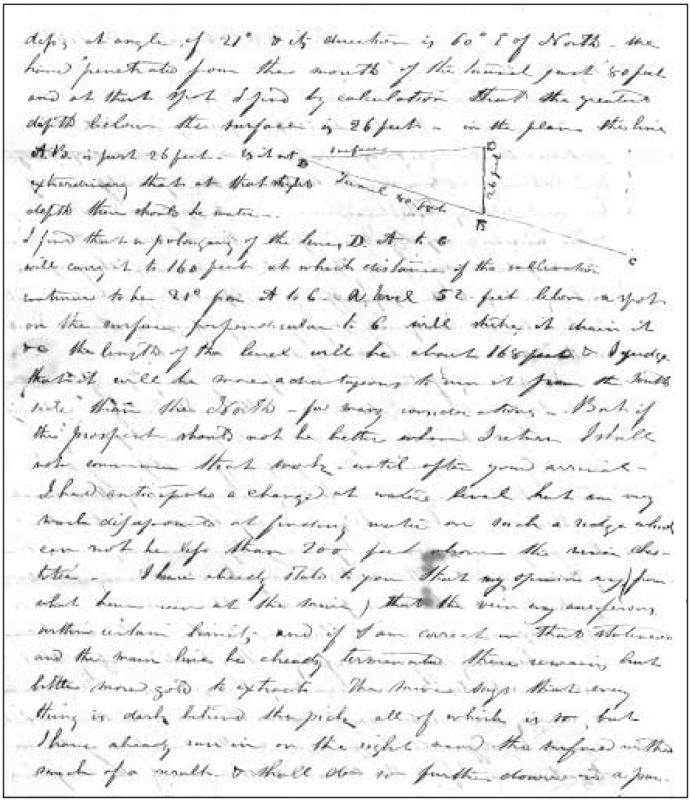
Chapter 6

Thomas Green Clemson: Scientist and Engineer

Chalmers M. Butler


dip, at angle of 21° & its direction is 60° E of North - we
have penetrated from the mouth of the tunnel just 80 feet
and at that spot I find by calculation that the greatest
depth below the surface is 26 feet - in the plan the line
A B is just 26 feet - It is not
extraordinary that at that depth
depth there should be water -
I find that a prolongation of the line D A to C
will carry it to 160 feet at which distance if the inclination
continues to be 21° from A to C - A level 52 feet below a spot
on the surface perpendicular to C will strike the vein at
C the length of the level will be about 168 feet & I judge
that it will be more advantageous to run it from the South
side than the North - for many considerations - But if
the prospect should not be better when I return I shall
not commence that work until after your arrival -
I had anticipated a change at water level but am very
much disappointed at finding water on such a ridge which
can not be less than 200 feet above the river Chestatee -
I have already stated to you that my opinion differs from
what have seen at the mine) that the vein are auriferous
within certain limits, and if I am correct in that statement
and the main has been already terminated there remains but
little more gold to extract. The miners say that every
thing is dark behind the pick all of which is so, but
I have already seen in on the right and the surface without
much of a result & shall see no further down in a few

Page from Thomas Green Clemson's letter to John C. Calhoun, August 5, 1842, describing Clemson's engineering work at Calhoun's O'Bar gold mine in Dahlonega, Georgia. Thomas Green Clemson Papers, Special Collections, Clemson University Libraries.

Thomas Green Clemson was a chemist of impeccable credentials and outstanding background for the mid-nineteenth century, and he possessed a deep understanding and working knowledge of mineralogy and geology. He also was a highly competent mining engineer with particular strength in metallurgy, derived from his foundation in chemistry. Judging from the papers and letters that he left, one sees in Clemson a propensity for applications of chemistry, but no evidence has been found that he contributed to the pool of fundamental knowledge in this basic science. Evidently, he focused his energies on the applications of these disciplines to accomplish practical results in commerce, industry, and agriculture, especially in fertilizer. Clemson was a man of wide interests, extending beyond chemistry and engineering to art, music, farming, hunting, politics, and, in particular, to education.

The importance of education to young Clemson manifests itself in his choice to travel to Paris in 1826 at age nineteen to study chemistry through 1831 or, perhaps, 1832, at the University of Paris [*La Sorbonne*] and the Royal College of France [*Le Collège royal de France*], and mining engineering at the School of Mines [*L'Ecole des mines*], under, by most counts, the finest nineteenth-century chemistry and mining engineering faculties in the world. Moreover, as Clemson later stated in court testimony, he was examined at the Royal Mint [*La Monnaie royale de Paris*] and certified as an assayer in June 1831.

Clemson was a skilled practitioner with a deep understanding of the science underlying chemistry, a man who held knowledge in high regard. From 1830 to 1836 he authored numerous journal papers and co-authored another with R. C. Taylor in 1839. After his service as chargé d'affaires to Belgium from October 4, 1844, to January 8, 1852, he published seven additional papers in the period from 1856 to 1859. From inspection of his published papers, one gleans facts about the man as an applied scientist. Chemist R. N. Brackett, who studied fifteen of Clemson's papers published before 1850, notes that twelve pertained directly to chemistry and include assays and analyses of iron ores, minerals, hydraulic limestone, copper ore, and coals, plus one on methods for manufacturing Nordhausen sulfuric acid in Germany. The other three, he explains, include a geological examination of a region of Virginia, an investigation of the physical geography of the Hartz region of Germany, and an assessment of the iron ore of Yates County, New York. The 1839 paper by Clemson and Taylor reports the findings of their analysis of bituminous coal outcroppings near Havana, Cuba. His last seven papers pertain to agriculture and further reveal his expertise in chemistry, mineralogy, and geology.

Upon his return to the United States from France in 1832 with his education in chemistry, mining engineering, and allied sciences, Clemson sought to establish himself as a professional consultant. During these early professional years, when prestigious jobs for qualified scientists were few in number, he applied for the position of state geologist in both New Jersey (1835) and Pennsylvania (1836), but, though well qualified for such a post, Clemson ultimately received neither appointment.

During late 1842 and early 1843, Clemson was in charge of John C. Calhoun's O'Bar gold mine near Dahlonega, Georgia, in an area where, in the sixteenth century, gold may have been mined by laborers of Ferdinand De Soto. The summer and part of the fall of 1842 are a short chronological span in the life of Clemson, but the prodigious, extant correspondence between Calhoun and him is a rich record of his mining engineering at an actual mine, from which one has the opportunity to examine his engineering prowess.

The above paragraphs provide a sketch of selected facets of T. G. Clemson's education and professional career as a chemist and mining engineer. Each is elaborated upon in the following pages, and the details are carefully documented in order to place in plain view some of Clemson's accomplishments and experiences.

Clemson's Paris Education

Knowledge and understanding of the principles underlying a discipline and skill in analyzing the interactions among these principles are the marks of a chemical or physical scientist. To these, add skill in selectively synthesizing the consequences of these principles within a constraining environment for the purpose of creating a desired result, and one has the marks of an engineer. Knowledge and understanding of principles are acquired through investigation and study. Skill comes from practice and experimentation, not only physical but also mental, within the framework of these principles. Many strategies lead to the acquisition of knowledge and understanding, but all effective methods, when stripped of their trappings, reduce to personal observation of fundamental phenomena and study of the writings and recordings of experts. Of course, in numerous ways the deepening of intellect, acquisition of knowledge, and development of skills can be significantly enhanced and rendered more efficient through the guidance of experienced teachers. Thomas Green Clemson wisely elected to seek further education in Paris under the direction of the world's acknowledged experts in chemistry and allied sciences, as well as in mining engineering, rather than to rely solely on unaided self-education or on guidance by less esteemed science and engineering mentors in the United States.

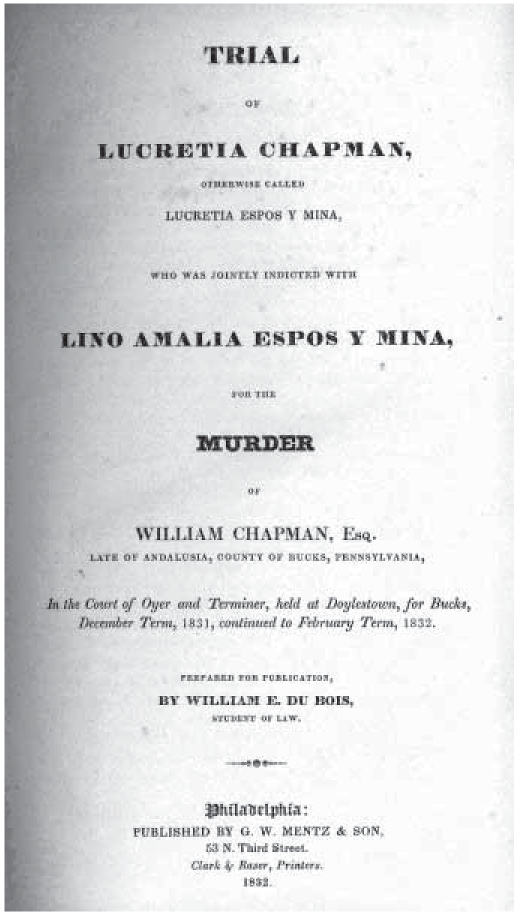
Clemson traveled to Paris in 1826 at the age of nineteen, and there he studied chemistry, geology, and mining engineering through 1831 or, perhaps, 1832.[1] A brief outline of the stature and accomplishments of scientists and engineers under whom he studied in Paris reveals, in part, the quality of the education to which Clemson was exposed, and, in addition, it sheds light on the background that he likely acquired. His professors and mentors are identified in two sources: one is a July 17, 1831, letter[2] to Clemson from Lefte Neal, a friend and fellow Paris student from Canada, written just days prior to Clemson's impending departure from Paris, and the other is an excerpt[3] from the record of a Bucks County, Pennsylvania, murder trial (December 1831 and February 1832) at which Clemson testified as an expert witness in chemistry.

During his Paris years, Clemson attended lectures by or worked under the guidance of Arcet, Jean-Baptiste Elie de Beaumont, Pierre Berthier, Ours Dufrénoy, Joseph Louis Gay-Lussac, and André Guenyveau, among others. These professors are named in the farewell letter (in French) of July 17, 1831, to Clemson from Lefte Neal, who is effusive in his description of Clemson's standing with his professors, suggesting that he was a good student, who enjoyed the respect of his teachers and mentors:

> …M. Berthier, whom I saw on the 12th regrets to see you leave. It was indeed wittingly that this scholar, the first [greatest] analyst of the century, gave to you the certificate that you bear. For the way in which he spoke to me of his great pupil is worth even more than the certificate. I congratulate you with all my heart for all the keen interest that you have inspired in all your teachers. You should feel a noble pride in thinking that you are honored by the friendship of an Elie de Beaumont, whose beautiful system of geology has just received the confirmation of the new discoveries made in India and in many other parts of the globe; of a Robiquet, whose numerous works and whose learned and numerous analyses reveal to us a successor to Vanquelin, of a Thénard, of a Gay-Lussac, of an Arcet, all on the summits of science, and of their learned collaborators, the learned engineer-in-chief Guenyveau, the engineer Dufrénoy, celebrated teacher in the most celebrated school in France. Few French, my dear Clemson, are as happy [fortunate] as we.
>
> In your country you are going to apply the knowledge acquired in our first [best] schools of Paris; and, thank God, it will not be knowledge that will be lacking in the geologist, the chemist, or the physicist.…[4]

Clemson was engaged by the Bucks County Court authorities to participate—as an expert witness for the prosecution—in the analysis of the contents of a murder victim's stomach to determine if poisons were present. No doubt Clemson was selected for this undertaking on the basis of his acknowledged expertise in chemistry, even at the young age of twenty-four years. In order to apprise the court of his qualifications and background as an expert in chemistry, Clemson, under oath, offered the following testimony:

> …before 1826, I engaged in acquisition of chemical information in the United States. In 1826 I went to Europe, and in the fall of that year entered the practical laboratory of Mr. Gaultier de Clowbry; at the same time I attended the lectures of Thénard, Gay-Lussac, and Dulong, as delivered at the Sorbonne, Royal College of France. In 1827 I entered the practical laboratory of Langier and Fiber and afterwards the private laboratory of Robiquet; after which I gained admittance to the Royal School of Mines. I was then examined at the mint, and received my diploma as Assayer. It is dated June 1831. I then came to the United States, where I arrived in the fore part of September, 1831.[5]



TRIAL

OF

LUCRETIA CHAPMAN,

OTHERWISE CALLED

LUCRETIA ESPOS Y MINA,

WHO WAS JOINTLY INDICTED WITH

LINO AMALIA ESPOS Y MINA,

FOR THE

MURDER

OF

WILLIAM CHAPMAN, Esq.

