Creating Southern Thunder: The Evolution of Confederate Gunpowder Production during the American Civil War

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Creating Southern Thunder: The Evolution of Confederate Gunpowder Production during the American Civil War

ABSTRACT: *This articles examines the access to and production of gunpowder in the Confederacy during the United States Civil War. Based on government documents and instructions for the making of gunpowder, it first addresses the shortage of gunpowder in the Confederacy, then explores how the Confederacy sought and gathered resources for gunpowder production, and finally analyzes the role the Confederate Powder Works played in producing gunpowder for the Confederacy. The author argues that the Confederacy, as a new nation seeking autonomy from the northern half of the United States, needed to develop and create self-sufficient sources of gunpowder to ensure its independence and survival.*

KEYWORDS: *U.S. history; Civil War; Confederacy; gunpowder; saltpeter; Josiah Gorgas; Isaac M. St. John; George Washington Rains; Confederate Powder Works*

Introduction

In the early hours of April 12, 1861, Confederate batteries opened fire upon a Union-held fort in Charleston Harbor, South Carolina. Even though the fort's outer defensive walls received minor damage from the rebel guns, Confederate mortars and hot shot started fires which destroyed the fort's interior wooden buildings. After a day and a half of continuous bombardment, the Union garrison was forced to surrender and give up the fort to the Confederacy. Considered as the starting point of the American Civil War, the cannons and shot used in the attack on Fort Sumter required a substance that was in short supply throughout the Confederacy: gunpowder.

Gunpowder had been an essential resource since the early days of Colonial America as settlers and colonists arrived in North America. As they moved west toward the American frontier, having access to an adequate supply of gunpowder meant the difference between life and death. Even with the establishment of small powder mills, the United States lacked industrial facilities before and after independence which limited domestic powder production. As a result, the United States depended on Great Britain for its gunpowder.[1]

Gunpowder supplied by Great Britain during the late 1700s and early 1800s was of high quality and inexpensive, which made domestic gunpowder production unprofitable. British gunpowder continued to flow freely through American ports until relations between the two counties became strained or they found themselves in a state of war. During the War of Independence and the War of 1812, Great Britain halted all exports of gunpowder to America.[2] As a result, the Colonial and later the United States armies suffered from shortages of

[1] Gary A. O'Dell and Angelo I. George, "Rock-Shelter Saltpeter Mines of Eastern Kentucky," *Historical Archaeology* 48, no. 2 (2014): 91-121, here 91.

[2] O'Dell and George, "Rock-Shelter Saltpeter Mines," 91.

gunpowder. Cut off from their only source of powder, the Colonial army employed expropriation and smuggling tactics until they were resupplied and assisted by the French. The War of 1812 saw the discovery of saltpeter caves in Virginia and Kentucky.[3] With the use of slave labor, these caves were extensively mined for their saltpeter which was delivered to the newly established E. I. du Pont de Nemours and Company in Wilmington, Delaware. As the first domestic supplier of gunpowder, the DuPont facility provided the American forces during the War of 1812 with all the gunpowder they needed.

Five decades later, the Confederacy experienced similar problems with the acquisition of gunpowder at the start of the American Civil War. With a slave-based agrarian economy as the source of its wealth, the South lacked the industrial facilities that were prevalent in the North. The absence of industrial centers meant that the South depended on outside sources for manufactured goods which included gunpowder. At the onset of the war, domestic and international sources of gunpowder were cut off, leaving the Confederacy in dire need of the explosive substance. Even though there were small powder mills throughout the South, the total amount of gunpowder produced was not enough to supply the Southern armies. Without gunpowder, the Confederacy's struggle to become an independent nation would end. To ensure its survival and achieve independence, the Confederacy established a self-sufficient industry for the large-scale production of gunpowder to supply the its armies.

I. Historiography

When analyzing and discussing the events and outcomes of the American Civil War, scholars typically focus their research on the interaction between the armies of the North and South and the men who commanded them. Yet, these studies fall short in the discussion of the manufacture and distribution of armaments and gunpowder. As a result, the conclusions of these narratives assume that the North aggressively pursued and engaged in rapid industrialization, while the South clung to its backward-thinking agrarian society.

By establishing a growing ironworks industry and railroad repair, the Southern states had engaged in small-scale industrialization during the middle and late 1800s. Even though Southern industrialization was not as rapid as in the North during the antebellum years, the Southern industrial base was slowly transforming its cities, like Atlanta, from farming communities into industrial centers. Understanding how the Confederate government took advantage of its technical and industrial capabilities is fundamental to this investigation of Confederate gunpowder production.

With essays by C. L. Bragg, Charles D. Ross, Gordon A. Blaker, Stephanie A. T. Jacobe, and Theodore Savas, *Never for Want of Powder* (2007) is a textual and

[3] O'Dell and George, "Rock-Shelter Saltpeter Mines," 91.

illustrated history of the Augusta Confederate Powder Works.[4] Even though *Never for Want of Powder* examines the lives and contributions of the multiple managers and workers of the gunpowder factory, its primary focus is on the builder and operator of the Augusta gunpowder factory, Colonel George Washington Rains (1817-1898). Bragg, Ross, Blaker, Jacobe, and Savas praise Rains's efforts—he had no munitions experience and was merely armed with a British pamphlet on gunpowder making—for being the architect and manager of the Confederate's biggest and most impressive gunpowder facility.

Credited with the construction of the most complex and self-sufficient powder mill in the Western hemisphere, Rains still had to acquire the raw materials needed for the manufacture of gunpowder. Being composed of charcoal and sulfur, the basic formula for gunpowder owes its explosive characteristic to potassium nitrate, commonly referred to as saltpeter. In *Saltpeter: The Mother of Gunpowder* (2013), David Cressy explores how saltpeter solidified the connections between the scientific, military, and political revolutions of early modern Europe and America.[5] Cressy's research explores not only the English Crown's procurement and refinement of saltpeter, but also the way England exploited men and land in its quest for potassium nitrate. Making up almost seventy-five percent of its mass by weight and considered gunpowder's chief ingredient, the acquisition and control over sources of saltpeter was a contributing factor in the success or failure early modern European gunpowder armies and empires.

With the demand for saltpeter skyrocketing during the American Civil War, prominent educators and scientists, sympathetic to the Confederacy, issued and distributed pamphlets and instructions on how to mine, grow, and refine saltpeter. The first of these was Joseph LeConte (1823-1901). Commissioned by the Confederate military while serving as a professor of chemistry and geology at South Carolina College, LeConte composed *Instructions for the Manufacture of Saltpetre* (1862).[6] Avoiding complex scientific language, LeConte's twelve-page pamphlet provides detailed instructions on how to harvest and refine naturally forming saltpeter. In addition, LeConte details the process of "growing" saltpeter with the use of compost piles known as "nitre beds."

Published a year before LeConte's treatise, George Washington Rains's *Notes on Making Saltpetre from the Earth of the Caves* (1861) details the extraction and refinement procedures of saltpeter production.[7] These similarities could lead one

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[4] C. L. Bragg, Charles D. Ross, Gordon A. Blaker, Stephanie A. T. Jacobe, and Theodore P. Savas, *Never Want for Powder: The Confederate Powder Works in Augusta, Georgia* (Columbia: University of South Carolina Press, 2007).

[5] David Cressy, *Saltpeter: The Mother of Gunpowder* (Oxford: Oxford University Press, 2013).

[6] Joseph LeConte, *Instructions for the Manufacture of Saltpetre* (Columbia: Charles P. Pelham, State Printer, 1862).

[7] George Washington Rains, *Notes on Making Saltpetre from the Earth of the Caves* (New Orleans: The Daily Delta Job Office, 1861).

to believe that LeConte had access to Rains's pamphlet and borrowed the facts to support his conclusions. Rains claims in his publication that the loss of one-fourth of mined saltpeter was due to inefficient extraction and refining practices. Before Rains's instructions, saltpeter mining had been wasteful and unprofitable. By enlisting the help of an Oglethorpe University professor, Rains calculated the loss of materials and resources close to $8 per barrel of saltpeter.[8] Considering the rate of inflation, the loss of materials and resources would roughly translate to almost $228 today. Under Rains guidance and direction, Southern saltpeter production reduced waste and labor costs while at the same time increasing production.

II. The Confederacy's Munition Crisis

During the first year of the American Civil War, the Confederacy was plagued by munition shortages. Not only was the South lacking the minerals of iron, copper, and lead, it was also severely limited in its supply of gunpowder. Before the war, the South had only a few small powder factories producing a few hundred pounds of gunpowder.[9] Due to mismanagement and the lack of planning, these Southern powder mills were unprepared for the war. Instead of expanding their facilities, increasing production, and stockpiling excess powder, Southern powder mills maintained their pre-war production levels.[10] Along with gunpowder purchased from Northern mills before the war and confiscated from Union forts, the quantity of powder in the South was insufficient for months of military operations, let alone a protracted war. To address the munitions shortfall within the Confederate Army, the Confederate Congress created the Bureau of Ordnance under the command of Major Josiah Gorgas (1818-1883).[11] As Chief of Ordnance of one of the first bureaucracies created in the Confederacy, Gorgas supervised and consolidated government control over the production and disbursement of munitions throughout the South.[12]

Born in Pennsylvania in 1818, Josiah Gorgas graduated sixth in his class at West Point Military Academy (New York) and became and ordnance officer for the Union Army.[13] Despite being born in the North, Gorgas developed strong

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[8] Rains, *Notes on Making Saltpetre*, 9.

