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GEOLOGY AND HISTORY OF CONFEDERATE SALTPETER CAVE OPERATIONS IN WESTERN VIRGINIA

Robert C. Whisonant
Department of Geology
Radford University
Radford, VA 24142

INTRODUCTION

During the American Civil War, Confederate military forces faced shortages of many critical materials, but gunpowder was rarely among them. Thanks to its abundance of saltpeter caves, the South built a first-rate niter and gunpowder industry almost from the ground up. Even at the end of the war, powder mills were still operating and a supply of gunpowder was on hand. This article, one in a series concerning geology and the Civil War in southwestern Virginia (Whisonant, 1996a; 1996b; 1997; 1998; 2000), looks at the geology of cave niter deposits, and the use of this invaluable strategic material to keep alive the dream of southern independence.

In the 1860s, the principal ingredient of black gunpowder was potassium nitrate, derived from niter or saltpeter as it was called (Figure 1). Each powder grain contained about 75 per cent niter, together with charcoal (15 percent) and sulfur (10 percent). When war began between North and South in April 1861, the Confederacy did not possess an adequate supply of gunpowder. Planned importation of powder could not meet all of the South's needs, as the Union blockade of Confederate ports quickly proved. Thus, the need for a strong, home-based gunpowder supply, and consequently a steady source of niter, became evident. Among the potential providers of niter were the numerous saltpeter caves in the limestone regions of the Southeast. Virginia has an abundance of such caverns in the carbonate rock masses west of the Blue Ridge (Figure 2), and these contributed substantially to the Old Dominion's unsurpassed role in the production of niter. Eventually, Virginia (along with parts of eastern West Virginia) provided more of this strategic resource than any other Confederate state (Schroeder-Lein, 1993a).

But niter was not Virginia's only important mineral contribution to the Confederacy (Boyle, 1936). Besides this most basic necessity for mid-nineteenth century warfare, the Old Dominion provided massive amounts of lead, salt, iron, and coal. Virginia was, in fact, the major mineral-
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But niter was not Virginia's only important mineral contribution to the Confederacy (Boyle, 1936). Besides this most basic necessity for mid-nineteenth century warfare, the Old Dominion provided massive amounts of lead, salt, iron, and coal. Virginia was, in fact, the major mineral-producing state in the South both before and during the Civil War (Dietrich, 1970). Saltpeter manufacture differed significantly from the other principal

Figure 1. *The Last Confederate Gun at Gettysburg* (courtesy of the Library of Virginia). This typical smoky battle scene illustrates the importance of gunpowder, and thus the saltpeter from which it was derived, during the Civil War. Southern armies were generally well-supplied with gunpowder throughout the war.

Figure 2. Photograph of the entrance to a niter-producing cave in western Virginia. Caverns such as these produced massive amounts of saltpeter for Confederate military forces.

Confederacy). For example, the lead and salt came exclusively from Austinville and Saltville respectively, iron mostly from well-defined belts in the Valley and Ridge, and coal nearly entirely from the Richmond coal fields. Virginia's saltpeter caves are scattered over numerous western counties and, like many caverns, not easy to locate. Consequently, the niter cave operations were never the principal target of Union attacks, although several such facilities were threatened and even destroyed from time to time during Federal invasions.

GEOLOGY OF NITER DEPOSITS

The connection between caves and nitrate-rich deposits has been known and exploited for centuries. For most of this time, organic material (primarily bat guano) was assumed to be the source of cave nitrates (Hill, 1981). Hess (1900) challenged this belief and asserted that the saltpeter sediments of Mammoth Cave and other eastern caverns formed through the activities of nitrifying bacteria in surface soils above the caves. There, he suggested, waters percolating through the soils dissolved the nitrate and carried it underground to be reprecipitated

