian

A continuous deposit of rocks assumed for Maine between the Devonian age and the commencement of the glacial epoch—Remarks of Prof. Charles H. Hitchcock upon the subject—Great thickness of glacial denudation of the surface of New England assumed—Carboniferous, Triassic,and Cretaceous times—Tertiary Period, and its times described—Its animal life and vegetation.

Having now shown I trust, a strong probability of a general upward movement of the continent of North America to account for the glacial age, I shall endeavor to trace out the assumed growth of the country upon what imperfect data remains to us, from the deposits of the Devonian rocks to that of the later ages which immediately preceded the introduction of the period of violent cold. Prof. Charles H. Hitchcock remarks concerning the formations of Maine "between the Devonian and the alluvial periods, there seems to have been no deposition of strata. Her history during this period is a total blank."[1] This unique hiatus of intermediate deposits, can not be justified on other grounds I think, than the supposition that they have been removed by glacial denudation. If there has been erosion of the rocky floor of New England to the amount of 1500 ft which Pres. Hitchcock conjectures has taken place in the valley of the Connecticut, assuredly the denudation was not less in the State of Maine.[2] The greater part of the rocks of this state is not more difficult of erosion than those of that locality. Prof. Ramsay when Director of the Geological Survey of Great Britain, gave the opinion from personal examination of the evidence of glacial denudation in the kingdom, that from 3000 to 10,000 ft in depth of the surface rocks had been removed; and remarked that "the matter torn from above the present surface was far greater than all which still remains above the level of the sea."[3]

From a brief examination of the rocks of New England, one finds it difficult to imagine a great loss of surface. Her formations are folded and tilted in different directions and seldom furnish reliable data to estimate loss by denudation. The conclusion however, is inevitable that nowhere in the northern states has there been a greater

[1] Scientific Report for 1861, p. 256.

[2] Elements of Geology, p. 227.

[3] Memoirs of the Geological Survey of Great Britain, vol. I, pp. 297 & 335.

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loss than in the State of Maine; and what ever may be justly said of the degradation of the surface of Great Britain, there is no probability that it has been of greater extent there than in this part of New England. All geologists are agreed that the climate of the British Isles from the commencement of the Tertiary period at least, has always been milder than that of New England for the time; and we may plausibly suppose that it was less vigorous during the glacial age than ours, or in other words, that glacial action there was not so intense as here, and consequently the denudation was not so great.

From the fact that the most distant islands of the coast of New England were swept by the great glacier, we may presume that the pre-glacial deposits of the mesozoic and cenozoic times do not exist off our coasts more than upon the dry land. The rocks of New England have registered no facts assuring us that the land rose at a single leap out of the sea nearly to her present status, at the close of the paleozoic age. We may then assure ourselves that her action of upheaval has been conformable in regard to slowness, with that of other lands. There seems to be therefore no escape from the conclusion that all the series of rocks from the Devonian age to the close of the Tertiary period must have been laid down in their order as found in other countries, while the State of Maine was rising out of the sea. Throughout this vast breadth of time, the seas teemed with an infinite variety of life. That which died in the sea, was buried in the sea; and that which died upon the land, was sometimes interred in the ocean. The sudden rise of rivers and the deluging of plains doubtless carried to the estuaries and the sea, terrestrial animals in those remote times, as these phenomena of the globe are known to do in the age in which we live. This accident of death and burial must have occurred along the coast of Maine, and the tombs of the ages were scattered up and down the land before the glacier reached New England, from the White Mountains to those hills now covered by the distant sea. I object *in toto* to the supposition, that when the glacial age set in, the Devonian rocks were within reach of the ocean or buried by its waters. I have sufficiently beat over this ground and shown I think, that such depression of the country never could have brought in the glacial age.

The order of sequence in the deposition of the rocks of Maine would be that when the older formation were finished, as of the Devonian and previous ages, and were partially perhaps, raised beyond the reach of the sea, the submerged lands that had been belted and capped with coral formation constituting the mountain limestone, were coming out of the ocean also; and that in the swamps, savannahs and jungles about the fresh water lakes, of the interior of the country and the margin of the sea, the vegetation of the Carboniferous age took root and grew vigorously as now along the low lying lands of the tropics. The fact that Pennsylvania, Massachusetts, New Brunswick, Nova Scotia, and Melville Island in latitude 77° north had all a vegetation so similar as to be referred to the same period, shows there must have been connection more or less uninterrupted along the coast.

These beds of vegetable matter had their periods of elevation and depression throughout a vast period of time and finally the Carboniferous age passed away in respect to the coast of New England by the general growth of the continent, and the consequent decrease of the temperature of the climate. The denudation of land by

oceanic and fresh water agencies always in motion, as well as the crystalizing forces perpetually in existence, and generally slow in operation in the mineral deposits, tending to flex the crust of the earth, must have tended perpetually to change the relations of the land and sea, in every direction of the continent. In a certain sense, nature makes an effort to repeat what she has already achieved, but perfect repetition can not occur, because matter can not be placed in its former circumstances. Progress through never ending changes, is a principle underlying all the operations of nature.

Thus it would seem that there has never been a blank in organic existence from the time when life first appeared upon the globe hundreds of millions of years ago, to the present age. Over large areas, and possibly over large continents, terrestrial fauna and flora have totally perished by periodic but slow submersion of the land, and consequent alteration of climates. But terrestrial life returned with the reappearance of dry land. In this process of subsidence and upheaval, the change in the character of the deposits would be so great during the protracted age of the oscillation when the fossils of the two completed periods of elevation were compared, it would seem that there had been entirely a new creation of life. I do not make this conclusion as favoring development theories of Mr. Charles Darwin and others, but simply against the supposition that great catastrophes have occurred upon the globe universally fatal to animal life, and were succeeded by a repeopling of land and sea. The supposition of repeated cataclysms and total renewal of life ages militates as much against the infinite wisdom and power of creation, as it exhibits these attributes. He who is able to govern a universe, could imbue it with animal life, most assuredly. And the creation of a microscopic animal displays a foresight as profound as the creation of Man. Though between the two the range of destiny is infinite, the wisdom manifested in the system of means by which both attain the ends of the creation is absolutely inconceivable to the genius of the philosopher; and this wisdom therefore must have had an origin in an intelligent exterior to, and independent of, the matter of the physical world.

The Triassic beds were laid down upon the beds of the Carboniferous and other ages, and their patches of sandstone, clays and silt from North Carolina through Virginia, Pennsylvania, New Jersey, Connecticut, New Brunswick and Nova Scotia, to Prince Edwards Island, argue their former presence also in Maine. A similar State of isolation of the middle Tertiary beds now seen on the Island of Mull off the coast of Scotland, and in Ireland, Spitzbergen, Iceland and Greenland, shows that the ancient coast of the Atlantic ocean from east to west, must have been connected by continuous lands, or separated by no considerable distances.[4] We do not indeed, suppose that when the Miocene flora was flourishing in those distant northern regions, the country of New England had passed through the same epoch of botanic growth. A climate nearly like the Eocene perhaps, extended at this time over our country. And what was said in a former chapter, of the Cretaceous deposits of New Jersey, may also apply to the border of Maine and the crust above, preceding the Tertiary times.

[4] American Naturalist for August 1867, p. 326, and Am. Jour. Sci. for 1868, vol. I, pp. 269–281.

The comparative nearness of Tertiary period to the advent of man, originates in the fact that its later animals passed through it and lived for a time coincident with him. Some of its earliest marine shells now exist in the seas of this and other continents; and its terrestrial and marine animals generally, wore a decided modern aspect. It was compared with the expressions of time in the great past, mammalian age of the world. As a large part of New England was under the sea during this period, there could have been no great rivers in the country. The Hudson was not a river, but a narrow channel through which a branch of the arctic waters communicated with those that flowed along the eastern coast of New England, by way of Lake Champlain which was a valley depression, and by no means so capacious as at present. Glacial denudation enlarged it to a great extent in after times. New England was therefore an island along with New Brunswick. The early Tertiary sea covered a large part of Canada, and extended to the great lakes of the west. The Missouri, Mississippi and Ohio were the principal rivers of the continent. It is probable that upon the north there were the McKenzie and a few other rivers emptying into the Arctic Ocean; and some small ones ran from the higher parts of the rising Rocky Mountains, discharging their waters into the Atlantic and Pacific oceans. Some of the later river beds of the age, have never been covered by glaciers, and show the undisturbed flow of their waters for millions of years, by deep channels called canyons. The Gulf of Mexico extended as high up as the mouth of the Ohio river, and in the early part of the period, is supposed to have had communication with the Arctic Ocean, by the low lands west of the great lakes. The Rocky Mountains were no such lofty peaks in those remote times, as they are now. During the Eocene era, the first division of the Tertiary period, those mountains were nothing but a chain of islands, as were the Alps and other mountains of southern Europe at the same time, and as the West Indies now are. The Alleghenies must have formed a well developed chain of hills, and embraced under the designation of Appalachians, extended into northeastern New Brunswick. It is doubtful whether snow had fallen as early as the Eocene epoch in North America, certainly not in New England, for the British Islands had her monkeys, and could not have been more than a few degrees warmer than the former region. The temperature of the polar waters circulating around the coast of New England during summer must have been as warm as now flow along the shores of the Carolinas.

The islands of the coast of New England at last began to emerge from the sea, to be connected, and to assume the character of hills in the Miocene era. A little snow now and then mantled the hills of the country. They were toothed, rugged and torn as the Rocky Mountains now are. The rough and contorted hills of shale and limestones had been worn and hollowed out by the sea while within its reach, and among their doleful gorges, glens and caverns, reptiles and wild beasts had their habitation.

In the vegetation of this Miocene epoch, new formed fossil in the United States were species belonging to the maple, oak, hickory, poplar, magnolia, cinnamon, northern palms &c. In considering the range of such vegetation, we should bear in mind that sometimes within a small province there will occur not far asunder, a strange intermingling of northern and southern vegetation, as now exists in the province of the Holy Land, which is about the dimensions of the State of Vermont. To find the leaves of deciduous highland trees along with those of the palm, buried in

the modern silt in the northern stones of the Dead Sea, would not seem strange to the geologist who knows that the palm anciently grew upon the west bank of Jordan and the waters of that river from the distant north, might have brought down the leaves of the forest shed as the cool winds of autumn shook their branches.

The coast continued to grow broader and the mountains higher. The land everywhere seemed to mass itself into the form of a continent. The country had decidedly got rid of a good deal of its adolescence. It was nearly out of its teens. Everything betokened that by and by it will become a real giant. At length the true Tertiary beds were laid down along the coast of New England, and upon its lakes and river bottoms. The last submergence of the coast preparatory to the glacial epoch, had taken place, and the country let us suppose, stood a few hundred feet lower than now in our own age. The features of the land we may reasonably conjecture were more or less like those of Mexico, Africa and Australia, where the soil is generally sparse and dry. No such soil was in existence then, as now covers the country. New England had indeed some choice gardens, secluded spots on the sunny sides of the hills, or along the meandering streams, or beside the spacious lake, but these were the gift of the vegetable kingdom rather than of the animal one. On some barren spot, the minute seed of a lichen was deposited, and by the means with which the Creator had endowed it, it attached itself to the bare rock and germinated. Its roots absorbing alkali from the rock, it grew and got a steadfast foothold, impregnable to the attacks of the winds however furiously they might blow. By its leaves, that is, the broad margins spread out like open hands of a child, it took also much of its nourishment from the atmosphere. When the lichen wore itself out with constant trot in providing for a numerous progeny, it died and left a rich legacy of a thin layer of vegetable dust upon the rock where it had lived. The invisible seed which it left behind hidden in its own dust, started into life under the fostering care of the sun, and took the place of its ancestor; and thus race after race continued to work and die upon the same ground, till there was left enough of their remains mixed with the disintegration of the rocks which the rootlets of the lichen and the rains of heaven had laboriously effected, for the nourishment of a moss. The moss also ate, grew, and died, and was succeeded for centuries as was the lichen, till there was depth of vegetable decomposition sufficient for the seeds of trees to take root therein and grow. Thus the semi-tropical plants and solitary old evergreens of the Tertiary period, waved here and there over the rocky surface of the country.

It is possible that at this time, some of the modern styles of of terrestrial animals existed, as the panther, wolf, hyena, fox, bear, dog, and apes of great size, among the hilly regions of the country. In the Miocene, crows, storks, flamingos, thrushes and sparrows have been found; and I have no doubt but that a great variety of birds and quadrupeds existed, though the feathered tribes may have been songless like those of Australia. The deer, camel, horse, oreodon, titanotherium (twice the size of a horse) and the rhinoceros, existed in America; and we have no reason to doubt that here also lived at this time the mastodon and deinotherium. Though in Europe it is certain that the great elk, cave bear, northern lion, hairy rhinoceros, modern hippopotamus, hairy mastodon, and wooly mammoth, were contemporaneous with the first races of men, we are not justified in supposing that they appeared upon the theater of life for

the first time with man.[5] The animals below him are longer lived, that is, the duration of the races is vastly greater. The greater the development of brain, the shorter the term of life of the type, I take it.

Besides the lakes and streams, the deer, elk and ox cropped the herbage green and rich. In the open glades and upland roads, the great mastodon, lord of the forest, fed solitary, or accompanied by a few of his species. With ponderous head extended, bearing tusks half a foot in diameter and protruding 10 or 12 ft the lower jaw also armed with short tusks, he reached aloft 25 or 30 ft, and twisted off with his trunk the branches for food, of the maple, birch and other succulent trees. On the high lands and cooler parts of the country, the mammoth, the first elephant and Goliath of his race, fed upon similar trees. His tusks protruding like the modern elephant from his upper jaw, were as long and large as those of the mastodon, but curved outward and upward, and his bulk was two or three times as great as the modern species. The dinotherium, still more bulky perhaps, and covered with hair, along with the hippopotamus, inhabited the lakes and sluggish rivers. The rhinoceros hunted his food in the low stagnant swamps and dozed in the hot sunshine as he lay wallowing in the mire. The camel fed here and then over the dry sandy plains, and the horse and bison roamed droves over the verdant lowlands rich with wild grass. The megatherium, mylodon, toxodon and megalonyx, delved among the succulent roots of the dense forests, and dug about and overturned the umbrageous trees to feed upon their juicy leaves and branches. Lions and tigers roared and screamed in the dark jungles and among the wild solitary hills of the country. Ferocious alligators lived in the sluggish rivers and bayous of the country, and fierce serpents basked upon the naked rocks, and hung from the branches of trees. Great turtles and gigantic lizards inhabited the scattered forests and miasmatic swamps.

In the waters of the coast lived the zeuglodon, a hundred feet long and 10 or 15 in thickness, whale-like in habits, with a long narrow head, and one eye 6 or 8 in. in diameter. Fierce sharks hunted the ocean as long as the zeuglodon, with sharp serrated teeth the size of the hand of man. Dolphins, porpoises, and whales cruised up and down the shores of the country. Birds inhabited the islands of the coast in vast multitudes, and covered its waters all seasons of the year. They filled the forests

[5] The evidence of the existence of the mastodon and mammoth at the same time with man in America, is now placed beyond a doubt, as is that of the wooly mammoth in Europe, coeval with the savage human races there. The traditions of the Delaware Indians mentioned by Pres. Jefferson in his "Notes" p. 79, and of the western tribes given by Dr. Albert Koch a German fossil hunter in this country 30 years ago, in his "Description" of his *Theristocaulodon* (mammoth) p. 10–13, all show that these megatherioid animals did not die out till man appeared. Koch found evidence under the remains of the mastodon and mammoth, by arrow heads and charcoal, that man had been concerned in the death of these animals. Ibid. pp. 25 to 27.
At a depth of 150 ft or more, in the gold bearing gravel, beneath Table Mountain, California, a human skull was found in connection with the remains of the mastodon and tapir, and a human pelvic bone was found at Natchez, Miss. associated with the bones of the mastodon, megalonyx, and native horse. See "Am Naturalist" for September 1868 p. 386, and Am. Jour. Sci. for May 1868, p. 378. Dr. John C. Warren in his monograph on his great Mastodon tells us that hair of a dun color, from 3 to 7 in. long was found with it. p. 148.

of the country by day with their ceaseless cries. On the inaccessible precipices of the hills, great eagles and vultures sat motionless surveying the distant plain, where roamed herds of deer and cattle. Bats and owls flitted ominously from place to place by night. The murmurs of insects filled the air of forest and plain, and their forms covered the lakes, rivers and stagnant pools.

The arctic lands at this time grew the pine, fir, cedar, spruce, hemlock, and other trees, and shrubbery more or less like those forms now seen in New England. The snow fell abundantly in the time of absent sunlight in those high latitudes; and the feathered tribes and many land animals which visited that region in summer, came into New England and the country to the southwest, to avoid the winter frost.

Chapter 23
The Climate Cools

A still cooler climate in the country—Pliocene and sub-Pliocene times—Fossils of previous ages—Reflections—Evidence of a former union more or less perfect, of the northern hemisphere—Trees found by Sir Robert McClure and others, a post-glacial growth.

A great change at length came over the country, and many of the inhabitants of the land and sea of former times, had passed away forever. During the autumnal and winter months in New England, the winds were bleaker than in ages before. Here and there a glade of trees looked sere and yellow like ours in September, and gave up their leaves to the fitful winds which sighed mournfully among the branches. The late autumnal and winter rains were longer and more furious than in ages before. Severe gales swept the coast, and cold storms of snow were frequent on the barren hills of the country. The flora and fauna of preceding centuries, were seriously effected by this long upward movement of the land. The mountains began to assume the vegetation of the north, and the growth of former ages to retreat lower and lower towards their base. Many animals whose races had lived in the higher latitudes for long periods of time, had retreated from the rigor of the arctic climes. The wild ox, bison, and horse trooped from plain to plain, to vary their feeding grounds, as summer declined and winter approached. Many species of animals that inhabited New England when snow was seldom seen there upon her mountains, were no longer seen within her borders.

At length the continent attained its present height above the sea. It wore however, no such aspect as is now presented to the eye. It was a rough and comparatively barren country, of shorter and hotter summers than at present, and of longer and severer winters. There was a greater breadth and extension of land north of New England than at the present time.

As we look around us and survey the deposits that have come more recently out of the sea, we behold the later Tertiary beds everywhere bordering the coast of New England. The remains of animals that died in the sea, or living on the land were overtaken by diluvial waters and carried into the rivers, are occasionally seen protruding from clay banks which the dissolving rains are denuding. Here lie a few bones, but a small part of those which composed the original framing and there an

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entire skeleton. Here again we find a few teeth, and perhaps a skull, and yonder are beds of marine shells. In these banks too, are forms of fish which lived and died in the old estuary and bay of the river. In that meadow where the meandering stream slowly pursues its way, great quadrupeds lie buried, entangled in the miry sedge of an ancient lake. Over their bones the mountain torrents have heaped gravel, sand, and clay.

