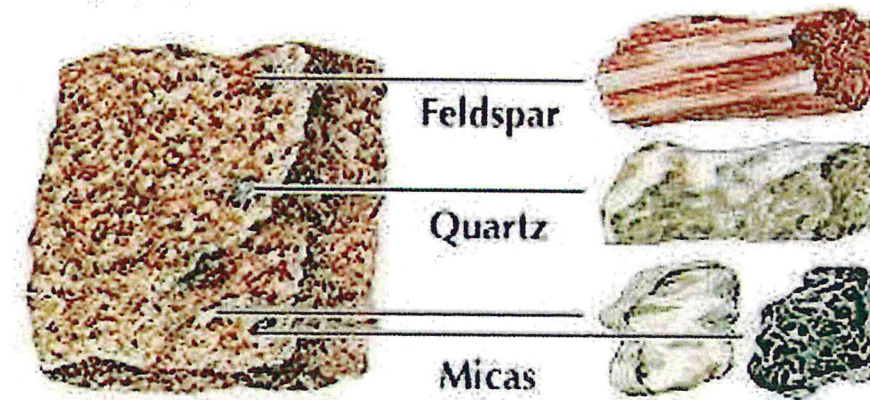


GRANITE

What is Granite?

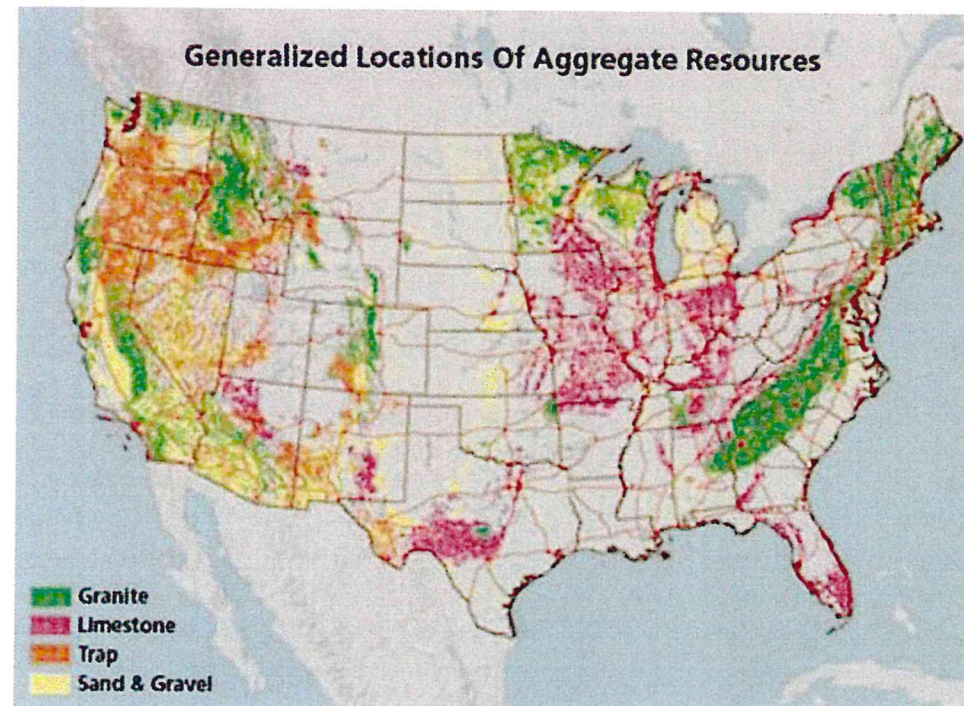
The word "granite" comes from the Latin *granum*, a grain, in reference to its coarse-grained structure. It is one of the hardest stones and one of the most common.

Granite contains several minerals: **FELDSPAR** (65 to 90%), **QUARTZ** (10 to 60%), and **MICA** or other accessory minerals (10 to 15%). This mineral composition gives granite a red, pink, gray, or white color with dark mineral grains visible throughout the rock.



Where is Granite Found?

The world's largest producers of granite are China, Brazil, and India. Most of the granite produced in the US comes from Massachusetts, Georgia, New Hampshire, South Dakota, and Idaho. However, as the map shows, there is a spot of granite production (green) right in the middle of Texas!



FAMOUS USES OF GRANITE



PYRAMIDS OF EGYPT

The Red Pyramid of the Pharaoh Sneferu (c.26th century BC) was named for the light crimson hue of its exposed granite surfaces. The King's Chamber of the Great Pyramid of Giza (c.2580 BC) contains a granite sarcophagus fashioned of Red Aswan granite. How the Egyptians worked the solid granite is still a matter of debate.



