

JOHN C. GREENWAY, THE AJO EXPERIENCE

by H. Mason Coggin
Phoenix, Arizona

A vandalized monument marks his burial on a small hill in the Sonoran Desert. It splits the distance between his desert home and the vastness of the Ajo open-pit copper mine. The plants died long ago and the surrounding wrought-iron fence is gone. His bronze name plate was removed from its copper stone, but the largest monument to John C. Greenway is his open-pit mine. Spanning the horizon for nearly a mile, it shows a million colors in bright pastels along deliberately sculptured contours. Viewers stand in awe of this engineering and industrial marvel. This, the largest man-made feature in Western Pima County, can be seen from space. The copper from this mine electrified the world and brought light and power to homes, schools, hospitals, factories and business.

Greenway's vision and creative genius organized and bootstrapped this mine through the first copper leaching operation in North America to a successful copper sulfide operation. The mine made a major company of the Calumet and Arizona Mining Company and, after the merger of 1933, it make an even greater company of the Phelps Dodge Corporation.

The Ajo operation outlived Greenway by fifty-seven years, until the operations were suspended in 1983. Unlike the man, however, the mine may live again in the next century. A large reserve of unmined copper still lies in the bottom and walls of this pit. Uneconomic to extract in 1983, this resource will be reworked with new methods and new technology when the world needs the copper.

Greenway's only physical problem was a troublesome gall bladder. After the New Year's holiday of 1926, he decided to have it removed. Soliciting the top medical technology available at the time, he underwent surgery in New York's Theodore Roosevelt Hospital. After a successful operation a blood clot developed, and he died a few days later. He was forty-six years old. His survivors included his wife, and infant son, John, and two stepchildren from Isabella's first marriage to Robert H. Monroe Ferguson.

His special funeral train to Ajo was followed by the General's friends and acquaintances. Even in death he commanded the respect of those who knew him. Some of the wealthiest and most politically powerful people in the United States sent condolences to his widow and children. Statesmen, executives, soldiers and fellow officers from the Rough Riders' campaign in Cuba and his command in France marched in his funeral procession with miners from his industrial developments in Michigan, Mesabi, Bisbee, Ajo and Mexico. Greenway would have appreciated the dropping of social status for the solemn occasion.

He wanted a "miner's funeral", to be buried in rock on the top of a hill, surrounded by friends, family and in full view of the mine he had created and the desert home he had designed. The excavation for his tomb penetrated solid rock on a small hill near the Ajo Pit. A concrete vault was constructed and clad in a half-inch thickness of copper armor to protect his body.

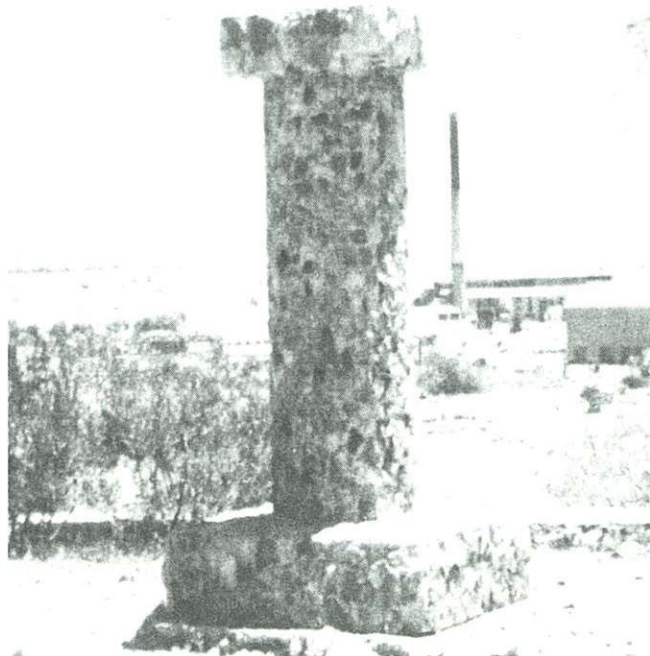
At the burial the flowering tribute from his many admirers was laid over the seal. People spoke elegantly of his many virtues, generals and soldiers told of his military honors, giants of industry recounted his achievements and politicians told of his dedication to policy and his many supporters.

