ART. XXXIII.—ARNOLD GUYOT.*

IT is a remarkable fact in the history of American Science that, forty years since, the small Republic of Switzerland lost, and America gained, three scientists who became leading men of the country in their several departments—AGASSIZ in Zoology, GUYOT in Physical Geography, and LESQUEREUX in Paleontological Botany; Agassiz coming in 1846, Guyot and Lesquereux in 1848. A fourth, Mr. L. F. DE POURTALÈS, who accompanied Agassiz, also merits prominent mention; for he was "the pioneer of deep-sea dredging in America."† The Society of the Natural Sciences at Neuchâtel lost all four. As an American Academy of Science we cannot but rejoice in our gain; but we may also indulge at least in a passing regret for Neuchâtel, and recognize that, in the life and death of Agassiz, Pourtalès and Guyot, we have common interests and sympathies.

My own acquaintance with Professor Guyot commenced after his arrival in America, when half of his life was already passed. In preparing this sketch of our late colleague, I have therefore drawn largely from others, and chiefly from his family, and a memorial address by Mr. Charles Faure of Switzerland, one of his pupils, which was published in 1884 by the Geographical Society of Geneva.‡

Youth—Education in Switzerland and Germany, 1807 *to* 1835. —To obtain a clear insight into the character of Professor Guyot it is important to have in view, at the outset, the fact that the Guyot family, early in the sixteenth century, became protestants through the preaching of the French reformer, Farel, the cotemporary of Luther; and also the sequel to this fact, that at the revocation of the Edict of Nantes, the Guyots were one of sixty families that moved into the principality of Neuchatel and Valangin from the valleys of Pragela and Queyraz in the high Alps of Dauphiny. Thus the race was one of earnestness and high purpose, of the kind and origin that contributed largely to the foundations of the American Republic.

Professor Guyot's father, David Pierre, esteemed for his "prompt intelligence and perfect integrity," married in 1796 Mademoiselle Constance Favarger, of Neuchatel, "a lady of

* From a biographical sketch by James D. Dana, prepared for the U. S. National Academy of Sciences, and read by Professor C. A. Young at the meeting in April at Washington.

† Mr. Alexander Agassiz, this Journal, III, xx, 254, 1880.

‡ Vie et Travaux d' Arnold Guyot, 1807–1884, par Charles Faure. 72 pp. 8vo. Read before the Geographical Society of Geneva, April 25 and Aug. 25, 1884.

great personal beauty and rare nobility of character." Arnold-Henri, one of twelve children, was born at Boudevilliers, on the 28th of September, 1807, and was named after the Swiss patriot of the fourteenth century, Arnold von Winkelried. About 1818, the family moved to Hauterive, three miles from Neuchâtel, where his father died the following year. From the house at Hauterive young Guyot had before him, to the southeastward, the whole chain of the Alps from Mt. Blanc to Titlis, and his sensitive nature must have drawn inspiration from the glorious view; the same deep draughts that he attributed to young Agassiz, in his Academic memoir of his friend, with reference to the same circumstance—the snowy Bernese Oberland, the Jungfrau, the Schreckhorn, the Finsteraarhorn, the Eigers, and other summits to Mt. Blanc, "looming up before his eyes in the view from his house." Such views are calculated to make physical geographers and geologists of active minds. Guyot early found pleasure in the collection of insects and plants, and evinced in this and other ways the impress that Nature was making upon him.

Previous to the year 1818 and for a while after, Guyot was at school at La Chaux-de-Fonds, a noted village "at the foot of a narrow and savage gorge of the Jura," 3,070 feet above the sea. In 1821, then fourteen years of age, he entered the College of Neuchâtel, where he was a classmate of Leo Lesquereux, the botanist. "Guyot and I," says Lesquereux, "were for some years brothers in study, working in common, and often spending our vacations together either at Guyot's home at Hauterive, or with my parents at Fleurier, and I owe much in life to the good influences of this friendship." His studies were classical—Latin, Greek and philosophy, arranged for preparing a boy for the profession of the law, medicine or theology, with almost nothing to foster his love of nature.