[9] C. L. Bragg, "An Urgent and Critical Need: The Confederacy's Gunpowder Crisis," in Bragg et al., *Never Want for Powder*, 1-10, here 4.

[10] Clint Johnson, *Bull's-eyes and Misfires: 50 People Whose Obscure Efforts Shaped the American Civil War* (Nashville: Rutledge Hill Press, 2002), 242.

[11] Fred C. Ainsworth and Joseph W. Kirkley, *The War of the Rebellion: A Compilation of the Official Records of the Union and Confederate Armies*, series IV, Vol. 1 (Washington D.C.: Government Printing Office, 1900), 211.

[12] Steven G. Collins, "System in the South: John W. Mallet, Josiah Gorgas, and Uniform Production at the Confederate Ordnance Department," *Technology and Culture* 40, no. 3 (July 1999): 517-544, here 522.

[13] Johnson, *Bull's-eyes and Misfires*, 182.

ties with the South during his service. As a result, Gorgas courted and married Amelia Gayle, the daughter of the former governor of Alabama, John Gayle.[14] When hostilities between the North and South started, Gorgas resigned his commission from the Union Army and accepted the supervisory position over the Confederate Bureau of Ordnance.[15]

As the director of this new administration, Gorgas had the South's munition arsenals inventoried and found that, in addition to a half million pounds of gunpowder, the Confederacy had over 100,000 cannons and small arms in its arsenal.[16] If these munitions and gunpowder were properly distributed, the soldiers in the field would be limited to 500 pounds of powder per gun, which was insufficient.[17] Faced with shortages of weapon-making materials and gunpowder, Gorgas looked for solutions both overseas and domestically by approving private and foreign contracts and encouraging Southerners to engage in the domestic production of munitions and gunpowder.[18]

At the start of the war, the Bureau of Ordnance acquired guns and armaments from individual weapon sellers or paid army volunteers to bring their weapons. As a result, the Confederate army had a mishmash of rifles and firearms of different calibers, ranging from 1812 flintlocks to muzzle-loading P53 Enfield rifles.[19] Having these multiple types of weapons throughout the Confederate army created trouble and confusion in securing the right kind of ammunition and led to complaints from ordnance officers who were receiving the wrong type and size of ammunition on a regular basis. Even if the men in the field received the correct ammunition, the bullets and musket shot, depending on where they were made, would vary in size and weight. These variations led to misfires or jammed their weapons, making them useless.[20]

Based on the principles handed down by British Major Fraser Baddeley, gunpowder progressed from a trial-and-error method to a technique based on science. As the production of gunpowder became more standardized, the number of mills that produced gunpowder increased in the United States, especially in Maine, New York, and Connecticut, which made gunpowder production an exclusively a Northern industry.[21] Even though the South had imported most of its gunpowder from Northern sources before the war, as soon as hostilities between the North and South started, powder mills like Oriental

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[14] Bragg, "Urgent and Critical Need," 2.

[15] Bragg, "Urgent and Critical Need," 2.

[16] Michael E. Lynch, "Confederate War Industry: The Niter and Mining Bureau" (MA thesis, Virginia Commonwealth University), 2001, 14.

[17] Lynch, "Confederate War Industry," 15.

[18] Lynch, "Confederate War Industry," 15.

[19] Collins, "System in the South," 524.

[20] Collins, "System in the South," 525.

[21] Bragg, "Urgent and Critical Need," 3.

Powder and Schaghticoke Powder only produced gunpowder for the Union Army.[22] Even though these mills supplied substantial amounts of powder, their contribution paled in comparison to E. I. du Pont de Nemours and Company.

Figure 1: "DuPont Powder Mill, Hagley Museum, on Brandywine River, Greenville, New Castle County, Delaware," photograph (1933), Washington, D.C., Library of Congress, Prints and Photographs Division, Historic American Buildings Survey, HABS DEL,2-HAG,1-[photograph no. 3], accessed May 25, 2019.

With four powder mills built along Brandywine River near Wilmington, Delaware, E. I. du Pont de Nemours and Company supplied over 40 percent of the nation's gunpowder (see Figure 1 above).[23] Before the outbreak of war, Southern requests for powder were substantial. As these powder mills processed these large orders, the DuPont powder mill and its competitor, Hazard Powder, shipped over 100,000 pounds of gunpowder to Georgia, and over 300,000 pounds of powder to South Carolina even before the Confederacy fired its first shots at

[22] Jack Kelly, *Gunpowder: Alchemy, Bombards, and Pyrotechnics: The History of the Explosive that Changed the World* (New York: Basic Books, 2004), 198.

[23] Harold B. Hancock and Norman B. Wilkinson, "A Manufacturer in Wartime: Du Pont, 1860-1865," *The Business History Review*, 40, no. 2 (Summer 1966): 213-236, here 213.

Fort Sumter.[24] Because of the large shipments and the powder mill's proximity to the Confederacy, the DuPont Company and the state of Delaware's loyalty to the Union were called into question. Even though Delaware supported and profited from the institution of slavery, the state rejected calls to secede and to join the Confederacy. With Delaware remaining in the Union, DuPont company president Henry du Pont proclaimed his allegiance to the Union and refused to sell any more gunpowder to the Confederacy. As a result of Delaware's and DuPont's actions, the South's only domestic source of gunpowder was cut off.[25]

Along with procuring gunpowder from the North, the Confederacy seized Union forts and installations that had powder depositories. While most of these installations had gunpowder supplies, it was powder left over from the Mexican War in 1848 which slightly increased the Confederacy's powder inventory. With its access to Northern powder severed and the small powder mills in the South only being able to produce a few hundred pounds of gunpowder a day,[26] the Confederacy looked beyond its shores for a stable source of gunpowder.

Sympathetic to the Confederacy's cause, the British Crown watched the emerging American Civil War with great interest. Even though most European nations were opposed to slavery, diplomatic recognition and providing aid to the Confederacy by Great Britain was a huge concern to the Union.[27] Toward the end of 1861, two Southern diplomats, James Mason and John Slidell, were traveling on the British vessel *Trent* to establish diplomatic ties with the Great Britain.[28] While it was Mason's and Slidell's mission to seek economic support for Confederacy's war effort and secure access to English powder and niter, they were also trying to hamper the North's connection to East India's niter market.[29] Stopped part way through its voyage, the *Trent* was boarded by sailors from the Union warship *San Jacinto*, and both Mason and Slidell were taken into custody, transported back to the United States, and incarcerated in a Boston prison.[30] This violation of British sovereignty led to an international incident, which almost put the United States in the difficult situation of having to fight a two-front war.

As a consequence of what became known as the *Trent Affair*, Great Britain established an embargo of all gunpowder materials destined for the United States.[31] Having to succumb to British pressure, Lincoln and his administration

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[24] Bragg, "Urgent and Critical Need," 3.

[25] Kelly, *Gunpowder*, 198.

[26] Kelly, *Gunpowder*, 199.

[27] Louis P. Masur, *The Civil War: A Concise History* (New York: Oxford University Press, 2011), 29.

[28] Bragg, "Urgent and Critical Need," 3.

[29] Bragg, "Urgent and Critical Need," 3.

[30] Masur, *Civil War*, 30.

[31] Alfred D. Chandler, Jr., "Du Pont, Dahlgren, and the Civil War Nitre Shortage," *Military Affairs* 13, no. 3 (Autumn 1949): 142-149, here 145.

released Mason and Slidell and issued an apology for their violation of British sovereignty.[32] Even though Mason and Slidell were able to resume their mission to Europe, European nations, including Great Britain, refused to recognize the belligerent South as an emerging nation.[33]

Even as Great Britain maintained its neutral status during the American Civil War, it still shipped gunpowder-making materials and manufactured items to both the North and the South. As a result, the Union Navy established a naval blockade against the entire Confederacy. Proposed by General Winfield Scott, the blockade was designed to cordon and choke off the Confederacy to make it submit to Union dominance.[34] Needing materials from Europe, the Confederacy relied on fast, low profile steamships to elude and maneuver through the flotilla of Union ships. Aside from being very profitable for the captain and the crew of these fast steamships,[35] blockade-running became one of the ways the Confederacy retained access to European goods, especially guns and gunpowder. Yet, as the naval blockade intensified in strength, blockade-running became more dangerous and costly.[36] As a result, gunpowder imported from Great Britain increased 1,500 percent in price from twenty cents per pound in April 1861 to three dollars per pound by January 1862.[37]

III. Confederate Saltpeter Production

To help satisfy the South's need for gunpowder, the Confederate Congress issued a bill allowing private citizens to establish or expand their production of gunpowder and saltpeter. Drafted in January 1862 and appealing to Southern patriotism, the bill provided an advance of fifty percent to cover the renovation and construction costs if the manufacturer invested twenty-five percent in the improvements. To receive the money, manufacturers would have to demonstrate in good faith that their venture would produce the needed materials and that they would be able to pay back the advance once production started.[38] Lacking government oversight and fearing that the manufacturers would not deliver on their promise of war materials, Confederate President Jefferson Davis vetoed the first draft of the bill. Since gunpowder production was depleting the already short supply of saltpeter, Davis, in his response to the bill, stated that the Confederacy did not need more powder mills, but more of the raw materials needed for the manufacture of gunpowder.[39] In response to Davis's veto, the

[32] Masur, *Civil War*, 30.