Although not entirely correct, Hess's basic idea of cave saltpeter originating through the interaction of nitrate-rich surface soils, groundwater, and nitrogen-fixing bacteria has drawn strong support (e.g., Hill, 1981, 1992; Hubbard and others, 1986; Hubbard, in review). Hill's (1981) work presents the most detailed model, and is based on a comparative study of southeastern saltpeter caves and western caverns rich in organic bat guano deposits. Her study showed clearly that, although bat guano can enrich cave earth in nitrate, it is not the only source and in the southeastern caves not even a major source. Hill's model begins with nitrifying bacteria in surface soils oxidizing organic nitrogen to nitrate (NO_3^-) which is then dissolved by percolating groundwater and carried downward to anaerobic soils and rock interstices where it is reduced to ammonium (NH_4^+). If caverns are present, the infiltrating waters move toward the caves due to a moisture-density gradient within the bedrock created by evaporation at the cave air-bedrock interface. Upon reaching the cave boundary, the ammonium in solution is oxidized to nitrate with the help of nitrifying bacteria. If porous cave sediment is in contact with the bedrock, seeping groundwater will be drawn to the surface of the sediment where evaporation and bacterial action cause nitrate concentration.

This theory explains a very interesting aspect of cave saltpeter deposits, namely the well-documented observation that nitrate content can be regenerated in very short time scales (within a few years or even much less). For example, saltpeter miners in 1812 evidently shoveled earth leached of nitrate onto the wall ledges of Dixon Cave in Kentucky for the express purpose of regeneration (Hill, 1981). During Civil War times, Craig (1862, cited in Hill, 1981) suggested that dirt be carried into caves so as to become continuously charged with nitrate. Hill's "seeping groundwater" model described an ongoing chemical process wherein saltpeter earth leached of nitrate could be placed back in the cave and new nitrate precipitated.

Hubbard (in review) noted that the question of "what is saltpeter" is confusing. Saltpeter is a synonym of niter, a nitrate mineral containing potassium (KNO_3). Potassium nitrate is the key ingredient of gunpowder, but is far from the only nitrate compound in the cave sediment commonly referred to as saltpeter. Part of the problem of studying the chemistry and mineralogy of saltpeter is that the nitrate minerals contained therein are notoriously deliquescent, meaning they absorb moisture from the air and dissolve. Hence, nitrate compounds such as magnesium nitrate and calcium nitrate may rarely crystallize into their naturally-occurring mineral forms (nitromagnesite and nitrocalcite, respectively) in the humidities found in Virginia and other southeastern caves.

Given the difficulties noted above, Hubbard and others (1986) attempted to shed some light on the mineralogy and chemistry of saltpeter earth in six Virginia caves. They found that the only actual nitrate mineral in these caves was niter, but it occurred in only a few samples. Leachates from the cave samples were rich in calcium and magnesium (as well as nitrate), leading them to conclude that the composition of cave saltpeter in the cases studied can be considered a mixture of nitro-magnesite and probably nitrocalcite with local concentrations of true niter. They also postulated that the nitrate compounds evaporated from cave leachates may occur seasonally in some Virginia caves because of summer-winter variations in cave humidities.

Recent work such as Hill's (1981) and Hubbard and others' (1986) helps to explain why most of the saltpeter caves in the United States are located in the southeast. Theories of origin that involve transportation of surface soil nitrate into caverns by slowly moving groundwater and biochemical precipitation by bacteria require certain conditions of organic content in surface soils, temperature, humidity, cave air circulation, and various aspects of ground- and cave water chemistry and movement. For instance, dripping or flowing water in cave passages is especially detrimental to the formation of saltpeter because such water will leach away the very soluble nitrates. Using these factors, Hill (1981, p. 115) summarized succinctly why American saltpeter caves are located primarily within the boundaries of the Confederate states: "the northward extent of saltpeter caves may be limited by lower temperatures or by the wetness of northern caves; their southward extent may be limited by higher temperatures and less highly organic soil types; their westward extent may be limited by drier climates and nitrogen-retentive soils."