In the valley yonder among the hills, the old creeks and coves of a former age, are the cemeteries of great races. There lie huge reptiles, and monster birds whose skins were thick and but slightly covered with feathers which stood far apart, with their barbs also scattered loosely over the shaft. The wings of these birds were thick near the body, and probably somewhat membraneous towards their extremities, like a bat's, or rather that of ramphorynchus or pterodactyl. The head and neck are reptilian, and the mouth large, and unlike that of a true bird. Some of these reptilian birds could fly, and often did so in flocks. They lived on fish, reptiles, and large insects. The bones of similar two footed reptiles, lie also here. These animals of the ancient world, had short robust bodies, with stout tails like a lizard. They could probably stand on one foot assisted by the tail. They moved awkwardly though easily along. They could spring through the air for a considerable distance. They bent their head like a duck while hunting for fish in the weeds of the tide left pools, and with a motion somewhat similar. Their necks were long and tapering, and the head flat and broad. Here too is the skeleton of another reptile, that was of gigantic proportions. Its body resembled that of a crocodile. Its motion was slow or rapid as it chose. Now it crouched and lay quiet as other reptiles approached, its great eyes glancing like flames of fire, and betokening death to every living creature except those of its kith and kin.

Upon weathering slabs of slate of the valley, we behold along with the foot prints of those reptilian creatures, the footmarks of the labyrinthodont, a gigantic marine frog, 10 or 12 ft long, a scaly, warty, horned creature, without much beauty to the common eye of the age in which he lived; but if now living, would be a glorious sight to the connoisseur naturalist, independent of the consideration of the "precious jewel in his head." As I look back through the twilight of the great past, I fancy I can see the brute hop, and imagine also that I can hear him croak. Such a batrachian in my garden to weed it of vermin! I shouldn't have a fowl left, nor indeed a living thing about my premises, within 24 h after the glutton's advent. Give me a landsman for a scavenger, the harmless little scamp of a modern toad, that I can carry in my pocket without danger of having a finger snipped off, and which would be contented with a dinner of insects.

How marvelously wise is the method nature often takes to bury and preserve her dead. Man builds costly tombs and pyramids, the long and patient labor of many hands, and in them he is laid in the sleep of death. A few generations that come after him, may find indeed the skeleton, perhaps the body itself, which has been embalmed with consummate skill, but changed to loathsomeness nevertheless. But all this labor of man's device must in a few thousand years, disappear from human recognition. But nature's mausoleums and cemeteries are made in the sea, and she seals them up for countless age with her preserving earths, where the corroding touch of time comes not nigh, where silence is absolute as in the depths of space. Thus the

most wonderful records which man has been able to comprehend, have been given to us, from the keeping of the sea. Go to, then O! son of fear, and be content! What matters it if thy friend sleep in the ocean, or thyself be destined to be buried in the sea? Soft is the bed of that silent grave. Human footsteps go not there indeed, to scatter pleasant roses, and plant the willow by thy tomb, but uncouth forms instead may gather around thee, and lie down with thee in the dreamless sleep of death. Thou will heed them not, nor will they disturb thy rest. Gentle nature will cover thee up with her preserving dust, and that motherly saxtant will faithfully keep what is committed to her trust. If man shall awake from the cemeteries of the land, where the grass springs up and the flowers bloom, and the eyes of affection are keeping watch, surely the sea also shall give up its dead. Blooming with immortal life, thou shalt awake to a new eternity of being; and the past will appear to thee as a dream, broken and indistinct, but which the wise ones perhaps, like Daniel may gather up and restore to the bewildered memory.

I can not however, turn away from tombs of the ages, without asking myself whether the vital condition which once actuated these "dry bones" now transmuted into *stones*, has perished forever; and whether this spectacle of nothingness announces the destiny which awaits the framework of the natural form of him who stands in the physical world as the upward terminus and total expression of vitality, sensation and consciousness, and who has been declared by the inspired poet to have been made but "a little *lower* than the angels." Wherein do the elements of my body differ from these? They are the same. These *stones* did once *live*. But every trace of life has been obliterated from the earth, gone back to its "mother dust" from which it primarily came into being. "Dust to dust" was the command of nature millions of years ago as it is now. But for what purpose, to what mysterious end? Must the infinite activities of life perish for naught, go back to total dreamlessness, silent and annihilation? The very dust I daily tread upon, nay, the hills and plains, and frowning rocks, for ought I know, were once pregnant with life, sunshine and joy. I too, like the wild Gadarene, live among the tombs, not wholly of my race, but of the races of the infinite ages, which have gone before me. To live and to die, to behold the earth and enjoy her fulness, and at last suffer the dissolution of this mysterious moral life where *thought* is enshrined, for no purpose but of the transformation of crude masses into another aspect, inert and cold, and dead, when the vital principle is removed this is the most appalling conception that can ever seize upon the mind of man.

Perchance the very bones of the fingers which clasp the pen with which these words are written, may be deposited in the sea, or upon the bed of some river or lake; and in future ages when the earth shall wear a different, and perhaps, a nobler aspect than the present one, when the bed of the sea, or stream, or lake shall have become dry land, and those fossil members of the hand shall be found therein by beings of a diviner mold-paradventure they too, shall question this mystery of future life. The prince and sage of Uz assured himself that he should live again; and if he knew it 4000 years ago, I, though neither priest or sage, but of the same form and race, may and must live also, when the silence and darkness of the grave shall settle down upon my lifeless body.

In sunshine and in darkness, in calm and in tempest, I have lain upon the bosom of the ocean, and have been swallowed up of the thought of a power *somewhere*, incomprehensible. The rushing of mighty rivers, the sweep of angry tempests, the silence of boundless forests, the ceaseless rolling of the earth through space, the face of the midnight sky jeweled with an infinitude of stars, so still with the thought of its sublime greatness, hush the ambition and egotism of man, and proclaim a *greatness* infinitely overreaching and controlling all. I am in the midst of these visibilities of nature as the "small dust of the Calance" as a "drop of the bucket"; yet an individuality, a *thought*. I see and comprehend though finitely, and feel that I am seen and comprehended infinitely, in the past and the future, as well as in the present. I am "placed in the middle of a scheme, not a fixed but a progressive one, every way incomprehensible, incomprehensible in manner equally with respect to what has been, what is now, and what shall be hereafter."[1]

I am every way hedged in by infinity, by the inscrutable unknown I came, I know not how; I am going I know not whether. Shall I weep an mourn because I know not the end of this "scheme", this eternity of the past and of the future? No! nature continually says to us "be of good cheer!" Infinite is her compassion and works of charity. She feeds and clothes us; nourishes us when in sickness, and comforts us when in sorrow. It is this voice which I hear along the march of the ages, the "still small voice" so sweet and gentle: "*I will not forsake thee though the sea even swallow thee up.*" Yea, there is a *presence* which teaches me thus. It shines upon my right hand and upon my left; and the light is alike brilliant everywhere, in the material universe and the divinely revealed *word*.

Thus I believe there was a regular succession in Maine of deposited rocks, between the Devonian and Tertiary ages. It would require a subsidence of the state of more than a thousand feet to bring the oldest fossiliferous beds within reach of the sea. A diminished breadth of the coast would occur then of more than a 150 miles; and not only Maine, but other territories to the north, had the ocean maintained that relation to the land, to the close of the Tertiary period, would have been too mild to permit the growth of glaciers within the state. This presumption of succession is further strengthened by the facts of the great similarity in the vegetation of the Miocene epoch throughout the arctic regions of both hemispheres, and in some cases, actual identity of species, as in the earlier ages during the Carboniferous times.[2] There was also a great similarity of the mollusks and other fish of the Silurian age on the continents of Europe and America. But the recession from the north towards the equator faded out this oriental and occidental similarity. This law has always existed. Contiguous lands have had to a certain extent, corresponding organic

[1] Bishop Butler's "Analogy of Religion", Part I, Chap. I: *Conclusion*.

[2] "Of the six hundred species (of the Carboniferous age) recognized here (in America) at least one third are considered identical with European forms, while the genera are nearly the same. In the Miocene Epoch, the European and American continents were connected at the north, and over this bridge the American flora passed to Europe", Prof. Newberry on the "Ancient Vegetation of North America."

expressions because the temperature of the waters and climates were nearly similar. The fauna and flora of northeastern Asia closely resembles that of northwestern America, and those of northeastern America approximates those of northwestern Europe. The skunk cabbage is supposed to have passed during the Miocene times, from the polar regions of America to Japan, where it is now found. This plant so well known to the housewives of New England as a pectoral in domestic practice, grows abundantly along the coast of Maine, and sometimes 50 miles inland, as well as around the great lakes and eastward over the British provinces. There is another plant, (the *Croomia panciflora*) growing in that eastern empire of Japan, which is found only in the south Atlantic States of North America. The Scotch heath or heather (*Calluna vilgaris*,) once supposed to be peculiar to Scotland is found in America, and as low down the Atlantic coast as southwestern Maine, and Massachusetts.[3] It has been found in Newfoundland, and in Greenland and Iceland, and in Ireland.

Upon the island of Disco and a neighboring island midway up the western coast of Greenland, in latitude 70°, 66 species of Miocene plants have been discovered, and some of these now grow in northern United States. There is evidence there, that this flora was scattered over lands now submerged, or denuded, around the pole,and that the region was comparatively free of ice at the time of its existence over this archipelago, free of ice certainly during the season of light. I believe these changes from a warm to a cool climate took place not from subsidence of land as some suppose, but from its rise and the and the merging of islands into continents. After the spread of this vegetation over the polar lands and the consequent diminished temperature, the flora and fauna of the region retreated towards the south, and continued its migration thitherward as the cold increased, about the northern parts of the American, European, and Asiatic continents. Finally the country by its persistent rise, became a glacier bearing region, and at last the ice streams united into one and came down into New England and other northern states. When this great ice age passed away by the depression of the polar lands and the general subsidence of the borders of all the continents in the northern hemisphere, the Miocene flora and fauna went back to the homes of their ancestors as far as they were provided with the means of migration; and that they are now in retreat again in consequence of the existence of another uprising of land throughout the hemisphere.

It was during the post glacial depression I presume, that those trees grew which were found by Captains McClure and Belcher in latitudes now infested with perpetual snow, where neither tree or plant of any kind is found growing. Sir Robert McClure discovered the trunk of a fir tree 3.5 ft in diameter sticking out of a ravine of frozen earth, from 350 to 500 ft above the sea in latitude 75 north, and sea shells 5000 ft above the ocean. Sir Edward Belcher saw a fir tree standing erect with its roots in the soil, more than 300 miles to the northeast of the point of greatest cold. These facts show that there was a depression of arctic lands after the glacial age, and that at the time the polar ocean was free of ice, at least during the summer season. It is probable that at this time, rivers were pouring their spring floods into this northern

[3] Mr. Pickard of Portland, found the true Scotch heather in the woods of Cape Elizabeth in 1865.

sea, bearing upon their bosoms as rivers do now, coniferous trees torn from the banks by the violence of the waters, and that they were deposited about their mouths or upon the distant bed of the ocean.

The arctic islands are islands of denudation, as are the islands along the coast of New England. They were connected to the mainland and probably there was a union of North America with Greenland, when the glacial age set in. When the high northern region was covered with ice, the land there and in New England, may have stood but a little above its present height over the sea. It is the partial circulation of warm water among those islands and around the polar basin, that makes the mean temperature higher now than in a former age.

This is the view that I take of the origin of the glacial age. It seems to me the most rational of any yet proposed. In it, we see nature working as now before our eyes. It is everywhere, the height of land above the sea, that gives it coolness. At the equator perpetual snow begins about 16,000 ft above the ocean. In latitude 40 it would be about 10,000 ft; at 60°, 4000 or 5000; at 70°, about 1000; and at 80°, about the level of the sea, But diverse courses of mountains, and the general level or uneveness of lands and also continental trends, tend to increase or decrease the temperature of climates, so that no mathematical rule can more than approximately estimate the heights of snow lines above the sea.

Chapter 24
A Glacial Time

New England elevated 10,000 or 12,000 ft above the sea—Her mountains covered with perennial snow—Scenery of the times—Flora and fauna of the age—First appearance of glaciers in the country—The peculiar phenomena connected with them—Scenery of the times—New England covered with a glacial cap—The glacier and the climate described—Aurora borealis—Separation of icebergs from the glacier—Their general appearance when first detached—A storm, and breaking up of floe ice—Boulder materials deposited by the glacier on dry land—Much of this debris washed away by floods and rivers towards the south.

In the preceding chapter I considered New England to have attained its present altitude or a little more above the sea, and the old Miocene and Pliocene islands of the north as united to the continent, and to have been glacial bearing regions to a greater extent than now in our own times. I purpose to consider now the mutations through which the country still further went before New England became a glacial land, and the nature and aspect of the age throughout its duration.

Many thousands of years more passed away, and let us suppose the highest mountains of New England to have attained an altitude about 9000 ft above the sea. If we should now go up among these hills as the summer is about to visit the country again, we should meet on every hand a succession of wonderful scenes, compared with those which we beheld in the later Tertiary times. From the sides of the highest hills upon whose tops the snows of winter now remain through the summer, whose voice fills the wilderness like the roaring of a tornado. Dark clouds are gathered there, as if they disdained not to hear the deep anthem of the hills. Profound and awful gorges are these among these mountains. The tall pinnacles are robed in white, the vestals of nature gazing forever up into the sky. The variety and sharpness of these forms, and the tender outline of distant peaks, all seem set like jewels in the deep azure of heaven, and form a picture of wild and wonderful beauty. At night above these altars of the clouds, the stars sparkle in the black cold sky with ineffable splendor. As the morning breaks upon the earth, the loftiest peaks first catching the coming aurora, are illuminated with the subdued light. Their dark shadows are cast upon the hills around. By and by the summits everywhere are kindled with dazzling gold, and the valleys and plains are covered with the first light of morning.

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The rivers swelled with the melting snows, shoot down the mountain valleys with the swiftness of arrows. The country wears the appearance of wildness and grandeur. Fierce storms incessantly rage among the hills. The oak, maple, beech and birch, have nearly disappeared from the forest, and their places are usurped by the larch and spruce, stunted by the wetness and coldness of the ground. Among the hills no tree is seen but the spruce, fir and pine, which maintain a foothold in the cliffs of the rock. As the floods subside, late in the season, and we range the forest and the plain, we see that many of the animals which once were accustomed to seek their food there, are no longer found; and the present races will in time become extinct, or be driven far towards the south. The face of the earth is but partially warmed with the summer's sun. Wild beasts roam the forests and howl among the hills. Herds of grazing animals feed upon the mosses and crop the stinted grasses by the side of lake and stream. In those deep valleys of the hills, the snows of winter are in excess of the waste during the summer. Year after year, and century after century, they increase, till finally there are formed thick beds of ice in the higher valleys away up among the hills of the country. It is now for the first time that we have indication of a perpetual winter there, a winter whose grasp never embraced the valleys before.

At length these ice streams begin an onward movement, always down the valley, more or less slow according to the descent of the mountain gorge toward the plain, either east or west, north or south.[1] Centuries pass away, and these valleys are stripped of their angular rocks, and every sign of vegetation. A few cone bearing trees yet live upon the sides of the hills, but they look old and desolate, and in a few centuries will be prostrated by the tempests which rage around them. The mosses and plants which once inhabited a far distant clime of the north, have come down into the country to "spy out the land" and to "possess it." The rocks along the hillside are rent by the intense frosts of the winter months, and the avalanches of the high mountains hurl them down upon the slow moving glaciers. These frozen rivers which ages shall not melt and dissipate, bear them onward to the plains below. In this new agent which has thus laid its hand upon the country with a growing vigor we perceive all the phenomena of the glacier of our time. Cast up along its sides we see the *lateral* moraine of earth, crushed trees, rocks great and small, and ground sand and clay, the combination of the coarser materials ground by the mysterious strength of the glacier.

But how can this glacier, this valley of solid ice hundreds of feet in thickness, move onward from day to day and year to year, never stopping for a moment? The bed of an alpine glacier is a plane of descent, and there is a ceaseless motive power within the mass, ever moving it onward by its unseen levers.[2] The upper reaches of the glacier are perpetually overflowing with masses of snow fallen from the tops and sides of the mountain, and this show by its great depth, is gradually converted into

[1] The supposition of the existence of New England alpine glaciers, must be taken with much caution. I am not disposed to doubt that they existed to a very limited extent; but snow must have covered the country generally, which would prevent alpine glaciers from flowing to any considerable distance.

[2] See Chap. 24, on the motion of Glaciers.

ice and granular snow; and the same forces which move the glacier below, push the accumulating mass towards the point of least resistance, where the glacier may be said to begin. As I have said, the glacier marches onward winter and summer, but its progress is greater during the latter season; and its flow is like that of a river of water, more rapid in the center of the stream and also near the surface. It is governed in a measure by the laws of motion as is a river.

At length this frozen stream approaches another, two valleys filled with ice opening into one broader and deeper than either. Thereafter they flow on forever united, with slow and silent foot step, day after day, summer and winter, age after age. The origin of a glacier there is first the pure snow of the sky, then the avalanche snow, then the first snow in motion which the French call *névé*, and the Germans *firn*, a granular snow, then the true glacier below the sumner snow line. This was the order of glaciation among the hills of New England at the commencement of the great period of cold; but in process of time the whole country became covered with snow the year round, and alpine glaciers were swallowed up by the crystalizing beds of snow, as they passed into glacier ice.

The materials chiefly composed of mineral masses which these glaciers bear upon their surfaces, and on the two sides nearest, mingled into the mass as the ice streams amalgamate, and form a *medial* moraine. This long train of rocks and dirt maintains its form to the lower limits of the glacier. As the spring returns the heat in the ice valley is greatly increased, and operates upon the lower terminus or wall, of the glacier. As the ice melts and the wall retreats up the valley, there is formed upon the bed rock recently occupied by the glacier, a ridge of dirt and rocks washed by the waters of the glacier, and extending quite across the valley, which constitutes a *terminal* moraine, and marks the yearly advance of the glacier. But every century carries the terminal wall of ice a little in advance, a little farther down the valley. As the summer returns the snows of the mountain slides melt, and the waters are poured into the valley of ice. The sides of the valley converge the solar rays as a gigantic lens. The air is then like a heated oven. The surface of the glacier melts also under this intensity of heat, and is everywhere covered with water. It pours along in rapid streams accumulating as they advance, till they plunge headlong down a fissure running perhaps, from side to side of the valley. Beneath the glacier also, flows a rapid noisy stream increased the falling waters from the high walls of ice, scampers madly down the valley like a wild beast.

The summer's heat as at last told upon the lower wall of the glacier. Week after week it retreats, till now there is no more upward progress. As the temperature of the season declines, and the waste of the wall diminishes, the glacier resumes its march down the valley again; and in the ensuing spring it will be found where it was a year before, supposing the snow fall and annual amount of heat to be about the same. Between the wall of ice and the windrow of dirt or moraine, extending more or less across the valley below the retreated glacier, we see the prevailing and more interesting phenomena connected with the boulder drift. The rocky bottom of the valley is smoothed and scratched in lines quite parallel with the course of the glacier. Here the striae are finely and delicately marked like etching with a diamond on glass, and there broadly and deeply furrowed, as though some hidden spirit within

the glacier had determined to leave its mark forever upon the rock. The instruments with which this polishing and grooving of the bed rock were accomplished, are sand, gravel and rocks, firmly fixed in the bottom of the slow moving river of ice. Here and there also, we see the lunoid furrows with their horns and steep walls looking up the valley.