[33] Bragg, "Urgent and Critical Need," 6.

[34] Masur, *Civil War*, 25–26.

[35] Bragg, "Urgent and Critical Need," 6.

[36] Masur, *Civil War*, 25.

[37] Bragg, "Urgent and Critical Need," 6.

[38] Ainsworth and Kirkley, *War of the Rebellion*, 864–865.

[39] Ainsworth and Kirkley, *War of the Rebellion*, 864.

Confederate Congress established the Niter and Mining Bureau on April 11, 1862.[40] Responsible for securing supplies of iron, lead, and copper for weapon making, the Niter Bureau was also responsible for acquiring gunpowder's primary ingredients.[41] As an ancillary organization to the Bureau of Ordnance, the Niter and Mining Bureau stood directly under the command of Major Josiah Gorgas. Looking to hand the responsibility of the newly created organization to someone he could trust, Gorgas delegated the authority over the Niter Bureau to Major Isaac M. St. John (1827-1880).

Born in Augusta, Georgia, in 1827, St. John studied civil engineering in New York and worked for multiple railroad companies before being appointed to head the Niter and Mining Bureau.[42] Along with his engineering background, St. John was familiar with the limestone geology of the caves in the South.[43] Believing that the South contained large deposits of saltpeter, St. John divided the South into fourteen separate districts, each with its own superintendent. By this sectioning of the South, St. John was able to work with private niter producers, thereby fixing prices and bringing gunpowder-making ingredients under the control of the Confederate government.[44]

With its extensive network of limestone caves rich in nitrous earth, the southeastern underground region of the United States provided the optimal environment for gunpowder's fundamental ingredient, saltpeter.[45] Saltpeter (potassium nitrate), also known as niter, is the waste product of two bacteria, *Nitrosomonas* and *Nitrobacter*.[46] As the bacteria feed on decaying organic matter, they produce a white crystalline substance. Naturally occurring on the walls and in the soil of limestone caves or underneath old buildings, this unrefined niter can also be artificially grown and cultivated in long mounds called niter beds. During the American Civil War, the Confederacy pursued multiple methods of obtaining saltpeter for gunpowder production.

As saltpeter was easy to locate, extract, and refine, the government of the United States, during times of war, used the limestone caves to extract saltpeter, but not all caves would contain saltpeter. To determine whether a cave had saltpeter, the miners, known as "petre monkeys," would conduct simple tests to ascertain the presence of saltpeter. If the miners found whitish, needle-like

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[40] Ainsworth and Kirkley, *War of the Rebellion*, 1054–1055.

[41] Bragg, "Urgent and Critical Need," 8.

[42] David S. Heidler and Jeanne T. Heidler, "St. John, Isaac Munroe," in *Encyclopedia of the American Civil War: A Political, Social, and Military History*, ed. David S. Heidler and Jeanne T. Heidler, 5 vols. (Santa Barbara: ABC-CLIO, 2000), 4: 1846.

[43] Bragg, "Urgent and Critical Need," 8.

[44] Bragg, "Urgent and Critical Need," 8.

[45] John Powers, "Confederate Niter Production," *The National Speleological Society Bulletin* 43, no. 4 (Saltpeter) (October 1981): 94-97, here 94.

[46] Kelly, *Gunpowder*, 5.

crystals growing out the cave's rock face or soil, they would verify the presence of saltpeter with a taste test. If the crystals had a cool and bitter taste, then the earth would be tested further for the existence of saltpeter. One of the most accurate tests consisted of scratching a groove in the nitrous rock. If the groove appeared smooth even after several days, then the presence of saltpeter was highly likely.[47]

Unlike copper and iron mines which were concentrated in one area, saltpeter caves were found in multiple locations throughout the South. This geographic diversification reduced the risk of saltpeter production being interrupted by a Union attack. In addition to the caves, the ground under barns, cattle enclosures, old buildings, and slave quarters produced significant quantities of nitrous earth. The amount of earth extracted from these locations would sometimes exceed the quantity harvested from the caves. These domestic sources of saltpeter remained a crucial resource for the Confederacy even after consistent Union advances resulted in the loss of saltpeter caves in the northern part of the Confederacy. Even though the Confederacy received saltpeter from Great Britain, the saltpeter produced in the South proved to be superior to East Indian saltpeter. Calling on its hundred years of experience in mining and refinement of saltpeter, the Confederacy exploited these multiple sources of nitrous earth to aid in gunpowder production, hoping to become a self-sufficient munitions producer.[48]

According to archaeological evidence of tools and infrastructure found in the caves of Kentucky, Virginia, and Tennessee, Southern saltpeter mining fit into one of two categories, type A or type B, depending on the scope of mining operations conducted within these caves.[49] Type A caves, which included Kentucky's Mammoth Cave (see Figure 2 below) and Great Saltpeter Cave, were immense in size and extended several hundred yards underground. Because of the massive size of large-scale mining operations, several tons of nitrous earth would be mined and processed. These mining operations required a large labor force which included commissioned miners and slaves to dig and operate the mining equipment. To facilitate the large labor force, donkeys and oxcarts were used to transport materials, tools, equipment, and men to and from the mining areas.[50] One item of equipment that set these type A caves apart from the rest of the saltpeter caves was the delivery of water and the export of nitrous liquid. Because of the substantial amounts of water needed for the extraction of saltpeter, miners installed a permanent plumbing and pump systems. Through the use of hollowed-out logs and the building of a two-story pump tower, water

[47] Powers, "Confederate Niter Production," 95.

[48] Powers, "Confederate Niter Production," 95.

[49] M. Susan Duncan, "Examining Early Nineteenth Century Saltpeter Caves: An Archaeological Perspective," *Journal of Cave and Karst Studies*, 59, no. 2 (August 1997): 91-94, here 91.

[50] Powers, "Confederate Niter Production," 95.

was piped deep into the caves to assist saltpeter extraction.[51] After a while, these mines were stripped of all of the valuable saltpeter or just abandoned, but the tools and structures were left behind. The age and condition of these tools and structures gives archaeologists and historians a fairly accurate timeline of when saltpeter mining and production started and stopped.

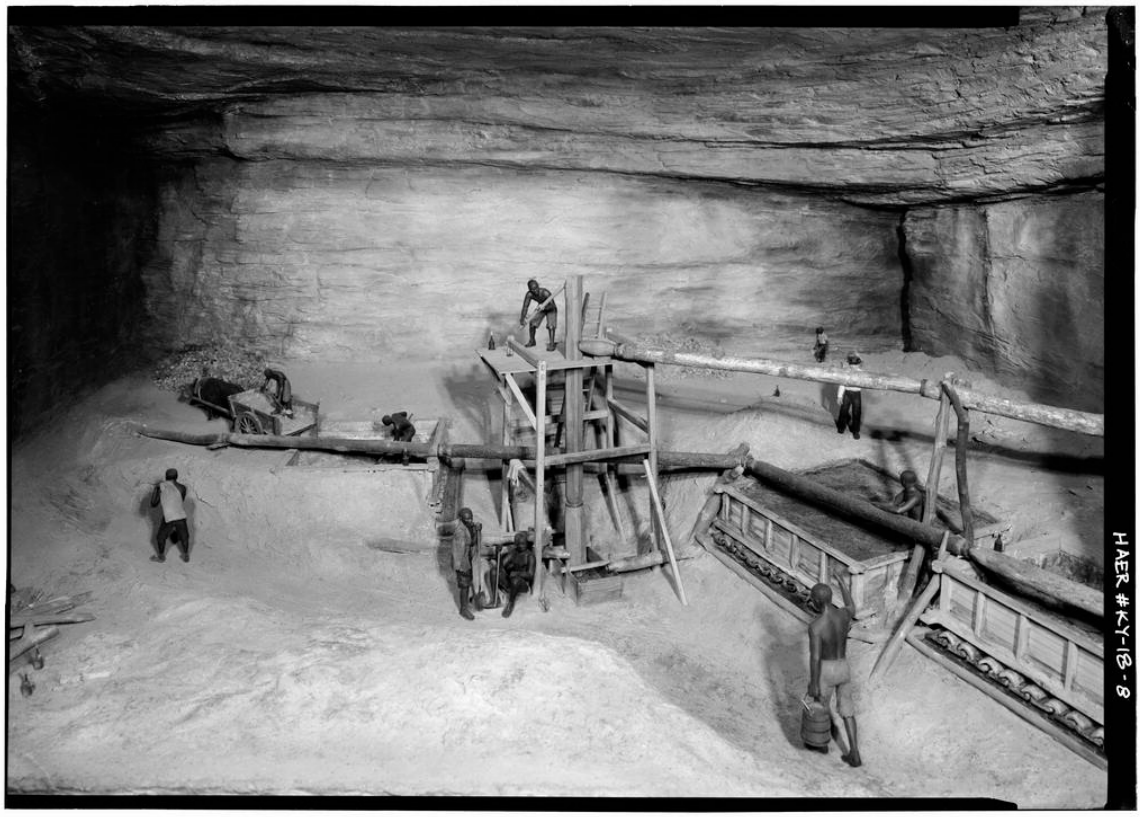

Figure 2: "View of model of Rotunda leaching complex, Mammoth Cave Saltpeter Works, Mammoth Cave, Edmonson County, Kentucky," photograph (1968), Washington, D.C., Library of Congress, Prints and Photographs Division, Historic American Engineering Record, HAER KY,31-MAMCA,1-[photograph no. 8], accessed May 25, 2019.