In 1825, then eighteen, he left home to complete his education in Germany. After spending three months in Metzingen, near Stuttgart, in the study of the German language, he went to Carlsruhe, where he became the inmate of the family of Mr. Braun, a man of wealth and scientific tastes, the father of the distinguished botanist and philosopher, Alexander Braun, the discoverer of phyllotaxis—terms of intimacy with the family on the part of several of his relatives having been of long standing. The family comprised also a younger son and two daughters. Agassiz was then a student at Heidelberg, along with young Alexander Braun and Carl Schimper, but he spent his summer vacations at the Carlsruhe mansion. A vacation soon came. "The arrival of the eldest son of the house," says Guyot, "already distinguished by his scientific publications, with his three university friends—Agassiz, Schimper, the

gifted co-laborer of Braun in the discovery of phyllotaxis, and Imhoff of Bâle, the future author of one of the best Entomological Faunas of Switzerland and Southern Germany, was a stirring event, which threw new life into the quiet circle. "After a short time devoted to a mutual acquaintance, every one began to work. The acquisition of knowledge was the rule of the day, and social enjoyment was but the sweet condiment to more solid food." "My remembrance," remarks Guyot, "of those few months of alternate work and play, attended by so much real progress, are among the most delightful of my younger days." "Add to these attractions the charm of the society of a few select and intimate friends—professors, clergymen and artists, dropping in almost every evening, and you will easily understand how congenial, how fostering to all noble impulses, must have been the atmosphere of this family for the young and happy guests assembled under its hospitable roof." "Months were thus spent in constant and immediate intercourse with nature, the subjects of investigation changing with the advancing seasons. Botany and Entomology had their turn; "and demonstrations of phyllotaxis," he says, "now reduced to definite formula by Braun and Schimper, and shown in various plant forms, but especially in pine cones, were of absorbing interest. The whole plan of the present animal kingdom in its relations to the extinct paleontological forms was the theme of animated discussions." He adds: "It would be idle to attempt to determine the measure of mutual benefit derived by these young students of nature from their meeting under such favorable circumstances. It certainly was great, and we need no other proof of the strong impulse they all received from it than the new ardor with which each pursued, and subsequently performed, his life-work."* Guyot took in, equally with Agassiz, the newly developed views in botany, embryology and zoological classification, that were the subjects of thought and discussion, and became profoundly impressed thereby, as his later work shows.

From Carlsruhe, Guyot went to Stuttgart and took the course at the Gymnasium, where he made himself a proficient in the German language.

Returning to Neuchâtel in 1827, and there quickened in his religious faith and feelings by the preaching of the Rev. Samuel Petit-pierre, his benevolent impulses under a sense of duty led him to turn from science to theology, and commence serious preparation for the ministry. In 1829, then 22 years of age, having this purpose still in view, he went to Berlin to attend the lectures of Schleiermacher, Neander and Hengstenberg, and there remained for five years (1830–1835). In order to

* Guyot's Academic Memoir on Agassiz, pp. 8–12.

meet his expenses he accepted the invitation of Herr Müller, Privy Counsellor of the King of Prussia, to live with him and give his children the benefit of conversation in French. The position brought him into intercourse with the highest of Berlin society, and was in many ways of great benefit to him.

While pursuing theology in earnest, his hours of recreation found him making collections of the plants and shells of the country and otherwise following his scientific leadings. Humboldt introduced him to the Berlin Botanical Garden, where the plants of the tropics were a source of special gratification and profit. Moreover, other courses of lectures attracted him, as those of Hegel, of Steffens on Psychology and the Philosophy of Nature, Mitscherlich on Chemistry, Hofmann on Geology, Dove on Physics and Meteorology, and especially those of Carl Ritter, the eminent geographer, whose philosophical views were full of delight to his eager mind and touched a sympathetic chord. Under such influence he found his love for nature-science rapidly taking possession of him, and, yielding finally to his mental demands, and to his conscience which would not permit him to enter the ministry with a divided purpose, he determined to drop theology and make science his chief pursuit.