VIETNAM VETERANS MEMORIAL

The Vietnam Veterans Memorial, located in Constitution Gardens near the Lincoln Memorial in Washington DC, honors the soldiers lost in the conflict. The design features a V-shaped memorial wall made from 500 feet of polished black Indian granite sandblasted with more than 58,000 names of veterans who died or were missing in action.



DIANA PRINCESS OF WALES MEMORIAL FOUNTAIN

The Diana, Princess of Wales Memorial Fountain in London's Hyde Park has drawn more than 1 million visitors a year since it was dedicated in 2004. It is made from 545 individual pieces of Cornish granite cut using computer-guided machines.



MOUNT RUSHMORE

Mount Rushmore stands 60ft tall and depicts George Washington, Abraham Lincoln, Thomas Jefferson, and Theodore Roosevelt. Workers had to hang from cables and use jackhammers to carve out the faces. There is also a mysterious Hall of Records carved into the cliff.

What Kinds of Granite Are There?

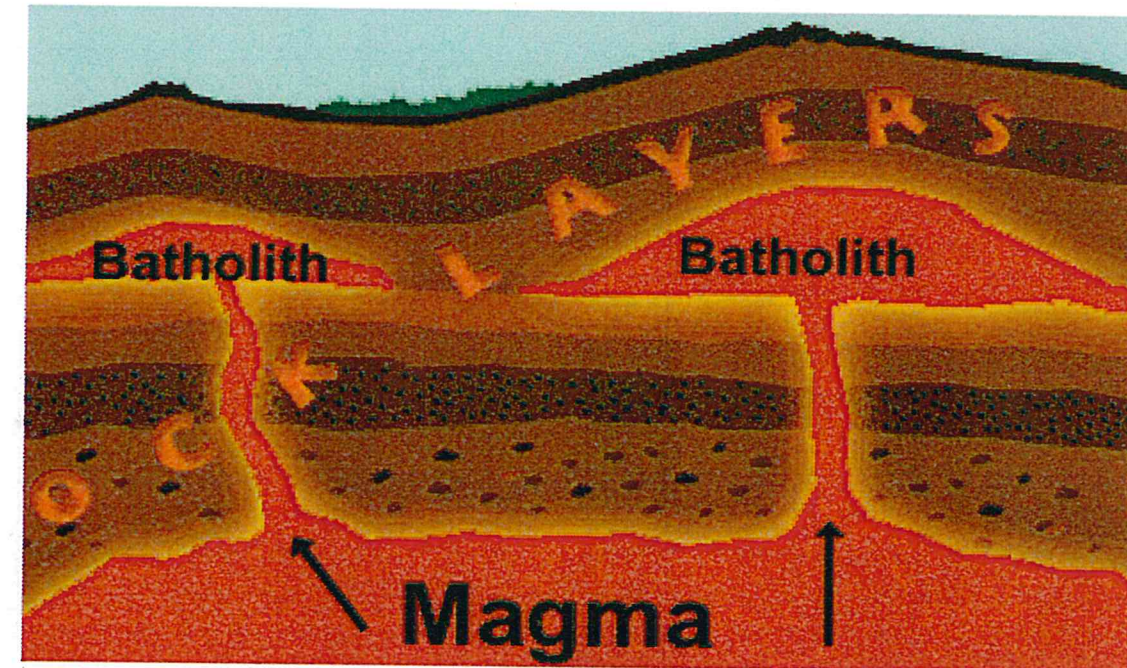
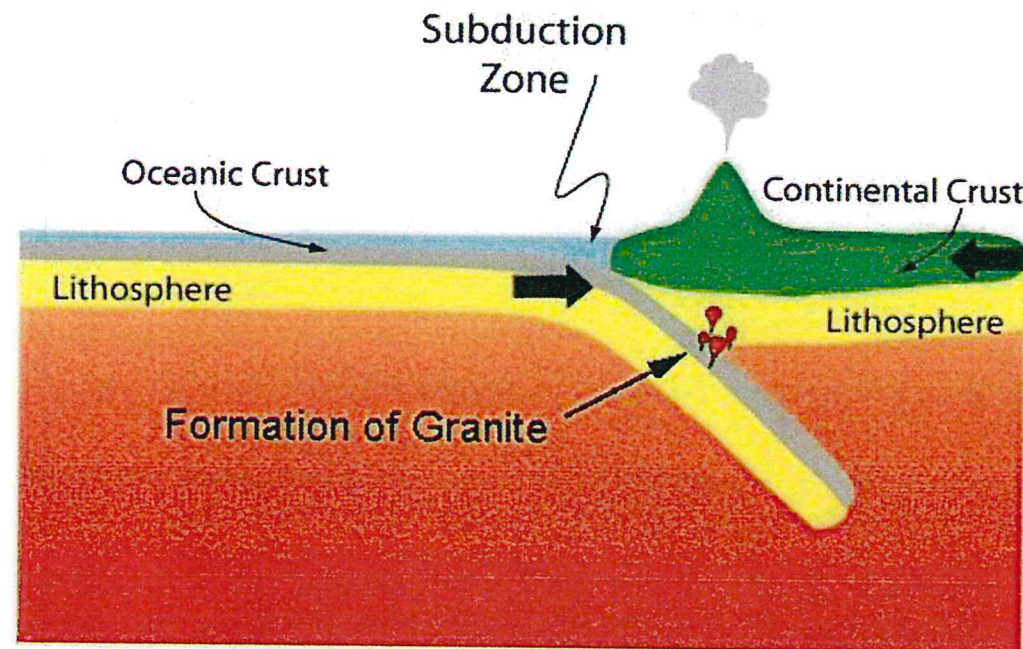
AGGREGATES are the most mined materials in the world, used for reinforcement to add strength to the overall composite material. Aggregates are widely used for foundations, retaining walls, roads, and railroad beds.