Financed and worked by an individual or a small group of people, type B caves or "rock shelter" saltpeter mines, were usually located at the base of bluffs near water sources. With operations being small in size, the miners would quickly strip these caves of their nitrate deposits.[52] Having depleted the area of its saltpeter, the miners would disassemble and remove all their equipment and tools and move on to the next location. Therefore, scholars and scientists are unable to determine when such mining operations started and stopped. The only

[51] Duncan, "Examining Early Nineteenth Century Saltpeter Caves," 91.

[52] Duncan, "Examining Early Nineteenth Century Saltpeter Caves," 92.

evidence of saltpeter mining left behind in these type B caves are tally marks carved into the cave walls and the occasional pile of waste soil and rock.[53]

Seeking to break its dependency on English saltpeter and to become an independent gunpowder producer, the Confederacy tried to capitalize on both naturally occurring and artificially grown forms of niter. In his treatise, *The Origin of Nitrates in Cavern Earths* (1900), geologist William Hess states that saltpeter occurs naturally from mineral-rich water inside caves. As the water flows into the cave, the minerals are mixed. When the water recedes and evaporates, it leaves behind the nitrates that produce saltpeter in the cave soil.[54] Even though the saltpeter crystals were able to grow and be harvested, it was not usable for gunpowder production. This raw form of saltpeter, known as *grough saltpeter*,[55] still needed to be purified and refined. As a result of being cut off from Northern supplies of gunpowder and blockaded from English sources of niter, the Confederate government consulted experts in the natural sciences to come up with solutions to their saltpeter shortage.

The scientist who provided the process for the purification and refinement of saltpeter was Joseph LeConte. As a professor of chemistry and geology at the University of South Carolina during the war, LeConte had been appointed to the Niter and Mining Bureau.[56] While working for the Bureau, LeConte published *Instructions for the Manufacture of Saltpetre* (1862), which details the manufacturing process of saltpeter from start to finish in concise and easy-to-follow steps.[57] In *Instructions for the Manufacture of Saltpetre*, LeConte also outlines the procedure on how to remove and purify saltpeter from cave soil. With a technique called "Leaching," the nitrous cave soil was placed in tubs called leaching vats (see Figure 3 below). Constructed out of plywood or logs, the leaching vats contained a drainage system comprised of hollowed-out logs. With the placement of the cave soil in the vats, the leaching process started with the addition of water and potash. This combination of substances was mixed thoroughly, set to soak for twelve hours, and then drained. The leaching process was repeated six times, until the soil was completely exhausted of its niter.[58] Since magnesium and calcium were still present in the niter-infused water, lye was added to remove the contaminants and to add potassium to the solution. After the lye process, the nitrous liquid or "liquor" was strained through cheesecloth and set to boil in copper or iron kettles. As the water boiled, saltpeter crystals formed and were

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[53] Duncan, "Examining Early Nineteenth Century Saltpeter Caves," 92.

[54] William H. Hess, "The Origin of Nitrates in Cavern Earths," *The Journal of Geology* 8, no. 2 (February-March 1900), 129-134, here 133.

[55] Rains, *Notes on Making Saltpetre*, 4.

[56] Joseph LeConte, *The Autobiography of Joseph LeConte*, ed. William Dallam Armes (New York: D. Appleton and Company, 1903), 184.

[57] LeConte, *Instructions for the Manufacture of Saltpetre*, 1.

[58] LeConte, *Instructions for the Manufacture of Saltpetre*, 7–8.

removed from the boiling liquor. After the removal of the crystals, the water was reused for the "leaching vats." Even though this operation produced saltpeter of decent quality, the entire leaching process would yield one hundred to two hundred pounds of saltpeter and take three men and three days to complete. Sometimes saltpeter manufacturers would initiate a second leaching and boiling process to remove even more impurities.[59] This extended period of labor and time would produce a purer form of saltpeter that was superior to other saltpeter that was being refined.

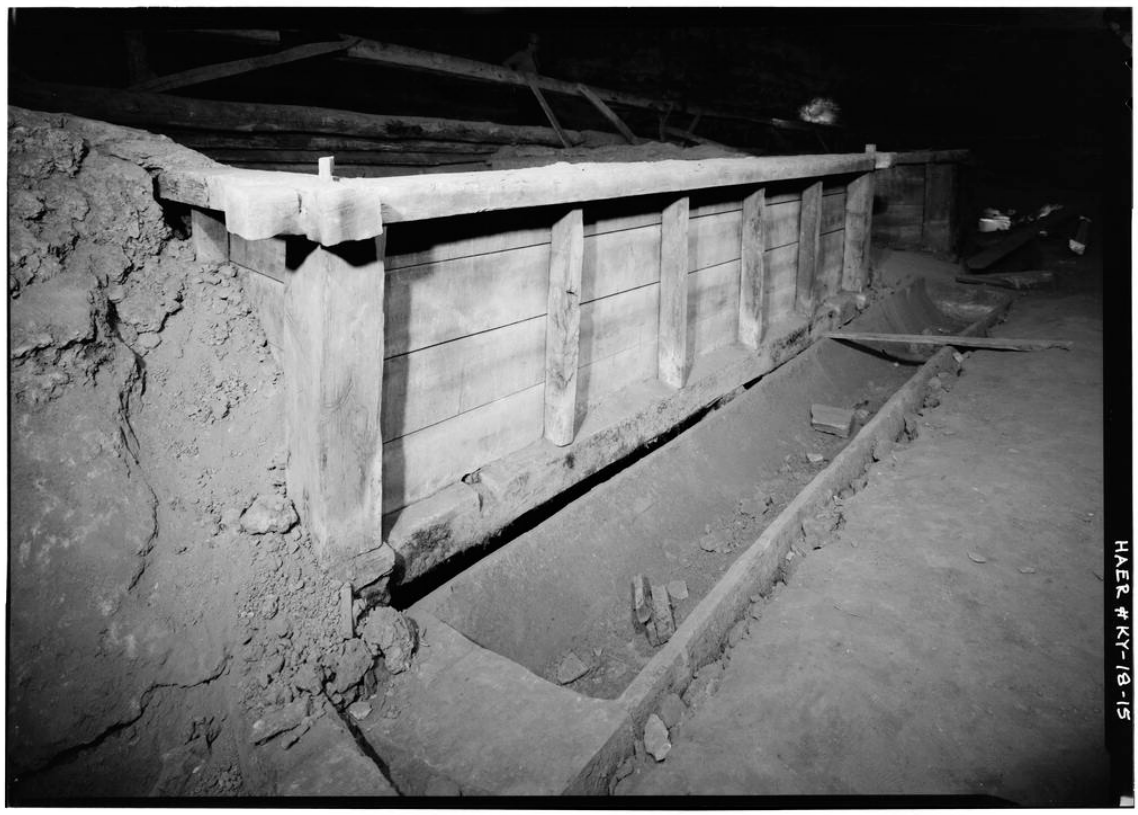

Figure 3: "Detail of leaching vat #2 and drainage trough in Booth's Amphitheater, Mammoth Cave Saltpeter Works, Mammoth Cave, Edmonson County, Kentucky," photograph (1968), Washington, D.C., Library of Congress, Prints and Photographs Division, Historic American Engineering Record, HAER KY,31-MAMCA,1-[photograph no. 15], accessed May 25, 2019.

Every district in the South produced saltpeter. While the states of Tennessee, Georgia, Alabama, and Arkansas mined and produced considerable amounts of niter, they paled in comparison to the state of Virginia.[60] With the largest and most productive saltpeter caves located in the valley and ridge regions of the Appalachians and possessing five of the fourteen niter districts, Virginia was the

[59] Donald B. Ball, and Gary A. O'Dell, "Bibliography of Niter Mining and Gunpowder Manufacture," *Ohio Valley Historical Archaeology* 16 (2001): 1-128, here 2.