Among the boulders lying in the terminal moraine, or scattered here and there between it and the wall of ice, and which had been torn asunder from the sides of the valleys by the moving ice mass, or precipitated upon it by avalanches of snow, we observe whose faces are smoothed and scratched similarly to the marked bed rock of the valley. But some of these boulders have two or more sides thus polished and scratched, and perhaps the lines on no two sides correspond in direction. The mystery seems not wholly inexplicable. These are always fissures running transversely across the glacier owing to the uneven bed over which it flows, and the contracting width and winding course of the valley. There the moving forces of the glacier tear and raise its surface into a thousand forms of ever varying aspect, which glitter in the bright sunlight of summer like gigantic diamonds. Into these fissures one may look down hundreds of feet into the blue abyss of the ice, yawning caverns where human ire and fretfulness might sink at least to zero, and overweening ambition become cool and gentle as in a hermit's life. More's the pity that this glacier business is not introduced into American urban society as a general refrigerator and Washington ought to be the "head center" of the institution. It is cool weather that takes the fiery and flighty qualities out of a man. It is seldom that a man is wrathful when the mercury is below zero. A woman's displeasure is metamorphosed into crystalline calmness and goodness at the freezing point of water, or 32° above the cooling point of the other sex.

Into these fissures or crevasses, the boulders are often precipitated, and frequently find their way to the bottom of the glacier. There they become fixed in the lower surface of the ice as a shoe to the foot, and as the glacier moves forward, are made instruments of polishing and scratching of the bed of the valley. To use Mr. Miller's language quoted in a former chapter, the boulder becomes a *scratcher*, while the bed of the glacier becomes a *scratchee*. One of the sides of this boulder therefore, is smoothed and scratched; But the glacier like man, needs new shaving now and then. It does not go barefoot. No rough work in madame's fields, can be done without a stout pair of shoes. Nature believed in traveling, in friction, erosion,and denudation; in the wearing down of old forms and the building up of new ones; in never ceasing motion and mutation. And so whether the scratches wear out or no, it is perhaps wanted no more at least for the present. The glacier casts away its old shoe from beneath its foot, and after a while, lo! it comes to the surface again, for thus these wonderful rivers of ice purify themselves. First is seen upon the surface of the glacier a knob of ice which protrudes more and more above the surface, till at last there is seen standing quite isolated a stately pillar of ice crowned with a huge boulder. Pluto or some hadeal spirit coming slowly out of the infernal regions bearing upon his shoulders the dark form of some obstinate ghost whom he has determined to cast out of the nether kingdom.

But the strength of the sun is greater than the strength of the pillar of ice. It yields day by day, and finally the pillar is dissolved, and the boulder rests again upon the bosom of the glacier. There the rays of the sun excessively warm it, and the ice is thereby dissolved around the boulder, and it continues to sink down deeper and deeper till it finally disappears. This upward movement of the rock is occasioned by the greater pressure or crowding of the mass, as it works its way through the contracting passages of its bed. Thus this process of the rising and sinking of boulders may go on repeatedly. But now and then they fall into the fissures of a glacier, and finally get to the bottom again, and are once more used as polishers and scratchers. Perchance another side of the boulder is now applied to the bed of the glacier, and thus two of its sides become scratched; or it may lie upon the bottom as at first, and be urged forward somewhat varying in the direction of its former grooved lines. This process of scratching the different faces of the boulder may go on till all its sides are grooved, or until the rock is ground to gravel and clay.[3]

In process of time the glacier has become a broader stream, and also reaches far down into the plain. We go again after many years at the beginning of summer, to visit this wonderful stream of ice. The golden sunbeams are at work overturning the handicraft of frost. Streams of water everywhere flood the country. The buds on the trees begin to burst. The voice of nature is jubilant again. Migratory fowl lurk in the open lakes. A few birds here and there chirp out an occasional short and musical note. The roaring torrent from the glacier fills the valley with noise. The country is everywhere flooded. The forest trees of the plain which the glacier has not yet reached look like a flock of herons on a hunt. They are in water at least knee deep, and the bath coming but once a year is not so distasteful after all, and moreover is conducive to their general health; and so in a quiet meditative way, they take it without a murmur. Ice, and snow and rain, with violent and long continued winds, have taken possession of the country. Once the climate was dry and the land barren, but now it is drenched with heavy rains, and therefore barren again from the opposite extreme. The animals which we meet in our path, are colored like the ground, the rocks, and the trees around us, as summer or winter awaits us. The fox, the deer, the wolf, the partridge, and other birds, all change the color of their dress as the seasons change. What we yonder suppose may be a stick, or a rock or a bunch of moss, as we approach suddenly starts away on legs or wings, and is gone in a minute. Nature ever infinite in her resources, thus adopts sagacious means to ends. The atmosphere is cold and the ground desolate, as autumn approaches. All animal life must be in motion, and must be vigilant and active. This is the empire of poverty yet vast activity. Labor is great but the compensation small. Nature's revolutions are like man's, or rather man's revolutions, civil or political are like those of nature of

[3] Boulders might also work up and down along the sides of a glacier, and there be subjected to repeated scratchings. Or in passing over great inequalities of surface the rock might be displaced in its bed; or it might be caught again at the terminus of the glacier as the winter growth extended the mass. Rocks scratched at different angles upon two or more sides are common about Penobscot Bay. At the Steam Boat Wharf, Camden, I saw a few years ago *many* such rocks.

whom he learns. The activities of nature sometimes take a vast breadth and depth, and go as she has dictated through the routine of operations, like the ages of man, youthhood, manhood and agehood. It is in the latter term of life where activity is often demanded, and poverty is the result of experience and exhausted energies. But wait and watch, and hope, saith Nature. "The day cometh that shall burn as an oven", the day when all these wasting materials shall be converted into mighty and fruitful forces. Then is the golden harvest, and the feast of manhood, and its coronation. When these animals rest, nature gives them security, at least partially in disguise. All the ancient vegetation of the country has now disappeared towards the south, and is supplanted by those of the distant north, which snow and ice expelled from that country.

At last the continent attains its maximum elevation and breadth. The highest mountain peaks of New England reach from 12,000 to 15,000 ft above the sea. The Grand Banks of Newfoundland and the submerged chain of hills to the south west, with all the sea bottom from the western border of the Gulf Stream to the continent, are now above the level of the ocean. The entire surface of the country above the parallel of 40°, is now covered with snow the year round. Below this snow plain a few feet, all is ice. The highest mountains of the land, appear as ridges slightly elevated above this sea of snow. The few glaciers that mainly ran down into the valleys from the highest peaks of the hills, have been long since swallowed up and lost under the boundless cap of ice. Day and night terrific winds sweep over this desolate domain of cold, and howl and shriek like fiends exalting of the annihilation of a world. It seems when they die away, that the very life had been frozen out of them. Then an awful stillness settles down upon the ocean of snow and ice. It seems as if the earth had passed before the presence of *frost*, and that he had touched her, and had deprived her of life. The moisture of every expiration of the lungs, is instantly transformed into ice. The most delicate and cunningly devised crystals constructed from a little impure vapor which the living body has rejected, spring into existence a miracle before our eyes. Slender and sharp as needles, they twinkle for a moment like diamonds in the frozen sunlight, as they fall from the hand of the chemist cold. This wonderful unseen spirit of frost besieges your very existence. It runs like electricity along the invisible and attenuated particles of moisture on your clothing, dashes into your skin, revels madly in your blood, and waves away with its hand your very senses. You can not speak if you would. Upon the least exposure for a moment of the tongue, or of the tender membranes of the mouth, this cold like a famished wolf, snaps at them with an energy inconceivably rapid and potent. If one could endure this positive cold by the greater play of the dynamic energies within us, it might even be agreeable, and disease would find no convenient habitation within our bodies. The sharp dense atmosphere purified of all foreign matter would be bracing and salutary like the battle of immortal existence.

What a stillness pervades the air! Nature seems to sit in sublime silence upon her icy throne, with her finger pressed upon her lips commanding silence of the earth and sky. The sunlight that falls upon this desolate empire of ice, is again thrown back into the sky, as though the earth in her desolation would accept no consolation from above. The setting sun glimmers from the sky with an eye of blood-red dullness, as

of sorrow and despair. Soon the coldness of the celestial spaces settles down around us. The frozen air seems compressed, and to be poured down upon the plain of ice. An indescribable blackness envelopes the earth. By and by the moon with ghost like face, looks from the east over the boundless plain of snow and ice. The stars glow as with the intensity of thought. We look into their eternal light to see if there is hope that the earth shall live again, and blossom with fragrant flowers and bear fruits, and whether songs of joyous life shall be heard over the hidden hill and dell once more.

But let us assure ourselves. The hand that has brought this wonderful desolation upon the land, which has uprooted life and beauty from the earth, will guide the change on to the end in profound wisdom. Over the face of the heavens and the earth mutation is written in lines which no corroding finger can erase. This change from life to death is the means for the reshaping of admirable ends unknown to man. Beneath our feet far down to an immense depth, these snowy treasures immeasurable of good, have been accumulating for ages. This realm of snow and ice that covers the land, whose bounds no mortal life can explore, is in motion like the bosom of the sea. Its march is omnipotent in its effects. It has usurped broad plains, deep valleys and high hills. It approaches the ocean and bids it begone, and the waves thereof retire, and the conqueror of the north marches on his host "dry shod" like that of Moses. All the forces of the winds of the sky, and the waves of the sea can not arrest its progress. Step by step it has come from the north. It has existed for myriads of years. It must go on for ages to come.

Here and there the ice plain becomes rough and broken, and piled up in gigantic masses as if for the dwellings of the fierce spirits of frost. This architecture in ruins is the path of the great glacier over one of the highest mountains in the country. Here and there we meet with rocks huge of form, torn out of the top of the hill by the hand of the glacier, and pushed upward to the light of day. The glacier will slowly carry them far away towards the south, and will perhaps, bury them in the profound depths of the ocean. Yonder we look down into an unfathomable grave of frost. There we see the work of nature's invisible quarrymen, rocks set as gigantic jewels in the face of the yawning fissures.

Strange and appalling storms of wind and snow sweep over this boundless sea of ice covering the land. Vast columns of snow that seem as if they were poured out of the gates of the sky, rise and fall like the billows of the sea, and dash along with fearful might. They whirl in fantastic dances this way and that, howling like demons as if intoxicated with the joy that they had permission to destroy the earth. But the storm at last passes by, and the sky becomes clear, and as the sun goes down and the stars come out, and glow with wonderful lustre. Along the distant north, the fleet couriers of the night, sons of lucifer, careen up and down the vast concave of the sky. Long lances of fire dart from their hands like tongues of flame from the volcano's furnace. They gather for battle, these fierce spirits of the sky. "The valiant are in scarlet, the chariots with flaming torches. They jostle one another in the broad ways. They run like the lightning". The listening earth hears the sound of the clash of arms, and the snow drinks up the purple hue of the celestial field of strife.

But the sunlight again illuminates the east. Like the instant drawing of innumerable sabers, the rays flash along the sky and over the boundless snows and ice. Let us

continue our journey in this coming morning, down towards the face of the glacier, where it overlooks the ocean. Here the glacier rests upon the bottom of the sea which we can not fathom, and towers up perhaps thousands of feet above it. Long lines of fracture run at right angles to the march of the glacier. Upon these outer bounds of the kingdom of frost, let us contemplate the sublime spectacle of the separation of the ice into broad masses, which float away as bergs bearing upon their bosoms and holding in their secret keeping rocks, gravel and sand, the ruins of distant and invisible hills, plains and valleys, of the old world. There greets our ears ever and anon, a sharp mysterious sound like the explosion of a meteor in the atmosphere of the earth. The thunder and the earthquake in the land of life may appall us, but these sounds thrill our being with awe, as we stand upon the great ice plain, and feel this crystal floor tremble and cast itself into the sea. The ocean boils with excitement and dashes its waves like hills from side to side. There they go, those mountain ships of ice! How sublimely they sit upon the ocean, like the broad lofty clouds of white in the sky at the closing of a summer's day in the land of verdue. Thus year after year the glacier sends out its icebergs, messenger ships to the climes of the sun. Silently and calmly they float away as the soul goes out from its mortal habitation, into the boundless ocean of eternity. What beauty and majesty surround them! Colors born of celestial thought, glow there indescribable by the tongue of man. The burning rays that flash from the face of that lofty berg, seems like a supernatural presence. Soon these ships will go away, never to return like those human forms that depart from us in their loveliness and strength, broken from the endearing fellowships of life, lost forever from our mortal eyes, swallowed up by the ocean of the unknown.

But summer comes apace, the summer of this frozen clime, where snow falls every day in the year, and where water that forms where the rays of the sun acts most powerfully, freezes thoroughly again at night. In front of the glacier the floe ice stretches far beyond the power of the eye to distinguish sea from sky. It resembles a vast plain of snow, not upheaved and hilly like the glacier on which we stand, but level excepting where the precipitous iceberg rises out of this ice plain. The wind from the south as it sweeps over this field of floe ice, grows cooler and increases in force. Dark clouds begin to skirt the border of the glacier. All things betoken a storm. That strange noise which we hear is the moaning of the ocean, a voice unlike any thing in nature, warning the earth of the approaching strife. Down there upon the frozen face of the ocean the mad tempest begins to dance, and rave and howl. The ice plain begins to tremble and anon is convulsed as if by volcanic fires within. It breaks up into fragments which toss about like leaves in the wind. The loud roaring of the storm amid the confusion of the crushing of the ice, mingle in one indescribable thunder which falters not for a moment. It is not like the dashing of the ocean's waves upon the rocky shores of the land, nor the thunder peals of the sky. The sounds thrill every fiber of our being, and impress us with the conviction that the foundations of the earth are about to be broken up forever.

But the wind goes down, and the summer days lengthen, and though cool and reeking with mists and storms of rain and snow, the floe ice aided by heavy gales from the north, breaks away from its winter birth place and drifts off towards the south, and carries perhaps a multitude of bergs with it. Upon the right hand far away

towards the west, where the hills and plains which the glacier has not reached, yet support vegetable existence, a different scene is presented to the eye. Cascades are everywhere leaping from the lofty wall of ice thousands of feet high, sky-skippers which the winds dissipate ere they fall to the earth below. Streams are everywhere rushing out from beneath the glacier. Thus the ice which has so overpowered the old Tertiary country of the north, re-waters the iceless plains and valleys of the south with cool streams and scatters its mud over the bottoms of distant estuaries, and seas, which in after ages will be rewashed and spread over land to be elevated above the sea as the dwelling places of man the promised heir, and the beasts then to be given for his use. It is along the southern boundary of the glacier that we see towards the close of summer, the phenomena of boulders torn from the rocky floor of the country, accumulated dirt heaps, and the polishing and scratching of the rocks, which are witnessed when glaciers first began to appear among the hills of New England.

Chapter 25
Duration of the Glacial Age

Rate of subsidence and elevation of tropical lands—Rate of elevation in the northern part of the northern hemisphere—Retreat of Niagara Fall 7 miles from its origin—Fossiliferous boulders carried from the region north of Katahdin to the islands of Penobscot Bay—High hills in New England and New Brunswick to oppose the march of the great glacier—Its annual rate of motion in these regions—History of a fossil boulder—Estimated thickness of the great glacier—The hydrographic features of the northern parts of northern continents indicative of glacial denudation.

Thus the great glacial age of North America became established. Its increase of cold was gradual, and would have been inappreciable to man had he lived upon the earth at the time. Its duration merely from the period when a general movement of the ice mass first took place in New England, to the time when it ceased there, must have been not *less* than a hundred thousand years. From what we know of very extensive areas of land in the north having had apparently a contemporaneous movement of subsidence since the glacial age and a subsequent one of upheaval, we have reason to believe that a cause existed for these diverse movements, and that its operation is uniform, and therefore these times of the uplifts and depressions of continents, must be periodical. The growth of the coralline islands in the Pacific have been estimated by Prof. Dana to be about one eighth of an inch yearly, and this is the annual rate of the subsidence of land there.[1] In Florida just without the border of the tropics though still subject to the influence of the heated waters, Prof. Agassiz computes the coralline growth to be about the same, namely a foot in a century.[2] The coral building keeps pace with the subsidence or elevations. But the rate of oscillation of New England, is probably more than a foot in a century, The rate of rise of the northern coast of Norway has been estimated to be not far from 4 ft in a century; but this probably is altogether too great. If the rate of rise of the coast of Florida is only about 1 ft in a century, that of the coast of New England can not be more than 2 ft. New England to have brought perpetual frost within its borders sufficiently intense to build a glacier overriding her highest mountains, must have been elevated during this period, at least 12,000 ft, or 6000 ft higher than it is now.

[1] Manual of Geol., p. 591.

[2] Methods of Study in Nat. Hist., p. 187.

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It is evident to all who have given the matter a close attention that the time accepted by the retreat of the falls of Niagara from Lake Ontario, is greater than that in which the revolution of the precession of the equinoxes is accomplished. This lake was filled with salt water to a height of 200 ft above its present shores, at the time the coast of Maine was last submerged. It was then a part of the sea which like some of the marine indentations of the present day, run far into the land. The St. Lawrence River now occupies the bed of this old sea, which has been alluded too in a previous chapter. The Niagara River was discharged over the rim of this inland sea making a fall below Lewiston, and has since cut its way 7 miles back from lake Ontario, in a canyon probably from 250 to 300 ft deep, and 600 ft wide. The time occupied in the denudation of this river bed, has been variously estimated by scientific men from 25,000 to 35,000 years.[3] If the rate of the elevation of the land there, has been uniform, we may suppose also the rate of the last subsidence to have been uniform; and if 30,000 years have been consumed in the elevation of 200 ft, a century and one half would pass away while the land was rising 1 ft. But for convenience, let us suppose the rise has been 2 ft in a century, or one third of this rate, and that the movements of the crust of New England have been at this rate. If then, the country was covered with snow all the year round when its highest mountains stood at 9000 ft above the sea, 150,000 years would be consumed before it had attained the 12,000 ft, the height which I have supposed New England must have attained during the glacial period. The time of subsidence back to the 9000 ft, would be as great, making the duration of the *glacial* age to be not less than 300,000 years. The time consumed in farther retrograde movement till the country attained its present height above the sea, of 6000 ft, would be 150,000 years more. How much farther the country sank we know not, but are sure it subsided 500 ft below its present level, which adds 25,000 years; and the final elevatory movement which has placed the continent to its present relative height above the ocean 25,000 years more, making in all 500,000 years since the commencement of the glacial period, and 200,000 years since it passed away.