Eight members of Arizona's 158th National Guard infantry fired a "soldier's farewell". A poem, written in tribute by Richard Howard Whiteside to his former boss and benefactor, was read at graveside.

JOHN C. GREENWAY

*They say he built five towns and wrote his name
in letters big on scrolls of fame,
His was the measure of a man, they say,
As cortege train with garlands hung
Southwestward wends its way.
Of hero's mould, as silvery taps
In silvery noted pain,
Now loud and clear, now sweet and low
Is sobbing its refrain.
I only knew he was my friend
And stumble blind through byways home
A whimpering child again.*

Richard Howard Whiteside¹



GREENWAY COLUMN, C. 1994. The unfinished column represents Greenway's untimely death. The smelter stack in the background was abandoned in 1982 when Phelps Dodge refused to bow down to the Union during a strike. The Copper Depression that followed in the mid 1980s insured the death knell for the operation. Photo by author.

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GREENWAY'S BRASS PLATE ARIZONA HISTORICAL SOCIETY IN TUCSON. Photo by author 1994

A circular concrete wall supporting a wrought-iron fence was built around the hilltop. A flagpole was erected in the center of the circle and an oleander hedge was planted inside the fence. A broken marble column indicating Greenway's early death and his unfinished life was placed beside a large copper stained rock that provided a mount for a bronze name plate. A galvanized steel pipe brought water to the green, well groomed hedge and the rare small plot of grass in the vastness of the Sonoran Desert. For decades the green of this grave marker contrasted with the surrounding forest of saguaro, cholla and prickly pear cactus.

His thin straight-lipped statue in future years would represent the state of Arizona on the nation's Statuary Hall in Washington, D.C. American Legion Posts across the country honor his name. Schools, roads and even buildings bear his name.

Politically, Greenway was following a path aimed at the presidency of the United States. He had joined the Rough Riders as a private and emerged at the end of the Spanish-American War a colonel. He was promoted for bravery on the battlefield by Teddy Roosevelt and after the charge on the San Juan Hill, Roosevelt said of Greenway:

Greenway was the second man to the top of San Juan Hill and the first behind enemy lines . . . I only envy Greenway. I wanted to be the first there myself, but he outran me!² He was a 200-pounder, slightly over six feet tall, who thrived on embalmed beef and regarded the entire Cuban campaign through intense heat and jungle as nothing but an enjoyable outing, the chance of fight on the morrow simply adding the needed spice of excitement.³

Roosevelt recommended Greenway for the rank of brevetted captain and gave him the Silver Star Citation for gallantry in action. Fourteen years after the Rough Rider experience, Teddy Roosevelt wrote a letter to Greenway immediately following an incident when Mr. Roosevelt was shot while making a speech in Oyster Bay on November 2, 1912. He said:

My Dear Jack: You'll probably never know how much your unflinching loyalty to me for the past fourteen years has meant - I believe in you, I'm very proud of you and while I cannot help laughing a little at the absurd overestimate you made of my conduct in the talk of the shooting, still I am glad that you do overestimate it.⁴

Roosevelt asked him to become the Commissioner of the General Land Office in 1906, but Greenway declined. He led Arizona's

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Bull Moose Party in Roosevelt's successful bid to upset Taft as a third-party Republican, only to lose to Woodrow Wilson, a Democrat, in the General Election. However, Roosevelt carried Arizona⁵, and Greenway received the ballots of eight states in a 1924 bid for the Vice Presidency at the Democratic Convention only to be passed over for Charles W. Bryan, the brother of William Jennings⁶. Had Greenway survived the gall-bladder operation, he might have achieved his goal. He won recognition as a Yale athlete. His World War I service won him honors and decorations from both French and American armies.