[60] Robert C. Whisonant, "Geology and History of Confederate Saltpeter Cave Operations in Western Virginia," *Virginia Minerals* 47, no. 4 (November 2001): 33-44, here 38.

largest producer of niter in the Confederacy. The combination of these five districts produced twenty-nine percent of the South's niter supply which totaled 505,584 pounds of saltpeter.[61]

With every Southern district mining and producing saltpeter, St. John assumed that the saltpeter extracted from the Southern caves would be sufficient to supply the Southern armies with enough gunpowder. Yet, even though the amount of saltpeter extracted from cave soil was impressive, it was only a fraction of what was needed for gunpowder production. In an effort to produce as much saltpeter as possible, the Confederacy started to explore the possibility of creating saltpeter by artificial methods.[62] By growing and cultivating niter by artificial means, the Confederacy could produce enough saltpeter to become an independent gunpowder producer. To demonstrate the need to create "niter plantations," Niter and Mining Bureau superintendent William H. C. Price published a booklet on the construction of niter beds.[63] According to Price, Napoleonic France was able to construct and produce saltpeter, despite being cut off from its primary source of niter. Because of the niter plantations, France had a reliable and stable source of saltpeter during its wars with Great Britain.[64]

The process of cultivating niter through artificial methods was not foreign to workers of the Niter and Mining Bureau. According to English social historian David Cressy, the procedure of obtaining niter by artificial techniques had been in practice since the mid-sixteenth century.[65] By establishing a working framework for the saltpeter plantation in *Instructions for the Manufacture of Saltpetre*, Joseph LeConte gave detailed instructions on how to construct "niter" beds. Set up in various caves throughout the South, saltpeter plantations were comprised of compost piles and were arranged symmetrically to economize space and resources. [66] According to LeConte's instructions, niter-bed creation required one main ingredient, namely rotten animal manure. Known also as "black earth," the rotten manure not only aided in the construction of the niter beds but also helped produce quality saltpeter in the shortest time possible.

In addition to the animal manure, niter bed construction had to abide by specific guidelines. After preparing a clay floor with adequate drainage, compost was shoveled lightly into a fifteen-foot-long, eight-foot-wide, and five-foot-high mound. In addition to the decaying vegetation and animal waste, niter workers

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[61] Whisonant, "Geology and History of Confederate Saltpeter Cave Operations in Western Virginia," 38.

[62] Ainsworth and Kirkley, *War of the Rebellion*, 1070–1071.

[63] Lynch, "Confederate War Industry," 27.

[64] William H. C. Price and G. W. F. Price, *Artificial Production of Nitre: Containing Practical Directions Concerning the Formation and Cultivation of Nitre Beds, the Cost of the Fixtures Employed, and Estimates of the Productiveness of Capital Invested in Making Saltpetre* (Montgomery: Montgomery Advertiser Book and Job Printing Office, 1862), 6.

[65] Cressy, *Saltpeter*, 16.

[66] LeConte, *Instructions for the Manufacture of Saltpetre*, 5.

also placed dead animal carcasses to stimulate the decaying process. When the construction of the niter bed was complete, it needed to be watered weekly to keep it moist and the decomposition of the existing matter active. While water could be used to moisten the beds, the preferred liquid was urine or liquid manure. With the compost moistened and turned weekly, saltpeter crystals would form on the upper layer of the compost. After a while, the top layer of the compost pile was then removed and set aside until a sufficient quantity of nitrous material was available for the leaching. Even though the building of multi-layer compost piles containing decaying vegetation and animal materials could produce a decent supply of niter, the process of growing and cultivating niter was a long, disgusting, labor-intensive process: it took approximately eighteen months to produce saltpeter.[67]

Even though animal urine was primarily used to water the niter beds, human urine could be used as a substitute. This lead to comical and poetic interaction between Confederate and Union newspapers. On October 1, 1863, Niter and Mining Bureau agent Jonathan Haralson (1830-1912) took out an advertisement in the *Selma Sentinel*, asking the ladies of Selma to "preserve all their chamber lye collected about their premises, for the purpose of making 'Nitre'." So, bizarre was the request, that Haralson's friend, Thomas Wetmore, penned a poem called *Rebel Gunpowder*, mocking his friend's request:

> John Harrolson! John Harrolson! You are a funny creature;
> You've given to this cruel war A new and curious feature.
> You'd have us think while ev'ry man Is bound to be a fighter,
> The women, (bless the pretty dears) Should be put to making nitre.
>
> John Harrolson! John Harrolson! How could you get the notion
> To send your barrels 'round the town To gather up the lotion.
> We think the girls do work enough In making love and kissing.
> But you'll now put the pretty dears To patriotic pissing!
>
> John Harrolson! John Harrolson! Could you not invent a meter,
> Or some less immodest mode Of making our salt-petre?
> The thing, it is so queer, you know—Gunpowder, like the crankey—
> That when a lady lifts her shift She shoots a bloody Yankee.
>
> John Harrolson! John Harrolson! Whate'er was your intention,
> You've made another contraband Of things we hate to mention.
> What good will all our fighting do, If Yanks search Venus' mountains,
> And confiscate and carry off These Southern nitre fountains![68]

Not to be outdone and seizing on this opportunity to ridicule and disparage the Confederacy, the Union soldiers offered a response to Wetmore's poem:

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[67] LeConte, *Instructions for the Manufacture of Saltpetre*, 5.

[68] Thomas Whetmore, "Rebel Gunpowder," broadside [October 1, 1863], Duke University, David M. Rubenstein Rare Book & Manuscript Library, RL.00036 (American Song Sheets Collection), American Song Sheets, circa 1850s-1880s, box 2, item 536, Duke University Libraries Digital Repository, accessed May 24, 2019.

> Jno Haralson! Jno Haralson! We read in song a story
> That women's [sic] in all these years, Have sprinkled fields of glory;
> But never was it told before That how, midst scenes of slaughter,
> Your Southern beauties dried their tears And went to making water.
>
> No wonder, Jno., your boys were brave; who would not be a fighter
> If every time he shot his gun He used his sweetheart's nitre?
> And, vice verse what could make A Yankee soldier sadder,
> Than dodging bullets fired from A pretty woman's bladder.
>
> They say there was a subtle smell that lingered in the powder;
> And as the smoke grew thicker, And the din of battle grew louder
> That there was found in this compound This serious objection;
> The soldiers could not sniff it in Without a stiff erection.[69]

In September 1864, Major St. John reported that the domestic production of saltpeter had totaled 1,735,531 pounds.[70] Even though the amount of saltpeter produced was impressive, it was still not enough to provide the amount of gunpowder needed to hold off the advancing Union Army. Also, the compost piles of the Southern niter plantations would take up to two years to fully "ripen" and be leached of their saltpeter. This prolonged period made the niter beds unusable during the war. If the war had continued for another year or two, the Southern niter plantations would have produced approximately three to four million pounds of saltpeter for Confederate powder mills. Because of its inability to produce a sufficient supply of domestic niter, the Confederacy was still bound to Great Britain for the majority of its saltpeter.[71] Even though its lack of saltpeter hindered its ambitions of becoming self-sufficient and independent, the efforts of George Washington Rains and the Augusta Powder Works restored the Confederacy's resolve to produce superior gunpowder domestically.

IV. George W. Rains and the Confederate Powder Works

During an address to the Confederate Survivors' Association on April 26, 1882, George Washington Rains reflected on his service in the Confederate Army and the insurmountable task that had been laid upon his shoulders. Recommended by Gorgas and trusted by Confederate President Jefferson Davis, Rains was required to produce and provide the Confederate Army with a stable source of gunpowder. When the South's guns opened fire on Fort Sumter, the Confederacy had enough gunpowder for a month worth of battles before it would be exhausted. Along with the limited supply of gunpowder, the South's lack of proper infrastructure made securing the raw materials necessary to produce

[69] Cameron C. Nickels, *Civil War Humor* (Jackson: University Press of Mississippi, 2010), 69 – 70.

[70] Bragg, "Urgent and Critical Need," 9.

[71] Bragg, "Urgent and Critical Need," 10.

gunpowder difficult.[72] Not to be deterred by these overwhelming odds, Rains started devising a plan to create a state-of-the-art powder mill in the Confederacy. Receiving full governmental support to do whatever would be necessary to achieve his goals, Rains began the daunting task of building the Confederate Powder Works.[73] Under his vision and leadership, the Confederate Powder Works produced and delivered superior grades of gunpowder from its opening on April 10, 1862, to its final shutdown on April 18, 1865. Thus, the Confederate Powder Works became one of the most advanced and successful powder mills of the nineteenth century.

Born on April 13, 1817, in New Bern, North Carolina, George Washington Rains was the last of five children born to the Rains family.[74] Brought up in a household that instilled the importance of firm discipline and education as preparation for adulthood, George excelled in his studies at the New Bern Academy, especially in the subjects of science and chemistry.[75] Even though the New Bern Academy structured its curriculum to prepare students for eventual entry into prestigious universities, Rains had his thoughts set on pursuing other avenues. Along with his interest in science and chemistry, Rains was fascinated by all things military.[76] Seeking to attain his ultimate goal of becoming a scientist and a soldier and to follow in the footsteps of his older brother Gabriel, George applied to enroll at West Point at the age of sixteen.[77]

After five years of frustration and bureaucratic red tape, Rains was finally accepted to West Point on July 1, 1838, at the age of twenty-one as one of its oldest cadets.[78] After four years of conforming to West Point's rigorous curriculum and code of conduct, Rains graduated third in his class at the rank of second lieutenant. This prestigious status allowed him to serve with the Corps of Engineers as an assistant engineer. Later in his military career, Rains served as an artillery officer at Fort Monroe, Virginia, and then educated West Point cadets in chemistry, mineralogy, and geology.[79] Even though his assignments, except for teaching, were dull and unfulfilling, Rains's theoretical knowledge of chemistry,

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[72] Theodore P. Savas, "The Best Powder Mill in the World: Rains and His Mission," in Bragg et al., *Never Want for Powder*, 20-30, here 21.

[73] George Washington Rains, *History of the Confederate Powder Works: An Address Delivered by Invitation Before the Confederate Survivors' Association, at its Fourth Annual Meeting, on Memorial Day, April 26th, 1882* (New York: The Newburgh Daily News Print, 1898), 4.