Fossiliferous boulders have been carried from the Silurian and Devonian rocks beyond Katahdin to the lower islands of Penobscot Bay 150 miles distant. And I see no reason to doubt that they are scattered from these islands to the border of the unfathomable ocean 200 or 300 miles farther, wholly through the agency of the glacier, and not by icebergs or drift ice. The movements of glaciers among the Alps of Europe, are from 50 to 500 ft a year; and the steeper the bed the faster the travel. There is comparatively no obstruction along their planes of descent. But as it regards that of the ancient great glacier of New England, there was no descent of its bed. The common level of Labrador north of the State of Maine and New Brunswick, may be put down as a 1000 ft above the sea, and this is not far from the elevation of the base of Katahdin over the ocean. If the mountains were leveled from Labrador to the coast of Maine, some 700 miles, the glaciers path might be said to have been a level plain. But mountains everywhere south of the St. Lawrence rise as barriers to check the movement of the glacier; and there were also many deep

[3] Dana's "Man. Geol." p. 591, Lyell's "Principles", p.217.

valleys to cross opposing the march of the boundless field of ice. Therefore in New Brunswick and New England, the glacier could have advanced but a few feet a year, and could have made no *progress* movement towards the south, till the ice sheet had attained a considerable thickness. Much time was consumed in counter movements and consolidation of the mass, preparatory to the momentum communicated to it by the great northern wave of ice approaching the glacial bed in New England. Had the glacier at the time of its first grand movement removed the fossil boulders above mentioned, and carried them no farther than Vinalhaven, flowing on at the rate of 50 ft a year, like some of the glaciers of the Alps, which have small but unobstructed planes of descent, it would have required nearly 16,000 years. But the glacier crept forward and occupied the bed of the ocean between the Gulf Stream and the coast of Maine, otherwise it could have sent off no icebergs, because these required deep water for their discumberment, or separation from the glacial border.

After careful examination of the country from the region of Penobscot Bay, north to the source of those fossil boulders, I am disposed to rate the average movement of the great glacier not more than 10 ft a year. About 80,000 years would therefore, be consumed in the transportation of those boulders the distance of a 150 miles; and further distance towards the south of supposed transportation of such boulders, must increase the amount of time. But this sort of carriage may have gone on for thousands of years, before those paleozoic boulders were removed from their native beds. As regards the deposit of these boulders by drift ice when the country was submerged, there is no probability of it. Drift ice not impelled by river currents run along the coasts rather than directly away from them. None of those Silurian and Devonian boulders are found east and west of a line running south from their original beds. Like others in the country, their native homes must be traced to the north. The last depression of the border of the state, gave rise to exceedingly limited distribution of boulders by shore ice. Again supposing this movement of 10 ft a year, of the glacier, would denude the rocky bed of the state one twentieth of an inch during that time, and that only 500 ft of the surface had been removed; it would require 120,000 years to do it. But from the estimates of President Hitchcock and Prof. Ramsay alluded to in a former chapter, we are justified in calculating a loss of surface of at least 100 ft; and it may have been twice the amount.

But how can we believe that the time is so remote when the last great revolution was enacted, which thus overturned the face of the country? This piece of metamorphic clay, lying before me, a few inches long and as many broad, bears on its face the glacial striae so beautifully delineated in small parallel lines, near together, spread over its flat and polished surface, that it seems the work of human hands rather than that of the hands of nature, and to have been executed in times by no means remote. It seems to have the same freshness and modernism about it that accompany the stone relics of the redmen buried in the earth of their ancient habitations. But no, it is not the handiwork of man. It was a part of a ledge by the side of a new road, uncovered of several feet of fine brick clay which had been necessarily removed; and there stood before me this graphic lineation of nature, written ages not only before I was born, but also before Noah laid the keel of the first ship that man knows anything of whatever. To me the term of 6000 years even, over which human history is supposed

to extend, is indeed very remote. The mind is bewildered as it runs over this expanse of the past, and can recognize but the outlines of the history of the human race. All is myst and confusion as soon as this written history terminates. Man leaps with trembling the obscure chasm that separates the known from the unknown. With all his far reaching knowledge and subtile skill, he knows not the length of time which his own race has possessed the earth. But nature has revealed to man that her time is an unbroken thread of infinite length, and along its outstretched line the dust of mighty changes has accumulated. These prehistoric times and seasons like the age in which we live, had their sunshine and rain, and cloud colored skies, and balmy winds, and restless ocean, and flowery hills, and valleys, and meadows; and lakes and rivers, and a fruitfu1 world. Innumerable generations of animal life had succeeded each other in the world, ere man came to inhabit it. Whithersoever we go by land or sea, we roam over the cemeteries of these lost races. The vision of the past haunts us perpetually. We see the ruins of antiquity about our path, and get glimpses of the faded sunshine, the driving cloud, the falling shower and the varying face of the earth; but the soul of the past is wanting to restore it as if yore. Thus though we are of "yesterday and know nothing", we are the keepers of nature's treasury of the past, of her chronicles written in her stone book of time. There is therefore, a great past antecedent to the coming of our race, a time that was not brief and fleeting. The impress of infinity is upon its face. All that we see around us was elaborated with care, and had the seal of perfection placed upon it. All things proclaim the eternity of time. The great revolving of stellar worlds are accomplished only in millions of years. The light of some of these burning orbs was sent out thousands of years ago, nay, ages before man appeared on the earth to "dress it and to keep it."[4] Their light was *old* then, no new fashions in those distant worlds. Who then can comprehend the past, or is prepared in the calmness of his soul to say that the operations of nature which we see around us, have not required vast ages for their accomplishment?

Thus the relics of the glacier scattered up and down the country hills partially uprooted and others reformed, valleys and rivers widened, and the country covered with clay, sand, gravel, and immense rocks, tell us of times that seem to come down to the human age but of which the traditions of the oldest races, have preserved no knowledge. There is before me as I write, a fossil boulder from the Silurian period of northern Maine. It has been a witness of wonderful sights, great changes in the features of the earth spread over millions of years. The most vivid imagination of the geologist could not overdraw this panorama of the past, of sea, and land, and vegetable and animal forms, which have appeared upon the theatre of time and vanished, since this little rock became the tomb of extinct beings. The bulk of this boulder is insignificant like some human forms, compared with the amount of knowledge acquired. It measures but 8 inches by 6, and 3 in thickness, and weighs 5 pounds. Enwrapped with the mantle of bygone glories, it is silent. The soul of thought broods over it, and writes upon its face the history of the past, fragmentary but wonderful as that accepted of the Roman sibyl.

[4] In Sir F.W. Herschel's "Essay on the Telescope" remarks that there are stars in the infinite depths of space whose light was emitted 2 millions of years ago.

This Silurian boulder had its birth place not far from the shore in shoal but still water, of a warm, misty, boundless ocean, with here and there a patch of land around whose shores a few sea weeds took out upon the rocks. Where the dark dense forests of northern Maine and Canada now flourish, where the wild beast lives and the eagle screams, and winter snows lay long and heavy upon the ground, this old Silurian sea tossed its billows in perpetual unrest. Katahdin and other magnificent mountains of Maine had then no existence. The materials which compose their forms, were possibly not then deposited upon the bottom of the sea, as sands. Yet, there was life "before the mountains were brought forth", even upon the *earth*. In a locality where the waves of the ocean just reached, and the minute sands which they held in solution were deposited undisturbed, two or three species of a shellfish of the Orthis family took up their abode, none of which were larger than the nails of a human hand. As the sands accumulated hundreds of fragments of a slightly branching coral, a Favosite, not larger than a pipe stem, there found rest from the buffeting waves. Sand and silt increased around them and covered them up. Overall solitary Rhynchonella was buried, and was finally covered by mineral matter, as were the others. Under the transforming hand of ages this tomb and its contents were wholly changed, the fine sand into stone, and the shells and coral transmuted and absorbed leaving only the impression of their former bodies upon the stone. Not a trace of their calcareous forms is left behind. This mausoleum of ancient races extinct so many millions of years before man came to contemplate the landscapes of time, has not been subjected to that kind of pressure which sometimes has distorted the extinct forms of organic existence. The impressions of the forms within, are beautiful, as if the dead bodies had just been laid in the dust. Putting my fingers into the hollow casts of these once living beings I can say that I have looked into the catacombs of some of the earliest races that ever appeared upon the globe, beings that lived in the sea, when no bountiful vegetation covered the land, when no mountains lifted their heads to the clouds, when no rivers discharged their pure waters into the ocean, where no quadruped walked the earth, when no bird winged its way through the air, when no reptile crawled along the silent shores of the land, when no flower unclosed its eye to the sun, or trembled in the breeze, when the hum of no insect disturbed this solitude of the past, when no sound was heard upon the earth, or in the heavens, except the mournful voice of the waves upon the solitary shores. The building of the palaces and tombs of Egypt, the gaze of the first man upon the sun, the birth of the cataract of Niagara, are events but of yesterday, compared with the long ago when these Silurian beings lived and were entombed by the hand of time.

This is one of the stories plainly told by the little Silurian boulder. But it has another, not less interesting. The ocean bed on which it lay entombed, became dry land. The waves of the sea no longer reached it. Vast ages swept over it that no man could number. Forests strange and reeking with moisture, warm, and silent as the tombs within the rock, meanwhile grew around it, and their remains covered the earth. Great tree ferns and trees whose bodies were scaled like that of a serpent, stood motionless in this morning of the floral age of the world. No fierce winds shook their branches as they now wildly toss those of the forests of Maine. Now and then the sun looked through the mists which hung over the strange landscape. A few reptiles hid

among the fallen and decaying trees, or sat silent upon the rock, dreamily surveying the scene around them. Insects murmured about the stagnant marshes, and spiders wove their cunning nets to take their prey. The fashions of these old forests passed away, and the aspect of the ocean and land was changed. New races of plants and animals appeared upon the earth. In the new forests, insects and reptiles innumerable lived, and fierce reptilian beasts and birds stalked about the silent shores. All these forms disappeared and others came dissimilar as the passing clouds of the sky. No footstep had crushed the tombs of the Silurian races. At length a fierce monarch came from the north and conquered the land. He transformed a fertile country into a treeless waste, and drove out the living inhabitants thereof. His army covered the country with snow and ice, and everywhere demolished the cemeteries of the ancient dead. It bore them over valleys and mountains, higher than could human hands, and strewed them over the bottoms of distant seas. The conqueror then withdrew into the land of the north whence he came. The ocean then encroached upon the land and possessed it for ages. At length this conqueror also retired. Then came man and gathered up the fragments of those broken tombs, as mementos of the most distant ages. Over them he sits in silent thought, and touch by touch, he restores the story of the great past.

As it regards the thickness of this ancient great glacier of North America the more I consider the matter, the more I am disposed to estimate it greater than has been done by anyone. Prof. Agassiz thinks from evidence afforded near the summit of Mount Washington, that it could not have been less than 6000 ft above the sea.[5] Two months before in the American Journal of Science, I had concluded from observations made upon the summits of the hills of Mount Desert, 2000 ft above the sea, that the glacier which passed over them was not *less* than 5000 ft thick. Prof. Hungerford states that he saw well marked glacial groovings running nearly north-south upon the top of Mount Mansfield, at the height of about 4000 ft above the sea, and probably three above the base of the mountain.[6] At nearly this height the glacier detached a portion of the top, 25 ft long, 15 ft wide and 11 ft thick weighing probably not less than 300 t. The glacier at the height of 3000 ft above the surrounding country had not time enough to transport this boulder beyond the summit of the mountain. It was old and decrepit. The days of its gigantic strength had begun to wane. Once it had triumphed over all the hills of the north, and had buffeted and humbled their lofty heads; but now its days were numbered. The empire of cold like the empires of man, must decline and perish. Nothing is eternal and unchangeable upon earth.

I have seen many similar causes of transportation upon the tops of the hills in southern Maine, and in Piscataquis County. It is evident that a glacier in order to detach a mass of rock weighing 300 t, at a height of 3000 ft above the sea, must override the mountain summit not less than 1000 or 2000 ft. Mount Katahdin, standing nearly in the centre of Maine, is about 4500 ft above its base, and perhaps more. I have in a former chapter, described the immense angular rocks collected

[5] "Atlantic Monthly" for July 1864 p. 92.

[6] "Am. Journ. Sci." for 1868. Vol. I, p. 2.

in countless numbers, upon the south side of the summit of this mountain, and have given my reasons for believing that they are transported boulders. Therefore considering the evidence in this case, and that the sweep of this ancient great glacier was more than twice the length latitudinally of the existing antarctic glacier, whose discharged fragments are known to be sometimes from 3000 to 6000 ft thick, I am forced to believe that the great ice cap in New England was from 8000 to 10,000 ft in thickness at the time of the greatest cold.

The glaciers of the Alps and the Pyrenees, of Norway, the Caucasus, of the Himalayas, of the Arctic and Antarctic zones, of all now known upon the earth, if gathered together and spread out upon the northern hemisphere beginning at the pole to the thickness of 4000 ft, would make a mass insignificant compared with this great ice sheet of other ages. Its intense action is seen in the lake features and broad river beds of Maine, New Hampshire, Vermont, New York and northwestern states. In the British possessions from the Gulf of St Lawrence and the Great Lakes to the border of the frozen sea, the hydrographic features of the country show the denudation by the glacier to have been upon the most magnificent scale. Indeed the map of North America most conclusively proves that the glacier covered all the upper part of the continent, and that its prevailing course was *south*. The soundings in the coast waters from Newfoundland to Cape Cod, given upon the marine charts from the last English and American surveys, show that the sea bottoms are conformable in orographic contour to that of the land. It is apparently a part of the continent, though submerged. There is a gradual shoaling of water towards the south till a minimum depth is obtained, when the water suddenly deepens to a certain extent, showing the south sides of the submerged hills to be abrupt and high. The oceanic bottoms off our coast, has the same roundness and embossed form which prevail over the surface of New England, and is altogether different from the sea bottoms where glacial action has not reached. It is a denuded oceanic bed, torn and revolutionized by glacial action like that of the continent, and was above the level of the sea when covered by the great glacier.

Chapter 26
End of the Glacial Age

The country undergoing a process of sinking—The climate of New England a wet one—The polar zone at this time destitute of molluskan life—Gradual migration back to the north of its fauna—Lowest subsidence of the country—Leda shells on the coast of Maine, the first horizon of life after the glacial age—The marine clays indicate no drifting ice at the time of their deposit—Bones of a whale found in Bangor 40 ft above the river—Speculation in regard to their deposit—Ancient coastline of Maine—The sea preserves what is committed to its keeping—The times of the Saxicava shells, the second horizon of life—Fossil shells found 350 ft high in Penobscot Bay—Age of the raised beaches and terraces—Fossil bones of boreal animals found in Maine—Conclusions upon the matter—The glacial age slow in growth and departure.

But at length the great glacial age began to wane. The continent had commenced a retrograde movement, and was slowly going down into the sea, as it had done many times before. The glacier upon its southern border as the summer returned, melted away more and more every year, filling the streams and rivers, which carried the gravel, sands, and clays over the low lands of the south, and in to the Atlantic ocean and the Gulf of Mexico. There was an excess of decay of the front of the glacier during summer, over the winters growth. As centuries rolled away, and the glacier continued to retreat toward the north, the arctic flora and fauna which had retired upon the south when the glacier occupied the surface of New England gradually returned back to their former habitats as far as their climates would permit.

It was at the time when the glacier had just disappeared from the country, that it presented the magnificent spectacle of spacious lakes and deep broad rivers. Everywhere the country was a theater of moving waters. Severe and long continued rainstorms were common occurrences. A cloudless day was rarely seen. Cold fogs hung over the land. Snows yet covered the highest hills all the year round, and lay deep in the alpine valleys. In winter appalling snow storms as now in northern Labrador and about Hudson's Bay, were a constant feature of the country. Some of the largest rivers north of Cape Ann were united at that time, and had their common discharge into the ocean far out at sea from the present coast. At this period the polar zone was nearly or quite destitute of molluskan life, and the land was everywhere covered with ice. About this time the Leda arctica a small shell now living about Spitzbergen, migrating north, took possession of our coasts, washed by the polar

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current. As the land continued to be depressed these approached the shore, till finally the water was no longer cold enough at depths in which they could live. This is the first horizon of post-glacial life in Maine.

At last the country attained its lowest point of subsidence. Maine was from 500 to a 1000 ft lower than it is now. The northern half of the continent was depressed still more. The shellfish, the Leda mollusks, that had come back from the south where driven by the glacier, and lived in our coast waters, could there exist no longer, as the sea by the great depression of its bed, had become too deep and probably too warm to support life.[1] These northern types then migrated to the north in process of time. Over the dead bodies of the Leda mollusks in the coast waters of Maine, the glacial clays carried by the rivers into the ocean, in connection with the result of the action of the sea itself upon the shores and shoal bottoms, gradually accumulated in some instances not less than 50 ft. But these rewashed or "modified" clays in some places, are three times as thick. These shells which are now living in the arctic waters, appear to have taken up their abode in our coast waters, when the shore was depressed from 1 to 300 ft more than at present, which would narrow the border of the state from 16 to 50 miles. The polar current approached the land nearer than at present, because a large margin of east Labrador, and much of Nova Scotia, New Brunswick and eastern Maine, were under the sea. This current bore directly down upon the coast of Maine, between New Brunswick and Nova Scotia. At the above distances from the shore, I should judge the arctic waters sufficiently cool for the Leda shells. As the coast continued to subside, these shells were removed farther from the shore into deeper waters, by which means they doubtless perished. It is evident that the overlying clays of the Leda beds, were deposited in deep water. This fact must not be lost sight of. The clay is fine, and generally destitute of organisms of any kind, precisely such a clay as was the origin of the shales and slates of Maine. The sea bottom was undisturbed and the ocean carried no drift ice where the clay was deposited, as it is free from rocks, gravel and sand. There is no probability that the country took any sudden plunge into the sea; on the contrary, every phase of the phenomenon connected with this instability of the coast, indicated a slow action. It was then the final depression of the coast, which destroyed the Leda mollusks. There are set bounds to all life, of heat and cold beyond which they cannot exist. Arctic or boreal mollusks, if they can not find congenial waters near the coast, will go to deeper bottoms for it. Some pelagic shells near Portland, came near the surface to the east, and became littoral shells where the water is shoal, but cool.

It was at this time when the Leda shells were overspreading with the boulder clays, that the whale found in Bangor near the railroad depot, settled quietly down on the sea bottom. We have the means of bringing its last bit of history to light. The region of Bangor was deeply covered by the sea, and was still subsiding. The mountainous country between the city and the present coastline, was an archipelago.

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[1] Mr. Charles Darwin in his "Origin of Species" takes the same view of expatriation towards the south, of the northern floræand faunæ, of Europe, during the great ice period of the northern hemisphere.

An open sea extended over Washington County and the border of New Brunswick, to the Bay of Chaleur, in the Gulf of St. Lawrence. The country between the Kennebec and Penobscot Rivers, formed an elevated mainland extending to the south, having the sea on the east and west, as high at least towards the north, as Lincoln on one side and Waterville on the other. Katahdin, the Massacook and Ebeemee Mountains looked down upon this post-glacial sea, as the hills of Camden and Mount Desert now overlook the ocean. But in after times when the coast was fully submerged, the sea probably extended nearly or quite to the base of Katahdin, and to the border of Oxford and Franklin counties. The Kennebec at this time was a mere outlet of Moosehead Lake, as the Presumpscot is now that of Sebago. The Aroostook and St. John were the principal rivers of the state; and the Allagash was longer than the Penobscot, which emptied its waters into the head of the Chesuncook, a broad lake or shallow arm of the sea. The east branch of the Penobscot and several other considerable rivers of our time, scarcely then existed. The Androscoggin and Saco Rivers, though small in those ages compared with their present size, were rapid voluminous streams during the rainy season.