Near Verdun, France, October 23, 1918, lieutenant colonel, One hundred and first Infantry, Twenty-sixth Division. During a terrific enemy shelling on two of his battalions, and after both his battalion commanders had been wounded, Colonel Greenway personally directed the activities and



JOHN CAMPBELL GREENWAY STATUE at the Arizona Historical Society in Tucson. Photo by author 1994.

greatly encouraged his forces by his presence. Leading them in attack, he demonstrated the utmost valor at the most critical moments, and he was the first of his command to enter the German trench which marked the objective for the day's attack.⁷

In the War Department files with his military record is a communication to General Greenway from Brig. Gen. George Van Horn Mosely attesting the valor Greenway displayed in action on the Toule, Cantigny, Chateau-Thierry, St. Mihiel, Menses and Douamont fronts. For good work and gallantry in action he was promoted to the rank of lieutenant colonel.⁸

Greenway was to earn his colonelcy on the field of battle. He sought service as soon as we entered the war and came to France in the autumn of 1917 as a major of Engineers. Reporting at General Pershing's headquarters at Chaumont, his marked ability and outstanding personality indicated him at once as an extremely desirable officer for staff duty. But he was so essentially an outdoor man that he was restless on the staff and longed for line duty. He was soon sent to the front and saw service with the First and Twenty-sixth Divisions, first as an engineer, and later as a field officer of Infantry, commanding his regiment in the principal battles of 1918. He participated in the actions of Cantigny, Campagne-Warns, Aisne-Marne, St. Michiel, and the Meuse-Argonne. He was severely gassed in action. My last memory of him in France was when, just before sailing for Lyons in December, 1918, he came to see me at Tours, wearing the eagles of a colonel which he had so gallantly won. His bravery in battle had been outstanding in an army of brave men. To the silver star won at Santiago in his splendid youth he now added the French Croix de Guerre, the Legion of Honor, and the Etoile Noire. From his own country he received the distinguished-service cross, given only for the most extraordinary heroism in action, beyond the call of duty, and to win which one must descend into the very valley of the shadow of death. We of the old Army have always held the faith that the highest reward that can come to him who wears the uniform is the approbation of those with whom he has served. No man ever had this in more generous measure than John Campbell Greenway. In another age than ours he would have been a Richard the Lion-Hearted, a Phillip Sidney, or a Chevalier Bayard, for his was the dauntless soul and the tender heart, without fear and without reproach.⁹

In both his athletic and professional careers, he played to every game. He had the courage of a champion and he never accepted second place. He was just as competitive in his professional life when he entered the field with a Bachelors of Science in Engineering.

After college he started as a furnace helper, a lowly position, with Carnegie Steel Company in Duquesne, where he earned \$1.32 per day. He advanced through foreman of the Mechanical Department at Duquesne¹⁰ to Assistant Superintendent of Mines for the United States Steel Corporation in Michigan. He was the

General Superintendent of the Oliver Mining Company in Minnesota's Mesabi Range, where he started the mining operations there¹¹. In 1910 he was named manager of the Calumet and Arizona Mining Company. In this position he developed the mine at Ajo that allowed him to reach the zenith in professional development.

AJO

Mineralization at Ajo had been known for thousands of years. Native Americans crushed and ground the iron and copper minerals with animal fat and used them to decorate their bodies. Local Pimans called this paint *au'auho*. The Spanish apparently corrupted this to *ajo*, their word for garlic¹². Their stone tools and grinding pits can still be found in the area.

After the Gadsden Purchase on 1853, American explorers tried to develop the area. Although highly mineralized, it defied development. Its remote, desert location and low copper content eventually discouraged all attempts at profitable operation. Shipments of the richest ores were hauled to the Gulf of California by mule train and shipped to Swansea, Wales, for treatment. The tenor of the ores, however, could not long support the extensive freighting costs, and this venture quickly failed. Several attempts to directly smelt the ores failed, because the copper content was too low and Ajo lacked a convenient source of cheap fuel.

One of the infamous attempts, the McGahan Vacuum Furnace¹³, was executed by Fred L. McGahan, a slick-tongued Irishman who spoke elegant chemicaleze and was able to court the influential out of their holdings. He convinced the two leading companies at Ajo that his furnace would solve their metallurgical problems. He claimed that his furnace, by not allowing nitrogen to contact the ores in the smelting process, would allow the constituents of the ores to separate into their natural elements. Once separate they could be tapped off at various levels and sold at market purity. After receiving nearly \$100,000 from the principals of the companies, McGahan started construction on the furnace.