DIMENSION STONE is granite that has been selected and finished to a specified size and shape, usually for building facings, countertops, tiles, or monuments. Texas is the top US producer of Dimension Granite with 202,000 metric tons/year worth \$47,100,000.

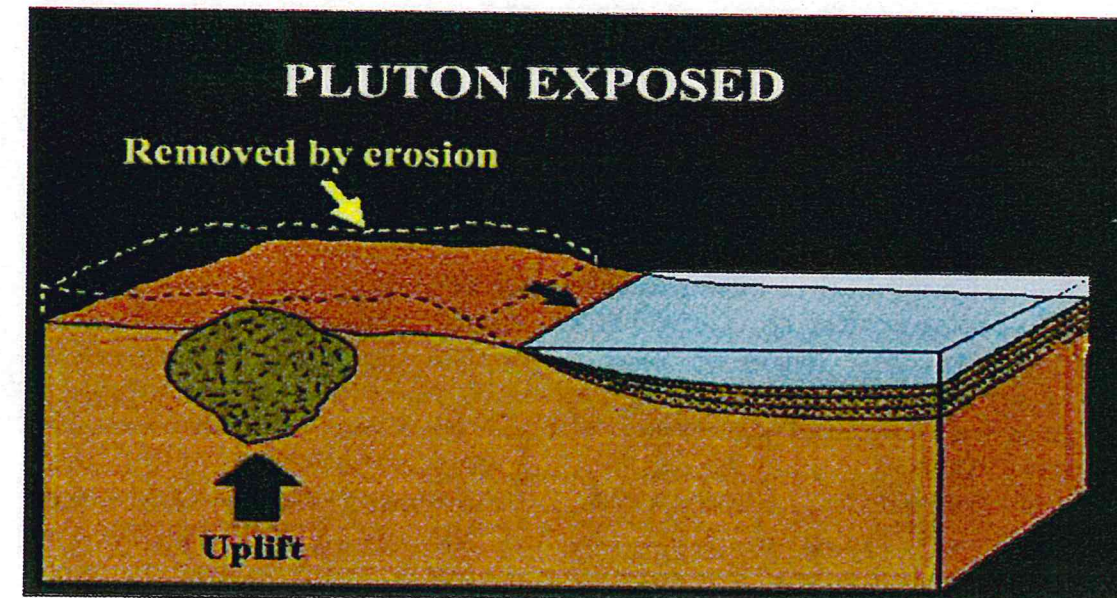
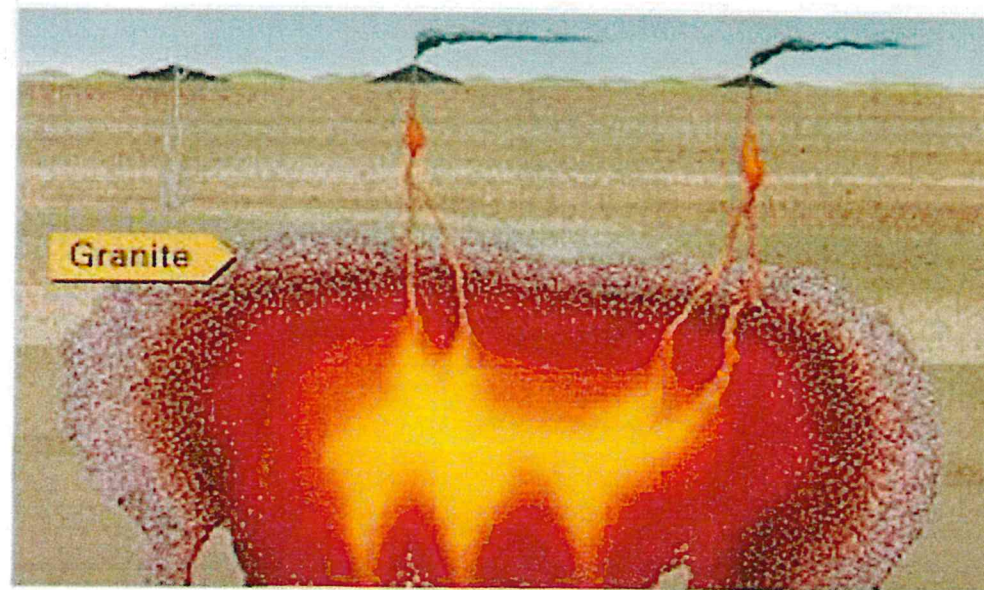
How is Granite Formed?