Fish probably such as now visit the coast, had free access to this inland sea. A whale that died a natural death, or was killed by mortal enemies, drifted toward the coast. A score of hungry mouths sought this banquet of the sea, as the eagle and fox snuff the carrion afar. Dogfish, sharks or other gluttons bit glibly at the luxurious blubber, till piece by piece the once lithe and comely flesh was spirited away. Nature knows no waste. Eat and live is her commandment to her household of low and high degree. The head or anterior portion of the skeleton being heavier than the caudal extremity began first to droop, and finally disappear beneath the surface of the ocean as does a water logged stick drifting in the river or sea; and at last it settled quietly down upon the ocean's bed. There it remained head foremost resting in the mud. We have reason to infer that the posterior extremity had not yet lost all its buoyant flesh, otherwise after touching bottom it would have settled down in a horizontal position. In this manner it remained till the fine clay which the ocean's waters held in solution from time to time, gradually entombed it, covered it up certainly 47 ft deep. But no doubt many feet of the superincumbent deposit, have been denuded by the sea, and the rains since it came beyond it. It was about 40 or 50 ft above the river. During this long continued process of interment, it is evident that the sea bottom was quiet, and of course deep; for had the skeleton not been beyond the reach of the ocean, or the current of the river, it could not have kept this nearly vertical posture. It is wonderful that this clay overlying the bones of the whale, is apparently destitute of marine forms, for fish like the existing species, must have been common in those ancient waters, as we find the teeth of sharks in about the same horizon. It appears to me that the clay must have been deposited in *deep* waters, and therefore the state must have been depressed to a greater extent than has yet been conjectured.

After the land had ceased to subside, the grave of this ancient cetus began gradually to approach the shore. When it was within the influences of the waves, or nearly out of the sea, the Penobscot above Bangor was a great estuary, in some places not less than 20 miles wide. The annual floods of the Kenduskeag brought down sands into this estuary and deposited them below its present mouth, upon the clay made grave

of the whale, to the extent perhaps, of half a dozen acres, a round oval hill, and a beautiful spot, in the infancy of the city, overlooking the Penobscot River. There the dead citizens at that time, were buried *above* the bones of the inhabitants of the sea. They both slept their last sleep together, the mammal of the sea, and the mammal of the land. In after years the thriving city of Bangor purchased the site of its present beautiful cemetery Mount Hope, 2 or 3 miles above, on the same bank of the river; and all the human remains which could be removed, were here finally deposited. The old cemetery was sold to the railroad company; and the workmen in making a section for materials to build up a site for the depot, after cutting down 47 ft, came upon the tomb of the ante-Adamic cetacean. As they dug up the bones, they supposed they were *rocks*. They were "quare lookin rocks intirely", they thought. They were thrown into the carts and the clay, and removed to build up the land for the site of the depot. Someone however who saw them, suspected I believe, that they were *bones*. Dr. A.C, Hamlin of Bangor, a gentleman of scientific tastes independent of matters which relate to his profession, casually heard of the circumstance, and visiting the locality, forthwith saw how matters stood. He gathered up these organic souvenirs, and thus this skeleton buried in the ocean's bed ages before man appeared upon the earth, has come down to our times complete and rich in the memories of the past, while that of the first man, nay, of his descendants for many ages thereafter, no living mortal knows anything whatever.[2]

About this time that the country had ceased to settle down into the sea, the buffalo came into the cool summer meadows of Maine, to find pasturage, as he was accustomed to do not more than a century in Labrador. A luckless wight crossing an arm of the sea which was too broad for his strength and endurance of his muscles, or swimming the Kennebec above its mouth when the late autumnal weather was congealing its waters, lost his life thereby.[3] When the returning warm weather of spring had dissolved the snows of winter, and the river was open again, the carcass drifted away towards the sea, and dropped a tooth upon the accumulating beds of clay where now is the town of Gardiner upon the Kennebec. The bodies of men drowned

[2] Dr. Hamlin told me no decision had been made by competent persons, upon the species of the whale; but probably it belonged to a living species. The remains of a whale have been discovered in Vermont, 60 ft above the surface of Lake Champlain, and 130 ft above the surface of the sea. It is called Beluga vermontana.

[3] There are some remarks by Sir Charles Lyell upon this subject of so suggestive a character, that I cannot refrain copying them: "A herd of mammoths returning from this summer pasture in the north, may have been surprised while crossing a stream, by the sudden congelation of its waters. The missionary Huc relates in his travels in Tibet in 1846, that after many of his party had been frozen to death, they pitched their tent on the banks of the Mouroni-Ousson, and saw from their encampment, some black shapeless objects ranged in file across the stream. As they advanced nearer no change either in form or distinctness was apparent; nor was it till quite close, that we (the party) recognized them a troop of wild oxen. There were more than fifty of them incrusted in ice. No doubt they had tried to swim across at the moment of congelation, and had been unable to disengage themselves. Their beautiful heads surmounted by huge horns, were still above the surface, but their bodies were held fast in ice, which was so transparent that the position of the imprudent beasts was easily distinguishable; they looked as if still swimming." - "Principles of Geology", p. 85.

near the shore, sometimes drift out to sea. They are often found with the loss of a few teeth, or finger bones, and sometimes of the head itself.

But at last New England became stationary, resting for a while before it commenced a retrograde movement, or one of upheaval, which has not since ceased. Her climate was colder then, than when first separated from New York State by the Champlain Valley, towards the close of the Tertiary period. Glacial action had greatly denuded that old valley bed, making it wider and deeper; and as it was now under the sea, there was an ingress into it of the west branch of the polar current flowing south over the submerged channel of the Hudson River. Thus the marine mollusks of Maine and the lower British provinces, would naturally be of northern type, from this division of colder water approaching its shores. The climate of New England meantime, may have had a higher mean annual temperature than at present. The summers were wet and cool, and the winters open with short snow storms and abundant rain.

While the country was thus stationary, and the Leda shells were covered by a great depth of sedimentary matter, and the beds removed from eighty to a hundred miles from the coast, the ocean made a great impression upon the shores, and erected the oldest beaches in the country. At last New England began its final upward march. The Leda beds began to approach the shore. Over them and sunken ledges, and about the shores of islands, a little shellfish took up its abode at the time. It is altogether a homely affair, if any of nature's children are homely, but has the pretty name of *Saxicava*, on account of burrowing in the sands of the shoal waters. The shell is nearly an oblong square, about 1 in. by three fourths. As it sits like a dish right side up before me, I am reminded by its shape, of a cast off shoe from the foot of one of the "poor-whites", or *blacks* rather, of the human family. The heel is sadly askew, and is apparently endeavoring to look the owner supplicatingly in the face. The sole seems as if it had long since ignored the burden of the foot, and had shifted it to the side of the shoe. The general aspect of the whole affair looks as if it had been shockingly *downtrodden* and abused, while even in its best days. From this corrugated, rugose feature of the animal, naturalists, have christened it *rugosa*. But one of the close observers of the Pine Tree State, I suspect, has preferred the more appropriate name of *distorta*. Well, this madam Saxicava distorta flourished in Maine a long time before the red man dug clams about our coasts. It is an abundant fossil in the state, and is also found in New Brunswick, and Canada along the river St. Lawrence. I have found it in Maine higher above the sea than has any other person, I believe, namely 350 ft. Along with was the ribbed scallop, two species of the mussel, two of the cockle, and some other shells, ten species in all.[4]

In Maine the beaches are not at uniform heights, but vary from 10 ft above the sea to 700 ft. They are all a part of one system of upheaval, which is not yet completed.

[4] Dr. Packard makes an error of a hundred feet, in his notice of the shells found by me. I took the height by the aneroid, 317 ft; but called it 350, because the tension of the spring had been somewhat injured by a fall. Vide Packard's "Glacial Phenomena", p. 242, and Am. Jour. Sci. for 1866, vol. 2, p. 426.

There is an old shore line of this kind in Westbrook three fourths of a mile from the Kennebec and Portland railroad bridge over the Presumpscot on the direct road from Gray to the city. I judge it to be about 300 and 350 ft above the sea. The entire top of Mount Independence West Falmouth, not less than 700 ft high, is an old shore line running north towards Gray. Walnut Hill, North Yarmouth is another. On Isle au Haut, in Hancock County, there is a sea beach in a notch of the mountain 300 ft high. The "horse back" in west Levant on the stage road from Bangor to Corinth, is a sea beach or a lake beach. The Saxicava period, or oldest beach age, constitutes the second horizon of life in Maine succeeding the glacial times. It is everywhere merged into the present marine life age and can not be separated from it, for some of the species then living, now exist in our shore waters.

In regard to the Champlain and Terrace epochs, they are doubtless dependent upon the last upward movement of the continent, and are thus associated with the beach era, but stand more towards its beginning. When the denuded river and lake beds were going down into the sea, gravel, sands, and clay, were deposited upon their bottoms. As they arose from the sea, the volume of the streams augmented, and cut out the terraces as we see in the river systems from the St. Lawrence to the Hudson. Some of the terraces upon the St. John and Connecticut Rivers are very high above their present beds. It is certain that these troughs were filled with eroded materials, of the glacial age, and have been denuded since the last upheaval of the country began. Chesuncook Lake through which the Penobscot River flows, may be taken as an example, of the manner in which river and lake terraces may be made. In places around its margin there are beaches of gravel and sand. As the country continued to rise, the waters will flow off, and the river will be confined to narrower and deeper bounds. But a series of wet seasons may occur in the process of time to modify the river margin, by denuding it into terraces. There is doubtless under the sea along the coast of New England, the exact counterpart of surfaces now above it, and some of the bottoms would be converted into lakes and river beds of the country if the country should continue to rise.

Because the tusk of a walrus has been found in the boulder clay of Maine, I do not think the conclusion inevitable, that the state at the time of that deposit, was as cold as Labrador is at the present time. Mr. David Calderwood of Vinalhaven, has in his possession a walrus tusk which I have seen, from the Magdaline Islands in the Gulf of St. Lawrence. He said, 35 years ago he got three of their tusks and an under jaw from those islands, from a place where the animals were killed by the French in former times. In writing to me upon the subject, he says in speaking of the tusks and bones "they are not dug out of the ground, but are where they (the hunters) dressed them. The sand blows away and leaves them exposed to the weather. I have seen a great many of them."[5] The walrus may have come into Maine in the winter, or even

[5] Walrus (in Maine) "It is stated in some of the older books on Natural History, that Walruses were at one time not uncommon on the coast of North America, in the Gulf of St. Lawrence 47 north lat."
I learned from Mr. McNamara of Thomaston, who visited the Magdaline Islands in 1871, for the purpose of examining the walrus bones there to ascertain the commercial value of the ivory of the tusks, told me they were principally situated on House Island (Isle de Maison).

in the summer, for aught I can see to the contrary. They were vastly more abundant anciently than now, and their habitats were not restricted by enemies as at the present time. But a high authority says "we find the walrus can live, at least for some time, in a temperate climate"; and so I think the climate when Maine was submerged to a greater extent, was not *colder* than at present as Dr. Packard seems to imagine.[6]

In regard to the former presence of arctic sea sea birds, and some other fauna of high latitudes being once common on our coast, and therefore indicating a severer climate, I would say that the puffin or sea parrot (Mormon arctica), a different species from the Salt Lake Mormon, I would have my younger readers to understand, is abundant now on Seal Island, south east of Isle au Haut. These birds breed there every season. A few years ago, I carried half a dozen old ones away from that island, which I pulled out of their holes in the rocks. There was some smart biting there, not on my part, and an innocent flow of blood thereby, that *was* on my part; but once committed to the hunt, I considered retreat out of the question. I kept them a week on fresh fish. The pugnacity of the beast is equal to a "cornered" rat. After their food was given them, they occupied some time in contemplating my movements. Making cautious and somewhat distant passes at them, didn't seem to effect their apparently complacent temper; but if the hand passed within reach of their bill, there was an invisible flash of the head, and presto! you suddenly found a digit between a pair of stout mandibles. The sea pigeon (little auk), the mur (razor bill auk), petrels (cary chickens), and some other northern birds, breed on Seal Island, Wooden Ball and Ragged Island, and possibly in other islands, off the coast of southern Maine. I consider the little auk one of the best divers in the world. Like a sort of an egg shell he swims lightly. He will pop out of sight in a twinkling, and can hold his breath like a sponge diver. So we see that for thousands of years probably, while the red race occupied the territory of Maine, and resorted to the sea coast for clams, and had a pretty liberal bill of fare generally, as their shell heaps indicate, among which are the remains of some boreal animals now unknown to the country, some of more high latitude types have kept up their old habits of visiting your coast. I have no doubt but that if the human race should be obliterated from the continent, many other northerners would come down again upon the shores of New England within a few hundred years.[7] It has been suggested that evidence of the former presence of the polar bear and reindeer may yet be found in New England. If this should be the case, it would not decidedly darken the probability that the present climate of the

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The fact that reindeer and musk-ox bones have been found in the lower part of the salt-licks of Kentucky, in connection with mastodons bones, is thought by Harper's Monthly's excellent "Scientific Record" to be a proof that a colder temperature existed at the time when the animals existed. We know that the Siberian mammoth had long shaggy hair and lived in a cold climate. Perhaps these animals exist and flourished just south of the belt of ice of the glacial period which did not extend much south of New York.

[6] Two skulls of the walrus have been found in the gravel near Long Branch, New Jersey, and I believe some bones of the reindeer. "Cook's Geology of New Jersey", p. 385.

[7] See "American Naturalist" for January 1868, p. 561. Article on the Shell Heaps of Maine and Mass. by Prof. Wyman of Harvard College.

country is warmer now than it was a few thousand years ago when the margin of the state was submerged to a greater extent then at present. Along the southern side of the Altai mountains, as high as 53° north, the Siberian tiger, supposed to be of the same species as the royal Bengal tiger of the hot countries of southern Asia, is found in the valley of the Amour, along with the reindeer. It is said that "sometimes he feeds upon the flesh of the white bear". Now if the bones of the tiger were found on our coast shell heaps, would it not materially distort the complexion of the supposition, that when they were accumulating, the country was colder than it is now? The bones of the white bear, reindeer, arctic fox and arctic seal along with the great tiger and red deer of southern Siberia, may be entombed together in the mud at the mouth of the Amour River.

I can not agree with Dr. Packard upon some of his conclusions regarding the glacial age of north eastern America, and the climatic conditions of the country during its final submersion. He imagines that an elevation of 600 ft above the present altitude of New England and the eastern border of the continents beyond, would bring down glaciers into the former region, and build up an ice wall "rivaling in height and breadth the enormous glaciers 1000 ft thick and 540 miles long discovered by Sir James Ross in the antarctic lands."[8] The old glacier covered New York City. Its groovings are seen in Fifth St. on the rocks underlying Columbia College, and on the naked rocks north of this street, and west of Sixth Avenue. About 10 miles north of the city, glacial striation has been described upon the trap rocks forming the palisades of the west bank of the Hudson, in New Jersey, by the Rev. W.B. Dwight.[9] If the glacier there, pushed its way along the eastern border of the continent as far south as the city of New York, it must have swept over Long Island, and the islands of Martha's Vineyard and Nantucket, south of Cape Cod. Every vestige of unconsolidated *clay* would have been removed by its march and therefore the "brown clay" underlying the drift beds supposed to be Tertiary by Desor and Cabot, referred to by Dr. Packard, can not be an ante-glacial deposit. Wherever the glacier overlooked the land, the waste of the glacier was effected through the action of the temperature of the locality; but where the ice front was immersed in the sea, the glacier could find escape only in deep waters, in fragments as icebergs. There were no local glaciers in the country during the intensity of the cold period, nor of any considerable breadth and extent during its wane. The notion of a Hudson Valley glacier, a Mohawk Valley glacier, a Connecticut Valley glacier, and a Penobscot Valley glacier is not tenable I think.[10] It is evident that such localities could have had no independent and permanent sources of snow to grow glaciers. A glacier of 1000 ft in thickness as Dr. Packard supposes, in New England would be nil when thinned out toward the western states, where the cold was evidently not so great as in the east. Furthermore, a glacier of such thickness, could not have overridden our highest hills. Like a handful of ballast in a common sailing boat under a stiff breeze, which could not keep the boat steady, this 1000 ft glacier would everywhere have been deflected by the uneven surface of the land. Are we then

[8] Glacial phenomena of Labrador and Maine, p. 261.

[9] Am. Jour. Sci. for 1866, vol I, p. 10.

[10] Dana's "Manual of Geology", p. 751.

to imagine to imagine that the ancient ice cap of North America covering a territory several times greater than that of the existing glacier which envelopes the southern pole, was really of no greater thickness than the latter? Furthermore, the conclusions of Dr. Packard in regard to the climates of New England during the two periods, first, when the land stood 600 ft higher, and second, when it stood 600 ft lower, than it is now, appears to me not very logical. His supposition is, if I understand him, that New England was elevated during the great ice period not less than 600 ft above its present height, and that the polar regions partook of this rise; and that thereafter a subsidence occurred of this same land to the amount of 1200 ft, or 600 lower than now in the Christian era; but that during this time of low depression, New England was actually *colder* than it is now in the human period. I am altogether at a loss to conjecture whence were derived the icebergs and floe ice that drifted down upon the coast of New England, if the arctic lands were correspondingly depressed with those of the former country. All geological writers are of the opinion that during the coal growing ages, as well as before that time, the ocean circulated freely around the regions of the poles, and that the land surfaces of the globe were greatly depressed and contracted compared with the present, and consequently the earth must have had nearly a uniform mild climate. I do not believe that when New England was depressed 600 ft *below* the present status of the land, her climate was *colder* than it is now; nor that an elevation *above* it, of 600 ft, would be sufficient to bring down south of the state of Maine, a glacier everywhere covering the land, and overriding its highest hills.

Neither can I accept the opinion expressed by some American as well as English writers, that the great cold period of the world came of a "sudden", and as speedily disappeared. It is true indeed, that the entombment of the mammoth and rhinoceros in ice looks much like the supposition. But if anyone believes that those pachyderms were pelted with a supernatural snowstorm, as were the rascally kings of the Amorites with hailstones at Gibeon, and thereby lost their lives, he will believe what never did occur, I conjecture. Mighty minds like the "strong east wind" of Moses, and very long continued, must have swept the ocean, and carried a marvelously thick vapor over the arctic regions, hitherto fine grazing pastures for the mammoth, which was "suddenly" converted into unfathomable snows, a very disagreeable state of things truly, for these primitive and noble brutes, the elephant mammoths. But one must remember as Sir Charles Lyell suggests, that those animals may have been transported to their present locality by water, ere their bodies decomposed, as most of the rivers of Siberia and the upper part of North America, run into the frozen ocean. There is no doubt but that the most of the fossil animals of the dry land, were swept away by floods, and carried out to sea, or the estuaries of rivers. The death of those gigantic quadrupeds occurred *since* the glacial age, while the country has been rising for the last time, though some may have perished before this submersion took place. I think the coming and going of the glacial age was *slow*, like the processes we now see in operation. He who judges that nature has performed such marvelous revolutions in a moment, ought to expect the end of the world at any moment. The injunction to "make haste *slowly*", is nature's motto, and assuredly she has never overstepped its import. Man hurries to and fro over the earth, shouting "time is *short*"; but blithe queen nature says "time is *long*, most noble lords, my servants."