Ritter, of all his Berlin teachers, made the profoundest impression on his course of thought; and his biographical sketch of him, presented to the American Geographical Society in 1860, four years after his death, exhibits the admiring affection of a pupil who was like Ritter in his profounder sentiments. A paragraph from the Memoir will show the tenor of Ritter's geographical teaching, and something of the mental affiliation between them. Guyot says:*

"Ritter, in the introduction to the 'Erdkunde,' declares that the fundamental idea which underlies all his work, and furnishes him a new principle for arranging the well-digested materials of the science of the globe, has its deep root in the domain of faith. This idea, he adds, was derived from an inward intuition, which gradually grew out of his life in nature and among men; it could not be, beforehand, sharply defined and limited, but would become fully manifested in the completion of the edifice itself. That noble edifice is now before us, and unfinished though it be, it reveals the plan of the whole and allows us to perceive that fundamental idea on which it rests. It is a strong faith that our globe, like the totality of creation, is a great organism, the work of an all-wise Divine Intelligence, an admirable structure, all the parts of which are purposely shaped and arranged, and mutually dependent, and like organs, fulfill, by the will of the Maker, specific functions which combine themselves

* Amer. Geographical Soc., ii, p. 48. Feb., 1860.

into a common life. But, for Ritter, that organism of the globe comprises not nature only; it includes man, and with man, the moral and intellectual life." "None before him perceived so clearly the hidden but strong ties which mutually bind man to nature; those close and fruitful relations between man and his dwelling-place, between a continent and its inhabitants, between a country and the people which hold it as its share of the continent; those influences which stamp the races and nations each with a character of their own, never to be effaced during the long period of their existence."

We have here ideas that took, in Guyot, a still larger expansion.

Guyot derived great profit also from the works and the friendship of Humboldt. His address at the Humboldt Commemoration of the American Geographical Society, in 1859, is a beautiful tribute to this model student of nature.*

The five years of study at the Berlin University terminated with an examination which brought him the degree of Doctor of Philosophy. His graduating thesis, written in Latin, as was then the rule, was on "the Natural Classification of Lakes."

To Paris, the Pyrenees, Italy, etc., 1835 *to* 1839.—From Berlin, Guyot, in his 28th year—June of 1835—went to Paris to take charge of the education of the sons of Count de Pourtalès-Gorgier, and continued with the family four years. Letters of introduction from Humboldt led to much intercourse with Brongniart and other savants of the great city. For the summer he accompanied the family to Eaux Bonnes in the Pyrenees. While there he made ascents of the higher peaks, and took excursions in various directions—to the amphitheater of Gavarnie, to the borders of Spain by the Pont d'Espagne and the pass beyond, to the valley of the Eaux Chaudes, etc.—in order to study the features and flora and compare the mountains in these respects with the Alps. In the autumn he went, with his pupils, to Belgium, Holland and the Rhine, to study the characteristic features of these countries. The following year he visited Pisa, and there, besides enjoying the new scenes, made various barometrical measurements, determining the elevation of the observatory at Florence, and of other points.

Trip to the Glaciers in 1838.—In the spring of 1838, Agassiz found Guyot still at Paris. During the summer preceding Agassiz had startled the scientific world by his declarations as to a universal Glacial era, contained in a paper read before the Helvetic Society of Natural Sciences assembled at Neuchâtel. His work in 1837—prompted in 1836 by Charpentier's discoveries proving the fact of a former epoch of immense glaciers in

* Journal of the American Geographical Society, i, 242, October, 1859.

Switzerland—had led him to the bold conclusion; and he was full of his new ideas when he met his old companion. He urged Guyot, who hesitated at accepting his views without examination, to study the facts; and obtained the promise that he would visit the glaciers that summer.

In his memoir of Agassiz, Guyot states that his six weeks of investigation that season in the central Alps (nearly two years before Agassiz commenced his investigations on the glacier of the Aar) were fruitful beyond expectation. He says, that from the examination of the glaciers of the Aar, Rhone, Gries, Brenva and others, he learned (1) the law of the moraines; (2), that of the more rapid flow of the center of the glacier than the sides; (3), that of the more rapid flow of the top than the bottom; (4), that of the laminated or ribboned structure ("blue bands"); and (5) that of the movement of the glacier by a gradual molecular displacement, instead of by a sliding of the ice-mass as held by de Saussure.

The facts and conclusions were communicated to the Geological Society of France at a meeting at Porrentruy in September, 1838. The communication is mentioned in the Bulletin of the Society for that year;* but no report of it is given, because the manuscript remained in his hands unfinished in consequence of his protracted illness the winter following. The portion then finished (which afterward was withheld from publication because, by special arrangement between them, Agassiz, in 1840, entered upon the special study of the glacier, and Guyot on that of the Swiss erratic phenomena, for their separate parts of a general survey) has recently been printed in volume xiii (1883) of the Bulletin of the Neuchâtel Society of Natural Sciences.