The furnace was a brick-lined structure, twenty-five feet high and six feet in diameter. Cylinders for oxygen and hydrogen gasses surrounded the furnace and a massive pump to maintain the vacuum was mounted over the furnace and above all else. Spigots placed up the side of the furnace would allow the operator to extract the elements at thier appropriate level. The spigot at the bottom tapped off the gold. a little further up one for the silver, the next for copper, then calcium, sodium, silicon - and at the top spigots for oxygen and hydrogen. It was convincing to all but those educated in metallurgy. To them it was delirious nonsense. The smelter could not and would not work. On the day that it was to be blown in McGahan called for an additional \$200,000 payment before he would proceed further. The investors realizing, at last, that they had been bilked by McGahan, had him arrested and taken to court on obtaining money on false pretenses. He countered that he was being victimized by the investors. They eventually dropped their charges and McGahan got off with most of the money they had given him.

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It is unfortunate that the furnace is not in existence. It would make a great monument to the investor's greed, a promoter's promise and fraudulent investments in mining.



START OF MINING c. 1917. As soon as the railroad started bringing in the equipment the mining operation started. Photo from George A. Newett.

The oxide nature of the near-surface ores prevented concentration of the low-grade oxide copper ores. This is still a problem today, although these same oxide ores produce about 50% of Arizona's copper. They are still treated using some of the process principles pioneered by Greenway and his staff at the Ajo mine.

Greenway first heard about the Ajo copper deposit from a driller friend of his who had just finished drilling for the New Cornelia Copper Company (NCCC) in 1910. After listening to the driller, he knew that the district should be examined by a professional. For this work he first recruited Ira B. Joralemon, a young mining engineer,¹⁴ who was already acquainted with the property.

Joralemon, who later wrote of his involvement in Ajo, said of Greenway:

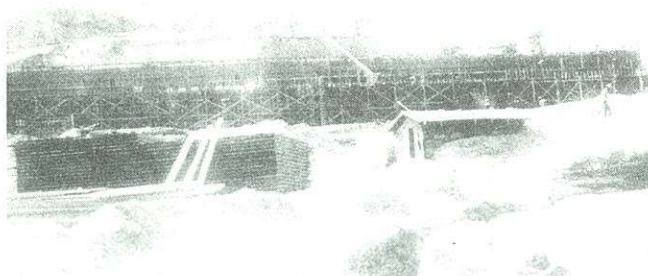
John C. Greenway was responsible for much of my success in the seven years from what I called the end of my apprenticeship in exploration until I entered the army in World War I. I first met Greenway on my return from the Promontorio and, as he was replacing Powell, he was to be my boss. Even at first glance you couldn't help liking and trusting him. He was tall, well built, and erect - an old Yale athlete. He became the best manager among those who ran the big copper mines. He was open-minded in encouraging discussion and even opposition -- until he made up his mind. Then, in military fashion, everyone must follow his decision without question. I think this is an essential for good management. Unfortunately, a few did not feel this way and they had to leave.¹⁵

He recognized the deposit as belonging to the copper bearing quartz monzonite porphyry model that was then being described by geologists from such diverse camps as Butte, Montana, Brigham Canyon, Utah and Ray, Arizona. Among the older and younger formations of the district, he mapped the six-square-mile outcrop of the Cornelia Quartz Monzonite. Noting the areas of intense alteration and the areas where copper oxides were most plentiful, he outlined an area of interest. In accordance with the current theories of the day, he anticipated that this copper

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oxide area represented a large deposit of copper sulfide mineralization that had been eroded and the original sulfide minerals leached to leave these oxide minerals. Still working within the geologic model, and by estimating the amount of copper minerals that had been oxidized and leached, he estimated that about 50% of the copper had been leached from the surface and would be redeposited as a sulfide at the water table. From the elevation of ground water in the sparse seeps and wells in the area, he would have been able to estimate the depth to the water table and from this calculate the thickness and grade of the enriched sulfide blanket. His report to Greenway stated his findings.^{16 17}

After reviewing Joralemon's report, Greenway was convinced that the deposit was a large one and made note of its many problems. Greenway then convinced the C&A to acquire an option on the New Cornelia Copper Company.¹⁸ This option, for 70% of the NCCC's 1,200,000 shares of stock, called for the stock to be issued to the C&A as it spent money in developing the property. The remaining 30% of the stock was delivered to its original investors.