LATE OF ANDALUSIA, COUNTY OF BUCKS, PENNSYLVANIA,

In the Court of Oyer and Terminer, held at Doylestown, for Bucks, December Term, 1831, *continued to February Term,* 1832.

PREPARED FOR PUBLICATION,

BY WILLIAM E. DU BOIS,

STUDENT OF LAW.

Philadelphia:

PUBLISHED BY G. W. MENTZ & SON,

53 N. Third Street.

Clark & Raser, Printers.

1832.

Title page of the published proceedings of the murder trial of Lucretia Chapman (Dec. 1831 and Feb. 1832), in which Thomas Green Clemson testified as an expert witness for the prosecution (Philadelphia: G. W. Mentz, 1832).

From the above segment of testimony, one has a partial list of the names of Clemson's professors and mentors, learns that he attended the Royal School of Mines, and finds that the Royal Mint certified him as an assayer. For many years no independent evidence surfaced confirming that Clemson actually attended the school until his enrollment as an auditor during 1828 to 1832 was claimed in a letter of July 1, 1926, from M. Chesneau, director of the School of Mines in Paris, to Robert Skinner, council general of the United States in Paris.[6] About his search of the school's records, Director Chesneau writes,

> I have been unable to find any record of a student by the name of Clemson either in the minutes or the directory of former students of the school. However, I entertained some doubts on the matter as a note under date of Nov. 4, 1828, indicated that a young American by the name of Clauson was authorized to attend classes at the school of mines [sic]. A further search of our archives revealed the fact that the Clauson of 1828 was none other than Thomas Clemson.[7]

Chesneau explains the details of his search and then says further, "a blue slip has just been discovered in the name of Clemson (Thomas), 1828–1832, which means that Thomas Clemson attended the classes at our school as 'auditeur libre,' from 1828 to 1832; therefore, the Clauson of November 4, 1828, can be no other person but Thomas Clemson."[8] Actually, evidence that Clemson attended the School of Mines has been available since the early 1830s: four journal papers published by Clemson bear the school's name as the author's affiliation.[9]

In his farewell letter, Neal is explicit about the rapport Clemson enjoyed with his eminent teachers and mentors and underscores their admiration for their American pupil. From Neal's observations, one infers that Clemson was looked upon as a serious and good student by the faculty. The letter also lists faculty to whom Clemson was exposed, in addition to those named by him in his Lucretia Chapman trial testimony.[10]

Who were these professors, teachers, and mentors? Among them one finds preeminent nineteenth-century scientists. For instance, Joseph Louis Gay-Lussac, who held professorships in both physics and chemistry and is claimed by both communities, discovered two fundamental gas laws, one of which bears his name and pertains to the temperature-volume behavior of gases. The other speaks to the way in which two gases combine and is known as *the law of combining volumes.* His careful experimentation enabled Gay-Lussac to demonstrate that inert gases, subject to a specified rise in temperature, undergo the same volumetric expansion. His discovery of the laws of chemical combination in gases aided in the establishment of the all-important atomic theory and led the way to *Avogadro's law*. The scientific world was amazed at some of Gay-Lussac's experimental findings in the combining of gases. For instance, Bernard Jaffe[11] describes the paradoxical outcome of one such experiment: "one volume of hydrogen chloride gas when brought in contact with one volume of ammonia gas yielded a white powder, and no residue of either gas left." Gay-Lussac also contributed to the development of analytical chemistry, especially titration, and introduced the name *pipette*, still used today.[12]

Joseph Louis Gay-Lussac, preeminent nineteenth-century scientist under whom Thomas Green Clemson studied in Paris. The Edgar Fahs Smith Memorial Collection, Department of Special Collections, University of Pennsylvania Library.

Louis Jacques Thénard was also a chemist of wide interests, who discovered hydrogen peroxide and developed cobalt compounds from which he created a practical pigment for French porcelain known as *Thénard's blue*. Thénard and Gay-Lussac together were the first to isolate the element boron (1808), and they pioneered photochemistry. A baron who was knighted, Thénard served as dean of the Paris Faculty of Sciences in 1822, and, ultimately, became (1845–1852) the chancellor of the University of Paris, the highest position in the French university system. He authored an expansive, prestigious, and widely adopted, four-volume chemistry textbook, *Traité de chimie élémetaire, théorique et pratique,* which underwent six editions during 1813–1836 and was translated into German, Italian, and Spanish, with parts into English.[13] Pierre-Louis Dulong was trained as a physician but became interested in botany, then chemistry and mathematics, and finally made his mark in physical chemistry and physics. He held professorships in chemistry in the Faculty of Science, Paris, and in physics at the Polytechnic School [*Ecole Polytechnique*], and he served as the director of the Polytechnic for eight years. He made many important contributions to both physics and chemistry, the most celebrated of which is the Dulong and Petit *law of constant atomic heat capacity*, developed in collaboration with the mathematical physicist Alexis Therese Petit, who died in 1820 before Clemson's arrival in Paris in 1826. This relationship between atomic weights of elements and their specific heats had a profound effect on the development of the system of atomic weights, upon which so much of modern physical science is founded. They also demonstrated that Newton's *law of cooling* is valid only for small temperature differences. *Dulong's hypothesis*, arrived at empirically, provides the means for a practitioner to compute the approximate heating value of a fuel from knowledge of its chemical composition.[14]

Pierre-Jean Robiquet, a professor of chemistry at the Polytechnic School, who today would be labeled a pharmaceutical chemist, is credited with the discovery of caffeine, among other compounds, and of codeine in opium.[15] Pierre Berthier discovered bauxite and was professor of assaying and head of the laboratory at the School of Mines. He was an expert in mineralogy and mining engineering and is credited with important contributions to techniques for locating and analyzing mineral deposits, especially those of phosphates, for use in agriculture. In his well-known and widely used *Traité des essais par la voie sèche*, Berthier prescribes accurate and practical field procedures for mineralogists and mining engineers.[16] Jean-Baptiste Elie de Beaumont served for fourteen years as engineer-in-chief of mines of France and was professor of geology at the School of Mines in Paris. He and Ours Pierre Dufrénoy, also an engineer and geologist, prepared the great geological map of France, a sixteen-year undertaking.[17]

These gifted scientists at the School of Mines offered courses in which were covered subterranean topography, mining techniques, ore processing, analytic mineral chemistry, mineralogy, geology, hydraulic and steam engines, and drafting, plus laboratory practice. After the second year, students undertook field study trips to mining or metallurgical regions. Study of a subject was complete when a prescribed level of attainment was reached, typically realized only after another year at the School of Mines. Then more field study trips were required for a student to complete the course of study.[18]

The noted American science historian, Bernard Jaffe, explains, "Previous to 1840, American students of chemistry went to Paris to study under Dumas, Gay-Lussac, and Thénard."[19] Much earlier, the famous Swedish chemist, Jons Jacob Berzelius, widely referred to as "the organizer of scientific chemistry," had reminisced in the winter of 1823–24 to a young colleague, who, in turn, recorded Berzelius's mentioning "Gay-Lussac, Thénard, Dulong, Wollaston, H. Davy, and other distinguished men of science of that period, upon whose shoulders we of a later generation now stand.…Chief in his esteem and veneration were Gay-Lussac and Humphry Davy."[20] Of the five international chemists Berzelius revered, three were Clemson's teachers mentioned in Neal's letter, and Berzelius chose Gay-Lussac as one of the two for whom he reserved worldwide preeminence. Robert D. Purrington, American physicist and noted science historian, writes,

> During the forty years before 1830, France was peerless among the scientific nations of the world. The names LaPlace, Poisson, Berthollet, Ampere, Fourier, Carnot, Fresnel, Biot, Cauchy, Gay-Lussac, Lavoisier, de Morveau, Fourcroy, Dulong, and Petit do not exhaust the roll of scientific luminaries working in France during this period. Despite the inclinations of scientists such as Fresnel and Fourier to eschew untestable hypotheses, French discoveries proved crucial in propagating the atomic theory. Notable among them was the work of Pierre Louis Dulong (1785–1838) and Alexis Therese Petit (1791–1820).[21]

Clemson's professors Gay-Lussac and Dulong are among the most esteemed in Purrington's view, with Dulong and Petit the paragons of the early nineteenth century.

The Chemist

The high quality of the education in chemistry and mining engineering to which Clemson was exposed in Paris and the rapport he enjoyed with his world-famous professors, e.g., Gay-Lussac, Thénard, and Dulong, as claimed in classmate Lefte Neal's letter,[22] suggest that Clemson's advanced education in chemistry must have been extraordinary, especially in the early nineteenth century. Moreover, the subsequent selection of Clemson as an expert witness by the Bucks County Court, Pennsylvania, to aid in the analysis of the stomach content of a murder victim underscores the confidence the authorities held in Clemson and his knowledge of chemistry.[23]

Dr. R. N. Brackett,[24] who in 1891 joined the faculty of Clemson College, Clemson, South Carolina, and who served for many years as head of the Chemistry Department, published a two-part paper in the April and May, 1928, issues of the *Journal of Chemical Education* entitled, "Thomas Green Clemson, LL.D., the Chemist, Parts I[25] and II."[26] Part I provides a sketch of Clemson's life, especially as a scientist, and a description of analyses of papers authored by Clemson. In Part II Brackett discusses Clemson's interest in and contributions to scientific education:

> During the period 1830 to 1836, part of which time he was a student at the School of Mines, and at the Royal Mint, and the remainder still living in Paris, fifteen papers were published under Clemson's name and one jointly with R. C. Taylor. Of these fifteen papers, twelve are distinctly chemical[:] assays and analyses of iron ores, minerals, hydraulic limestone, copper ore, and coals; one on piperin; and one on the method of manufacture of Nordhausen sulfuric acid in Germany. The other three papers by Clemson were on the physical geography, etc., of the Hartz; [a] geological examination of the country between Fredericksburg and Winchester, Va; [and] native iron of Yates County, New York. The joint paper of Clemson and Taylor was on a vein of bituminous coal in the vicinity of Havana, Cuba.[27]

Brackett's invaluable list[28] of these papers, with which he concludes Part II, reflects the following publishers and titles:

Transactions of the Geological Society of Pennsylvania

1. "Analysis of the Copper Ore of Hunterdon County, New Jersey." 1 (1835): 167.
2. "Examination and Analysis of Several Coals and Iron Ores Accompanying Mr. R. C. Taylor's Account of the Coal-field of Blossburg." 1 (1835): 220–223.
3. "Analysis of the Minerals Accompanying Mr. E. Miller's Donation." 1 (1835): 271–274.
4. "Analysis of Some of the Coal from the Richmond Mines." 1 (1835): 295–297.
5. "Notice of a Geological Examination of the Country between Fredericksburg and Winchester, in Virginia, Including the Gold Region." 1 (1835): 298–313.
6. "Notice of Native Iron from Pen Yan, Yates County, New York." 1 (1835): 358–359.