In 1842 this manuscript was deposited, by motion of Agassiz, in the archives of the Neuchâtel Society, and in 1848 it was withdrawn by Guyot when he left for America. It is to be regretted that publication was not substituted in 1842 for burial. Its recent publication was made by the request of Guyot early in 1883 from a certified copy of the original manuscript.

This paper gives the facts on which Guyot based his conclusions; and since these conclusions comprise some of the most important of the views now accepted relating to glacier motion and structure, and antedate the observations of Agassiz, Rendu and Forbes, they have special interest.

The fact of *a less rapid movement of the bottom ice than the top, owing to friction*, he ascertained by the observation that in glaciers of steep descent, like the Rhone at its rapids, and the Gries, the transverse crevasses and the masses they cut off are

* Volume ix, page 407.

at first vertical or nearly so; but below the rapids, where the slope is gentle and the crevasses become mostly closed, the masses are inclined with the pitch up stream; and this up-stream inclination is reduced, at the termination of the glacier, to a few degrees. The crevasses, although closing up below, are still traceable. He says: The so-called layers are not strictly layers; but great numbers of cracks remain which give to the mass the appearance of being made up of beds several yards thick, as may be seen in the glaciers of the Grindelwald valley, Aar and others.

Further: to this pitch in the stratification at the lower extremity, the beds rising outward, Guyot attributes also the origin of the majestic ice-chambers, whence in most cases flow great streams, as that of the Rhone, of the Arveyron at the foot of the Mer de Glace, of the Lütschinen from the glaciers of Grindelwald.

The more rapid movement of the center than the sides also was learned from the Rhone glacier and others of steep descent. The crevasses, at first transverse, were found to be arched in front below the rapids, and increasingly arched to the extremity, and the successive crevasse lines were very nearly concentric with the semicircular outline of the extremity of the glacier. He gives a figure of the Rhone glacier as seen from the Maienwand in illustration; and other later glacialists have appealed to the same evidence of lateral friction.

The semicircular outline of the terminal moraine was found to be another result of the cause just mentioned; and so also the "eventail" arrangement of the several moraines immediately above the termination. The greater height and breadth of the central moraine is made a consequence of the greater velocity of the ice at the middle of the upper surface, more transportation taking place consequently in a given time.

Again: The conclusion that *the movement of the glacier was largely through molecular displacement* was supported by his observation that the ice, instead of breaking up and rising into an accumulation of masses on its passage by an isolated rock, or rocky islet in its course, spread around and enveloped it without fracturing; and he refers to a fine example of this at the two isolated islets of rock in the midst of the great Brenva glacier, called the "Eyes of the glacier." "The same thing is observed at the Jardin du Talèfre, a true islet in the midst of a *mer de glace*, having a border of blocks of rock, or of a moraine, cast upon its sides by the march of the glacier, just like the coast dunes of an island in the ocean."

In view of such facts Guyot observes: "If it is true that the different parts of a glacier move with different velocities; if the glacier adapts itself to the form of a valley and fills all depres-

sions without ceasing to be continuous; if it can bend around an obstacle and closely enclose it without the fracturing of its mass like a spreading liquid, we may affirm that the movements take place through a molecular displacement, and we must abandon, at least as the only cause, the idea of a slow sliding of the mass upon itself as incompatible with the phenomena presented."*

The *blue bands* of the glacier were first described by Guyot. He called the structure *stratification*, and observed it in the ice of the summit of the glacier of Gries, at a height of about 7500 feet. A peculiar furrowing of the surface of the ice, the furrows one or two inches broad, attracted his attention; and this result of weathering he found to have come from the unequal firmness of the layers constituting it, layers of a softer "snowy ice" alternating with those of firm bluish glassy ice. The stratification was found by him to extend over hundreds of square meters, and downward, on the sides of crevasses, 20 to 30 feet deep, or as far down as the eye could penetrate; and it was evident that the layers of the two sides of a crevasse were once continuous, "like the strata of the opposite sides of a transverse valley." He compared the stratification to that of certain coarsely schistose limestones.† He remarks in conclusion: "We should say that the layers were not annual layers, but rather a series made day by day from small successive snow-falls that were melted in part by the sun of the day, and covered each night by the thick frost-glazing which envelops all the snowy summits of the high Alps."‡