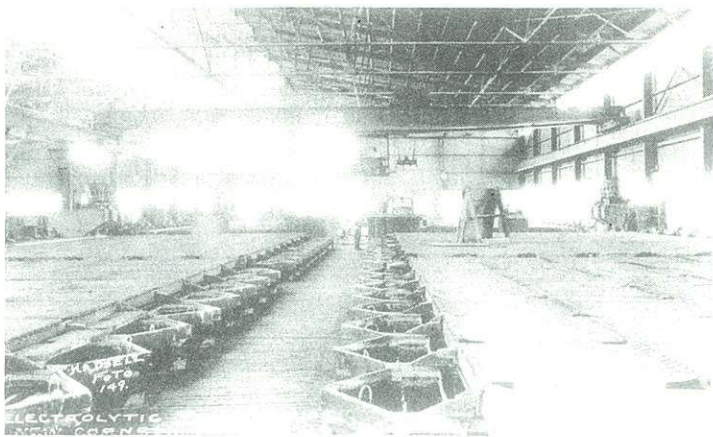
VAT LEACHING, c. 1917. These are the vat leaching tanks that the NCCC constructed to hold the broken oxide ores while they were being leached. Photo from George A. Newett

Greenway based his faith in the property on his conviction that the great masses of oxidized ores would be amenable to a new technology which he would develop. He immediately consulted metallurgist Dr. L. D. Ricketts, an acquaintance from Bisbee. Together they devised a complicated leaching process that included sulfur recovery from smelting the Bisbee ores at C&A's Douglas smelter. As sulfuric acid, it could be used to leach the copper from the surface oxides. The copper could then be recovered by precipitation on iron or perhaps through electrowinning.

Greenway expressed his optimism in a letter to his close personal friend George A. Newett on Feb. 11, 1913 as follows:

When I came west three years ago to take charge of the Calumet & Arizona properties, I formed the belief that the future of rich Bonanza properties, like those owned by the Calumet and Arizona Mining Company in Bisbee, should be coupled with their natural complement, a low grade steam shovel property, where the tonnage and characteristics of the ore could be fully developed by drills prior to the mining and beneficiating of the ore. I found this property at Ajo. I do not care to give you the figures at this time, but will tell you something of interest when you come out to see us later.

Greenway's optimism found immediate opposition from several noted professional engineers and metallurgists, who immediately recorded their belief that a process could not be developed to render the Ajo ores commercial.^{20,21} The C&A showed caution in 1912, when the Annual Report described the New Cornelia as "an outcrop of copper-stained monzonite... being developed for disseminated ores by a systematic drilling program to find an open-pit minable deposit."²² No mention was made of the metallurgical problems, the remoteness of the site or the drastic lack of water.



ELECTROLYTIC TANK HOUSE, NEW CORNELIA COPPER CO. AJO, ARIZONA, c. 1920. Photo by Harsell. This photo shows the surprising amount of automation that the NCCC achieved at this early date. Photo from George A. Newett.

Diamond drilling and test pitting began as soon as the agreement with New Cornelia was signed. Greenway personally directed the drilling. But, before this reserve could be classified as ore however, the bench scale leach tests had to be corroborated by a pilot plant operation. If this program would upscale and Ajo's oxides could be leached economically, ore reserves would stand at 30 million tons of 1.5% copper. Infeasible results would mean these reserves would be as worthless as its detractors predicted. The pilot work started as Douglas, followed the next year by a larger program at Ajo. If there were any doubts about the feasibility of the process, they would be worked out in still a larger pilot plant.

In his letter to George A. Newett of December 1, 1914, Greenway describes the process at Ajo:²³

Ajo is coming on fine. No. I well is down to the water and I believe we have plenty of it. We will know in the next month.

On the leaching we are making very satisfactory progress with the process I originated. I

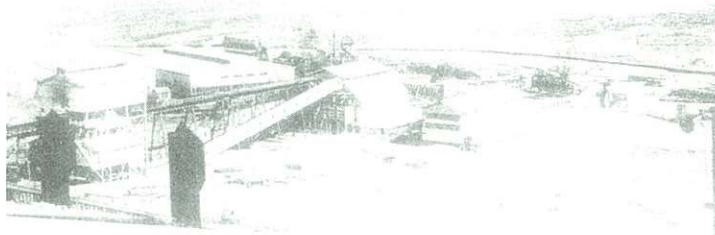
should say we will be ready to make final recommendations is this matter within three months, perhaps sooner.