Granite is an **IGNEOUS** rock, formed when part of the Earth's crust melts and then cools, eventually coming to the surface as a solid mass called a **PLUTON**.

Ages ago, when the Earth's continents were forming, part of the oceanic crust slid under the thicker continental crust where it was melted by the magma in the Earth's mantle. Then it rose toward the surface to form a **BATHOLITH**. (If it had made it all the way to the surface, it would have erupted as a volcano!)



While in the **BATHOLITH**, the cooling magma goes through a transformation as its constituent minerals crystallize and meld into granite. Over time, the mass is pushed to the surface as a **PLUTON** and eventually exposed by erosion. Besides Granite Mountain, the best known **PLUTON** in our area is Enchanted Rock.



QUARRYING

Ancient Tools

Methods of extracting stone and other materials have changed since the first quarries were mined in the Aswan area of Egypt. The earliest quarries were mined with hammers, picks, and chisels made of stone or metals such as bronze and iron. During the period of the Old Kingdom (2650 - 2152 BC), quarrying techniques consisted of prying loose stones from the surface of the quarry. However, by the time of the New Kingdom, which began in 1539 BC, quarrying techniques had advanced.

The Egyptians hacked off the upper layers of weathered granite first. They then dug a trench around the granite to be cut. After the required depth of the trench was measured using a cubit rod, the workers cut in beneath the rock, making a series of holes with hammers and iron chisels, and then inserted wooden wedges. They soaked the wood with water and as it expanded, the rock would split. Workers then used the iron chisels to break the granite apart. They cleared a pathway on one side of the cut granite slabs and pushed them out horizontally and then up a ramp, rather than trying to lift them directly. Stones had to be carried or dragged out of quarries manually. Large stones would be hauled with pulley systems involving ropes and moveable wooden sleds. This process often involved thousands of slaves and other workers. The method used to build the Great Pyramid is still highly debated.

ANCIENT QUARRY IN ASWAN WITH A PARTLY CUT GRANITE BLOCK



Quarry Production

Many kinds of stone are quarried all over the world, including marble, limestone, bluestone/brownstone, and granite. Most common are various kinds of **AGGREGATES** used in construction fill, but the highest value products are **DIMENSION STONES** used for buildings, monuments, and countertops.

- Large size **BLOCKS** blasted from the quarry face used for jetties and levees to shore up sea fronts and river banks.
- **SLABS** shaped and polished for use as building facings, tiles, monuments, or countertops.
- Rubble drawn direct from the shot pile, called **FACE FILL**, used as large scale fill on construction sites.
- Material screened immediately prior to primary crushing, called **SCALPINGS** (or 'grizzly'), also used as fill on construction sites.
- Screened out fine material from the crusher, called **BLINDING**, used for final shaping of construction sub bases, particularly in road construction.

BLOCKS



SLABS



FACE FILL



SCALPINGS



BLINDING



Historical Tools

PLUGS AND FEATHERS. To split a large piece of stone, it is scored according to its grain and a line of holes are then cut or drilled into the stone face approximately 6" apart. Plug and feather sets are then inserted in the holes with the "ears" of the feathers facing the direction of the desired split. The plugs are then struck with a small stone maul in sequence, producing a 'ringing sound' when the wedges are tight. As the stone reacts to the pressure, a crack eventually appears and the stone splits apart.

BLASTING. A survey of the quarry face allows the explosives engineer to design the blast and to place shot holes so that the blast can be carried out safely and efficiently. An air operated rig drills shot holes at the angles and depths required. Detonator cord is placed in each hole and then high explosives to within a few yards of the top with the remaining depth "stemmed" with quarry dust. The site is cleared, the circuit is checked, and the shotfirer sets off the explosives. A single blast can fragment up to 60,000 tons of rock.