Journal of the Franklin Institute

7. "Analysis and Observations on Diverse Mineral Substances." 13 (1834): 78–79.
8. "Assay of an Iron Ore from Franklin County, New York." 13 (1834): 79–80.
9. "Analysis of Two Varieties of Hydraulic Limestone from Virginia." 13 (1834): 80.

Silliman's Journal (aka ***American Journal of Science and Arts***; since 1880, ***American Journal of Science***)

10. "Assay and Analysis of an Iron Ore (fer titanne) from the Environs of Baltimore." 17 (1830): 42–43.
11. "Notice of Piperin." 17 (1830): 325–356.
12. "The Hartz—Its Physical Geography, Etc." 19 (1831): 105–130.
13. "Notice of the Method of Manufacturing the Smoking Sulphuric Acid, as Practiced at Nordhausen, Braunlage, and Tanne in Germany." 20 (1831): 347–350.
14. "Analysis of American Spathic Iron and Bronzite." 24 (1833): 170–171.

American Farmer

15. "Sources of Ammonia." 11 (1856): 339.
16. "The Importance and Advantage of a Scientific Institution for the Advancement of Agriculture." (Letter to J. T. Earl, Esq., president of Maryland State Agricultural Society, October 4, 1856) 12 (1857): 161.
17. "Microscopic Organisms, etc." 12 (1857): 114.
18. "The Marl Formations: Their Composition and Value." 13 (1858): 5.
19. "Infusorial Organisms." 13 (1858): 5.
20. "The Necessity and Value of Scientific Instruction." 14 (1859): 275–277.

Others

21. [with R. C. Taylor, co-author], "Notice of a Vein of Bituminous Coal, Recently Explored in the Vicinity of Havana, in the Island of Cuba" (1836). *American Philosophical Society Transactions* 6 (1839): 191–196.
22. "Description et analyse de la Seybertite, nouvelle espèce minérale." *Annal. des Mines* 2 (1832): 493–495.

To the above list could be added an 1844 paper[29] by Clemson in the journal, *The Orion*. This interesting paper is on gold, including extraction from the earth, metallurgy, mineralogy, assaying, and its history; its pages are replete with descriptive terms of chemistry-based techniques, such as *departing* and *sweating a guinea*, both of which are, of course, applications of chemistry but which Clemson would classify as assaying and metallurgy. For this reason, the content of this twenty-third paper is addressed later in terms of mining engineering.

From his study of Clemson's papers on chemistry and from his perspective as a chemist who had benefited from almost a century of subsequent enhancements in the science, Professor Brackett characterizes chemist Clemson as a highly skilled practitioner in fundamental chemistry: "It has not been found that Dr. Clemson made any contribution to the development of chemistry as a science, but that he had an exceptional grasp and clear understanding of chemical facts and principles, was a competent analyst, and that he had a keen appreciation of the dependence of agriculture and industry on chemistry."[30] Edgar F. Smith, Blanchard Professor of Chemistry at the University of Pennsylvania, partially confirms Brackett's observation: "It is said that Thomas G. Clemson (1807–1888), educated in Chemistry at the School of Mines in Paris, was the first to announce the discovery of the diamond in the itacolumite of North Carolina. Other minerals were announced by him at various times, but his contributions to pure chemistry do not seem to be well known."[31] In applications in agriculture, Brackett again characterizes Clemson as an accomplished chemist with a practical bent:

> Clemson's interest in agricultural chemistry is shown by the numerous papers on this subject which were published in the *American Farmer*, but more especially by his two papers on 'Fertilizers,' published in the Patent Office Reports,

> Agricultural Division, for 1859 and 1860. Together these two papers constitute a scholarly, and for the time very complete treatise on agricultural chemistry, and show a thorough knowledge of the status of chemistry, both as a science and in its applications, especially to agriculture, but to industry as well. His familiarity with the literature of chemistry and its applications, past and current, is abundantly shown by numerous quotations and citations. These papers contain a number of original suggestions and interpretations, and several references to his laboratory and work, which prove that Dr. Clemson was a practical chemist of ability.[32]

Clemson is credited by some scientists with the discovery of phosphoric acid in atmospheric air about which he spoke and wrote, but others award credit for this important finding to a French chemist M. Barral, a disparity which drew the ire of American physician and professor, Dr. Thomas Antisell,[33] who reported his dissatisfaction in a letter to the editor of the *American Farmer* in which the discovery was first published:

> In the number of your excellent journal for May, 1856, Mr. Clemson states, from his own inquiries and experiments, that phosphoric acid exists in the air and in the snow and rain water percolating through the atmosphere. This deduction is quite original on his part, and he deserves much credit for the clearness of the enunciation and the continuousness of the exposition of the means by which this acid is found as a normal constituent of the atmosphere: I mean the infusoria and animalculae which exist everywhere.…(*American Farmer,* May, 1856, Vol. XI, page 330.) In a letter addressed to the President of the Maryland State Agricultural Society, in October, 1856 (*ibidem,* Vol. XII, page 162), he [Clemson] repeats the statement and declares the presence of infusoria and the decomposition of animal matter to be abundant sources of ammonia and phosphoric acid in the air. In the paper on microscopic organisms, published in the *American Farmer* for October, 1857, the fact of the presence of phosphoric acid in the air…is distinctly pointed out; and this whole matter was strongly set forth before the United States Agricultural Society at the meeting for 1857. The novelty of the fact stated then struck the writer of this with considerable surprise at the time, but…we may look upon it as an acknowledged fact that this acid—the phosphoric—must be looked upon as a normal constituent of the atmospheric air.
>
> I have been led to make the foregoing general observations upon the atmospheric constituents, and the new fact with regard to it with which Mr. Clemson has enriched science, because I perceive that in the *Presse Scientifique de deux monds* [sic; *mondes*] for 1st December, 1860, a statement that M. Barral, a French chemist of considerable eminence, has communicated to the Academy of Sciences a similar discovery; which he asserts he made lately, but which he had suspected seven years ago, namely, the presence of phosphoric acid in the air.…It is not often discoveries are made by men of science in this country in anticipation

> of European chemistry, as has happened in this instance, and when made, as they have been so lately in Europe, the effect will be that the credit of this discovery will be given to M. Barral and not to the present Superintendent of the Agricultural Department of the United States [Clemson] to whom it justly belongs. As the original memoirs and communications of this discovery have been made to your journal, I take the opportunity of publishing, through your columns, the facts of the case, which show that this discovery, now claimed by France, was made before, and published in this country in the columns of the *American Farmer* in 1856.[34]

Though born and educated in Ireland, Dr. Antisell resolutely asserts his fellow American's privilege to claim to be the first to identify phosphoric acid in air.

Clemson's contributions to scientific agriculture are elaborated elsewhere in this book, so information provided here on this subject is limited to support of his eminence as a chemist. In this regard, Alester Holmes and George Sherrill report that "in his article on 'Fertilizers' outlined elsewhere, he assembled the experiments, theories, and knowledge from all parts of the world and pointed out practical means of applying them to agriculture in the United States. In this article alone he refers to…[forty-two eminent scientists are listed by name, including his Paris professors Gay-Lussac and Berthier], and many other noted scientists."[35] Other evidence of Clemson's ability as an applied chemist can be found in Brackett[36] and in Holmes and Sherrill.[37]

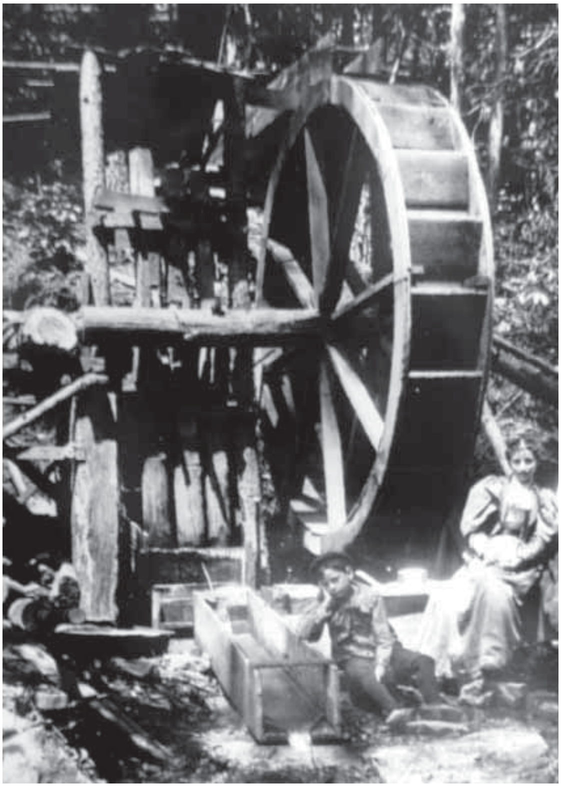
Mining Engineer

Mining in the Southern Appalachians dates back many years with copper mining dating to prehistoric times. Gold was found near Dahlonega, Georgia, in the late 1820s and lured treasure hunters to area towns, swelling them by thousands in the years immediately following the discovery, but, when gold was discovered in California in 1848, most of the miners "rushed" west, effectively emptying Dahlonega and surrounding towns.[38] Notwithstanding this exodus, gold mining near Dahlonega survived with modest success into the twentieth century and provided a rather continuous supply of income for mine owners and skilled miners. John C. Calhoun became interested in ownership of a gold mine, probably in hopes of bolstering his always-precarious income from an enterprise that did not require his regular, physical presence on site. According to Sherry L. Boatright, who searched the pertinent deeds and litigation records thoroughly, Calhoun purchased what became known as the Calhoun Mine or the O'Bar Mine and owned it, perhaps initially with his son Andrew Pickens Calhoun, from June 28, 1833, until his death on March 31, 1850.[39] The mine is located in present-day Lumpkin County, Georgia, about four miles south of Dahlonega on a hillside overlooking the banks of the Chestatee River.[40] Calhoun leased or rented the mine for a share of the take from 1833 until June of 1842, when Clemson took over direction of its operation.[41]

As early as 1830 members of the United States House of Representatives from gold-producing states urged the establishment of federal assaying offices in order to standardize the valuation of mined gold, but, after no progress in creating legislation, the effort evolved into demands by a few senators that the United States Mint be branched. Led by John C. Calhoun and supported by a handful of senators from gold-producing states, the effort met with success on March 3, 1835, when President Andrew Jackson signed into law a bill creating branch mints in Charlotte, Dahlonega, and New Orleans.[42]

By the early part of the nineteenth century when Clemson returned home from Paris to embark upon a career, mining of various metals had been practiced for more than 6,000 years,[43] and there is evidence that gold, which often was found on the surface of the earth in several forms, had been used for ornamental purposes prior to any human record.[44] Methods of mining and releasing gold from its *in situ* environment, primarily by washing or panning, were known by the Egyptians prior to 3800 BCE.[45] Although gold is often found in the form of nuggets on the surface of the earth and in stream beds, most must be extracted from within the earth and subsequently parted from the material in which it is embedded. It is usually found as minute particles, as a fine powder, or in very, very thin layers within sand, gravel, shale, slate, or rock of varying hardness, and it often is concentrated in veins within these materials. Through the years, numerous techniques have been developed for removing gold from its host material, with the method of choice dependent on the material and its form as well as on the configuration of the gold. If the gold is embedded in rock, shale, or slate, the composite is crushed by pounding and then is ground into a powder, after which the unwanted lighter-than-gold material is washed away, leaving the gold as a residue. If the host material is softer than rock or slate, the crushing step may not be needed. And the gold recovered from the washing process often can be further refined by smelting. These methods have been perfected over many, many years, and the details of the steps may vary depending on the nature of the gold and its host material encountered by the miner.[46]

Crushing is accomplished by laborers pounding with hammers or by stamps, the latter a simple device comprising a very hard stone or iron base on which the hard ore is placed and a stone or iron head for pounding the ore. Once the ore has been crushed into small particles, it is often reduced further in size to a fine powder by means of a mortar and pestle or is ground by a mill fashioned from abrasive wheels much like those of a gristmill used to produce meal or flour from grain. Often a sieve is used in an intermediate step to separate large particles to be stamped again.[47] Washing could be as simple as water poured over the pulverized gold and host material on a flat board, it could be done in a pan with water,



Water-driven stamp mill (ca. 1830-1840), similar to the one constructed under Thomas Green Clemson's supervision at the O'Bar Mine in Dahlonega, Georgia. The Dahlonega Gold Museum.

or it could be accomplished by means of water passing through a sluice bearing the pulverized material.[48] If ore conditions are suitable, the sieving and washing can be accomplished in a single step by a *rocker* designed to sieve and wash simultaneously.[49]

As they are described and illustrated in line drawings in *De Re Metallica* (1556), ganged stamps, or *stamp mills,* which obviously were invented prior to 1556, reduced manual labor and increased the rate of crushing ore. These mills are based on the principle of the hand-operated stamp but are driven by humans, draft animals, or the weight of water. In the case of a stamp mill powered by a water wheel, the angular displacement of the turning water wheel is transformed via linkages and cams into periodic translational motion which serves to lift and subsequently drop the heads of an array of individual stamps ganged together.[50] *De Re Metallica* includes eleven illustrations of stamp mills having different numbers and sizes of ganged, individual stamps.[51] Grinding mills and rockers also can be arrayed and driven by water or other sources of power.