Getting patents through the Government Office will probably be the last thing we have to clean up. I expect this information will be sufficient for the present, so with kind regards, I will close.

Greenway, Ricketts and the Calumet and Arizona's research staff quickly developed a pilot plant flow sheet for the Ajo ores. This system involved crushing and leaching the ores with dilute sulfuric acid in lead-lined vats. From the start the plan leaned toward electrowinning copper directly from solution. This would produce cathode grade copper which could be marketed directly and within a month of mining. Precipitation and conventional smelting required six months from the time the ores were mined until a copper product could be sold. This quickened cash flow was a large plus for the electrowinning process. Greenway's direct involvement in this work would later be recognized by two of his chemists when they referred to his approach as the "Greenway Process."²⁴

The pilot plant allowed the observation and resolution of many problems before the plant was built. Among these problems, how to handle increasing amounts of dissolved iron in the solution and how to insure the purity of the resulting copper cathodes required innovative solution and resulted in net savings of about 2.5 cents per pound of copper.²⁵ As a result, the NCCC cathodes from the final plant assayed within the required 99.9% copper.

Finding an adequate water source at Ajo was a challenge that has followed the camp to the present time.



THE MILL AT AJO c. 1923. An overall view of the mill. The smoke stack at the left was from the sulfide roasting plant which roasted ores from Bisbee to provide sulfur gasses for the leaching operation.

Photo from George A. Newett

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Greenway tackled this problem in his typical technical manner. He and one of the C&A's geologists theorized that some of the later volcanic formations in the area had flowed over a large alluvial basin. They suspected that the trapped gravel was a confined aquifer filled with water. They were right, but the gravels were not as open as they might have wished.

The first well was drilled in 1913 and tested at 197 gallons per minute. A mine shaft into this formation was planned for a location about 100 feet south of this. They were located about thirteen miles northwest of the Ajo open-pit, where the well and shaft were completed to a depth of 665 feet. Together they produced a little over 500 gallons per minute. This was considered adequate for the planned 4000-ton-per-day leaching plant and the townsite.

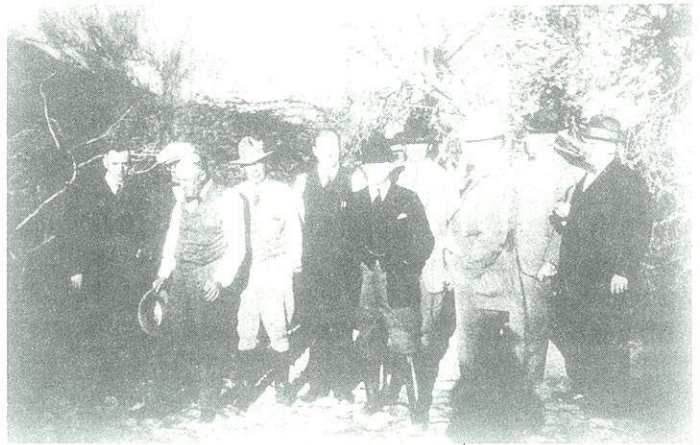
Meanwhile, testing of the Ajo leaching system continued at C&A's Douglas Smelter. At this pilot leaching plant, a recovery of 80% was easily demonstrated.²⁶ The smelter demonstrated its ability to make surplus sulfuric acid. The anticipated iron build-up was solved by aerating some of the high-iron solution with sulfur dioxide. In this operation, the iron was precipitated out of solution. Operation of the pilot plant also indicated that some of the pregnant solution would have to be bled off and sent to iron laundries to further check the ferric iron build-up. Now the company decided to move the pilot plant to Ajo for additional testing. After an entire year of operation they expanded the capacity to 40 tons per day, and on Jan. 31, 1915, they put this larger plant into operation. During its first year, it treated 12,000 tons containing 1.25% copper and achieved a recovery of over 70% on the copper in the ores.