He further observes that "these beds were evidently formed at a greater height and in a different position from that where observed." He adds, in closing his remarks on the subject—"Do the beds, at first horizontal, or at least parallel to the surface of the glacier, accomplish, during its movement, evolutions, as yet imperfectly understood, analogous to those before mentioned [that is, those occasioned by differences in velocity of the middle, sides and bottom, owing to unequal friction]. This is a point which should have further examination, with observations as minute, numerous and universal as possible. Unfortunately a thick fog and threatening weather forced me

* In French his words of 1838 are: "On peut affirmer que ces mouvements ne peuvent avoir lieu qu'en vertu d'un déplacement moléculaire, et il faut abandonner, au moins comme cause unique, l'idée d'un glissement lent de la masse sur elle-même, comme incompatible avec les phénomènes que presente la marche des glaciers."

† His words are: "stratifié à la façon de certains calcaires grossièrement schisteux;" and he explains it himself as implying a *lamellar structure.*

‡ In the original, the words are: On aurait dit, non pas des couches annuelles, mais une série de couches plutôt journalières de neige tombée successivement par petites quantités. puis fondue en partie par le soleil de la journée, et couverte chaque nuit de cet épais verglas qui, au-dessus de la région des glaces, recouvre toutes les sommités neigeuses des hautes Alpes."

to stop work before I had ascertained whether this structure was general for the whole mass of the glacier at that altitude, or whether restricted to that locality notwithstanding the proof of so large an extension of it." Guyot had some confidence in his conclusions, but he also felt, as he states, the importance of more detailed investigation in order to decide on their real value.

On the 1st of December, 1841, Guyot communicated the results of his observations of 1838, so far as relates to the "blue bands," at a meeting of the Neuchâtel Society of Natural Sciences—"reading some passages from his notes written in 1838." This communication contains the additional fact that the layers of the stratification in the Gries glacier were inclined about 45°; were nearly transverse to the principal glacier; and appeared also to have sinuosities due to lateral compression.* Agassiz, in his Système Glaciaire (1847), cites from Guyot's manuscript (then deposited with the Neuchâtel Society) the part relating to the "blue bands" (the only part he ever cited); and in this citation there is a paragraph on the inclination or pitch of the layers, with Guyot's additional suggestion that the pitch of the layers looked as if a result of the advance of the surface portion over that below, a point already explained by him [by reference to friction at bottom.†]

Guyot opens his account of the blue bands with the remark that as he had seen them only on one occasion, he dares not hazard an explanation. But his later sentences show that he was inclined to regard them as a result of deposition, and to consider the varying inclinations in the layers as due to subsequent disturbing action, that is, to the irregularities of glacier movement caused by friction and pressure under the varying conditions of the glacier valley as to form and size.

Whether right or wrong in these suggestions as to the bands, Guyot's six weeks' work in the summer of 1883 was indeed fruitful. He had the satisfaction of seeing his conclusions for the most part confirmed by the facts collected by Agassiz, Forbes and others, but not of receiving credit for his work and

* The report of the meeting of the Neuchâtel Society is contained in the Verhandlungen of the Schweiz. Nat. Gesellschaft, Altdorf, 1842. The *abstract* of Guyot's communication here given (pp. 199–200) says: "La position de ces couches etait inclinée d'environ 45° dans le sens de la pente générale du glacier. Leur direction semblait presque transversale a celle du glacier principale, mais longitudinale à celle de son penchant méridional. Elle présentait quelquefois des sinuosités qui semblaient un effet de compression laterale."