While in Washington in the spring of 1842, John C. Calhoun learned[52] that a new gold strike had occurred at his O'Bar mine and, because he worried that his property—now apparently much more valuable[53]—might be compromised, he asked a trusted friend John R. Mathewes of nearby Clarkesville, Georgia, to visit the mine and report what he found. In the same letter Calhoun informs Mathewes, "I shall write to my son-in-law, Mr. Clemson, and request him to make a visit for me, as soon as he arrives home from Cuba."[54] Calhoun did write to Clemson at Fort Hill, not a great distance from Dahlonega, and asked that he go to the mine to investigate and to protect Calhoun's interests. Calhoun follows with another letter expressing hope that Clemson will find it "convenient" to comply with the request and states further that, even though he has no reason to distrust his two lessees, his agent is not present at the mine and he fears that he may lose heavily if gold continues to be extracted in abundance.[55] From a letter to Clemson from Calhoun,[56] one infers that Clemson and his family arrived in Charleston from Cuba on or before May 27, 1842, so he should have reached Calhoun's mine by very early June.

A few days later on June 10, Calhoun left Washington,[57] for the first time ever during a session of Congress,[58] and reached Dahlonega sometime before June 14[59] where he met Clemson, who had hastened to the mine, departing Fort Hill very soon after receiving Calhoun's request. Initially Clemson lived in a tent on the mine property but apparently decided, soon after arrival, that he could serve Calhoun's interest most effectively by a stay of some length. And so, he and his hands began construction of a cabin at the mine site.[60] In his words, "I have had McDaniel [sic; Matthew McDonald?] and Daniel employed in putting up a stable & lumber house for bacon, meal, tools &c. All they require now is covering so that by the time Mrs. Calhoun & Anna arrive I shall have every thing very comfortable—as they I am sure will find."[61]

Lander gives an account of the gold taken from the O'Bar mine by Clemson and his workers and provides interesting descriptions of the Spartan life endured by Clemson and his wife and, occasionally, other family members, in the rugged North-Georgia hills of the O'Bar mine site.[62] As entertaining as Lander's narrative of life at the mine site is, the focus here is upon Clemson's mining activities as his prowess as a mining engineer is uncovered. Though not highly erudite from a modern-day engineer's point of view, letters from Clemson to Calhoun are rich in many of the details of the mining techniques employed by Clemson during his operation of the O'Bar mine, roughly from early June through the first week of October in 1842, with a short stint in early January of 1843.[63]

Clemson first arrived at O'Bar in early June of 1842 and immediately conducted a survey of the mine and its ongoing activities in order to acquire an appreciation of the mine activities upon which to base a preliminary plan for the operation. Aside from providing shelter for himself and others in his party, he faced several concurrent problems. It was mandatory that he keep the hands working and producing gold albeit initially using methods employed prior to Clemson's arrival; otherwise, Calhoun's venture would collapse due to failure to offset operating costs by revenue from gold.[64] Clemson surveyed the site in search of new veins of gold in order to acquire the data needed to place bounds on the size that the mining operation should ultimately reach, and he assayed the gold found in order to estimate the yield that might be realized.[65]

In a letter of June 28, Clemson conveys encouraging information to Calhoun and in doing so reveals confidence in his own mining experience: "so you perceive thus far our plan of operations works admirably. Some of the pans gave, not including the rock specimens, I think may safely say from forty to fifty penyweights [sic] of loose gold. I have seen a good deal in the way of mining but this specimen of the capability of the mine passes every thing I have heard of—& if it continues as I think it will for reasons I shall assign, you may really say that money is no object."[66] In fact, Clemson's words, "I have seen a good deal in the way of mining," characterize a person who judges his mining experience above the ordinary. Clemson also reveals familiarity with mining engineering methods when he writes:

> I think after they have finished the buildings in progress I shall set about putting up a dam & small mill below the junction of the two branches. To beat the ore by hand will be too expensive (not expensive for the ore will warrant that) but it will give occupation to too many hands which must be avoided for the accumulation of persons will decrease the yield, few resist the temptation of gold. If we conclude to work before the mill is constructed it will require extra hands for the rocker & hands to wheel the ore to the rocker. Whether the rocker is started or not I think an additional number of hands can be kept at work with advantage. If the construction of the mill (which will be cheap) meets with your aprobation [sic], they will be required about the dam race &c. I think that a road cut down taking advantage of the slope not making it too rapid & hauling it from the mouth of the mine in a cart drawn by oxen will be for some time the best mode of operating—it will be the most economical at first if not always. Beating by hand is a long & tedious operation[;] a mill with three or four stamps will do all the work we want & will require little attendance. McDaniel has constructed several here abouts & he says he thinks the water will be sufficient to drive that number of stamps.[67]

Here Clemson writes of "stamps" used in mining to crush and pulverize materials, in this case gold-bearing rock, and rockers used to separate gold from the crushed aggregate. Moreover, he suggests knowledge of how to construct a water wheel to drive the stamp mill, and it is apparent that he, with help from McDaniel, will construct the dam, wheel, and stamp mill.

In mid-July, Clemson, in part, occupied himself with additional analyses—assaying—of the gold being produced so he could determine what future extraction techniques might be most efficient and lead to optimum use of available labor. All the while he contemplated plans to improve the operation by implementing mining techniques not used before at the O'Bar. However, at this time he seems less certain than in late June that construction of a water wheel and mill is wise, as can be inferred from the use of the word *if* in a parenthetical expression about McDaniel made by Clemson: "He is honest & useful & *if* [author's emphasis] we build a mill will be necessary."[68] About the continuing search for ore, Clemson reports to Calhoun,

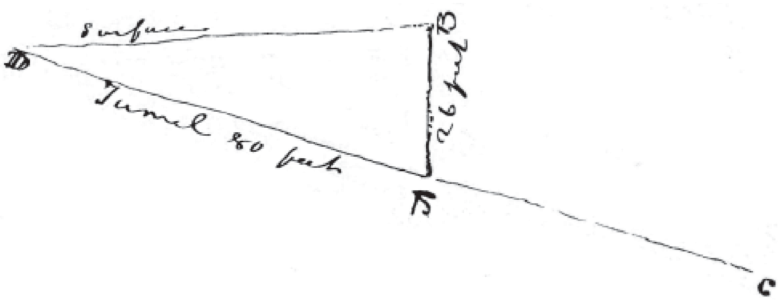
> I put two hands to experimenting on the side of the hill due north, where [ ] made the discovery. We have found some specimens & those rocks which do not contain visible gold yield amazingly well when beaten up—& what is surprising gave coarse heavy gold. It is not continuous to the bottom of the hill nor have I been able to find it on this side—I cannot say if the present ore will continue. But if it does it will be the next richest vein, to that already discovered, that has been found in the country. The ore is very hard and white. When the gold is visible it occurs in solid roundish pieces often continuing from one end of the specimen to the other.…My present impression is that it is entirely a distinct vein from the one we are working & which is so rich. Now that I have gotten regularly to work it will not take a very long time for me to possess myself of [a] pretty good idea of the extent of the gold bearing rock.[69]

As Clemson and the workers collected ore from the mine and concentrated the gold itself by methods in place when Clemson arrived at the O'Bar, he spent at least some of his time and energy devising techniques to improve yield without increasing labor and incurring the associated costs. All of these plans were tempered day by day as the miners pursued a vein and Clemson evaluated its yield. On July 31, he informs Calhoun of the installation of a railroad for hauling ore, "The rail road is down & working well."[70] And he continues, "On the morning I left I hired a hand to test on the other side of the ravine to the North, & I am pleased to say that at 10 foot in the vein is large (2 or 3 inches) & rich in gold."[71] After weighing the data, projecting potential production, and reconsidering more than once his decision to automate the mine and take advantage of water power, Clemson convinces himself in the positive and writes to Calhoun on July 31, "As soon as I can spare McDaniel to go at other work I will commence the building for a mill as I am now confident (as far as confidence can go without a perfect knowledge) that we shall have enough to do for some time for a mill. But I would much rather you were here before we progress far as I am in hopes you will be."[72]

In mine tunnels, water encroachment is an ever-present problem and can be dangerous to a miner, not to mention an interference to those who follow a vein that eventually becomes submerged. The statement below relates how Clemson, the engineer, addresses such a difficulty and uses his knowledge and skill to project a reasonable course of action:

> The rock is very hard and increasing in that particular & the vein poorer than I have seen it—this is at the extreme end of the tunnel. & the water which comes in is becoming very embarrassing. This made necessary that I should set about investigating the ground with a view to running an adit level upon the vein, without which it will be difficult to work it in the direction of the inclination. I find the tunnel & consequently the auriferous dips at angle of 21º & its direction is 60º E[ast] of North. We have penetrated from the mouth of the tunnel

just 80 feet and at that spot I find by calculation that the greatest depth below the surface is 26 feet—in the plan the line AB is just 26 feet. It is not extraordinary that at that slight depth there should be water. I find that a prolonging of the line DA to C will carry it to 160 feet at which distance, if the inclination continues to be 21° from A to C, a level 52 feet below a spot on the surface perpendicular to C, will strike it [,] drain it &c [;] the length of the level will be about 168 feet & I judge that it will be more advantageous to run it from the South side than the North—for many considerations. But if the prospect should not be better when I return I shall not commence that work—until after your arrival. I had anticipated a change at water level but am very much disapointment [sic] at finding water on such a ridge which cannot be less than 200 feet above the river chestatee. I have already stated to you that my opinion was (from what [I] have seen at the mine) that the vein was auriferous within certain limits and if I am correct in that statement and the main line be already terminated there remains little more gold to extract.[73]

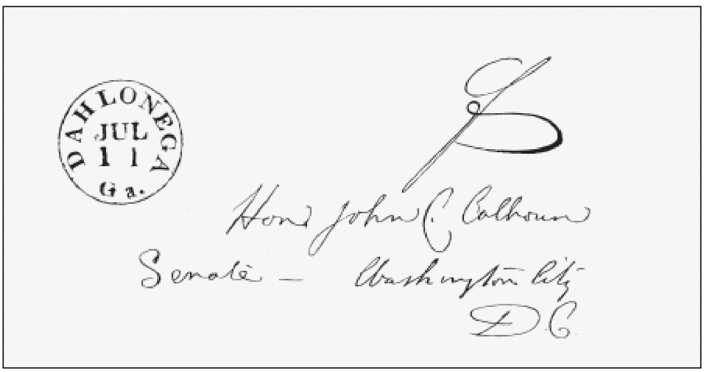


Thomas Green Clemson's sketch of a tunnel axis, included in his August 5, 1842, letter to John C. Calhoun. (See excerpt of this letter above and the chapter's opening illustration.) Thomas Green Clemson Papers, Special Collections, Clemson University Libraries.