Based on the continued success of the pilot plant, the company directors committed to a \$4 million investment for a production plant at Ajo. The plant would produce 36 million pounds of copper annually and could be completed by July 1, 1917. This thirty-six million pounds of copper was sufficient to electrify a community of about one million people at that time.

George Newett, in a letter to Greenway²⁷, quoted Mr. T.F. Cole, another director of the C&A and the NCCC, as saying: "Greenway has dug up a most valuable property in New Cornelia, and is doing good work for all our interests in the Southwest."

Greenway argued with the C&A management that good housing and a town with churches and schools would attract the stable labor force that the operation requires. He won, over the objection of several C&A officers and directors.²⁸ Although they agreed with Greenway's approach, they argued over how much and when.

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NCCC DIRECTORS IN ROUTE TO AJO, c. 1923. From left to right, James E. Fisher - Secretary and Assistant Treasurer, William H. Newett - Visitor, William B. Mershon - Director, M. Curley - Superintendent, Thomas H. Collins - Director, Charles Briggs - Director, Thomas H. Collins - Director, Walter B. Congdon - Director, Thomas F. Cole - Director, Frank J. Kohlhaas - Director.

Photo from George A. Newett - Director

He had just come from a similar environment, where he had built the town of Colarine and must have been convincing in his arguments. He hired reliable architects and started building a model company town in the Southwest. The townsite was nearing completion by the end of 1916 and included a plaza, business block, schools and the best hospital in Pima County.

To manage the day-to-day operation of the mine, Greenway invited his old friend and former employee from the Mesabi to join him in Ajo. Mike Curley arrived in Ajo in 1913. He would have received a written offer from Greenway that would have been very business-like and short of words. If his letter to Harry Clark was typical of his offering, it tendered a reasonable wage, moving expenses, a short description of the job situation and little else. There were no promises, but a general tone of great appreciation.²⁹ Mike Curley stayed with the New Cornelia through all its mergers and retired as Manager of the New Cornelia Branch from the Phelps Dodge Corporation in 1939. In all of his work at Ajo from 1913 on, Curley supervised the day-to-day operations.

The initial mine design called for three 100-ton steam-shovels and a system of rail haulage that dumped directly into a gyratory crusher where the ore would be crushed to ¼ inch. The crushed ores were conveyed to one of twelve 5,000-ton lead-lined concrete tanks. Four sulfur dioxide adsorption towers reduced the ferric iron to an insoluble ferrous compound, which was precipitated out of the solution. Electrical power for the entire operation was provided by a power plant, brought on in July, 1917.³⁰

Connecting Ajo to the outside world, the Tucson Cornelia and Gila Bend railroad (TC&GB) tied into the Southern Pacific at Gila Bend. This short line started from Gila Bend, a stop on the Southern Pacific,³¹ and began making daily service to Ajo when completed in 1915. The entire 35 miles was lined with 70-pound rail. During its first year of operation, it hauled 64,000 tons of freight.³² Ownership was held by the El Paso and Southwestern railroad and the Calumet and Arizona Mining Company. The El Paso and Southwestern was a

wholly owned subsidiary of the Phelps Dodge Corporation and the Copper Queen Mining Company, the C&A principal rival in Bisbee. This railroad ownership is another curious aspect of the strange courtship between the Calumet and Arizona and its friendly competitor, the Phelps Dodge Corporation, which ended in the merger of 1931.

To be continued in the next issue

Endnotes

1. Funeral Papers, *Greenway Collection* at the Arizona Historical Society in Tucson.
2. Clippings from the *Greenway Collection* at the Arizona Historical Foundation in Tucson.
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18. "John C. Greenway", *Arizona Mining Journal*, Phoenix, Arizona, October 1917.
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20. Joralemon, Ira B., *Adventure Beacons*, *op cite*, p. 63.
21. Joralemon, Ira B., *Copper, The Encompassing Story of Mankind's First Metal*, *op cite*, p. 194.
22. *C & A Report to Stockholders 1911*. The term monzonite describes a certain type of igneous intrusive rock that is slightly different than the rock type being recognized as bearer of most of the world's low grade copper deposits. Greenway's break with the popular preachments of the geological pundits of the time was yet another perceived blunder.
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