Chapter 27
On the Motion of Glaciers

Glaciers of the Alps—Researches on their growth and motion— Prof. Agassiz's views—Their comparative winter and summer motion—Hydrostatic pressure and infiltration of water not sufficient to account for the accelerated motion of the glacier during summer—The motion also increased during the coldest weather of winter—The mere dead weight of the mass not sufficient to account for its motion—The theory of heat and cold proposed to explain the motion—How bodies are effected by changes of temperature—Experiments on ice—The winter motion of the glacier, due to contraction of the mass through the influences of cold; and the summer motion to expansion of the mass through the agency of heat—The running waters on the surface of the glacier, communicates heat by their falling force—Dead weight of a mass resting upon an inclined plane, considered—No inclined bed for the ancient great glacier of North America—Its progress slow—Its thickness in New England—The sun puts the sublime structure in motion.

A simple alpine glacier, wherever it exists, whether among the lofty valley's of the Alps of Europe, or the elevated mountainous regions of that or other continents, has the upper terminus of its plane at the gate of a basin of accumulating snows, bounded by the higher peaks of the hills. Through this pass the imperfectly impacted mass of snow is forced into the upper reach of the valley, and immediately thereafter the glacier begins; first as névé or granular snow, and below as a stream of solid ice. This ice stream is in constant motion winter and summer, and is apparently subjected to the same laws of motion as a river of water. The remoter sources of a glacier are the lofty sides and summits of the mountains. The snows there collecting in vast masses, especially during winter, are avalanched into the basins below. The descent of the bed or plane of the glacier, may vary from a few degrees to 25, or nearly double this number.

The glaciers of the Alps of Europe have afforded almost exclusive data for the theories of scientific men concerning the phenomena of their growth and motion. More than a hundred and sixty years ago, John James Scheuchszr, a physician and mathematician, and professor of Zurich, attempted to explain the motion of a glacier on the theory of freezing and consequent expansion of infiltrating waters throughout the ice mass, forcing it along its plane. Charpentier of France, many years afterwards, adopted the idea and thoroughly developed it. H. B. De Saussure, a famous professor

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of Geneva about the middle of the last century, imagined the glacier slid along its bed independent of the freezing of the water which finds its way into the body of the glacier. He supposed the mass resting upon an inclined plane to have a tendency to slide along the bed, being lubricated in every direction there by the interpenetrating waters. The late Professor James D. Forbes, of Edinburgh, considered the glacier to be a viscous body, having a tendency per se to slide down hill as tar would be supposed to do. Additionally to this falling force of the glacier, he thought the waters distributed over and perhaps throughout the ice body, "exercises a tremendous hydrostatic pressure to move onward in the direction in which gravity urges it, the vast porous mass of seemingly rigid ice in which it is, as it were, bound up." Prof. John Tyndall, the popular successor of the late Dr. Faraday in the Royal Institution of Great Britain, has investigated the various phenomena connected with glaciers, probably to a greater extent than any other one. In his work on the "Glaciers of the Alps," he does not seem to give us clearly his views upon the origin of glacier motion, though he criticizes those of other observers. If I understand him aright, he thinks the motion simply due to the vertical pressure or weight of the mass itself urging the body in the direction of the slope of the bed on which it rests. In this country, Prof Louis Agassiz, of Harvard College, may be said to be pre-eminent in the investigation of glacial phenomena. As early as 1836, when about 30 years of age, he began to study practically the glaciers of the Alps, and a few years afterwards published his "Glacier System." In 1846, when first visiting America, he observed, according to his own statement, the fact of the ancient existence of glaciers in regions immediately south of the mouth of the river St. Lawrence.[1] In his "Atlantic Monthly" papers he has given us his views of glacial action in Europe and America, and of the laws by which the motion of those vast masses of land-ice are governed. His theory of their motions is essentially that of Charpentier. But that he be perfectly understood in the matter, I will quote a paragraph or two from the "Atlantic Monthly" for 1863: " Physicists seem now to agree that pressure is the chief agency in the motion of glaciers". No doubt all the facts point that way; but it now becomes a matter of philosophical interest to determine in what direction it acts most powerfully, and upon this point glacialists are by no means agreed. The latest conclusions seem to be that the weight of the advancing mass is itself the efficient cause of motion. But while this is probably true in the main, other elements tending to the same result, and generally overlooked by investigators, ought to be taken into consideration.

"The weight of the glacier as a whole is about the same all the year round. If, therefore, pressure resulting from dead weight be the all controlling agency, its progress should be uniform during the whole year, or even greatest in winter, which is by no means the case. This can be accounted for only by the increased pressure due to a large accession of water trickling in spring and early summer into the interior through the network of capillary fissures pervading the whole mass, The unusually large infiltration of water at that season, is owing to the melting of the winter snows. Here then is a powerful cause of pressure and consequent motion, quite distinct from

[1] "Atlantic Monthly" for July, 1864, p. 68.

the permanent weight of the glacier itself. The water thus introduced into the glacier, acts in various ways, by its weight, by loosening the particles of snow through which it trickles; and by freezing and consequent expansion, at least within the limits and during the season at which the temperature of the glacier sinks below thirty two degrees Fah. The simple fact that the glacier swells on an average about five feet more than its usual level, shows how important the infiltration must be. It is admitted by all that the waste of the glacier at its surface, in consequence of evaporation and melting, amounts to nine or ten feet a year. The water supplied by infiltration, no doubt, repairs the loss to a great degree." The phenomena observed upon the glacier of the Aar, where Prof. Agassiz's special observations were made, are everywhere constant with all alpine glaciers. The unequal motions of these bodies, independent of the seasons, are due to the comparative inclinations of beds, breadth of surface, and thickness of mass. In examining the various theories of glacier motion, I will first notice the very important fact of irregular winter and summer progress of the glacier familiar to all glaciologists. Prof. Agassiz gives for illustration the approximate relative winter motion of the glacier of the Aar to that of summer, as 150 ft are to 250, or as 3–5. He, it will be seen, attributes the differential motion to infiltrating and freezing waters, while Prof. Forbes, who made a glacier exploration among the Alps in company with the former, refers the increased motion to the dynamic energy of their hydrostatic pressure. Prof. Tyndall ignores the explanation of both, but nowhere offers us a solution of the significant fact. The increasing summer progress of the glacier can not be due to the waters penetrating the bed on which it rests, and assisting or producing motion of the mass as De Saussure supposed. The pressure of the glacier is so great as to exclude all running water except what finds passage in its own tunneling. The inferior surface of the glacier resting upon the rocky floor of its bed, must be comparatively dry, as that portion of the mass is subjected to tremendous pressure, and must therefore be hard like the rocks on which it rests. Let us admit that much water escapes along the bed during the winter season, when the glacier is growing; but the annual increase of snow at this time is more than an equivalent of the loss of water by this pressure, as exhibited at the end of the glacier. If that were not the case with the addition of the loss during summer, the glacier would annually be reduced, and would finally disappear. On the other hand, it seems to me that pressure is so diminutive in the quantity of its increase during the winter season, that whatever moisture is thereby produced, must chiefly tend to regelate the ice to the bed on which it lies.[2] The friction of the glacier must thus be enormous, and of too great a magnitude to permit progress providing there were no living force (vis viva) within the mass. This view of resistance agrees with the conclusions of Prof. William Hopkins of Cambridge England, as referred to by Sir Charles Lyell.[3] This friction is proportionable to the weight of the glacier, and its dip, and is therefore a constant amount if "the weight of the glacier as a whole, is about the same all the year round," as Prof. Agassiz supposes, though it scarcely seems probable.

[2] "Glaciers of the Alps," p. 351.

[3] "Principles of Geology," p. 224.

In regard to capillarity, which Prof. Agassiz argues is distributed throughout the glacier, it seems to me, waving the objections of Prof. Tyndall, that this porous nature of the mass can not exist. I believe it utterly impossible to exist in fresh water ice recently frozen. I consider a sheet of such ice comparatively as impervious to water as a sheet of lead or beaten gold, and would hold water equally as well under favorable circumstances, if molded into the form of a vessel. If capillary fissures do not exist in fresh water ice, surely much less should one expect them to exist in that of a glacier subjected to great lateral and vertical pressure even at a few feet beneath the surface. Beyond this depth all such capillaries must be entirely absent. If, however, the surface water of the glacier should penetrate to a moderate depth, and could there possibly freeze solid from top to bottom in one night, this nocturnal freezing and consequent expansion would be no efficient agent in accelerating the progress along its bed, of the mass below that depth, though the ice above might have a motion of expansion. These infiltrating waters, in order to produce an auxiliary motion by the expansion of congelation, must penetrate the center of the glacier at least. The whole body, from top to bottom, has an accelerated motion from spring to summer. Prof. Agassiz tells us of fissures 250 ft deep, in connection with his thoughts upon the capillarity of the glacier. Well certainly, these fissures are not capillaries. Running waters, when they penetrate the glacier through these profound crevasses, or any visible fissures, do not extensively freeze, I imagine; but run off through unknown channels, as the abounding stream at the lower end of the glacier indicates. I cannot conceive of any important fissure without imagining its commencement at the bottom of the glacier, either in the middle or obliquely along its sides. It is certain that running water over the face of the glacier does not accumulate in these fissures, and the presumption therefore is that they find escape as just suggested. As night approaches, and the temperature is about to be depressed below the freezing point, the surface waters gradually abate. It is therefore evident that capillary freezing must be emphatically superficial if it ever exists, and consequently ineffectual as an active agent in the increased summer motion of the glacier. The immaterial freezing of a summer's night is dissolved next day, and this state of things goes on while the warm weather lasts. The experiments of Prof. Thomas H. Huxley, of London, who accompanied Prof. Tyndall in one of his excursions to the Alps, to ascertain the presence of these capillaries, show their absence upon the glacier.[4] It would be most singular if such experiments were insufficient when conducted under the eye of a thoroughly educated chemist of mature judgment like Prof. Tyndall; and he sums up the matter by saying "the very existence of these capillaries is rendered so questionable, that no theory of glacier motion which invokes their aid, could be considered satisfactory."[5] He remarks upon a previous page of his book, that the observations of one of his intelligent employees during the cold December of 1859, upon the Mer de Glace leading into the valley of the Chamonix, "militate as far as they go, against the idea of proportionality between the capillary supply and the motion" of the glacier. This

[4] "Glaciers of the Alps," p. 338.

[5] Ibid.

alpine guide, Betmat, who registered thermometrical and kinetic observations for Prof. Tyndall at the time alluded to, records the motion of the glacier augmented also during the coldest weather, another singular fact unexplained by Tyndall or Agassiz, but which I consider of great significance. From the sixteenth to the twenty second of this month the weather averaged 25.5° below the freezing point, of F., and for the next 7 days, 9° below it. One day, Dec. 2l, the mercury was 5° below zero—twenty and a half of the Centigrade.[6] This agrees with the experience of Forbes, who found the same great ice plain to have an increased motion from 24 in. daily in December, to 34 in. 4 months afterwards, during a cold winter when the temperature of the air was constantly below the freezing point.[7] The same author noticed the increased motion of a point of the Mer de Glace for a few days in summer of nearly 2.25 in., which he attributed to the augmented heat of the weather at the time.

If, therefore, no such capillarity exists as Prof. Agassiz supposes, the hydrostatic pressure of Prof. Forbes is of no value whatever as a theory of glacier motion. And if the supposed porous nature of the glacier is a fact, such pressure could not contribute towards accelerating the march of the glacier, more than Prof. Agassiz's infiltrating and freezing waters. These waters are a part of the glacier, and a constantly diminishing quantity of it. Their channels are everywhere arrested by transverse fissures, broad and deep, extending to the bottom of the glacier as heretofore suggested. Therefore a summer section of the ice bed between two fissures, would generally weigh no more at 3 p.m. when flooded with water, than at 7 a.m., when it is absent, nor so much, if the waters are derived from its melting surface. How then can hydrostatic pressure in the capillaries of such a section produce motive power? There is force in the falling waters, as we shall hereafter see, but not in hydrostatic pressure in the glacial capillaries, if they really exist. Such a force, it seems to me, would be as insufficient to assist in accelerating the motion of a glacier, as would the attempt of a man seated in a boat to sail it by producing wind from a hand bellows.

Considering, therefore, the theory of superficial freezing of water in the supposed capillaries of the glacier, or that of hydrostatic pressure of water in them, upon the question of increasing summer motion of the mass, neither one nor the other is sufficient to account for the phenomenon. Nor is the simple fact of pressure, which Prof. Tyndall evidently favors, able to solve the mystery. The increasing summer motion of the glacier cannot be due merely to vertical pressure, for at this season there is no increase of it, but on the contrary the mass is constantly undergoing a process of superficial degradation by solar heat. Upon this theory the greater motion of the ice stream ought to be during the winter, when the weight of the glacier as a volume is at its maximum. Winter is the season of snow harvest, when glacial growth takes place. But its motion then is a minimum rate. At this time there is no running water upon its surface. In the spring however, when the sunbeams warm the alpine valleys, the glacier begins to travel with greater speed, which increases to the point of hottest weather, It is now that the glacier's surface is everywhere covered with running

[6] "Glaciers of the Alps," p. 336.

[7] Forbes' "Occasional Papers," p. 224.

water. The loss by this means in the Aar glacier, Prof. Agassiz tells us, amounts to 9 or 10 ft a season. Notwithstanding this enormous loss, the glacier swells till it attains the height of about 5 ft over its winter volume. Two remarkable facts are thus placed in the closest intimacy with each other—(1) increasing motion of the glacier during warm weather and (2) increasing bulk at the same time, notwithstanding a daily loss by the melting of the glacial mass. These two phenomena, thus placed in juxtaposition to the deportment of the glacier during winter, when the temperature of the alpine valleys is below the freezing point, show distinctly that no correct solution of the phenomena has yet been presented to us. Having carefully examined the subject of glacier motion, and thus found the theories of eminent authorities deficient I think in regard to it, I purpose to explain it upon the new views of kinetics, as applied to the expansion and contraction of bodies.

The foot-pound theory, now revolutionizing some of the doctrines of physical science, teaches us that the fall of 1 pound through the height of 772 ft, or 772 lbs. through 1 ft, produces heat sufficient to raise 1 pound of water 1° of Fahrenheit's thermometer, And conversely, the force produced by this 1° of heat is sufficient to raise 1 pound 772 ft, or 772 pounds 1 ft high. It is thus seen that there is a correlative quantity between cause and effect in the expenditure of force, as all men have believed in a general way, for ages. Thus in the domain of heat we can say the cause equals the effect, and the effect equals the cause. The effect as a dynamic unit, is always resolvable into the cause. There cannot therefore possibly be in the universe, any motion without producing heat, nor can heat possibly exist without producing motion. Still further, heat is the origin of all thought as well as ordinary physical movement in the universe, all that man was, is, or ever will be, in body and mind, results from heat. His thoughts, as well as the play of his muscles, whether directed for his physical wants or turned to the sublime contemplations of nature, are born of heat, originally and immediately from sun force. The earth when cast from the sun, was as a possible convertible mass, precisely the coefficient of the energy with which it was projected into space; and if it should ever fall back into the sun, it win return with the same force with which it was originally cast off, and will restore all its primitive weight, having lost not a grain of it. But this state of things can never be. Motion when once begun with the earth is eternal. Perpetuity of matter is secured by its never ending motions and mutations.

If the sun then, as the earth's center, gives light, heat, actinism, magnetism and electricity, or any other form of force whatever by the energy of his forces, whether they exist independent of his motions, axical and orbital, or not, the earth must restore a counteracting force or forces. Even cold itself may be the result of some of these forces, either of the sun or the earth, or of them both mutually, and there may not be therefore any such effect in space as cold, certainly not that intensity supposed here to exist by some philosophers. Thus there is no giving without compensation, from primitive nature down through orientalism to modern society, and the newest views of dynamics. Interchangeability of force was the first magnificent thought of nature. The idea runs through all matter, animate and inanimate. If I give, I shall receive back its value, utters every voice in the universe. The sun and the earth then, are like two immense magnets in juxta-motion. The motion of the former gives motion

to the latter. If the earth should stand still in space, though even looking upon the sun at a fixed distance, all life upon its surface would speedily perish. No motion, no life, nature writes upon the heavens and upon the face of the earth. This infinite strife of the sun, pushing and pulling all matter in the universe, originating terrestrial motion, evolving life and death, and all action whatsoever upon the earth, is the grandest idea of the age. Not blindly was offered to the sun the adoration of ancient men. Furthermore, over the minds of some of those noble souls who have long since ceased to talk audibly upon the earth, the light of truth shone most clearly. Three thousand years ago sages thought matter destined to pass perpetually into new forms, and not to remain inert nor be annihilated. This is precisely what we know nowadays, but only through the light of modern science. Though there may be no new thing under the sun, as the wise king hath said, old forms are ceaselessly taking new shapes more vivacious and energetic than before, ever looking onward to a higher destiny. Thus heat, whether solar or terrestrial, in performing work, becomes the coefficient of the work, and is consumed thereby, and there is no longer that heat in existence. Thus the simple definition of heat is MOTION. It is therefore evident that heat is not matter, nor can there be such a fact as "latent" heat, a postulate common in our older books on physics.

Having stated these newly discovered laws of heat, I shall now consider the deportment of ice under pressure, according to the researches of experimenters. Prof. Tyndall says, " I have more than once cooled a sphere of the substance in a bath of solid carbonic acid and ether, to a temperature of one hundred degrees below the freezing point. During the time of cooling, the ice crackled audibly from its contraction, and afterwards quite resisted the edge of a knife, while at thirty two degrees it may be cut or crushed with extreme facility."[8] Dr. Kane tells us, that during the excessively cold weather of the arctic winter, when the thermometer stood at 70° below zero, and chloroform froze, and the oils of sassafras, juniper, cubebs and wintergreen thickened to a point between liquidity and solidification, ice resembled granite in hardness.[9] It thus appears that intense cold operates upon ice as upon all other bodies, to contract its volume, and consequently to render it of greater density and harness. Prof. Tyndall has given us the rationale of the expansion of ice above its volume of water.[10] The centers from which the crystallizing spiculae of ice radiate, are vacuous points. There is a tremendous energy exercised invisible and silent as the footfall of night, in the transformation of only a few pounds of water into ice. It is this victory of the crystallizing forces over air, which makes it so difficult to fuse ice , to change it to a point less than one additional degree of Fahrenheit. As much heat the must be expended upon the ice at 32°, as there was working force lost in the passage of the water into ice, before the grasp of the crystallizing forces will relax. It is these minute vacua which buoy up the ice, by enlarging its volume above that of water, independent of air which some erroneously imagine is contained within

[8] "Glaciers of the Alps," p. 332.

[9] Kane's "Arctic Explorations," vol. I, p. 308, and vol. II, p. 184.