† The cited paragraph in the Système Glaciaire (p. 209) is as follows: "La direction de ces couches coupait à angle droit la ligne de marche (de pente) du glacier; leur inclination deviait de 30° à 40° de la perpendiculaire vers la partie inférieure, comme si la pente superficielle gagnait de l'avance sur la partie inférieure ainsi que je l'ai décrit plus haut." I learn from Mrs. Guyot that this paragraph is a part of the original manuscript, and that it was by oversight that it was not sent to the Neuchâtel Society in 1883 with the rest.

original conclusions, except on one point; and chiefly because of the want of proper publication.*

Having attended at Berlin, the lectures of Dove on Physics and Meteorology, and those of Ritter on Physical Geography, Guyot knew, when he went to the mountains, what to look for in case the glaciers were great flowing streams of ice, as had often been supposed; he knew that the flow of a stream is retarded along the sides and bottom by friction; and he naturally looked also for something in the encounter of the glacier with rocks answering to molecular displacement. Hence, in his six weeks of observations on the glaciers, he reached, without waste of time, good conclusions—the conclusions of a physical geographer. His investigation did not enable him to appreciate the interior fracturing that works along with molecular displacement in the flow of the ice, but his conclusion was still far in the right direction, and decisive against the hypothesis he opposed. That he did not continue his study of the glaciers to thoroughly established results was owing to his yielding the subject afterward to Agassiz. Fidelity to his friend and his volunteered agreement curbed in and silenced

* Rendu's "Théorie des Glaciers de la Savoie" was published in 1841 (Mem. Soc. Roy. Savoie, Chambery, vol. x). Forbes's first letter from the Alps, announcing his discovery in August, 1841, of the "blue bands" in the Aar glacier, was communicated to the Royal Society of Edinburgh, Dec. 6, 1841, and published in January in Jameson's N. Phil. J., vol. xxxii, 1842. Agassiz's first work on glaciers, "Études sur les Glaciers" was published in 1840. Neither of these publications mentions Guyot or his observations.

Guyot's communication of 1841, published in the Altdorf Verhandlungen, was drawn out by a discussion between Forbes and Agassiz relating to priority as to observations on the blue bands, and it was made just five days before Forbes's first letter was read in Edinburgh. Agassiz claimed credit for Guyot at the meeting in 1841, as a set off against Forbes's claim, and, again, in the N. Phil. Journ., xxxiii, 265, 1843. Forbes, in the following volume of that Journal, xxxiv, 145, 1843, gives Guyot credit for original discovery as regards the "blue bands" and speaks of his corresponding with him on the subject; and he repeats the acknowledgment to the "ingenious Professor of Neuchâtel," in his Travels through the Alps of Savoy, 1843 (1st edit.) and 1845 (2d edit.), page 28. Desor in the same Journal, xxxv, 308, 1843, in a paper on Agassiz's recent glacier researches, introduces a translation of Guyot's account of the banded structure, but cuts it short at the words "opposite sides of a transverse valley," leaving off the explanatory remarks which follow.

Tyndall, in his "Forms of Water" (1872, p. 183) gives Guyot credit for priority, and he cites, both in this work and in his earlier "Glaciers of the Alps" (1856), a translation of Guyot's account, ending it a sentence short of Desor's citation, with the words "certain calcareous slates," in place of Guyot's "certain schistose limestones;" and, on page 187 of "The Forms of Water," not knowing all of Guyot's explanations, he does him more than credit (admitting Tyndall's view to be established) in saying that he "threw out an exceedingly sagacious hint when he compared the veined structure to the cleavage of slate rocks:" for the comparison in Guyot's paper implies rather true stratification from deposition. The first detailed comparison of the "blue bands" to slaty cleavage, in structure, position and origin, appears to have been made by Professor Henry D. Rogers, at the Cambridge meeting of the American Association in 1849 (Proc. Am. Assoc., ii, 181). But Rogers attributed the structure in both to conditions of temperature, and not, like Tyndall, to pressure.

him; and so his paper, excepting the paragraphs on the "blue bands," remained buried until after Agassiz's decease.

At Neuchâtel—Professor in the Academy, 1839–1848. —In 1839, at the age of thirty-two, Guyot left Paris and returned to his native town. He at once became an active member of the Society of the Natural Sciences (which had been initiated by Agassiz in 1832), and was made, by the Society, one of a committee—including also M. A. Osterwald and H. Ladame—for the organization of a system of meteorological observations in Switzerland and the selection of the best instruments for the purpose. On the establishment of the "Academy" at Neuchâtel for the purpose of furnishing a university education to the graduates of the college or gymnasium, he was appointed to the chair of History and Physical Geography, and became a colleague of Agassiz. He hesitated about taking charge of the department of History, as it had not been one of his special lines of study; but once committed to it, he plunged into the subject with great earnestness. He says, he groped on among the details for two years before he began to distinguish its grand periods; and the light as it broke in upon him caused so intense excitement that he was made ill.