Modern Tools

AIR JET BURNERS. Currently, the prevailing method is jet burner channeling. The burner is like a miniature rocket motor burning a pressurized mixture of fuel oil and air, attached to a long steel pipe. The system is aptly named the "jet burner", for the flame leaves the pressurized combustion chamber at approximately five times the speed of sound and causes the granite to disintegrate or break down into small flakes or a dust as the heat crystallizes and expands the granite. The burner cuts a 4-in. wide channel as the heated granite flakes off with each pass. Using the burner, it is possible to cut a vertical channel 12 to 15 feet deep at a rate of about 14 square feet per hour.

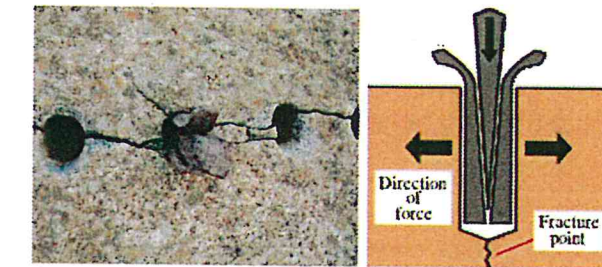
DIAMOND CHAINSAWS. The latest extraction technique is an engine pulling wire cable through a system of pulleys and return wheels. The wire is a steel cable with diamond grit-impregnated beads, threaded through intersecting vertical and horizontal holes and jointed together making a large loop which simultaneously cuts the top, bottom, and one end of the granite mass. Water is fed continuously through the narrow cuts to cool the wire. Quarriers say the wire sawing method will cut 35 to 40 square feet of granite per hour, or four to five times faster than a jet burner.

CRUSHERS AND SCREENERS. Each stage of crushing produces progressively smaller sized stones. In order to produce a usable end-product, the crushed rock has to be screened into various size categories. Crushed and screened rock is called **AGGREGATE**.

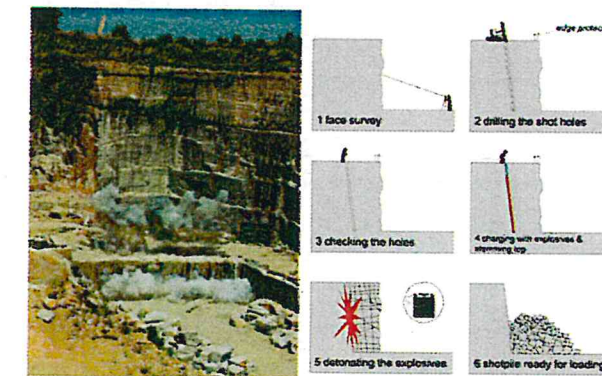
The primary crusher is fed via a chute and vibrating feeder. The base of the feeder is made of steel "grizzly" bars and it is here that the first screening operation is actually done. Fine material and dust produced by the blast, along with any remaining subsoil or weathered rock from the top of the quarry face, drops through the bars onto a separate conveyor belt and onto a stockpile. This screened material is called **SCALPINGS** and is used as rock fill. Primary crushing is usually by a jaw crusher consisting of a heavy metal plate which moves backwards and forwards against a fixed plate. Secondary, tertiary and quaternary crushers are generally cone crushers, where granite is fed in at the top of the cone and crushed product falls out below.

ENVIRONMENT: Quarrying granite rates very well in sustainability. No toxic materials are used in processing. There are no direct greenhouse emissions during processing. The dust is controlled. Water is almost completely recycled. Granite is a perpetual resource (virtually inexhaustible in a human time scale). There is no scrap needing off-site disposal.

PLUG AND FEATHER



BLASTING



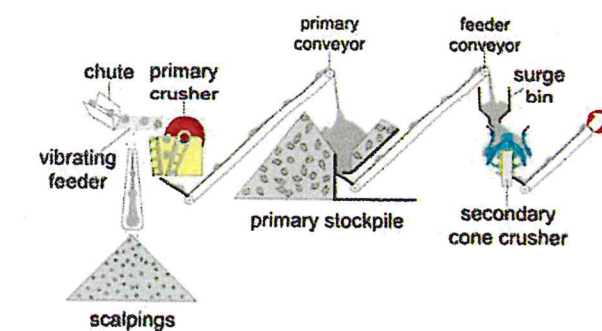
AIR JET BURNER



DIAMOND CHAINSAW



FOUR STAGE CRUSHER



LOCAL QUARRY HISTORY

Burnet County Granite

Rich granite deposits are found all over Burnet County, as seen on the map. Medium to fine-grained granites are shown in pink, while coarse grain or PORPHYRITIC granites are red. Notice that GRANITE MOUNTAIN itself is much larger than the 160-acre quarry with that name. It is part of the Town Mountain granite formation, created by the Balcones uplift. Enchanted Rock is another Town Mountain PLUTON.