The calculation upon which Clemson based the prediction that the vertical depth from surface to tunnel end is 52 feet for a 160-foot-long tunnel, declined 21° from the horizontal, is very interesting and would not be within the capacity of a person devoid of knowledge of trigonometry, geometry, or what today is called engineering graphics. He probably measured the 80-foot tunnel length and estimated or roughly measured the 21° tunnel declination with a protractor, allowing him to find the 26-foot intermediate depth. Once the intermediate depth is determined, finding the tunnel depth of 52 feet for a 160-foot-long tunnel is very easy. With modern engineering background and a handy electronic calculator, the author finds that the 26-foot intermediate depth should be 28.7 feet provided the 21° declination is correct. Measurement of tunnel declination angle in the hilly terrain of the O'Bar mine would be inaccurate even with today's instruments, so, in view of what he had at his disposal, Clemson's calculations are impressive and adequate for the application he intended. With knowledge of the depth of the end point C of the extended (imagined) tunnel, Clemson could tunnel toward C from a point on the side of the hill at an elevation below that of C, hopefully strike the gold vein near C, and follow the vein back toward the original tunnel. The new tunnel, because of its designed slope, would provide self-drainage as the miners followed the vein.

At times the gold yield did not justify the added expense of modernizing the operation and, as always, Clemson did not want to incur additional cost of improvement without concurrence from Calhoun. By September 6 Clemson was again pessimistic and so informs Calhoun:

> There is nothing transpiring here that is wrong but the misfortune of our getting but little gold, whilst the expenses of the establishment are going on, notwithstanding the economical scale upon which we are mounted; still the expenses will destroy the profits without an income beyond what we are getting at present.…I have done a good deal of work since your absence & with your presence we may be able to make some changes & come to results without disapointment [sic].[74]



Thomas Green Clemson letter from Dahlonega, Georgia, to U.S. Senator John C. Calhoun, July 11, 1842. Thomas Green Clemson Papers, Special Collections, Clemson University Libraries.

The descriptions above of the exchanges between Clemson and Calhoun are representative of what one finds in their numerous other letters during mid-1842 and very early 1843 and provide abundant evidence of Clemson's knowledge of gold mining methods. The mill was ultimately constructed and completed sometime between November 8 and December 9, as is ascertained in two letters, one by Matthew McDonald on November 8 to Calhoun stating, "I have not got my mill underway as yet"[75] and another[76] in which Clemson informs Calhoun of a letter of December 9 from McDonald who states that the mill is running. In the same letter,[77] Clemson tells Calhoun that McDonald has received the jar of mercury that Clemson had asked Calhoun to order on July 25—"You had better bring with you from the North an Iron jar of Mercury. You are aware that it comes in jars of Iron & when the mill is built it will require a good deal of that metal which you can procure much cheaper North."[78] In the age-old amalgamation technique, which no doubt Clemson studied as a student at the School of Mines, mercury or quicksilver is mixed in a slurry with powdered gold and its host material, allowing the mercury to form an amalgam with the pure gold, leaving the host material behind. The mercury is removed by forcing it through a skin or cloth strainer enabling the miner to capture the contained gold.[79]

Ever hopeful of finding a technique for improving the yield of his mine, Calhoun passes on to Clemson a letter containing information about a method for treating ore reputed to be used in Russia, and, in doing so, remarks, "It will, however, I suppose, contain nothing that is not familiar to you."[80] Clemson replies with confidence derived from his scientific background:

> The information contained in the printed extract is not new to me. I have often stated to you that the only means by which all the gold could be extracted, from the ores here found, is by smelting; but there are many difficulties which prevent the practice of that mode. If the ore be simply heated to the point of fusion of the gold it would I think advance nothing—because the ore by itself is not fusible & the fine gold disseminated through so great a proportion of ~~gold~~ *rock* would prevent the small particles of that metal from uniting & forming by their reunion pieces or buttons sufficiently large to be separated without loss by ulterior washing. Nor is there sufficient Iron in the majority of ore to form any thing like a treatment founded upon the reduction of the oxide of Iron, nor am I convinced that the reduction of the oxide of Iron would facilitate the collection of the contained gold. Indeed I have great doubts as to the alloying of Gold & Iron (& place no confidence in that statement, if which is somewhat doubtfully expressed, is there meant that the gold & Iron alloy.) If there was an abundance of lead to be procured cheap, there would be a great probability of a treatment being formed through the medium of that metal, by which greater quantities of gold could be saved at remunerating prices. A smelting process would be far more expensive than the present crude modes of collecting. They are however very efficient so far as the clean coarse gold is considered but entirely inefficient for the fine gold or that which is covered with a thin coating of the oxide of Iron. I have thought upon the subject a good deal & the conclusions at which I have arrived are, that no process can be instituted at once without a good deal of *preliminary* research to be made upon the ores of the countrey [sic] in a laboratory, & in the countrey and as I have stated to you, the officers of the mint should be men of scientific capability entirely adequate to the investigation of such a subject—without which little advancement in the process can be expected—& no place is so fit as the mint which should have supplies of such substances as are necessary for chemichal [sic] research. As to the miserable mode in which the mint is at present supplied, if capability were present & those enquiries part of the duties of the officers they would be prevented for the want of the necessary conveniences, as it is the supplies are scarce adequate to more than the ordinary

> routine of assaying &c. But Sir granting all the conveniences at hand I know not where the capacity would be found—for that kind of capacity is not intuitive.[81]

Clemson thus tells Calhoun that there is nothing new to him in the abstract from Russia and that smelting is very expensive and, for reasons given based on alloying of gold with iron or lead, might not offer improved extraction. No procedure without research conducted on the local ore holds hope of improved efficiency, and such research can be supported only by a laboratory with competent chemists and instrumentation, stocked with an adequate supply of chemicals. Analyses of the type needed do not yield to intuition, Clemson declares, and the laboratory and its personnel at the U.S. Branch Mint in Dahlonega fall far short of meeting this need. Clemson's education and his practical work experience in the leading chemistry laboratories of his time in Paris qualify him well to specify what is needed to support analyses and to render judgment of the U.S. Mint laboratories.

After some absence from the mine, Clemson returns and submits a report to Calhoun on the water wheel and mill:

> The wheel at the mill is pretty well constructed & very efficient. One of less diameter would not have answered. It runs all day & the water of the branch alone will turn it & keep the stamps in motion, but the amount of water in the branch without the dam (or when the latter is low) does not move it with as much rapidity as desirable. McDaniel thinks it can pound 150 bushels a day, which I think is above the quantity of work it is capable of performing without a flush stream. There are some little changes to be made which will make the whole work better.[82]

Clemson continues, "The arrangement of the whole affair works well & notwithstanding the small number of hands there is no mine in the country doing the same amount of profitable business."[83] He again writes to his father-in-law and then expresses satisfaction over the long term, "The beauty of the whole is the small number of hands & the compactness of the whole arrangement which can go on with out any difficulty but merely requ[i]ring common attention."[84] Apparently, Clemson feels that he has realized his goal of leaving in the hands of Calhoun an efficient, automated, and productive mine requiring minimum labor. And after returning home to Fort Hill from the O'Bar for the last time, Clemson writes to Calhoun, "The Mine and everything is going on as well as you can expect with a man of Mr. McDaniels [sic; Matthew McDonald's] roughness. But the main point is he is honest which is not a thing daily to be met with any where [and in] the gold region out of the question. I gave him some directions to follow about some little improvements in the mill &c & I now think that it will produce handsomely and regularly."[85]

In all likelihood, no mining methods or technologies employed at the O'Bar mine, or at any of the other mines in the Georgia gold region, were new to Clemson, given his education at the School of Mines in Paris and his subsequent experience. As a student he learned about applications of steam engines in mining, but surely procurement of such an engine would have escalated operating costs well beyond the affordable investment in the water wheel fabricated from on-site hewn lumber and blacksmith iron.[86]

Assayer, Metallurgist, and Geologist

In an 1844 invited paper entitled "Gold and the Gold Region,"[87] Clemson sketches the history of gold and some of its uses and attractions, lists a number of areas of the world in which gold is found, and mentions some of their common geological features. He explains that gold occurs in a large variety of physical shapes and degrees of purity, nearly pure in some instances but often in combination with a host material. Gold ore may contain other metals or, at the other extreme, gold may appear as a trace in the ore of another metal.[88] Interestingly, Clemson writes that

> in the sixteenth century, Ferdinand de Soto and his followers, explored the country between Florida and the Ohio, in search of gold.…In Washington County, Georgia, the remains of an old furnace were discovered some time since, and specimens of various kinds, from near that locality, were submitted to me for my judgment.…But what goes far to prove that the Spaniards visited the country around Mount Yonah, in Habersham [County], are discoveries of ancient habitations and works for gold mining, laid bare by the recent gold operations. Among other articles that have fallen under my notice, is a small pair of silver cigar tongs, which were disinterred from several feet below the surface of the ground, and which are precisely similar to those now used by the Spaniards for holding their 'cigaritos,' or paper cigars.[89]

Clemson also mentions a cup dug from a pit and fabricated from very hard quartz, thought by many to be an incantation cup of the aborigines, but he judges it to be of European "fabric" and for use as a mortar for "purposes connected with the extraction of gold."[90] In this paper, Clemson displays a superb knowledge of gold, its history, and its various discovery sites. Notwithstanding the extent of discussion reserved for gold, he also gives the reader a synopsis of the metallurgy and mining of iron ore, especially in the United States. He goes on to write about determining the purity of gold. For an approximate analysis for finding the purity of a gold sample, Clemson says the "touch-stone" is commonly used due to the method's speed and simplicity, but, if greater precision is needed and the quantity of the sample is not small, the assay is always the resort, and he proceeds to explain *depart*, a metallurgical operation involving several chemicals, especially nitric acid.[91] Probably both to entertain and educate the reader, Clemson writes:

> Gold is soluble in nitro-muriatic acid, or Eau Regale and a knowledge of this fact gives rise to the fraud, called in England, 'sweating a guinea.' The piece or pieces to be robbed are submitted to the action of the above named mixture, and if not permitted to remain too long under its influence, a portion of gold is removed equally from all parts of the surface without sensibly defacing the impression or form of the coin. When a sufficient number of pieces have been passed through the solution, the gold is precipitated and fused, and, by this means, in time, a considerable quantity is often obtained to the detriment, of course, of the currency.[92]

Such comments convey but a sampling of the information in Clemson's 1844 paper.