[74] Theodore P. Savas, "Character is Destiny: George Washington Rains," in Bragg et al., *Never Want for Powder*, 11-19, here 11.

[75] Savas, "Character is Destiny," 12.

[76] Savas, "Character is Destiny," 12.

[77] Savas, "Character is Destiny," 12.

[78] George Washington Cullum, *Biographical Register of the Officers and Graduates of the U.S. Military Academy at West Point, N.Y.: From Its Establishment, in 1802, to 1890, with the Early History of the United States Military Academy*, 3rd ed., 5 vols. (Boston: Houghton, Mifflin, 1891), 2: 113.

[79] Cullum, *Biographical Register of the Officers and Graduates,* 2: 113.

coupled with his practical experience in engineering and artillery, helped provide a strong organizational foundation that would prove to be valuable when he started his work of creating the Confederate Powder Works.

When hostilities started between Mexico and the United States, Rains gave up his teaching career to serve in combat. While he served as a quartermaster at Point Isabel, Texas and aide-de-camp to General Pillow, Rains was breveted two times for gallant conduct during the Mexican-American War.[80] Following the Mexican surrender, Rains's military duties consisted of monotonous engineering work and putting down random Indian revolts. After meeting and marrying his bride, Francis Ramsdell, Rains resigned his commission with the U.S. Army and became the proprietor of the Washington Iron Works in Newburgh, New York. It was here at the iron works that Rains created, published, and patented his inventions concerning steam engines and boilers.[81] The ability to come up with innovative ideas and processes to streamline production would serve Rains well when he became the superintendent of the Confederate Powder Works.

As the South's first shells had their destructive impact on Fort Sumter in April 1861, Rains answered the call to defend his homeland, this time for the Confederacy. Receiving a commission as a major in the Confederate Army, Rains was appointed to restructure, oversee, and manage the Confederacy's gunpowder manufacturing apparatus.[82] Given *carte blanche* by the government, Rains was charged to construct a permanent gunpowder making facility. Even though the Powder Works was his priority, Rains was faced with an immediate problem, namely keeping the armies in the field well stocked with gunpowder.[83]

Due to mismanagement and the uneven distribution of gunpowder from seized Federal forts, most of the gunpowder was distributed to the armies in the East. This disparity left the Confederate soldiers in western theaters, between the Appalachians and the Mississippi River, with little or no gunpowder. Directly impacted by the shortage were the Confederate Armies under the command of General Albert Sidney Johnson.[84] Already stretched thin defending forts and outposts in the West, Johnson relied on the Sycamore Powder Mill in Nashville to keep his armies stocked with ordnance materials, especially gunpowder.[85]

Small in size and privately owned, the Sycamore Powder Mill was unprepared and overwhelmed by the sudden demand for gunpowder.[86] To deal with the crisis, Tennessee governor Isham Harris placed the Sycamore Powder

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[80] Cullum, *Biographical Register of the Officers and Graduates,* 2: 113.

[81] Savas, "Character is Destiny," 18.

[82] Rains, *History of the Confederate Powder Works*, 4.

[83] Savas, "Best Powder Mill," 21.

[84] Paddy Griffith, *Battle Tactics of the Civil War* (New Haven: Yale University Press, 1989; first published 1987 as *Rally Once Again*), 43.

[85] Savas, "Best Powder Mill," 21.

[86] Savas, "Best Powder Mill," 21.

Mill under government control, which allowed for its expansion. Harris also established contracts and agreements with private saltpeter suppliers to mine the limestone caves on the Confederate western frontier. Even as Rains arrived in Nashville to take control of the gunpowder manufacturing in the summer of 1861,[87] problems persisted with procuring and refining saltpeter, which limited the mill's production of gunpowder to five hundred pounds in September 1861.[88] If production remained the same at the Sycamore Powder Mill, Johnson's armies would run out of gunpowder and be forced to surrender to the Union Army advancing on the Confederate West.

Reprimanded by Gorgas and having no gunpowder-making experts, Rains took matters upon himself to fix the deficiencies of Nashville's gunpowder production. Rains first needed to gain control of the supply of saltpeter. Even though the mining operations were under Confederate control, the excavation of niter was inefficient. Hence, Rains personally visited these mining sites and reorganized the mining process to increase saltpeter production.[89] Next Rains established a separate refining facility to produce purified saltpeter. To assist in the production, Rains created and published a twelve-page pamphlet, *Notes on Making Saltpetre From the Earth of the Caves* (1861), which laid out the best practices and techniques concerning mining and refining saltpeter.[90] Because of Rains organizational skills and hands-on instruction, the Sycamore Powder Mill was able to refine fifteen hundred pounds of saltpeter on October 9, 1861, and then gradually increased the daily production to 3,000 pounds.[91] The increased production resulted in 100,000 pounds of gunpowder being delivered to Johnson's powder-starved armies in the West until the surrender of Nashville in February 1862.[92]

After the fall of Nashville, Rains devoted all his time to the construction and operation of the Confederacy's first permanent gunpowder-manufacturing facility. Before he engaged in the activity of securing gunpowder for the armies in the western theater, Rains spent two weeks aboard a train car, scouting out locations in the Confederacy to find a suitable place for a powder mill.[93] With a list of ten favorable conditions, Rains selected the site of the old U.S. Arsenal outside Augusta, Georgia.[94] In addition to being centrally located in the South and far away from the eastern and western theaters, the Augusta location had access to needed raw materials through the transportation corridors of the

[87] Rains, *History of the Confederate Powder Works*, 4.

[88] Savas, "Best Powder Mill," 21.

[89] Savas, "Best Powder Mill," 21.

[90] Rains, *Notes on Making Saltpetre*, 4.

[91] Rains, *History of the Confederate Powder Works*, 5.

[92] Rains, *History of the Confederate Powder Works*, 6.

[93] Rains, *History of the Confederate Powder Works*, 4.

[94] Savas, "Best Powder Mill," 20.

Augusta, Georgia, and Savannah, South Carolina, railroads.[95] In addition to the railroads, the location of the U.S. Arsenal had access to the waterways of the Savannah River and the Augusta Canal.[96]

Unlike the Northern powder mills whose water supply would freeze during the winter, Georgia's temperate climate allowed for the Savannah River and the Augusta Canal to flow year round, which was ideal for gunpowder manufacturing.[97] Along with serving as essential transportation corridors for material and men, the river and canal supplied the Powder Works with power. Using waterwheels, the Powder Works would be able to generate power for its daily operations, thereby reducing its need for outside resources.

With the location selected, Rains made preliminary sketches of a two-mile-long series of buildings along the Augusta Canal to coincide with the sequence of gunpowder production.[98] Having put his vision onto paper, Rains purchased the land, issued contracts for building materials, and planned the area where the main buildings were to be erected, but he had no idea how a powder mill worked despite his extensive engineering and scientific knowledge. With "singular good fortune," Rains came across a pamphlet penned by Major Fraser Baddeley, the Superintendent at the Waltham Abbey Works in England.[99] This *Pamphlet on the Manufacture of Gunpowder* exposed Rains to the process and the machinery used in the production of gunpowder.[100] Rains also met with Frederick Wright who, according to Rains, was the only Englishman in the South who had worked at Waltham Abbey and was experienced in the production of gunpowder and armaments.[101] Yet, Rains still needed architects and engineers to help turn his vision of world-class powder works into a reality.

With a background as an architect and a civil engineer, and a recommendation by the owner and operator of the Tredegar Iron Works in Virginia, Charles Shaler Smith was hired as Rains's chief architect and right-hand man.[102] Prior to being employed by Rains, Smith had worked as a rodman and assistant engineer for multiple railroad companies.[103] His experience with these companies allowed Smith to gain extensive knowledge in the construction of railroads and bridges, as well as perfect his architectural skill. Being able to work under Rains's demanding schedule, Smith took Rains's rough sketches and

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[95] Savas, "Best Powder Mill," 20.

[96] Johnson, *Bull's-eyes and Misfires*, 242.

[97] Savas, "Best Powder Mill," 20.

[98] Savas, "Best Powder Mill," 24.

[99] Rains, *History of the Confederate Powder Works*, 7.

[100] Savas, "Best Powder Mill," 23.

[101] Rains, *History of the Confederate Powder Works*, 7.

[102] Savas, "Best Powder Mill," 24.

[103] C. L. Bragg, "The Architect of the Powder Works: S. Shaler Smith," in Bragg et al., *Never Want for Powder*, 181-186, here 183.

diagrams and developed them into beautiful and highly detailed architectural plans. In addition to his architectural work, Smith was the director of the building and labor operations while Rains was away at the Nashville powder mill.[104] Even though Smith was the chief engineer and architectural genius of the Confederate Powder Works, the complexity of the job was more than one man could handle. Seeking other help, Smith recruited civil engineers Miller B. Grant and Albert L. West. [105] With the help of Smith, Miller, West, and the surrounding communities, Rains started construction on the Confederate Powder Works on September 13, 1861.

Figure 4: "Confederate Powder Works, Augusta, Georgia," photograph (between 1861 and 1865)/albumen print on card mount (between 1880 and 1889), Washington, D.C., Library of Congress, Prints and Photographs Division, LOT 4164-A, no. 3 [P&P], accessed May 25, 2019.