Granite domes are common around here and include Granite Mountain, Kennison Rock, School Rock, Goose Rock, Hickory Rock, Corner Rock, and numerous smaller occurrences. Our own Hog Mountain is one of those.

Granite Mountain

Granite Mountain was part of a Republic of Texas land grant made to the family of colonist William Slaughter. Confederate veterans George and Frank Lacy bought the mountain for \$3,453 in 1867. The quarry was opened in 1882 and by 1931 it had become the world's leading granite producer, having turned out 3.5 million tons with over 50 million tons remaining. Jobs at Granite Mountain were greatly prized during the Depression and helped sustain many families in Burnet County.

In the 1890s, Thomas Darragh came from New York to purchase the site for \$100,000, forming the Texas Pink Granite Company. Granite Mountain was purchased from the Darraghs by Cold Spring Granite Company of Cold Spring, Minnesota in 1951 and operated under the name Texas Granite Corporation since that time. As Coldspring®, the company is the country's largest fabricator and quarrier of granite products.

Granite from Granite Mountain was used in the construction of many buildings known for their beautiful design, the most famous being the Texas State Capitol. The Bob Bullock Texas State History Museum chose Sunset Red for facings, as did the Lorenzo de Zavala Library and Archives Building, the Sam Houston Building, and the Robert E. Johnson building. It was also used for the Georgia Pacific Building and the Coca Cola Building in Atlanta, the Wyndham Hotel in Dallas, the Inter-North building in Omaha, Sohio Corporate Headquarters in Cleveland, and the Crocker Building in San Francisco.

In our local area, many buildings have been built from Granite Mountain stone. In Marble Falls, Thomas Darragh built a granite house on Main Street for wife Rosa. The Old School on Broadway is now home to the Falls on the Colorado Museum. The Badger House on Ave M is another beautiful local example of granite use. And naturally, the Burnet County Courthouse is faced with Sunset Red.

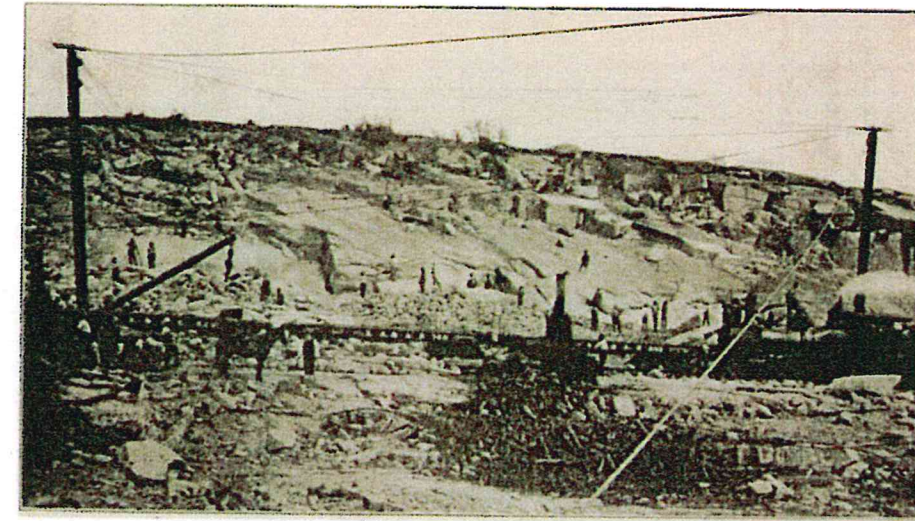
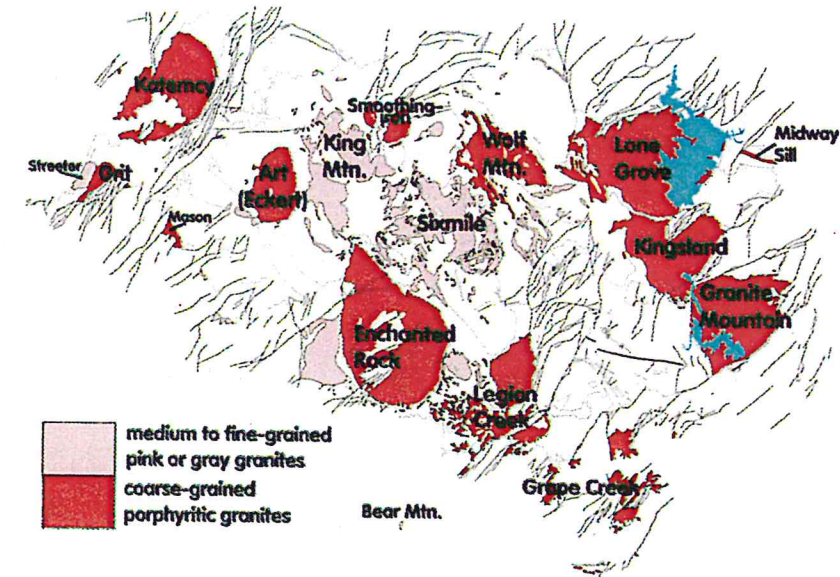
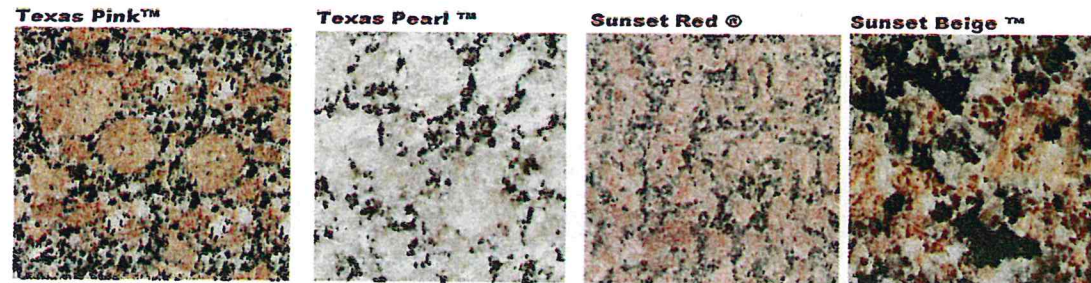