He was keenly sensitive to the value of science to business and commerce and was concerned that the United States' lack of scientific sophistication not only impeded national progress but also was costly in hard cash. In a letter to James T. Earle in 1856, published in the *American Farmer,* Clemson writes[93] concerning the U.S. currency minted in the early and mid-nineteenth century and comments that he knew as a student in France of the flow of our currency to Europe and of the extraction of traces of gold present in our silver coinage. Always the advocate of more science literacy and education, he contrasts the skill of European scientists, who understood the technology for separating gold and silver from ore bearing both, to that of our mint employees who seem unable to address the problem of allowing significant gold to remain in the silver and leave the country at the price of silver. He recalls in Belgium years later, when he was chargé d'affaires, having seen large quantities of our uncirculated silver coin fresh from the U.S. Mint undergoing gold extraction. And he adds that, when he was recalled from Belgium in 1851 after his tenure of service as chargé d'affaires, he was offered the agency for purchasing and collecting U.S. coins for shipment to Belgium.[94]

While a student in the School of Mines, Clemson served as a consultant to interests here in the United States. He conducted an analysis of an iron ore found in New York State which, subjected to techniques then current in the United States, did not lend itself to the production of iron. This ore was analyzed by Clemson and found to be that of "natural steel," and a procedure was prescribed for the production of a steel suitable for manufacture of high-quality tools and implements. Ultimately, an enterprise on the brink of financial ruin became successful.[95] Similarly, an ore found in abundance near Baltimore defied all attempts at successful smelting, and another capital-intensive business appeared to be heading toward failure. A half-ton of ore was shipped to Clemson in Paris for analysis, and, after conducting an assay, he formulated a method for efficient production of high-quality iron from this ore. Clemson was proud to report that the process had been put into practice, "greatly to the pecuniary advantage of the proprietors."[96]

For a period of time from 1837 to 1839, Clemson was affiliated with Mine LaMotte in Missouri and wrote a paper on the subject. Other than a record of his claim at a public gathering at the mine site that mining techniques used in the past were primitive and would be improved, little or no technical information is found in this paper. It reminds one of a prospectus more than of a scientific paper.[97] He apparently owned[98] a one-fourth interest in Mine LaMotte at one time, but affiliated financial matters created an extended source of worry for Clemson.[99] An 1839 paper by Clemson and Taylor reports their findings of an analysis of bituminous coal outcroppings near Havana, Cuba.[100] The owners must have been pleased with the work, for they offered Clemson the directorship of the mine as he informs Calhoun in a letter of January 10, 1841: "Since I wrote you last I have received an offer to take the direction of a mine in the environs of Havana. I have accepted the appointment so far as to make a preliminary visit provided they agree to my terms.…The terms are high but considering the duty, distance &[c.] not exorbitant."[101]

Geological Survey Directorships

Land, raw materials, minerals, fuel, and water and water power were among the principal physical needs in the lives of the early citizens of the United States. Many of these life-supporting requisites were right before the eyes of the nineteenth-century Americans, but others were uncovered only through systematic exploration. Knowledge of location, accessibility, and quantities of these resources was very important, as was classification and documentation for future reference. North Carolina and South Carolina were the first two states to address this dearth of information by authorizing or initiating geological surveys in 1823 and 1824, respectively, followed by surveys in Massachusetts in 1830; Tennessee and Maryland in 1831; New Jersey, Connecticut, and Virginia in 1835; and Maine, New York, Ohio, and Pennsylvania in 1836.[102] The importance of and benefits to be accrued from state geological surveys were appreciated by leaders in science and commerce, and a number of influential politicians in the various states saw the surveys as keys to economic development. Not surprisingly, geologic data were viewed as pertinent in the knowledge base compiled to support the defense of the young nation, as evidenced by a directive by the Secretary of War John C. Calhoun to Major Stephen H. Long that he lead an expedition in 1819–1820 from Pittsburgh to Denver at the eastern reaches of the Rocky Mountains for the purpose of collecting information about the sparsely explored region. Major Long was accompanied by an entomologist and a botanist-geologist who surveyed and recorded geological features along the expedition route and its environs.[103]

Upon his return to the United States from France in 1832[104] with his education in chemistry and mining engineering, augmented with substantial background in geology and mineralogy, Clemson sought to establish himself as a chemist and a consultant[105] in mining engineering. Geological surveys in the United States were in their infancies in the first third of the nineteenth century and were among the few technological enterprises that offered employment opportunities to scientists of Clemson's educational background. New Jersey authorized its survey on February 19, 1835,[106] and Pennsylvania did so on March 29, 1836,[107] and Clemson applied, or, perhaps, friends applied in his behalf, for the position of state geologist[108] of both states. But he was appointed to neither of these choice posts.

Clemson's pursuit of the appointment to head the New Jersey geological survey is inferred from an April 11, 1835, letter written by Henry Darwin Rogers, himself a candidate anxious to secure the position, to his well-known friend Joseph Henry, in which Rogers asks Henry to influence New Jersey Governor Vroom and members of his staff in favor of Rogers's appointment. At this time Joseph Henry lived in Princeton, New Jersey, where he was a professor at New Jersey College, later to be renamed Princeton University, and was an acquaintance of the governor. Excerpts from the letter include:

> …In a former interview with the Governor at Somerville I had a good deal of conversation from the *general tenor* of which I was induced to be sanguine of my success. I find that afterwards some other names were brought before his notice and backed I presume with a good amount of weight in their favour.…It has occurred to me that an interview on your part[,] if I can ask you to attempt so unpleasant a task, with the Governor…would be perhaps the most useful thing remaining to be done.…I wish you in conversation on the subject to dwell with stress on the necessity there is that the executor of the survey be a *Chemist*, for the analysis of the *soils* & many mineral products is to be one half of the useful portion of the plan. Now most of my competitors are not chemists.
>
> The Geologist again ought to be a To[po]grapher which I do not think one of them is. I mean he ought to be familiar from practice with field research of a scientific kind such as I have witnessed with De la Beche in Eng. so that when necessary he can *amend* or *resurvey* his *map*.
>
> Clemson is neither Geol[ogist], topographer nor naturalist, knowing nothing of *fossils* so essential to all accuracy in the science. Mr. Pierce of Conn, was spoken of by the Governor as an ardent cultivator of the subject. True he did some years ago…, but this does not make him the fitter man for the survey.… Tho Clemson understands a little mineralogy & chemistry, [of] geology he is grossly ignorant in all its improvements as you may readily see by reading his pamphlet on York County, Pa. Come to Phila & you will learn the true position here of this very specious intriguer.
>
> The circumstance that my brother Wm. has received the appointment to the survey in Va. which will be something superior is certainly a reason why I

> could perform that of Jersey better [than] any other person. For all discoveries made in the *same formations* I could have knowledge of long before they could reach anyone else in print & thus I should work with greatly improved light. If a chance occurs dwell on these points & pray let me hear from you as soon as you have anything to communicate.[109]

Aware from a recent audience with the governor that other candidates to head the New Jersey survey are under serious consideration for the position, Rogers writes to Henry to request that he speak to the governor in the writer's behalf. After presumptuously relating to Henry the attributes and background a qualified candidate must possess, Rogers disparages Clemson by name. From Rogers's letter in which he (1) asks an influential friend to support his candidacy for a state position by speaking to the governor, (2) defines the background and qualifications candidates must possess, and (3) declares the lack of these defined attributes in two persons named explicitly in the letter, one can only infer that the persons named are themselves candidates for the position. The editors of the Joseph Henry papers share the inference that Clemson was a candidate for the position of New Jersey state geologist.[110]

Rogers submitted to both legislative bodies unsolicited, detailed plans for organizing and performing surveys, even though at the time neither state had done more than contemplate the benefits of geologic data.[111] If Rogers's rather intrusive strategy to ensure appointment, including his specifications of qualifications of candidate directors, should be adopted, other candidates for the directorship would be at a decided disadvantage, as noted by a Rogers biographer as well as by the editors of the Henry papers.[112] Moreover, Rogers points out to Henry that benefits would accrue to the New Jersey survey should he become the director, owing to the assured scientific collaboration of his brother, William Barton Rogers, the state geologist of Virginia, especially insofar as the common geology of the contiguous regions of the two states is concerned. He, thereby, draws the criticism, "scientific nepotism," from the editors of the Henry papers: "Pierce and Clemson could, no doubt, counter the previous arguments [inadequate qualifications for the position]; this [nepotism] was unanswerable."[113]

On March 9, 1835, a mere eleven days after the New Jersey Legislature passed a bill authorizing a geological survey on February 26, Joseph Henry wrote to Rogers, "I know you must be very anxious to learn something relative to the Geological survey and I am sorry that I can give you no definite information with regard to the final result."[114] A period of eleven days seems a very short time for Rogers to become anxious, given that he must receive the announcement of the position, prepare and submit an application, and inform Henry that he had not received notice of an offer, unless, of course, Rogers had been apprised of the circumstances of the position and offer well prior to February 26, before which the job would not have been created, at least not officially.

Clemson was also a candidate for the head of the Pennsylvania survey, as one learns from Calhoun-Clemson scholar, E. M. Lander Jr., who says[115] that the Pennsylvania position was offered *tentatively* to Clemson. Interestingly, however, an April 3, 1839, letter from Calhoun to Clemson suggests not only was a firm offer tendered by Governor Porter, but also it was definitely accepted by Clemson: "You have, in my opinion, done right in accepting the offer [of the position of state geologist] made to you from the Governor of Pennsyl[vani]a [David R. Porter]. It is in line with your profession."[116] Calhoun also writes to his daughter Anna Calhoun Clemson[117] and to his brother-in-law James Edward Calhoun,[118] informing them of the offer and of his approval of Clemson's acceptance. A letter of May 4, 1839, from Calhoun to Anna C. Clemson reveals that Clemson was not appointed Pennsylvania state geologist, but no hint of what spoiled the deal is offered.[119]

Thus, Clemson was not the director of either survey, for Henry Darwin Rogers was appointed director of the New Jersey survey in 1835 and of the Pennsylvania survey in 1836, and he served in the former position until 1842 and in the latter at least through 1858.[120]

Criticisms by Henry Darwin Rogers

In seeking support to promote his candidacy for the directorship of the New Jersey Geological Survey, Henry Darwin Rogers asked Joseph Henry to approach New Jersey Governor Peter D. Vroom in his behalf, and, in his letter, Rogers writes, "Clemson is neither Geol[ogist], topographer nor naturalist, knowing nothing of *fossils…*" and "Tho Clemson understands a little mineralogy & chemistry, [of] geology he is grossly ignorant in all its improvements as you may readily see by reading his pamphlet on York County, Pa. Come to Phila & you will learn the true position here of this very specious intriguer."[121] Given the criticism[122] of Clemson by Rogers, one is led to ask who this man was.

Henry Darwin Rogers was born in Philadelphia in 1808, but spent most of his early years in Baltimore. He was one of four brothers who became well-known scientists, all of whom were educated principally by their father, Dr. Patrick K. Rogers, a physician and later professor of natural philosophy at William and Mary College.[123] In 1829, before his twenty-second birthday, Henry Rogers was elected professor of chemistry and natural philosophy, Dickerson College. Soon, however, he clashed[124] with the authorities, and his tenure lasted only through March 1831, when his service was terminated by the Dickerson trustees due to disagreements over academic discipline, adherence to the classics,[125] and lack of courses available to students in practicable subjects.[126] After leaving Dickerson College, Rogers worked for a railroad company, lectured to laymen on subjects in the sciences, and pursued his interests in scientific writing until May 19, 1832, when he sailed for London to pursue further study[127] as well as to lecture in the sciences to the working class.[128] Though educated in mathematics and chemistry and though he refused to teach geology at Dickerson, it was shortly after arriving in London that Rogers began to turn much of his attention to the subject of geology.[129] As opposed to a formal curriculum at a university, his studies in England appear to have comprised writing and publishing, inspecting and analyzing specimens in London museums, and attending public lectures by, and mingling with, many of the principal British scientists of the day.[130] After only a year in England, Rogers returned to Philadelphia in the summer of 1833 and began a study of U.S. geology, particularly that of the Appalachian Mountains.[131] On January 2, 1835, Rogers was elected a member of the American Philosophical Society, and on January 6 he was elected professor of geology and mineralogy at the University of Pennsylvania.[132] He was appointed state geologist of New Jersey in 1835 and of Pennsylvania in 1836,[133] two positions pursued by Clemson.[134] In 1840 Rogers and Edward Hitchcock organized the American Association of Geologists, which in 1848 evolved into the American Association for the Advancement of Science,[135] and in 1863 Rogers became a charter member of the U.S. National Academy of Sciences.[136] George P. Merrill, head curator of geology (1917–1929) at the United States National Museum, wrote, "he [H. D. Rogers] was unquestionably the leading structural geologist of his time and was designated by the English geologist, J. W. Judd, foremost in the school of American orographic geology."[137]

Rogers and his brother, William Barton Rogers, professor of geology and natural philosophy at the University of Virginia (1835–1853), were the prime movers in the establishment of the Massachusetts Institute of Technology; William served as the first president of MIT (1862–1870) and served again during 1878–1881.[138] In 1857, having failed in his efforts to secure appointment to the Rumford professorship at Harvard,[139] Henry Rogers was elected to the Regius professorship of natural history at the University of Glasgow, which position he held until his death in 1866.[140] While in Scotland, Rogers was elected to membership in the prestigious Royal Society of London.[141]

Controversy and personal attacks and counterattacks were not foreign to Rogers in 1835 and throughout most of the remainder of his career in the United States. They range from near defection of young geologists employed by him in the New Jersey and Pennsylvania surveys, involving such scientists as J. Peter Leslie[142] (subsequently, professor of mining, University of Pennsylvania, dean of the Towne Scientific School, and director of the second geological survey of Pennsylvania), to acrimonious encounters with those who sought to ensure that he not be appointed to the Rumford professorship at Harvard. In ten pages of her biography of Rogers, Patsy Gerstner tells the story of the Rumford professorship controversy and describes the pro and con stances taken by prominent Bostonians.