Instruction was a great pleasure to him, because of his deep interest both in his subject and in his pupils. His two departments called out from him thirteen general and special courses of lectures. With regard to the lectures, Mr. Faure says: "From the first, in spite of his apprehensions, he captivated his audience by his easy, elegant, sympathetic words, by the breadth of his views, and the abundance and happy arrangement of his facts. He had each winter afterward the pleasure of seeing men of cultivation of all classes in Neuchâtel pressing into the large hall of the college and listening to him with riveted attention." His pupil adds: "What zeal he inspired! What ardor for work! The fire with which he was filled passed to us. He was more than a professor; he was a devoted friend, a wise counsellor, associating himself with us and encouraging us in our work."

Guyot, besides lecturing and instructing, did all he could of outside work: meteorological, barometric, hydrographic, orographic and glacialistic. The hydrographic work was the careful sounding of Lake Neuchâtel (in all 1100 soundings) as the commencement of a study of the annual variation in the temperature of the waters of the Swiss lakes. His chief research—that on *the distribution* of the bowlders or erratics over Switzerland, occupied him "single-handed, seven laborious summers, from 1840 to 1847," he allowing himself, only "at the end of his working season, the pleasure of a visit of a few days to the

lively band of friends established on the glacier of the Aar, in order to learn the results of their doings and communicate his own to them."*

Switzerland in the ice-period was his subject; and the sources of the bowlders and the courses of ice-transportation were the chief enquiries. The investigation involved excursions on foot and careful examination over the whole range of the Swiss Alps, the slopes into Italy, the plains of Switzerland, and the mountains on the northern and western borders, including the Juras—in all an area of 190 by 310 miles—in order to trace the erratics to their high sources among the snowy summits, examine the rocks of all peaks, ridges and valleys for comparison with those of the erratics, measure the heights along the lines and limits of the erratics from plain to mountain peak, and note all glacial markings. The task was accomplished with the greatest possible fidelity; thousands of barometric measurements were made in the course of it, and from 5000 to 6000 specimens were gathered in duplicate.

Thus, says Guyot:

Eight erratic basins were recognized on the *northern* slope of the Alps—those of the Isère, the Arve, Rhone, Aar, Reuss, Limmat, Sentis, and Rhine; and four on the *southern* slope—that of the Adda including Lake Como, of Lugano, of Ticino including L. Maggiore, and that of the Val d'Aosta. Moreover a question left hitherto untouched—the distribution in each basin of the rocks special to it, was minutely examined, and the final results of all the laws observed in the arrangement of the erratic fragments were shown to be identical with the laws of the moraines. This identity, and the absolute continuity of the erratic phenomena from the heart of the Alps down the valleys and beyond to the Jura left no alternative but to admit the ancient existence of mighty glaciers as vast as the erratic regions themselves, having a thickness of over 2000 feet.

Brief notes on his work were published in the Bulletin of the Neuchâtel Society of the Natural Sciences, for November, 1843, May and December, 1845, and January, 1847,† he reserving the complete report for the *second* volume of Agassiz's great work on glaciers. But, unfortunately, after the first volume by Agassiz appeared at Paris, in 1847, there came the revolution of 1848, which put an end to their plans.

The study of the geological structure of the Jura Mountains, in which he worked out the system in the flexures of the strata and proved that it must have been produced by lateral pressure, was another of Guyot's labors soon after his return to

* Memoir of Agassiz, page 39.

† The facts are well presented also, though briefly, in the second volume of D'Archiac's Histoire des Progrès de la Géologie, pp. 259–265.

Neuchâtel, although not reported on until 1849, at the Cambridge meeting of the American Association.*

Guyot had been teaching at Neuchâtel nine years when, suddenly, the "Academy" was suppressed by the Grand revolutionary Council at Geneva of 1848. The 13th of June brought the tidings; and on the 30th, the end came "without any indemnity to the Professors." Letters from Agassiz urged Guyot to come to America. Though reluctant to take the step because of the many ties of friendship and association that bound him to Switzerland, and especially on account of the family under his charge (consisting of his mother, then 70 years old, and two sisters), which he should have to leave behind, he had the decision of his mother, after her careful reading of Agassiz's letter, in favor of it; and in the following August he left friends, home, and Europe.