In the 1860s, the southern war machine benefited immeasurably from the conditions of climate, vegetation,

HISTORY AND TECHNOLOGY OF NITER PRODUCTION

Knowledge of saltpeter extends back to the earliest times of recorded history (Lewis, 1989). Sumerian writings from about 2200 or 2100 B.C. refer not only to saltpeter but also to black saltpeter, suggesting that refining of this material was already accomplished. Alchemists in Europe knew of saltpeter in the first century B.C.; Chinese workers mixed it with other ingredients to make fireworks in the seventh century C.E. and military explosives in the tenth century. Gunpowder (made from saltpeter, sulfur, and charcoal) appeared on European battlefields for the first time in the battle of Crécy in 1346. The first modern book on mining and metallurgy, *De re metallica*, in 1556 described the extraction and refining of saltpeter in great detail. Apparently, artificial niter beds had been developed by then also. As the gunpowder age continued to develop rapidly in Europe, niter became a crucial resource not only to supply the national armies but also to ensure the survival of colonists in the hostile new world.

As noted by Faust (1964, p. 32), almost from the time of arrival at Jamestown, Virginia settlers were concerned about a reliable source of saltpeter for gunpowder. In 1629-1630, the Virginia colonial government passed an act "for the better furtherance of and advancement of staple commodities, and more especially that of potashes and saltpeeter (sic)... (cited in Faust, 1964, p. 32). This early legislation contained specific directions for the production of saltpeter from wood ashes and plant and animal refuse. In 1745, the Virginia General Assembly passed an act for the encouragement of saltpeter making in which a bounty was offered on the precious material.

As war between England and her colonies loomed in 1775, the Continental Congress advised the Colonists to "collect the saltpeter and sulfur in their respective colonies...to be manufactured, as soon as possible, into gunpowder... (cited in Faust, 1964, p. 33). A national Committee on Saltpeter was formed, and Richard Henry Lee represented Virginia on this body. Production records from the Revolutionary War period are poor, but western Virginia caverns, which had been producing niter for several decades prior to the conflict, likely produced a considerable amount of this strategic material.

Following the surrender of Cornwallis, the demand for saltpeter did not abate; indeed, frontier fighting, hunting, government military uses, and the expanding use of black powder blasting in mining and construction drove the need upward (Faust, 1964). The War of 1812 only exacerbated this trend. During the early 1800s, caves in western Virginia (which then included present-day West Virginia) contributed substantially to the young nation's saltpeter supply. Faust (1964, p. 36) provides an interesting statistic in this regard. "The 1810 (3rd Federal Census) reported that 447,174 pounds of saltpeter valued at $80,434.00 – of which Virginia provided 59,175 pounds, valued at $16,243.88 – were produced during this report period. Virginia's share of this came from Bath, Botetourt, Lee, Montgomery, Pendleton, Russell, and Tazewell counties." Another feature of these times was the Old Virginia Saltpeter Route, a network of at least 12 caves in western Virginia. This route wound from Pendleton County, West Virginia, through Highland, Bath, and Alleghany Counties, Virginia, ending in Monroe County, West Virginia. At the same time, other niter caverns were active farther south, including Buchanan Cave in Smyth County. Here, saltpeter production can be traced back to about 1750, making it one of the oldest niter producers in North America. Thus, by the mid-1800s, the caves of western Virginia had established a long history of niter production and stood ready to supply the Confederacy with this crucial resource in the coming struggle.

The actual production of niter from cave earth was a relatively simple process that could be done on a small scale using fairly common implements (Faust, 1964; DePaepe, 1981; Powers, 1981). Workmen (sometimes called "peter monkeys") excavated the nitrate-bearing earth ("peter dirt") using various tools such as shovels, mattocks, wooden scraping paddles, hoe-like scrapers, and chisel-shaped bars, the latter needed to obtain material from ledges and cracks and to serve as pry bars. Faust (1964, p. 44) described excavations of 16-20 feet depth in one of Virginia's large saltpeter caves in Bath County. Miners constructed footpaths, stone steps,

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