Plate 6. Darragh Brothers' quarry at Granite Mountain, Burnet County.

"In the suburbs of Marble Falls is the largest granite quarry in the world with ONE HUNDRED MILLION CUBIC FEET of as fine granite as can be found, already stripped and, being in the shape of a mountain of solid stone with natural bed seams from time to time occurring, is the easiest and cheapest quarried of any similar stone in America, and when this mountain shall, in the course of the next 1000 years, become exhausted, there is another of practically the same size and texture within one mile and some 500 acres of smaller mountains of granite adjoining." MARBLE FALLS REAL-ESTATE MARKETING BROCHURE, circa 1947

Hog Mountain Quarry

You are standing on the site of the HOG MOUNTAIN QUARRY, which opened in January 1964 by the Texas Construction Material Company as their Granite Shoals division. The first shipment from this deposit was made June 4, 1964, and during the next 4 years approximately half a million tons of granite jettystone was shipped. This granite was used for the repair and construction of jetties on the Gulf Coast.

In the 1980s, the quarry was operated by Capitol Marble and Granite, then was acquired by Cold Spring Granite in 1988. At this point it had become a source for DIMENSION STONE used for facing buildings such as the Federal Reserve Bank of San Francisco. The local variety is called "Texas Pearl" and is slightly grayer than Sunset Red. (Texas Pearl is still quarried about 3 miles from here. Another variant called "Sunset Beige" comes from nearby Honeymoon Ranch.)

The quarry site occupies 131 acres and includes 3 large shops and an administrative building. In 2008, the property was acquired by the City of Granite Shoals for use as its new city complex. The offices, constructed in 1985, were converted to serve as the new City Hall and the surrounding acreage was laid out as QUARRY PARK with a wide range of recreational activities. The first of these are the Roddick Tennis Center and the Manzano Track, as well as this Quarry Interpretive Center and its wildflower garden. This building was made from some of the left-over slabs scattered around the site. You can see the quarry marks on the outside.

Granite Jetty on Padre Island



Federal Reserve Bank of San Francisco



Bycrus-Erie Crane



Gardner-Davis Air Track Drill



There are only a few published records of operations at Hog Mountain:

"Granite was quarried by 17-man crews with as many as six crews working during the peak shipping period, opening the face and operating the equipment (including a 54B 21h-yard Bycrus Erie crane). Line drilling at the face was done with Gardner-Davis air tracks drilling 21h-inch holes to the depth of the bedding. Once the face was opened to the natural horizontal bed some 50 feet deep, the ends of the block were broached out with Gardner-Denver channel bars. Prima cord was used with cement for stemming to lay the burden (large blocks) down. After the block was on its side, jackhammers were used to start the feathering and wedging process to make specification blocks, which ranged from 2 to 18 tons. These blocks were loaded on rail cars which TCM switched 4.5 miles to the main line north of the quarry." The University of Texas at Austin Bureau of Economic Geology To Accompany Map-Geologic Quadrangle Map No. 44 GEOLOGY OF THE DUNMAN MOUNTAIN QUADRANGLE, LLANO, BURNET, AND BLANCO COUNTIES, TEXAS VIRGIL E. BARNES 1968

JOBS IN QUARRYING

SPLITTERS: Their main responsibility is to separate specific blocks of stone from the quarry mass, usually with a jackhammer and wedges. These employees work in dangerous conditions with heavy equipment and machinery, so many precautions must be taken while on the job. Job training is almost always completed on-site, but a few employers do prefer employees to complete an apprenticeship program before beginning formal work.