The first of many buildings constructed was the Powder Works' Refinery. In his address to the Confederate Survivor's Association, Rains described the Refinery as a grand monumental structure.[106] Built in the Norman Gothic style similar to the Smithsonian Institution,[107] the Power Works looked more like a medieval castle than a powder mill (see Figure 4 above). Despite its antiquated look, the Norman Gothic style provided the Powder Works with some advantages. Large windows kept the Refinery optimally illuminated during the day, which

[104] Savas, "Best Powder Mill," 24.

[105] C L. Bragg, "Architects, Engineers, and Mechanics: The Professional Men of the Powder Works," in Bragg et al., *Never Want for Powder*, 187-212, here 189.

[106] Rains, *History of the Confederate Powder Works*, 12.

[107] Stephanie A. T. Jacobe, "An Incredible Task: The Construction of the Confederate Powder Works," in Bragg et al., *Never Want for Powder*, 31-70, here 36.

eliminated the need of torches. Also, using brick instead of stone in construction reduced the Powder Works' building costs.[108]

The Refinery's primary purpose was the preparation and purification of gunpowder's raw ingredients of saltpeter, sulfur, and charcoal. When the saltpeter arrived at the Refinery, the chemical makeup of the crystals was of poor quality. Contaminated with six to twelve percent of other substances, the unrefined saltpeter needed to be washed and purified.[109] To remove all traces of contaminants, the water, according to Rains, had to be "free from lime and earthly salts."[110] In addition to serving as transportation corridors and supplying the Powder Works with a source of power, the water in the Augusta Canal and the Savannah River was free from impurities. With the saltpeter washed and dissolved into the water, the mixture was boiled in copper kettles to remove all its contaminants. As the solution boiled, chlorides would sink to the bottom, while other contaminants rose to the surface. With these impurities removed, the water with dissolved saltpeter would be pumped into another container to be cooled. As the water cooled, saltpeter crystals formed and were removed from the water. This boiling process would be repeated two more times with less water until a purified form of saltpeter remained. This process, called the "old method," took six days to complete and was time-consuming, labor-intensive, and wasted hundreds of gallons of water.[111]

To refine saltpeter more quickly and to produce a more purified form, Rains consulted a process called the "new method" that was outlined in the Waltham pamphlet. With the implementation of raking machinery, the water with the dissolved saltpeter was constantly swept and stirred while it cooled. Even though this process led to the formation of smaller saltpeter crystals, these crystals contained fewer contaminants after the first cycle and were thereby purer than the crystals formed using the "old method." Next, the crystals were allowed to drain and then covered with cold water to remove any lingering impurities. Finally, the crystals were dried for two hours. Instead of taking six days to perform, the process of the "new method" took only one day to complete.[112] Even though Rains followed Baddeley's refining guidelines, he modified the crystallizing process. Instead of using rakes, Rains built a machine consisting of a large bronze wheel with buckets attached to its periphery. As the wheel turned, the buckets would rake and stir the hot saltpeter solution as it cooled, while at the same time removing the saltpeter crystals as they formed. Rains's variation of Baddeley's process allowed him to speed up the refining

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[108] Jacobe, "Incredible Task," 36.

[109] Charles D. Ross, "The Production Process, Part 1: Refining, Mixing, and Incorporating the Ingredients," in Bragg et al., *Never Want for Powder*, 71-88, here 73.

[110] Rains, *History of the Confederate Powder Works*, 10.

[111] Ross, "Production Process, Part 1," 74.

[112] Ross, "Production Process, Part 1," 74.

process to two to three times a day. During the Civil War, the purity of gunpowder saltpeter stood at less than 1/3,000 parts chlorides. Through his double and triple refining method, Rains claimed that his saltpeter contained less than 1/100,000 parts chlorides. which placed it at a degree of purity "beyond that of the most celebrated powder factories."[113]

Just like the saltpeter that arrived at the Powder Works, sulfur needed to be processed and refined. Refining sulfur required it to be melted to have impurities rise to the top of the liquefied sulfur to be skimmed off. Even though this method was the easiest, it left behind acidic compounds that degraded the effectiveness of the gunpowder.[114] The second method of refining sulfur was through a distilling process. Referring to Baddeley's pamphlet, Rains distilled sulfur in enclosed kettles with pipes leading out from the top and the side. The pipe leading out from the side was encased by another pipe to allow water to cool the inside pipe. When the sulfur in the kettle was heated and vaporized, sulfuric acid and other contaminants were filtered out through the top pipe, and the purified sulfur, in liquid form, was left behind. This liquefied sulfur would pass through the pipe cooled by water into receiving molds. According to Rains, the distilled sulfur, "was of a beautiful citron yellow when cold, and entirely pure."[115]

Unlike receiving the saltpeter and sulfur from outside sources, the Powder Works produced charcoal from resources near the facility. While the preferred wood for charcoal was Willow, the proximity of Cottonwood trees to the Powder Works provided an abundant and stable resource for the production of charcoal. Charcoal production requires an extensive supply of tree branches that need to be skinned and dried before heating. In addition to the convenience of having wood on the premises, the Powder Works personnel found that Cottonwood was easier to work with because it did not contain any knots to impede the preparation process.[116] As the branches were skinned and dried, they were placed into four-feet-in-diameter and six-feet-long iron cylinders and set into a furnace. After two hours, the cylinders were removed, and the charcoal inspected.[117] The efficiency of this process allowed the Powder Works to mass-produce the required amount of charcoal for sufficient gunpowder production.

After the refining and distilling processes, the saltpeter, sulfur, and charcoal each were pulverized into fine dust and were separated into sixty-pound proportions: forty-five pounds of saltpeter, nine pounds of charcoal, and six pounds of sulfur. These proportions were sent to the mixing house and were combined, forming a "green charge."[118] After the charge was roughly mixed, it

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[113] Rains, *History of the Confederate Powder Works*, 14.

[114] Ross, "Production Process, Part 1," 75.

[115] Rains, *History of the Confederate Powder Works*, 14.

[116] Ross, "Production Process, Part 1," 77.

[117] Rains, *History of the Confederate Powder Works*, 15–16.

[118] Ross, "Production Process, Part 1," 81.

was then sent to the incorporating mills to be mixed thoroughly to ensure proper integration of the saltpeter, charcoal, and sulfur. Before the modern era, the incorporation of saltpeter, charcoal, and sulfur was done by hand[119] which resulted in the gunpowder's unpredictability. After hundreds of years of perfecting the incorporating process, the rolling mill was considered the best method for the incorporation of gunpowder. Using the same process that had been perfected in the 1700s, the Confederate Powder Works used the rolling mills to incorporate and press the "green charge" into a mill cake. Each mill was comprised of two large iron wheels revolving around a central shaft that was powered by a steam engine (see Figure 5 below).

Figure 5: Derek Taylor, "Powder Grinding Wheels, Centennial Park, Nashville, Tennessee," photograph (October 10, 2018). © 2018 by Derek Taylor/the author.

Standard gunpowder manufacturing during the Civil War required the charge to be pressed on the incorporating mills for four hours.[120] Even though the incorporation process improved the mixing and density of the powder, Rains found the amount of time too long. Rains faced other problems besides time. During the incorporation process, water was used to bind the saltpeter, charcoal,

[119] Ross, "Production Process, Part 1," 83.

[120] Bragg, "Urgent and Critical Need," 17.

and sulfur together.[121] The challenge was using the right amount of water.[122] The lack of adequate water would result in the formation of gunpowder dust, which could easily ignite and explode. Saturating the charge with water also proved to be dangerous due to the generation of chunks of powder, called "clinkers." These chunks would easily lift the mill wheel from the powder to have it come crashing back down on the powder, causing sparks which could result in an explosion.[123]

The problems with the use of water in the incorporation process left Rains with only one option, the use of steam. Even though it is unverified that the change from water to steam reduced the danger from explosion, Rains stated that his incorporating mills suffered three explosions before using the steaming process and none after he started steaming the unincorporated gunpowder mixture.[124] The change from water to steam also changed the makeup of the gunpowder's raw ingredients. Charcoal, observed under a microscope, is highly porous. Through the use of his steaming process, Rains found that the charcoal's pores could be filled with saltpeter, thereby enhancing the gunpowder's quality.[125] Even though the process could be achieved by keeping the unincorporated ingredients moistened, it required a considerable amount of time for the saltpeter to permeate with charcoal. To speed up the process, Rains placed the gunpowder mixture into revolving eighteen-inch-in-diameter by three-feet-long steam-infused cylinders. By raising the temperature to just below boiling point and creating condensation within the cylinder for eight minutes, Rains was able to combine the saltpeter and charcoal more rapidly.[126] After that process, the semi-liquid "green charge" was transferred to the incorporating mills. Because of Rains's steam process, the mixture was hot and slightly wet, therefore only requiring an hour in the incorporating mill before the mill cake could be removed.[127] The resulting mill cakes were transported across the canal to the cooling magazines to await granulation. According to Rains, his steaming process not only saved time, but tightly bound the saltpeter, charcoal, and sulfur together, which produced gunpowder that exhibited the "same first-class character,"[128] which was as good or better than most of the gunpowder produced during the American Civil War.