[10] " Heat" p. 120, and "Glaciers of the Alps," p. 316.

the ice. If these vacua were absent, or could be obliterated by pressure, I think that ice would sink if thrown into water of the density of that from which it crystallized. There is here in the buoyancy of ice, a magnificent and far-seeing provision for the wants of life on the globe. If ice would sink immediately upon forming, seas, lakes and rivers would be encumbered and cooled with the material; life there would perish, the globe would be chilled, and its economy subverted. It is in this light that the congelation of water forms no exception to the law of contraction of cooling and crystallizing bodies, or of their expansion by heat.[11] Thus it is seen that ice cools in common with other bodies, and thereby contracts when subjected to low temperatures, notwithstanding its normal is the freezing point. And if it can thus absorb cold and contract its volume, it can inversely absorb heat in this condition, and enlarge its volume until its temperature attains the point of 32° or nearly that, above the zero of Fahrenheit. As it regards pressure upon ice, experiments have not yet been carried to the extreme of perfection. Those of Prof. Edward Hungerford, of Vermont, given in a paper presented to the American Scientific Association in 1867, show that the glacification of ice from snow under heavy and prolonged pressure, takes place at all temperatures even down to zero. This is an extended experiment of that of the conversion by the pressure of our hands, of snow into imperfect ice. In Professor Tyndall's experiments upon pressure once, the "liquid layers" appear to me to be the product of heat in consequence of the friction of the molecular particles of ice while in motion under pressure. However correct his conclusions may be, that "the fusing point of substances which expand in solidifying, are lowered by pressure;" and that from this opinion the inference apparently should be drawn that the liquefaction of ice under pressure is due to the depression of the melting point, the resultant liquid having a temperature below 32°, it strikes me that the liquid is immediately due to the generation of heat within the ice, which may not be rendered sensible perhaps, except by the liquefaction.[12] In another work Prof. Tyndall remarks, "on applying pressure, dim spots were seen forming in the middle of the ice, and as they expanded laterally, appeared in a state of intense motion, which followed closely the edge of each surface as it advanced through the solid ice. Once or twice I observed the hazy surfaces pioneered through the mass by dim offshoots, apparently liquid, and constituting a kind of decrystallization. From the closest examination to which I was able to subject them, the surfaces appeared to be due to internal liquefaction; indeed when the melting point of ice having already a temperature of thirty two degrees, is lowered by pressure, its excess of heat must be applied to produce this effect."[13] If water boils at an elevation of 8000 or 9000 ft above the sea, at 184° of heat, or thereabouts, and near the ocean at 212°, the conclusion is natural that pressure must keep the liquid cool, because its particles have an abridged freedom of expansion, or a restricted motion among themselves. If the earth's atmosphere were denser, ebullition would be still more difficult. In regard to ice, a form of

[11] Youman's "New Chemistry," p. 201.

[12] "Heat," p. 120.

[13] "Glaciers," p. 411.

water, pressure must keep it cool; and so it must any liquid or solid whatever. But if compression renders ice abnormally dense, there must be by the process, a crowding together of the particles of the material, there must be motion. Now in the motion of contraction heat is yielded up, and the body is cooled; in the motion of expansion, heat is consumed, and the body is warmed. Thus it is not the mere act of pressure independent of the creation of heat, that cools a body. Excess of heat is merely an excess of expansion, compared with another body. The heat given up by a body in cooling, is the measure of the force used in the compression. A mass of ice projected from the mouth of a cannon, would fuse to a certain extent, from friction with the atmosphere. Ice would also melt if beaten with a mallet or hammer. The effects are precisely analogous, whether ice be fused from friction with the atmosphere, from concussion with the mallet, or by pressure. Each and every cause is a falling force producing heat. What are we then to understand by "excess of heat" in Dr. Tyndall's experiment? If the temperature of the ice was diminished by pressure, say 4°, that is, reduced to 28° of Fahrenheit, was this excess of warmth of but 4°, sufficient to annul the tenacious compact of crystallization? To melt 1 pound of ice by contact with a pound of water, requires the latter to be at not less than 174° of heat. When the ice is melted, the water is only of the temperature of the ice, or at 32°. There were then, 142° of heat consumed upon the work of decrystallization of the ice. How then could the impartation of 4° of heat accomplish a work in one case, which requires 142 in another? The liquefaction of ice under pressure, must therefore, have been derived predominantly from friction of the molecules of the ice. Nor do I imagine that Prof. Tyndall the eloquent expounder of the laws of heat, took a different view of the matter.

A cubic inch of unporous ice at a temperature of 32°, weighs about one ounce, and will sustain a weight of 300 pounds, and in very cold weather, 400 pounds, Or on an average, 11,200 times its own weight. A column of ice 1 in.^{2}, if it could be supported laterally without regelation along its sides, would therefore sustain itself 11,200 in. high, or about 1000 ft. But in a glacier where ice is doubtless very dense and hard, it would support a superimposed pressure to any extent. Thus it is evident that pressure, though it may cool ice there, does not melt it, unless the friction of the ice atoms be sufficiently active to produce sensible heat. If this were not the case, ice could not exist in a glacier beyond a few feet in depth. Compression by every accession of snow, is exerted so slowly, that the evolved heat escapes before liquefaction can lake place. It tends to a limited extent to warm the mass in opposition to the force of congelation, and to resist pressure. Thus ice cools down and contracts its volume under pressure; and this phenomenon is analogous to its deportment when exposed to a low temperature in the open air. It contracts and becomes hard in proportion to the increase of pressure or cold. And snow, through the same agents, is also converted into ice.[14] But after a volume of ice has been cooled and contracted by a low temperature, or by direct pressure of superimposed masses of its own substance,

[14] The required force of pressure in cooling bodies, is as the square of the cooling rate. Thus, to cool a piece of ice 1°, requires a unit of force; 2°, four units; and 3°, nine units. To cool it 32°, or to

is it capable of expansion when that cold or pressure is removed. Without doubt, as already intimated, "a piece of ice at the temperature of zero, F., would expand by heat, and produce mechanical force by such expansion, till it arrives at thirty two degrees".[15] It is therefore evident that every alternation of heat or cold, affects ice as it does the ultimate atoms of other bodies; and thus force or motion to a certain extent, is perpetually produced in ice, however uncognizable the fact may be to our ordinary observation.

The bearing of these facts upon the motion of glaciers, appears to me to be of vital consequence. It is therefore by the new views of heat I believe, that their motion must be explained. I conceive then, that the winter motion of the glacier is due to the contraction of the mass by the depression of the atmospheric temperature below the freezing point; and the summer motion to be due to the expansion of the mass, when the temperature of the air is elevated above the freezing point. The glacier during the summer, readily conducts the focalized heat of the glacial valley, and is no longer able to maintain its winter contracted volume, but swells not only upward towards the zenith, but downward along its bed or plane, of progressive motion. The glacier can not swell upward along its bed, because in that direction, it is met by an irresistible barrier, and must therefore move towards the direction of minimum resistance. This accelerated motion must continue as long as warm weather lasts. The quantity of motion must of course be in direct ratio to the quantity of heat daily absorbed by tile glacial mass. I consider the infiltrating waters to assist in this increasing motion, but not in the manner indicated either by Prof. Agassiz or Forbes. I regard the waters which cover the glacier during the summer season, though their temperature may not vary from 32°, as materially tending to warm the interior of the glacial mass. Their wide spread extent, and falling force as they plunge into profound fissures must produce heat, enough of course, to raise the fallen waters back to the glacial precipices from which they fell. And this falling of the waters into the abysses of the glacier, occurs for several hours in the day throughout the summer season. The warming power of 1 t of water falling to the bottom of a glacial fissure of 250 ft, more than equals the expansive energy of two quarts of water in passing into ice. This heat is not lost without producing immense effect; the motion of a glacier is therefore caused by contractile and expansive processes. It is similar to the movement of lead sheathing upon the roof of a house. By contraction and expansion from every change of temperature, it is well known that this lead will detach itself and move down towards the eaves.[16] It cannot move up hill, because in that direction there is the greatest resistance. Progress then, must be in the other direction.

The question here presents itself, is the heat generated or given up, by contraction, lost without producing dynamic energy in the glacial mass? Evidently no. This

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the zero of Fahrenheit, requires 1024 units of force. I suggest this law, though I have had no means of demonstrating it.—J. De L.

[15] Grove, on "Correlation of Physical forces," article Heat.

[16] Prof. Tyndall does not apply this action of the lead to explain the movement of a glacier; but it seems to me the most rational of any view. See "Heat" p. 99.

heat must be expended in work , in resisting the contracting force, or warming the glacier in the direction of greatest cold, or in the production of imperfect liquefaction according to the intensity of the agent. This force cannot be annihilated without producing action. It is evident that glacial pressure, or gravity of' the glacial mass, is inadequate to explain the differential motion of the glacier, whether it acts at the source of the stream affecting the whole mass laterally, as in the case of a river of water, or vertically compressing the mass throughout, thereby producing motion, from a tendency of the ice atoms to roll over each other on a descending plane. As I have intimated, and Prof. Agassiz before me, if mere pressure were the motive power, the motion of a glacier would be greatest during winter or near its close, when the weight of the glacier is a maximum, because of the full annual growth of the mass at that time. Upon a horizontal plane, gravity is nil, or at zero; but if the plane departs from this position, resistance comes into existence and continues in full force till the plane approaches perpendicularly, or obtains a fall of not less than 45°. At this point there is an equilibrium of gravity and resistance, beyond which resistance diminishes and gravity augments. The body supposed to be in equilibrio upon an inclined plane, can only remain at rest by the nature of its composition. A bank of clay, sand, or gravel, rests securely upon its rocky bed, often steeper than any of the alpine ice troughs, without manifesting a tendency to slide, unless supersaturated by rains. Is ice more yielding than this clay, sand, or gravel, always moist? Neither is it a better conductor of heat, than such bodies. Does not their non-homogeneity compared with ice, favor gravity rather than resistance? A stream of melted lava flows like water down a plane of but slight dip, overcoming resistance because its non-crystallized atoms are excited by heat. Tar or pitch, and concrete gum, as of acacia or scammony, upon a similar plane, would move down hill, if subjected to extremes of heat and cold. But ice regelates itself firmly to any substance with which it comes in contact; and this attachment is vastly greater than that manifested by either of those bodies. To its bed, then, a glacier is attached with a force greater than that of the normal adhesion of the molecules of ice, because its inferior surface is subjected to enormous pressure. Yet down a plane of the smallest descent, the glacier moves like the tide of the sea, uprooting rocks from the sides and bottom of its cradle, scoring, scratching, and polishing the rocks like the hands of man. Therefore as ice is a solid body firmly crystallized, and in the interior of the glacier extremely hard, and capable of sustaining immense pressure without being crushed, I must reject the hypothesis that gravity is the chief agent concerned in producing the motion of the glacial mass.

In regard to the motion of the ancient great glacier which simultaneously covered so large a part of North America, it is evident that there were neither alpine snow-fountains nor inclined troughs for its path, as for those of the Alps of Europe. The hills of New England and the north generally, were in a very circumscribed sense, feeders of glaciers. When perpetual snow covered the great mountains of the country, most assuredly the country itself was clad in perennial snow, and the lower as well as the higher valleys were filled with it. There was no plane at descent for the march of the glacier from the center of Labrador to Portland, Maine, a distance of 10°. Beyond the latitude of the river St. Lawrence, the glacier ought to have moved in some other

direction rather than south, towards the north, or east, because the upper part of the continent dips in these directions. But moving south of this point, it had innumerable and lofty bills to climb, and broad deep valleys to cross.

Its path was everywhere met with inconceivable resistance, infinitely overmatching its force of gravity. Therefore neither lateral pressure from elevated snow basins, nor dead weight acting upon the mass pulling it down a plane towards the south, was a condition of the motion of this great terrestrial ice sea. A motion of contraction and expansion within the glacial mass as has been explained, producing progress along its bed in the direction of least resistance, that is, towards the south, was doubtless the motive power. Neither could running water have had an agency in the motion of this glacial sheet. Motion had begun before there were fissures for the reception of such waters. These crevasses are the result of progressive motion. The glacier grew in thickness as it grew in breadth. During winter, the season of special growth, contraction or consolidation of the mass took place, principally in a vertical direction. Here alone gravity came into play. The glacier during this process was obliged perforce, to move along its bed. At length warm weather approached. An expansion or swelling of the mass then took place. By the influence of the solar beams, the icy atoms were awakened out of the profound sleep of winter contraction. They startled into life, and jostled each other like human beings in a crowd. There was confusion within the mass to the utmost penetration of heat.

In conclusion, we may say then, that it is the sun that not only builds up the glacier through the effects of his beams upon the ocean, or diminishes its form by his direct heat, but it is he, also, that puts the sublime structure in motion.

Chapter 28
Purpose of the Glacier

Nature of the pre-glacial age; its rocks, soils, and climate—Effects of the glacier upon New England in the preparation of soils, harbors, coves, lakes &c—Constituents of soils—Agricultural vegetation adapted to the north—The best domestic animals raised there—Temperature of the south too hot—The civilized man has no food from the wild earth—It is of foreign origin and cultivated—The white man and savage contrasted—The geographical band of civilization—Man came when nature was fully prepared for him—Laws of natural supremacy, as manifested by ancient and modern nations—American north and south—These countries should thoroughly fraternize—Their destiny one—Prophetic types of her past—Curious researches upon the relative proportion of brain to spinal cord in the vertebrate class of animals—Its gradual elevation to the vertical line—Growth of the human mind slow—Advent of man—His "high antiquity".

As the ancient great glacier that overspread so large a part of North America, has come and gone, let us survey the past and present, and see whether nature had purpose in thus revolutionizing the old surface of our continent. The transformation of the topographical features of New England of the Tertiary age, has no doubt been wonderful. The mountains of these ancient times were sharp and castellated like gothic towers and temples. Cliff overhung cliff, and valley overlooked valley. These inhabited uncouth reptiles, songless birds, and quadrupeds now unknown in the country. From the sides of the lofty hills where had collected earth sufficient to encourage the growth, huge pines looked down into the dark ravines and silent valleys, aged gigantic, and voiceless, save when the gentle wind or mad storm swept these air harps of the hills. Then they sang their plaintive songs and tossed their arms to and fro, and bowed down their heads under the celestial inspiration. Ah! me, that wise men seldom behold the magnificent glory of the mountain pine. Where it stands in the dwelling place of thought and peace, where the soul knows no solitude out of which it can not come forth strengthened and purified.

The vegetation of the Tertiary period in New England compared with the present, was very meager. The alluvial valleys and lake borders, yearly inundated by the overflowing of annual waters, afforded a coarse tall grass to the ruminants. The plains like those of the distant territories of the southwest, of arid sand and gravel, as the hills were approached, afforded a scanty pasture. As the hot season returned,

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some of the herbivorous tribes had frequently to change their feeding grounds. The elevated granite lands were barren. The slates had but a thin soil. The open country must have bean dry in consequence of the general bareness of the uplands and hills. Springs of water did not everywhere gush out from the ground as they do now. The glacier has so shaken the granites and slates by its terrific march, that now receptacles for the rains are abundant in the land. The rivers confined within narrow and deep channels, were sluggish until during the cooler and rainy seasons of the year. Almost every vestige of the Tertiary has been eradicated from the country; nothing but the stunted flora of regions much farther north, remained. The climate of the northeastern states maybe cooler and wetter to a certain extent, on account of extensive frosts, than when the land anciently stood at the existing height. The entire contour of the surface of the country has been changed, old and once popular fashions have passed away as with the human family, and nature has introduced new styles admirably adapted to the requirements of the present races of brutes and men.

The glacier has rounded the hills of New England into asymmetrical shapes. Once they were abrupt on every side, angular, and spacious of base; now they are oblong, smooth and curve gently from their summits down to their bases on the north. Their southern fronts are precipitous, and often too steep to be ascended by man or beast. The altitude of these hills as contemplated at a distance is that of repose and watchfulness, as of a couchant lion, or the Sphynx gazing forever upon the wonderful Nile. Their faces are turned towards the sun, the source of light and life of the earth. I like this looking forth towards the south. The sun is of more consequence to the living of the dry land, than the north star. The height of many of these hills has been cut down, their tops rounded, enlarged, and rendered more approachable to organic forms There the plants that love a cool atmosphere, are more exposed to the winds which assist in developing their growth. By this remolding of the hills, animals have also a wider range. They climb and descend the hill tops more readily than in ancient times, and thereby healthily change their feeding grounds. Ponds of water for the wants of animal life, are frequent upon the tops of the mountains, remaining during the heat of summer months. The labors of the glacier were also expended in enlarging the old valleys, in reforming lakes and originating others; and in reshaping the river beds of the country. The crust once uniform in outline, with here and their an inlet where a river or stream poured its waters into the sea, by the denuding action of the glacier is now broken into a multitude of coves, bays and harbors, where the fleets of the coming man may find a safe retreat, and where his great commercial habitations will be erected. This long line of coasts chiefly abounding in granites and highly altered clay slates, has been subjected to such glacial action, cut, torn and eroded, that islands everywhere dot the border, with free access between them and the mainland, for the sea, whose waters less interrupted there, afford a resort for a variety of fish.[1] But it was the cutting down of the asperities of the surfaces of the old world, and the transformation of chips into soils of gravels, sands and

[1] The direct length of the coast line of Maine from Kittery Point to Quoddy Head, is 210 miles; including the indented coasts, the length is about 600 miles.

clays, the coming of these materials of different formation, and their distribution sometimes over considerable extent through the agency of water, that the grandest achievement of the glacier is exhibited. It is a singular fact that the prevailing rocks of the middle an upper part of the northern temperate zone, are the oldest known upon the globe. They are altered sedimentary beds, consisting of granites, sandstones, and clay slates, interspersed with limestones. Their ordinary ingredients are quartz, feldspar, mica, hornblende, talc, calcite, andalusite, tourmaline &c. They are rich in silica, potash, soda, lime, oxide of iron, alumina, and phosphoric acid, the chief constituents entering into wheat, oats, barley, rye, indian corn, grass, potatoes and the most invigorating fruits. These set free by frosts and the annual irrigation of the north by melting snows, are available to the labor of the agriculturist. The humus of the climate, consisting of decaying vegetation and moisture, or carbon and water, does not rapidly escape from the soil as in the south. Grass and potatoes grow best in this peculiar physical band of the globe, and they are the prime motive powers of modern civilization. Where they thus flourish, there are the greatest population, the greatest men, the best system of learning, the most intuitive intelligence, the most wealth, the most commercial activity, the most profitable railroads, and the purest religion. The countries which grow them, are the countries of the best pork, the best beans, of the best butter and genuine beef and mutton, and consequently, the best developed human muscle and brain. They can not grow well in the warm climates of the south. There the soil is composed of fine sand and clay, a glacial donation of the north, splendid in its way, but not for raising potatoes and grass in a hot climate. This sand and clay soil is enriched with a vegetable mold, and is full of weeds, the remains of the northern Tertiary world. The high temperature of the south taps the moisture of this soil, and consequently the fertility, before those plants can come to maturity. They may grow on the mountain slopes of the country, but the whole north is a potato and grass garden. The pastures of the north, are never seeded; those of the south, are seeded annually. Grass is natural to the north, and there the grass eating animals are in abundance and perfection. There it *hibernates* like the bear and reptiles of the clime. It goes to sleep under a warm blanket of snow, nicely tucked up all round, as our mothers did their urchins in old times, not to be waked up till sunrise and general breakfast time. No counterfeit summer occurs there, to start it spasmodically into a short and premature verdure. When the voice of spring is heard in the land, it awakes refreshed with its long and invigorating sleep, and begins to grow with earnestness, and to eliminate its delicious juices.