Given his ultimate stature as a scientist and his support from leaders of Joseph Henry's reputation,[143] one can hardly discount Rogers's criticism of Clemson. Perhaps Clemson was not as well qualified to lead the Pennsylvania and New Jersey surveys as was Rogers or, perhaps, Rogers's strong desire to secure these appointments and thereby to realize steady income prompted him to become overzealous, or even reckless, in denigrating other candidates. And he may have suspected that Clemson sided with part-time geologists in the Philadelphia area who feared diminished employment opportunities resulting from competition for jobs from Rogers, the first full-time professional geologist in the Philadelphia area. This perceived unfair playing field did not endear Rogers to his predecessors in the Philadelphia community of geologists, almost all of whom were acquaintances through membership in the recently organized Geological Society of Pennsylvania, which Clemson served as recording secretary.[144]

Whatever the case, Rogers's criticism of Clemson's competence and expertise in chemistry, geology, and mineralogy is unfounded in view of Clemson's premier Paris education and his published contributions to the scientific literature by 1835. In fact, it is not unthinkable that, at the time Rogers wrote to Henry, Clemson's knowledge and understanding of chemistry exceeded what Rogers had acquired under his father and through self study.[145]

A Final Overview

Thomas Green Clemson was educated in Paris under the finest chemistry and mining engineering faculty the world had to offer in the early part of the nineteenth century, and, upon returning to the United States, he established himself as a consultant in chemistry and mining engineering, which profession he pursued actively for a number of years. He applied for the position of state geologist in both New Jersey and Pennsylvania but, in both cases, was unsuccessful. Even while a student in Paris, Clemson began writing papers for publication in scientific journals, and, though his interests changed over time and his productivity abated during some periods, he continued to write for much of his life. His papers are a rich source of information upon which one can base an evaluation of Clemson as a scientist and engineer, but no source is richer than the extensive collection of letters exchanged with John C. Calhoun on the latter's O'Bar mine in Georgia. These letters afford a reader the opportunity to follow Clemson step by step as he fashions and implements a mining strategy peculiar to what he faced at the O'Bar and commensurate with Calhoun's objectives, and they reveal Clemson's engineering acuity and his knowledge of gold and gold mining. Later in life, he maintained his interest in science but devoted more and more of his time and energy to politics and to bringing technology to bear on problems in agriculture. Thomas Green Clemson was a man of wide interests, extending well beyond chemistry and engineering, whose last years were occupied with his lifelong passion: furtherance of science education.

Notes

1. Clemson's early education is outlined by Jerome V. Reel in Chapter 2. Reel also traces Clemson's travels in Europe and between the United States and Europe.
2. Lefte Neal to Thomas Green Clemson (hereafter, TGC), 17 July 1831, Clemson Papers, Special Collections, Clemson University Libraries, Clemson, SC (hereafter SCCUL).
3. Sworn testimony, 21 February 1832, of Thomas G. Clemson as the twenty-third witness for the prosecution in the trial of Lucretia Chapman for the murder of William Chapman of Andalusia, Bucks County, Pennsylvania, in the court of Oyer and Terminer, held at Doylestoun, for Bucks County, February term, 1832. It is recorded in J. Jay Smith, *Celebrated Trials of all Countries and Remarkable Cases of Criminal Jurisprudence* (Philadelphia, PA: Harding, 1835); Alester G. Holmes and George R. Sherrill, *Thomas Green Clemson, His Life and Work* (Richmond, VA: Garrett and Massie, 1937), 4–5.
4. See Lefte Neal to TGC, 17 July 1831, SCCUL.
5. See TGC testimony, 21 February 1832, in the Lucretia Chapman murder trial.
6. R. N. Brackett, "Thomas Green Clemson, LL.D., the Chemist, Part I," *Journal of Chemical Education* 5, no. 4 (April 1928): 433–444; Holmes and Sherrill, *Thomas Green Clemson*, 4–5.
7. Ibid.
8. Ibid.
9. Thomas G. Clemson, "Assay and Analysis of an Iron Ore (fer titanne) from the Environs of Baltimore," *Silliman's Journal* [also known as *American Journal of Science*] 17 (1830): 42–43; Thomas G. Clemson, "Notice of Piperin," *Silliman's Journal* 17 (1830): 325–356; Thomas G. Clemson, "The Hartz—Its Physical Geography, Etc.," *Silliman's Journal* 19 (1831): 105–130; Thomas G. Clemson, "Description et analyse de la seybertite, nouvelle espèce minèrale," *Annal. des Mines* 2 (1832): 493–495.
10. See TGC testimony, 21 February 1832, in Lucretia Chapman murder trial.
11. Bernard Jaffe, *Crucibles: The Story of Chemistry*, 4th ed., revised (New York: Dover Publications, 1976), 123.
12. Charles Coulston Gillispie, ed., *Dictionary of Scientific Biography*, vol. 5 (New York: Scribner, 1972), 317–327; Forrist Jewett Moore, *A History of Chemistry,* 3rd ed., revised by William T. Hall (New York: McGraw-Hill, 1939), 122–125; Robert D. Purrington, *Physics in the Nineteenth Century* (New Brunswick, NJ: Rutgers University Press, 1997), 77, 133; William Francis Magie, *A Source Book of Physics* (New York: McGraw-Hill, 1935), 165–173; Jaffe, *Crucibles: The Story of Chemistry*, 87, 98, 123–124, 127, 134–135.
13. Gillispie, ed., *Dictionary of Scientific Biography*, vol. 13 (New York: Scribner, 1976), 309–314; Moore, *History of Chemistry*, 122–125; Jaffe, *Crucibles: The Story of Chemistry*, 98.
14. Gillispie, ed., *Dictionary of Scientific Biography*, vol. 4. (New York: Scribner, 1971), 238–242; Moore, *History of Chemistry,* 161–167; Purrington, *Physics in the Nineteenth Century*, 133; Ernst Von Meyer, *A History of Chemistry,* trans. from German (London: Macmillan, 1891), 207–208; Magie, *Source Book of Physics,* 178–181.
15. Gillispie, ed., *Dictionary of Scientific Biography*, vol. 11 (New York: Scribner, 1975), 494–495 (hereafter cited as Gillispie, *DSB*).
16. Gillispie, *DSB*, vol. 2 (1970), 72.
17. Gillispie, *DSB,* vol. 4 (1971), 347–350.
18. Ibid.
19. Bernard Jaffe, *Men of Science in America,* revised ed. (New York: Simon and Schuster, 1958), 320–321.
20. Moore, *History of Chemistry*, 173–174.
21. Purrington, *Physics in the Nineteenth Century*, 125–126.
22. Lefte Neal to TGC, 17 July 1831, SCCUL. Farewell letter in French, written upon Clemson's departure from Paris.
23. The trial of Lucretia Chapman for the murder of William Chapman of Andalusia, Bucks County, is recorded in J. Jay Smith, *Celebrated Trials of all Countries and Remarkable Cases of Criminal Jurisprudence* (Philadelphia, PA: Harding, 1835). Clemson examined the content of the victim's stomach on 22 September 1831 and testified under oath on 21 February 1832.

24. Wright Bryan, *Clemson, An Informal History of the University 1889–1979* (Columbia, SC: R. L. Bryan Company, 1979), 39.
25. R. N. Brackett, "Thomas Green Clemson, LL.D., the Chemist, Part I," *Journal of Chemical Education* 5, no. 4 (April 1928): 433–444.
26. Brackett, "Thomas Green Clemson, LL.D., the Chemist, Part II," *Journal of Chemical Education* 5, no. 5 (May 1928): 576–585.
27. Ibid., Part II: 438–439.
28. Ibid., Part II: 584–585.
29. T. G. Clemson, "Gold and the Gold Region," *The Orion* 4, no. 2 (April 1844): 57–66.
30. Brackett, Part I: 438–439.
31. Edgar F. Smith, *Chemistry in America: Chapters from the History of the Science in the United States* (New York: D. Appleton, 1914), 219–220.
32. Brackett, Part I: 443–444.
33. James A. Steed, associate archivist, Smithsonian Institution Archives, Washington, DC, in private communication to author, 17 January 2007. Steed writes, "Dr. Antisell was a Washington doctor, trained in medicine and chemistry.…However, he was not a member of the Smithsonian staff." From a Georgetown University Library website (provided by Steed), one learns that Antisell also was a professor of chemistry at Georgetown University and the University of Maryland.
34. Brackett, Part I: 440–441.
35. Holmes and Sherrill, *Thomas Green Clemson*, 122.
36. Brackett, Part I: 433–444.
37. Holmes and Sherrill, *Thomas Green Clemson*, 47–69, 92–122.
38. Susan L. Yarnell, *The Southern Appalachians: A History of the Landscape*, Report SRS-18 (Asheville, NC: Southern Research Station/USDA, 1998), 13.
39. Sherry L. Boatright, *The John C. Calhoun Gold Mine: An Introductory Report on its Historical Significance,* Report to State of Georgia, Department of Natural Resources, Historic Preservation Section, 17–19. See 15 June 1974 photocopy in SCCUL. Boatright traces deeds and reviews litigation and thereby confirms Calhoun's ownership. She mentions other spellings of *O'Bar*, which derive from short-term ownership of the mine by Robert Obarr: *Obarr, O'barr, O'bar*.
40. Clair M. Birdsall, *The United States Branch Mint at Dahlonega, Georgia: Its History and Coinage* (Easley, SC: Southern Historical Press, 1984), 25.
41. Ernest M. Lander Jr., *The Calhoun Family and Thomas Green Clemson: The Decline of a Southern Patriarchy* (Columbia: University of South Carolina Press, 1983), 46.
42. Birdsall, *United States Branch Mint at Dahlonega, Georgia*, 1–2.
43. William Barclay Parsons, *Engineers and Engineering in the Renaissance* (Baltimore, MD: Williams and Wilkins, 1939), 177.
44. Georgius Agricola, *De Re Metallica*, Trans. from 1st Latin Ed. of 1556 by Herbert B. Hoover and Lou H. Hoover (1912; repr., New York: Dover Publications, 1950), unnumbered footnote, "Historical Note on Gold," 399.
45. Ibid.
46. Ibid., 267–351.
47. Ibid., "Historical Note 8," 279–283.
48. Ibid., 267–351.
49. Robert S. Lewis, *Elements of Mining* (New York: John Wiley and Sons, 1945), 226.
50. Agricola, *De Re Metallica*, 279–287.
51. Ibid., 284–287, 299, 313–314, 320–321, 373, 501.
52. John C. Calhoun to John R. Mathewes, 22 May 1842, in Clyde N. Wilson, ed., *The Papers of John C. Calhoun*, vol. 16 (Columbia: University of South Carolina Press, 1984), 254–255 (hereafter cited as Wilson, ed., *Papers of JCC*).
53. The press got word of a strike at the mine of the famous Calhoun and published the news widely. See Wilson, ed., *Papers of JCC*, vol. 16, unnumbered footnote, 255.
54. Ibid.
55. John C. Calhoun to TGC, 28 May 1842, in Wilson, ed., *Papers of JCC,* vol. 16, 259–260.