After the mill cakes were cooled, they were transferred to the granulating building. The granulation process placed the mill cakes on a conveyor belt which fed them into the granulation machine. Comprised of four sets of rollers that

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[121] Bragg, "Urgent and Critical Need," 17.

[122] Ross, "Production Process, Part 1," 87.

[123] Ross, "Production Process, Part 1," 87.

[124] Rains, *History of the Confederate Powder Works*, 18.

[125] Rains, *History of the Confederate Powder Works*, 16.

[126] Rains, *History of the Confederate Powder Works*, 16.

[127] Rains, *History of the Confederate Powder Works*, 16.

[128] Rains, *History of the Confederate Powder Works*, 17.

turned toward each other, the machine would break up the mill cakes into progressively smaller fragments which would fall through the rollers into sifters. Powder that fell through the sifters was collected in receptacles underneath the sifters.[129] This process was repeated until chunks that were too large to pass through any of the sifters were collected in a wooden carriage at the end of the granulating machine. Even though there are no drawings or blueprints of the granulation machine used in the Powder Works, it is assumed that Rains built a granulating machine that was similar to the one found in Baddeley's pamphlet.[130]

Following the granulation process, the powder was dusted, dried, and glazed in a process called "finishing." During the granulation process, Rains's gunpowder accumulated considerable amounts of dust. Being easily ignitable, gunpowder dust needed to be removed multiple times during the manufacturing process.[131] Also, gunpowder dust tended to attract moisture which could lead to the misfires and ruin of weapons.[132] The dusting procedure placed the gunpowder in a "dusting reel" which was a cylindrical wooden frame covered by mesh canvas. As the reel was rotated, the dust was expelled through the canvas, leaving the gunpowder dust-free.[133]

Since moisture had a detrimental effect, the gunpowder needed to be glazed to remove all rough edges. After the dusting process, the gunpowder was placed into wooden revolving barrels to tumble. In addition to removing the rough edges, the tumbling process strengthened the gunpowder's density which made it more resistant to moisture and improved its combustibility.[134] Finally, the powder reached the final step in the finishing process: drying. To reduce the moisture content of the powder to one half of one percent, the powder was placed on wooden racks in a heated room for eighteen hours.[135] Even though the drying process required no labor, Rains found the eighteen-hour process laid out by Baddeley too time-consuming. To save time, Rains combined dusting, glazing, and drying into one operation with revolving hollow cylinders that had hot air blown through them. Although this process reduced the initial production time, much of the powder was rejected and returned for "re-glazing."

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[129] Rains, *History of the Confederate Powder Works*, 20.

[130] Charles D. Ross, "The Production Process, Part 2: 'Finishing' the Powder," in Bragg et al., *Never Want for Powder*, 89-102, here 93.

[131] Ross, "Production Process, Part 2," 94.

[132] Ross, "Production Process, Part 2," 94.

[133] Ross, "Production Process, Part 2," 95.

[134] Ross, "Production Process, Part 2," 95.

[135] Francis Montagu Smith, *Handbook of the Manufacture and Proof of Gunpowder as Carried on at the Royal Gunpowder Factory, Waltham Abbey* (London: Her Majesty's Stationary Office, 1870), 71.

Forced to reassess the functionality of his innovation, Rains returned to the original glazing, dusting, and drying procedure.[136]

With a superior finished product waiting to be used by the armies in the field, Rains needed a safe way to transport the gunpowder. During the Civil War, gunpowder was packed and delivered in round wooden barrels or smaller wooden containers called kegs. Considering these barrels inferior to hold his powder, Rains designed powder boxes to ship his product. With dimensions of two-and-a-half-feet-long by one-foot-square and secured with a two-inch wood screw, Rains's boxes were stronger and took up less room than the typical powder barrels. As his gunpowder left the Powder Works facility to be delivered to the armies in the field, Rains stated that his boxes were better and safer for transportation because there was never a threat of an explosion of his powder due to faulty boxes. Even though Rains's boxes were safer and could hold more powder than the typical barrel, they were also harder to move and adjust.[137]

Armed with his knowledge of engineering and chemistry, George Washington Rains was able to organize and procure the resources necessary to create a first-rate powder mill within the South's agrarian landscape—one of the South's modern military marvels: the Confederate Powder Works. Between April 10, 1862, and April 18, 1865, the Powder Works produced various types and quantities of gunpowder, which totaled over three million pounds.[138] Despite threats of being sacked by Sherman's Army, the Powder Works remained operational throughout the war and never fell behind on its production of gunpowder until the surrender of the Confederacy.[139] As a result, the Confederacy never lost a battle due to a lack of gunpowder.

As its administrator, Rains worked tirelessly to produce a superior grade of gunpowder and increase its production. Through his unorthodox ideas and technological innovations, Rains implemented a steaming process, where the saltpeter, charcoal, and sulfur were fused together. This process not only saved time and allowed the Powder Works to produce more gunpowder, but it also increased and enhanced the quality of the powder. This enhancement was proven after the Union seized the gunpowder that was made at the Powder Works and used for training exercises at Fort Monroe. After using Rains powder to test-fire a naval cannon, the Union artillery gunners said that it was the best powder they had ever used.[140]

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[136] Ross, "Production Process, Part 2," 97.

[137] Ross, "Production Process, Part 2," 100.

[138] Savas, "Best Powder Mill," 29.

[139] Johnson, *Bull's-eyes and Misfires*, 244.

[140] Johnson, *Bull's-eyes and Misfires*, 244.

Conclusion

For years, the Conventional historiography on the American Civil War has focused on the North's industrial superiority over the South. While it is true that the North had a distinct advantage over the South due to its rapid industrialization, it was far from being technologically superior. When the Confederate government decided to overcome its agrarian roots and utilize its few precious mechanical resources, it accomplished great things. This is evidenced by the Confederacy's production of gunpowder during the Civil War. As the North enveloped the Confederacy in its blockade, the Confederate government, along with its forward thinkers, Josiah Gorgas, Isaac St. John, and George Washington Rains, created a Southern industrial apparatus that allowed it to procure gunpowder's primary ingredients and establish industrial facilities to manufacture a superior grade of gunpowder.

When the administrative head of the Confederate Bureau of Ordnance, Josiah Gorgas, inventoried the Confederacy's munitions arsenal, he found it lacking. Not only did the Confederacy not have enough weapons, but the Confederacy's gunpowder supply was also severely inadequate for a prolonged war against the Union. Even though the South was able to purchase gunpowder from Great Britain, the war and the resulting blockade put those supply lines in jeopardy. With all outside sources of gunpowder and munitions virtually cut off, Gorgas, looked for domestic solutions. Through government investment and management, Gorgas purchased private munition facilities and created state-owned industrial centers. His actions organized and mobilized the South's limited industrial complex. As a result, these facilities produced and supplied the Confederate Army with sufficient munitions throughout the war.

As the superintendent of the Niter and Mining Bureau, Isaac St. John was responsible for the Confederacy's acquisition of minerals needed for the war effort. One of the raw materials that was in constant demand was saltpeter. St. John was familiar with the limestone caves of the South. With the South's minerals under the control of the Niter and Mining Bureau, St. John sectioned the Confederacy into different districts. This sectioning fixed prices and controlled the flow of materials within the Confederacy. In addition to material control, St. John was able to establish state-run niter facilities. The government-controlled saltpeter mines allowed the Confederacy to mine and process saltpeter more cheaply than private contractors.

Possibly the person who had the most effect on the Confederate war effort was George Washington Rains. Having no prior gunpowder-making knowledge, Rains built one of the most impressive facilities in the South, the Confederate Powder Work. As a scientist and engineer, Rains was in control of every aspect of the Powder Works, from the construction of the buildings to the production of gunpowder. When the Powder Works finally closed in April 1865, Rains had produced and shipped over three million pounds of gunpowder to the Confederate Army and Navy. While the production of three million pounds of

gunpowder is an impressive feat, Rains, through his shortcuts and innovations, was able to reduce production time and increase the quality of the gunpowder manufactured at the Powder Works. As a result, the Confederate Powder Works in Augusta, Georgia, not only produced the most gunpowder but a powder of superior caliber which rivaled and surpassed that of any other powder mill during the Civil War.

In April 1861, the American South broke away from the Union to claim its independence. In April 1865, the South's dream of being an independent nation was over. During those four years, the South attempted to convert itself from an agrarian society into an industrial nation. As it did so, the Confederate government established a bureaucracy for the procurement of gunpowder material. Due to the efforts of Gorgas, St. John, and Rains, the Confederacy was able to transform its small gunpowder-making industry into an industrial powerhouse with the Confederate Powder Works as its cornerstone. Despite suffering from all kinds of want, the Confederacy never suffered from a lack of gunpowder.

ABOUT THE AUTHOR: *Derek Taylor earned his B.A. in History with a minor in Mathematics from California State University, Fullerton (CSUF) (2018), where he is also a member of the Theta-Pi Chapter of Phi Alpha Theta (History Honor Society). He is currently employed as a library circulation assistant at the Leigh H. Taylor Law Library (Southwestern Law School, Los Angeles) and pursuing a Master's degree in Library Science (San Jose State University). His article printed above originated in a senior research seminar on Gunpowder Technology offered by CSUF's History Department.*