Upon this glacial soil of the north, all the domestic animals are also better developed than in the south. The sheep of northern New York, Vermont, New Hampshire, Massachusetts, Maine and the British provinces, are the best in North America. The wool is fine, like the furs of the country. The cattle of the south look like Pharaoh's "lean kine". The cows there afford the poorest quantity and quality of milk and butter made of it resembles hog's lard. The horse of the north is better limbed, of harder muscle, more enduring, and more docile, because he is better fed. Like the domestic ass of the east, he "knoweth his master's crib" of yellow corn and timothy hay. Northern grass, potatoes, cattle &c.,carried to the south deteriorate and; southern cereals, bulbous and tuberous roots, and fruits, carried to the north improve. The hot sun

of the south forces vegetation too rapidly, and the consequence is, its juices are too watery. Stalk and leaves are developed at the expense of seed, fruit, and nourishing root. Vegetation is much like animals, man included. It does not always show its best qualities till it finds its proper soil and climate. Some of our best garden roots in southern soil, forget their old northern habits at once, and like some migrating men "go in" for a free "good time." They flourish for a while without stint, and ambitiously go to seed the first year, leaving the root fit only to be contemplated as a contemptible failure; whereas, in the north they grow slowly, take matters *cooly*, and don't think of having a seedy head till the second year.

But the man of the north and the highest civilization, gets no food from the wild barbarous earth. His wheat, oats, barley, rye, indian corn, best grasses, fruits, and edible roots, are foreign to his home, and to yield their best qualities, must be cultivated by the "sweat of his face", a very forbearing and profitable "curse". His cattle, horses, sheep, hogs and fowl have also come from a foreign land, where they all were wild and too dwarfed or robust to be useful to man without the skill of his plastic hand. This vegetable and animal growth, if it did not originate in the birthplace of the real white man, the prince of civilization, was not far away. His discerning eye as he went abroad, detected their qualities, and he soon appropriated them to himself and brought them to perfection. On the southern side of the cold caucasian hills, he made his pastures, cornfields, and orchards. This birth place of civilization is the region of abundance of snow, of cool streams, and of the best grasses, cereals, and cattle, as are the, western centers of the most thrifty and enlightened nations. It is the spontaneous productions of the earth that surfeit and degrade the human race. The red and the black man do not know how to labor for the future in the cultivation of the soil. One gets his living from the wild forest and its waters; the other, from the tree-fruits of the tropical world. In the wilderness, the caucasian is debased; in the hot regions of the globe, he is transformed into a living mummy. Here the banana grows for the indolent and religionless man. It is to him a never failing larder, but a means of savageness which northern art, science and christianity have hitherto been unable to cure. It is variety of food as well as quality, which the civilized man furnishes for himself; and the more extensive and better his variety, the more rapidly civilization goes on. The most crafty and treacherous nations are within the tropics; and there had their birthplace, if found beyond. In the extreme north, the climate produces also a deteriorating effect upon the human frame and mind. But the nations here are more active, if not less brutal in habits. Excessive heat and cold by their drying qualities shrivel the skin of the white man, and saps his body of its natural fluids. The climates of countries of great heat and cold, can not therefore, be the climates of extensive civilization.

There runs a broad northern circle around the earth, following by no means a uniform distance from the equator, within which the greatest amount of physical and mental energy has always been developed. In the old world it is between the parallels of 30 and 55°; and in the new between 35 and 50. The centers of this human energy are compressed within a narrow circle. It is within this belt that the great glacier of the past, has performed its most fruitful labors, and from which it scattered its detritus by fluvial and oceanic waters still farther towards the south. Here man has

maintained a persistent influence for good upon the world. The peoples occupying this geographical zone, can not remain under the domination of nations from without. This zone is not a volcanic one. As already observed, it is the country of the oldest rocks, which have been worn down, and the ruins thereof elaborated for the advent of the white man. It is the empire of vast activities and realities, because the creator had so decided millions of years ago. The countries which have undergone the greatest volcanic changes in the later times of the earth, are those whose inhabitants have been most subject to repeated and fearful revolutions by war. They are the warmest parts of the earth. Where there is therefore, the greatest stability in the earth's crust, there is the theater of the greatest amount of physical and mental labor, and consequently the greatest amount of human refinement and happiness.

Thus the white man of the north is the type of supremacy. The red man who lived before him, had no extensive pastures and vineyards; no expanded commerce and navigation; no schools of learning; no profound abstract thought. He had no conception of human progress; no love of mankind; no idea of brotherhood of his race. His domain was an interminable forest, forever suggestive of silence, solitude and bloodshed. The white man came when ordered by nature, not before, to look upon the wilderness of the red man. He cut down the forest; cultivated the earth; discovered the use of various metals, built houses, cities, and ships; invented machines; constructed grand highways; established schools for the development of the human mind; discovered laws by which matter is governed; made civil laws whose foundation were laid in reason; discovered the use of mineral coal; erected manufactories; projected schemes for the prosperity of the race; girdled the earth with the lines of his telegraph, and sent his iron horse careering over the earth with the swiftness of the wind. To this man nature freely opens her arcana on the earth and in the depths of space. He claims relationship with infinity, and is a creation but a "little lower than the angels."

I have said this man can not be conquered by the savage or semi-savage who lives without the bounds which nature has allotted to the other. All history assures us that the southern nations have never supplanted those to the north of them, unless their natures had been vivified by the climate of a mountain home. The Egyptians never retained their conquests over the Hebrew Syrians who like themselves had a northern, though an eastern origin. But the Persians conquered both countries, and left them nearly deserts, but could make nothing out of Greece, whose cool and sagacious warriors overran and subdued a vast extent of southwestern Asia. The Romans, in turn who had their home farther north than the Grecians, conquered all the important possessions of the latter, and Egypt and Carthage to the south and southwest. Though the generalship and infinite labors which Rome brought to bear upon the north, were of the highest order, they were not a perfect success. The southern blood could not overpower that of the north. The Mohammedans from having a strong infusion of northern blood in their constitutions subdued Syria and Egypt, and were able as Saracenic Moors to enter Spain and held its southern part for a few centuries; but the mountain men of the country finally drove them out forever. The Huns from the slopes of the Altai of southwest Siberia, wandered all over Europe fighting along till they sat down as conquerors on the northern shores of the Adriatic. The Alans

from the southern valley of the river Don, did better. They had not naturally so much pugnacity as the Huns. They felt this way coaxingly along till they got into northern Germany, where gathering strength from the people, they renewed their wanderings till they finally sat down in western Spain. The Goths from the north of the Huns, marched straight to the west, the natural path of the spirit of empire, till they got into Scandinavia, where they tarried for ages on her eastern coast, snuffing the salt sea breezes, and hardening their hides and muscles in the winds from the arctic world. There the fierce scoundrels multiplied like rats in a granary; and starting anew like Satan of old, to go to and fro through the earth and to walk up and down in it, their hordes of pure blood and mixed breeds, overran the civilization of Rome and Greece.

It is after this ancient and semi-ancient manner of the going forth of the nations, that the moderns creep towards the south; the English to America, India and elsewhere; the French to America and Algeria; the Spanish to America, the Dutch wherever they can raise cabbage for kraut; the Russians towards Turkey, Persia and China; and the mongrel Yankee towards all parts of the world, where a foot of land or a dollar is to be had at a bargain. The strong Russian bear of the north must drive out the turbaned Turk from Europe. I say that boreal quadruped must come forth and angrily scent the odored Mussulman of the Orient. Be not surprised and moved therefore that the leaven of northern Puritanism and civilization, has been too much for the chivalry and serfdom of the south. Conquest does not always imply enmity. The people south of Mason and Dixon's Line, are bone of our bone and flesh of our flesh, for all they sorrily mistook in their countrymen of the north, the full amount of the capabilities of the race. Once the southerners considered the north as fit only to raise ice, pestiferous abolitionists and oleaginous mechanics. It has raised them in perfection, and marvelous has been the influence upon the "sunny south." The mission of the northern man had infused into it a watchword of negro high authority, "overturn, overturn, overturn it." But this "overturn" has been strictly after the order of nature, and none could hinder; and the ultimate results will be glorious. The southern man is spirited, heroic, impassioned, and impetuous; the northern man is cool, deliberate, persistent, and immoveable as the hills of his native home. The spirit of decay exhibited in the manifestations of reckless boast, the pomp of wealth, and the unbrotherhood of east, began insinuatingly to poison the constitution of the south. It was necessary that an antidote should come through the man of the cold and invigorating north; it could not have come from any other source. The result of the great strife between the south and the north, will be that diversity of every kind will be centered into unity of purpose. The blind and the deaf will henceforth see and hear perfectly. The civilization of the north must flow on like the tide of the ocean, and can never stand still until its divine mission is accomplished.

To fully comprehend destiny of this country, it is necessary for the man of the south to dwell a while among the hills of New England, and the healthy, populous plains of the west everywhere glowing with life and distributed wealth. He would see the land of the northeast overflowing with refreshing mountain streams; its people supplied with a great variety of food, the best grown upon the earth, and everywhere happy without ostentation and caste. He would also see there the great lake country of the United States, whose waters in the future not far off, will give immense wealth

through the cultivation of fish. Maine is destined by the multiplicity of its lakes, to be the great nursery of it, in the northern states.[2] It is fish which the people of the north and south will soon need to a greater extent to supply by its phosphorous more fully the waste of nervous energy resulting from their future glorious career.

In conclusion, I would remind the reader, that the evidence appears to be of the strongest kind, that there has been a purpose designed and supervised by an infinite forethought, in the evolution of the earth, whose sublime story of the past is written in her book of stone. Millions and millions of years ago, the earth had types in succession, that pointed as the ages rolled round, more and more emphatically to future progress in life, and at last to the coming of man who should be the crowned heir of the vast heritage of the earth. Indeed as the earth grew older these typical forms, "anticipations of man in nature," as Prof. James D. Dana calls them, became stronger, marked and filled the whole earth with their presence.[3] As the Israelite had types and promises everywhere before him from the dawn of his race to the glorious fulfillment, indicative of the coming of the Just One and Prince of Peace, so the world has had premonitions of the coming advent of man. In the plant, there was the simple principle of *life*; in the animal, *life* and *sensation*; in man, *life*, *sensation*, and *reflection*. In the spinal column and skull, where are the organs of sensation and thought, the proportion of brain to the spinal cord is in the *fish* as 2 to 1; in the *reptile* as 2 1/2 to 1; in the *bird* as 3 to 1; in the *mammalia* as 4 to 1; but in *man* it is 23 to 1; Man has therefore not only the sum of the proportion of brain to spinal marrow, in the vertebrate style of life, of all the classes that went before him, but the beneficent creator has given him a "double portion" of it, a sign of his superior heirship. In the *fish*, the spinal column and brain are prone, or horizontal; in the *reptile*, the sensorium is elevated 30°; in the *bird*, 45; in the *mammalia* 70; in *Man* the column is erect, and crowned with a splendid gift of brain. The column has thus swept the sky from the horizon to the zenith. Creation could go no farther in the animal organization that is subject to death. The promised heir appeared and entered into his possessions. The growth of his mind has been slow. He has been a good steward; has kept what he got, and has improved upon his original gains. His course upon the earth has been a marvelous one, and must continue to be so in an increasing degree to the end of the present order of material things; and if beyond this mortal life he shall live again to die no more, as I believe he will, he will never cease the pursuit of knowledge, wisdom, honor, glory and felicity throughout the endless age of eternity. It is not my purpose here to discuss the remoteness of his advent upon the earth, from our age; but there is left for us hardly a doubt but that it was a long, long time ago, beyond the historic past. It is probable that man has been upon the earth from 12,000 to 20,000 years at least. There is no reliance as I imagine, to be placed upon the calculations of some anthropologists, that he had his advent in the past whose duration vastly exceeds the time just supposed.

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[2] Maine has 1568 lakes. Moosehead the largest is 1071 ft above the sea, and is the source of the Kennebec. The head of the Penobscot is 1800 ft. and the Androscoggin is 3000 ft above the sea.

[3] "Anticipations of Man in Nature," *New Englander*, for May 1859.

Chapter 29
Late-Glacial Cold-Water Marine Shells of Maine and Adjacent Regions

Shells are found from a few feet above high water underlying the boulder drift, to several hundred feet above the sea. I found ten species named below 350 ft high. It is possible that recent fossil shells may be found still higher in Maine. In addition to these shells, the remains of whales, large and small fish, teeth of sharks, the walrus and buffalo; and of crustaceans and radiates. Mr. Charles B. Fuller conchologist and cabinet keeper of the Portland Society of Natural History has been indefatigable in his researches for post-glacial shells embedded in the drift. Dr. Packard and True have also done a great deal in the same direction, the former of whom has made two visits I believe, to Labrador for Scientific observation in connection with the phenomena of the drift. For necessary information, I have consulted Dr. Packard's work on the "Glacial Phenomena of Labrador and Maine" and the Geological Reports of New England and the British Provinces.

Abbreviations: ME for Maine; NH for Hew Hampshire; MA for Massachusetts; SL for St. Lawrence Valley; NB for New Brunswick; L for Labrador; G for Greenland. Small (a) signifies that the fossil shell is abundant in the region beside whose initial letter it is placed; (c) for common; r for rare; (l) for littoral, or shoal water species, or near the shore; and (p) for pelagic, or deep water species.

List of late-glacial shells embedded in the boulder drift, the most of which are living species in and about the regions where the fossils are found. For convenience, I have arranged these shells alphabetically.

Aporrhais occidentalis—ME (r)—L (a).
Astarte semisulcata—ME (r)—SL—G.
Astarte castanea—MA (r).
Astarte arctica (lactea)—ME (r)—SL (r)—L (c).
Astarte compressa—ME (c)—L (c).
Astarte banksii—ME (a)—NB—L (c).
Astarte striata—ME (a)—SL—L (c).
Astarte richardsoni—L (c).
Astarte warhami—L (c).
Astarte fabula—L (c).

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Astarte corrugata—G.
Amicula emersoni,(a chiton?)—SL.
Amauropsis helicoides—SL.
Admete veridula—SL—L (c).
Arca transversa—MA (a).
Balanus balanoides—ME (a).
Balanus hameri ME—NB.
Balanus crenatus—ME (a).
Balanus porcatus—ME—NB—L (a).
Balanus regosus—ME (s).
Bulla occulta—ME (r).
Bela pleurotomaria—ME (r).
Bela terricula—SL.
Bela harpularia—SL.
Bela robusta—L (r).
Bela americana—L (c).
Bela exarcta—L (c).
Bela discussata—L (c).
Bela pyramidalis—L (r).
Bela violacea—L (c).
Bela woodiania—L (c).
Buccinum undulatum—ME (r)—SL (r)—MA (r)á— L (r).
Buccinum plectrum—ME.
Buccinum ciliatum—ME (c)—SLá— L (c).
Buccinum gronlandicum—ME (c)—L (c).
Buccinum totteni—ME (r)—SL
Buccinum donovani—ME (r).
Buccinum triviltatum—MA.
Buccinum tenue, (scalarifornis)—ME—L (c).
Buccinum plicosum—MA (a).
Buccinum glaciale—ME—L (r).
Buccinum cretaceum—L (r).
Cardium islandicum—ME—SL Ð NB—G.
Cardium pinnulatum—ME—NB.
Cardium gronlandicum—ME (c)—G.
Cardium hayesii—L (a).
Crenalla glandula—SL.
Crepidula fornicata—MA (a).
Cryptodon gouldii—ME (r).
Cryptodon flexuosus—G.
Cyrtodaria siliqua—ME (c)—L (c)—G.
Cemoria noachina—ME (r)—L (c).
Chiton marmoreus—L (c).
Cardita borealis—MA (r)—L (c).
Cumingia tellinoides—MA (r).

Diaphana debilis—SL.
Fusus tornalus—ME (a)—SL (a)—L (r).
Fusus decemcostalus—ME (a)—SL (a)—L (r).
Fusus borealis—SL.
Fusus labradorensis—L (r).
Fusus tortuosus—L (r).
Fusus pygmaeus—L (r).
Fusus despectus—G.
Fusus gracilis—G (r).
Hypothyris psittacea—ME (r)—L (a).
Leda truncata (Portlandia, arctica)—ME (a)—NB—SL (a)
Leda minuta—SL—L (c)á— G.
Leda buccata—ME—NB
Leda tenusulcata—ME (r).
Leda gronlandica—L (c).
Lacuna neritoidea—SL—NB.
Lunatica gronlandica—L (c).
Littorina gronlandica—G.
Littorina palliata—SL.
Lyonsia hyalina—ME (r).
Mercenaria violacea—MA (c).
Modiolaria nigra—ME (r) Ð SL.
Modiolaria discors—G.
Modiolaria discrepans—ME (r)—L (r).
Mya arenaria—ME (a)—MA (c)—SL (c)—NB (c)—L (c).
Mya truncata—ME (a)—SL—NB—L (a)—G.
Mytilus edulis—ME (a)—MA—SL—NB—L (a)—G.
Mytilus modiolus—MA.
Macoma fusca—ME (a)—SL.
Macoma sabulosa—ME (a)—NB—L (c).
Macoma gronlandica—ME (r)—NB.
Margarita lielicina—SL.
Margarita glauca—G.
Margarita cinera—MA—L (c).
Margarita varicosa—L (c).
Menestho albula—ME (r).
Menestho alberta—SL.
Mactra polynyma—ME (c).
Mactra solldlssima—ME (r).
Natica pusilla—ME (a).
Natica gronlandica—ME (c).
Natica affinis—ME (r).
Natica ialandicus—ME (r).
Natica clausa—ME (c)—SL—NB—L (c)—G.
Natica heros—SL.

Nucula antiqua—ME (a)—NB.
Nucula tenula—ME (r).
Ostrea borealis—ME (r).—MA (a).
Ostrea canadensis—ME (r)—SL.
Panopaea noregica—L (r)—G.
Pectin islandicus—ME (a).—MA (c)—SL (c)—NB(c)—L (c)—G.
Pectin similis—ME (r).
Pectin tenulcostatus
Pandora trilineata—ME (r).
Pandorina arenosa—ME (c).
Pholas crispata—ME (c).
Purpura lapillus—ME (r).
Rissoa minuta—SL.
Rynchonella psittacea—SL.
Scalaria grolandica—MA (a)—SL.
Saxicava rugosa (distorta)—ME (a)—SL (a)—NB.
Saxicava arctica—ME (c)—L (a)—G.
Solen enais—ME (r)—MA (r).
Spirorbia glomerata—L (c).
Spirorbia vitrea—L (r).
Spirorbia nautiloides—ME.
Tectura testudinalis—ME (r)—L (r).
Tellina calcaria—G.
Tellina gronlandica—G.
Tellina fragilis—G.
Trebratulina septentrionalis—ME (r).
Thracia connadi—ME (r).
Thracia truneata—ME (r).
Trichotrapus borealis—ME (r)—L (r).
Trichotrapus tulipara—ME (r).
Trophon clathrasus—ME (r).
Territella erosa—L (a).
Territella reticulata—L (c).
Territella ac1cula—ME.
Yoldia pygnaea—ME (a)—SL.
Yoldia limatula—ME (r).
Yoldia myalis—ME (r)—L (c).
Yoldia arctica—L (c).
Yoldia sapotilla—L (c).