56. Ibid. In his letter to Clemson, Calhoun writes, "Mr. Clapp delivered me your letter yesterday, which gave me the agreeable intelligence that you, Anna & John had arrived safely in Charleston." Calhoun's letter is dated 28 May, so the Clemsons arrived on or before 27 May 1842.
57. Dixon H. Lewis to Richard K. Cralle, 10 June 1842, in Wilson, ed., *Papers of JCC*, vol. 16, 274. Dixon writes to Cralle that Calhoun "left here this morning for Dahlonega."
58. Ibid., xxvii.
59. Anna Calhoun Clemson to Maria E. Simkins, 14 June 1842, in Wilson, ed., *Papers of JCC*, vol. 16, 278. Anna writes in this letter that Calhoun "is now in Dahlonega."
60. TGC to JCC, 23 June 1842, in Ibid., 282–283.
61. Ibid. In the TGC to JCC letter of 23 June 1842, in Wilson, ed., *Papers of JCC*, vol. 16, 282–283, the phrase "I have had McDaniel [sic; Matthew McDonald?]" appears. This uncertainty about Matthew McDonald and McDaniel, both of whom worked at the O'Bar mine, is, in fact, founded on a number of similar confusions in Clemson and Calhoun's letters about the O'Bar operations.
62. Lander, *Calhoun Family and Thomas Green Clemson*, 46–67.
63. Clemson arrived before 14 June 1842 (see Anna Calhoun Clemson to Maria E. Simkins, 14 June 1842, in Wilson, ed., *Papers of JCC*, vol. 16, 278). He departed Dahlonega during the first week of October, 1842 (see Lander, *Calhoun Family and Thomas Green Clemson*, 53).
64. TGC to JCC, 28 June 1842, in Wilson, ed., *Papers of JCC*, vol. 16, 288–291.
65. Ibid.
66. Ibid.
67. Ibid.
68. TGC to JCC, 15 July 1842, in Ibid., 311–314.
69. Ibid.
70. TGC to JCC, 31 July 1842, in Ibid., 346–347.
71. Ibid.
72. Ibid.
73. TGC to JCC, 5 August 1842, in Ibid., 349–351.
74. TGC to JCC, 6 September 1842, in Ibid., 444–445.
75. Matthew McDonald to JCC, 8 November 1842, in Ibid., 533–534.
76. TGC to JCC, 13 December 1842, in Ibid., 569–570.
77. Ibid.
78. TGC to JCC, 25 July 1842, in Ibid., 331–333.
79. Agricola, *De Re Metallica*, 295–298.
80. JCC to TGC, 3 August 1842, in Wilson, ed., *Papers of JCC*, vol. 16, 347–348.
81. TGC to JCC, 14 August 1842, in Ibid., 387–390.
82. TGC to JCC, 23 January 1843, in Ibid., 624–626.
83. Ibid.
84. Ibid.
85. TGC to JCC, 29 January 1843, in Ibid., 635–637.
86. For the reader interested in a thumbnail sketch of the O'Bar mine and Clemson's activities there, the letter from TGC to Captain Patrick Calhoun, 12 October 1856, SCCUL, is recommended; see also Holmes and Sherrill, *Thomas Green Clemson*, 66–68.
87. Thomas G. Clemson, "Gold and the Gold Region," *The Orion* 4, no. 2 (April 1844): 57–66.
88. Ibid.
89. Ibid.
90. Ibid.
91. Ibid.
92. Ibid.
93. Thomas G. Clemson, "Letter to Jas. T. Earle," *American Farmer* 12, no. 6 (Dec. 1856): 161–163.
94. Ibid.
95. Ibid.
96. Ibid.
97. Thomas G. Clemson, *Observations of the La Motte Mines and Domain in the State of Missouri* (Washington, DC: Blair and Rives, 1839), 1–16.

98. Holmes and Sherrill, *Thomas Green Clemson*, 64–66.
99. Ibid.
100. Richard C. Taylor and Thomas G. Clemson, "Notice of a Vein of Bituminous Coal, Recently Explored in the Vicinity of Havana in the Islands of Cuba," *American Philosophical Society Transactions* 6 (1839): 191–196.
101. TGC to JCC, 10 January 1841, in Wilson, ed., *Papers of JCC*, vol. 15, 420–422.
102. George P. Merrill, *The First One Hundred Years of American Geology* (New Haven, CT: Yale University Press, 1924), 94, 101, 127.
103. Ibid., 69.
104. Clemson traveled from Europe to the United States and back several times after completing his formal education in Paris, which is traced by Jerome V. Reel in Chapter 2 of the present volume.
105. Henry Darwin Rogers to Joseph Henry, 11 April 1835, in Nathan Reingold, ed., *The Papers of Joseph Henry,* vol. 2 (Washington, DC: Smithsonian Institution Press, 1975), 374n5.
106. Patsy Gerstner, *Henry Darwin Rogers, 1808–1866, American Geologist* (Tuscaloosa: University of Alabama Press, 1994), 45.
107. Ibid., 52.
108. "State geologist" and "director or head of state geological survey" are used synonymously.
109. Henry Darwin Rogers to Joseph Henry, 11 April 1835, in Reingold, ed., *The Papers of Joseph Henry,* vol. 2, 373–375.
110. Ibid., 375n8.
111. Gerstner, *Henry Darwin Rogers, 1808–1866*, 45–46.
112. Henry Darwin Rogers to Joseph Henry, 11 April 1835, in Reingold, ed., *Papers of Joseph Henry,* vol. 2, 375n8; Gerstner, *Henry Darwin Rogers, 1808–1866*, 45–46.
113. Ibid., 375n8.
114. Joseph Henry to Henry Darwin Rogers, 9 March 1835, in Ibid., 364.
115. Lander, *Calhoun Family and Thomas Green Clemson*, 18.
116. Wilson, ed., *Papers of JCC*, vol. 14, 598–599.
117. Ibid., 600–601.
118. Ibid., 602–603. James Edward Calhoun had changed his name from James Edward Colhoun.
119. Ibid., 612–613.
120. The following sources confirm that Henry Darwin Rogers, not Clemson, was appointed state geologist in both New Jersey and Pennsylvania: George P. Merrill, *First One Hundred Years of American Geology*, 167; Marc Rothenberg, ed., *The History of Science in the United States: An Encyclopedia* (New York: Garland, 2001), 478–479; Clark A. Elliott, ed., *Biographical Dictionary of American Science: The Seventeenth through the Nineteenth Centuries* (Westport, CT: Greenwood Press, 1979), 218–219. The 1836 date of Rogers's appointment to the Pennsylvania position might prompt one to question why Calhoun would correspond with family members in April and May of 1839 on the matter of Clemson's potential appointment.
121. Reingold, ed., *Papers of Joseph Henry,* vol. 2, 373–375.
122. Ibid.
123. Emma Rogers, ed., *Life and Letters of William Barton Rogers,* vol. 1 (New York: Houghton, Mifflin, 1896), 10–11; Rothenberg, ed., *History of Science in the United States*, 478–479; Elliott, ed., *Biographical Dictionary of American Science*, 218–219; Merrill, *First One Hundred Years of American Geology*, 167–168; Gillispie, ed., *DSB*, vol. 11 (New York: Scribner, 1975), 504–506.
124. Henry Darwin Rogers to William Barton Rogers, 2 February 1830, in Emma Rogers, ed., *Life and Letters of William Barton Rogers,* vol. 1 (New York: Houghton, Mifflin, 1896), 83–84.
125. Gerstner, *Henry Darwin Rogers, 1808–1866*, 19. The trustees actually made the decision on 10 February 1831 to terminate him, but allowed Rogers to finish the term.
126. Ibid., 18.
127. Rogers, ed., *Life and Letters of William Barton Rogers*, vol. 1, 92; Rothenberg, ed., *History of Science in the United States*, 478–479; Merrill, *First One Hundred Years of American Geology*, 167–168.
128. Gillispie, ed., *DSB*, vol. 11 (New York: Scribner, 1975), 504–506.

129. Rothenberg, ed., *History of Science in the United States*, 478–479; Gillispie, ed., *DSB*, vol. 11, 504–506.
130. Henry Darwin Rogers to William Barton Rogers, 6 March, 30 March, and 22 May 1833, in Rogers, ed., *Life and Letters of William Barton Rogers,* vol. 1, 104–108.
131. Ibid., 115; Rothenberg, ed., *History of Science in the United States*, 478–479; Merrill, *First One Hundred Years of American Geology*, 167–168.
132. Rogers, ed., *Life and Letters of William Barton Rogers*, vol. 1, 115; Merrill, *First One Hundred Years of American Geology*, 167–168.
133. Rogers, ed., *Life and Letters of William Barton Rogers,* vol. 1, 119; Merrill, *First One Hundred Years of American Geology*, 167–168; Rothenberg, ed., *History of Science in the United States*, 478–479.
134. See *Geological Survey Directorships* section of this chapter.
135. Rothenberg, ed., *History of Science in the United States*, 478–479; Gillispie, ed., *DSB*, vol. 11, 504–506.
136. Gillispie, ed., Ibid.
137. Merrill, *First One Hundred Years of American Geology*, 167–168.
138. Gillispie, ed., *DSB*, vol. 11, 504–506.
139. Gerstner, *Henry Darwin Rogers, 1808–1866*, 150.
140. Regius professor: "a holder of a professorship founded by royal subsidy at a British university." See Frederick C. Mish, ed., *Webster's Ninth New Collegiate Dictionary* (Springfield, MA: Merriam Webster, 1983), 992.
141. Gerstner, *Henry Darwin Rogers, 1808–1866*, 208.
142. Gillispie, ed., *DSB*, vol. 8 (New York: Scribner, 1973), 260–261; Rothenberg, ed., *History of Science in the United States*, 313–314; Merrill, *First One Hundred Years of American Geology*, 498–499.
143. Bernard Jaffe writes of Joseph Henry, "Henry was the most distinguished man of science in America at this time. He enjoyed an international reputation." In Jaffe, *Men of Science in America*, 200. And Leonard Carmichael, secretary of the Smithsonian Institution during 1953–1964, says, Henry "was probably the greatest scientist born in America between the days of Franklin and the Civil War." In Carmichael, *Joseph Henry (1797–1878) and his Smithsonian Institution* (New York: The Newcomen Society in North America, 1956), 9. The international unit of magnetic induction is the *henry* in honor of Joseph Henry. See also Robert Sullivan, "Castle in disrepair," *The Washington Post*, Sunday Regional Edition (Washington DC: The Washington Post Company, April 1, 2007), B01. It is of interest that Joseph Henry was invited by Clemson to be a trustee of the educational institution envisaged by Clemson—ultimately founded as the Clemson Agricultural College (TGC to J. Henry, 24 August 1874, Smithsonian Institution Archives Records Unit 26, Office of the Secretary, Incoming Correspondence), but Henry declined, saying, "My engagements in connection with the Light House Board, in addition to those relative to the Smithsonian, are occupying all my time." Henry closed the letter with, "I am, however, willing to indorse [sic] your proposal as fully as you may desire." In J. Henry to TGC, 10 September 1874, Thomas Green Clemson Papers, SCCUL.
144. Merrill, *First One Hundred Years of American Geology*, 139.
145. Moreover, instruction and practice in mineralogy and geology were integral parts of the curriculum at the School of Mines during Clemson's attendance (Gillispie, *DSB,* vol. 4 (1971), 347); and Clemson's certification as assayer from the Royal Mint suggests further mastery of knowledge of importance to one who leads or conducts a geological survey.