BLASTERS: In this highly dangerous job, workers prepare and detonate explosives to demolish large amounts of rock. They're involved in every step of the blasting process, starting with a careful evaluation of the job and the materials needed to do it safely and effectively. They use drilling construction equipment with specialized tools to create blast holes. Then they fill them with explosive charges and connect the charges with detonating systems into a pattern of timed explosions. To become an explosives worker, ordinance handling expert or blaster, a high school diploma or GED is sometimes required.

DRILLERS: They operate machinery such as shears, plows, and cutting machines to cut or channel along the face or seams of quarries to facilitate blasting, separating, or removing minerals or materials. Operators of diamond chainsaws and air track drills typically have a diploma/GED.

LOADERS: Loading machine operators help clear the quarry of debris. They control machinery equipped with power shovels, scrapers or scoops, or with gathering arms and a conveyor. Loose rock is loaded into the vehicles that will transport it away from the job site.

HELPERS: They assist other extraction craft workers, such as earth drillers, blasters and explosives workers by performing duties requiring less skill -- such as supplying equipment or cleaning work areas.

GRANITE FOR THE STATE CAPITOL

The first Capitol of Texas was built of Bastrop plank lumber on a hilltop west of Congress Avenue. The next was located at Capitol Square and completed in 1853. When this Greek Revival structure burned in late 1881, plans were already underway for a new Capitol. The Capitol Board which was meeting in the building at the time fire broke out, quickly moved the plans to safety.

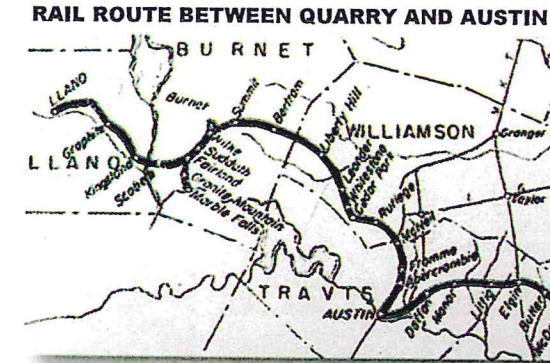
Local materials were specified to be used whenever possible and originally, limestone from nearby Oatmanville (now Oak Hill) was planned. Unfortunately, it soon became evident that on exposure to air the limestone discolored and would not do for facing the Capitol. For two years, the Legislature debated what stone should be used. The issue was settled in 1885 when Governor John Ireland resisted demands to use non-native limestone. Red granite from nearby Burnet County was as close to home as could be agreed on.

Granite Mountain's owners, "donated to the people of Texas, granite sufficient and suitable for the building, erection and completion of the entire State Capital Building." In return, a narrow gauge railroad was specially built to haul the 15,700 carloads of granite from the quarry to the Capital Building site in Austin.



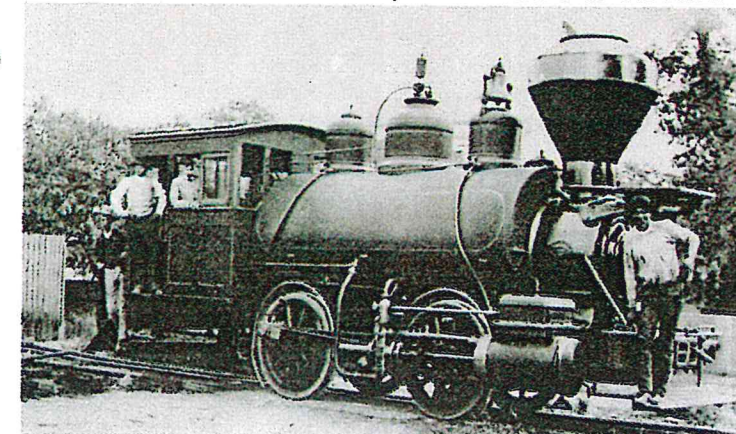
Railroad Comes to Marble Falls

The owners of Granite Mountain offered to provide free "Sunset Red" granite for the job, hoping the exposure would raise its popularity. This also meant that to ship the granite, the State would have to extend the railroad to Marble Falls from Burnet, boosting the local economy. Marble Falls founder Adam Johnson and others provided land for the railroad right-of-way. Completed in December 1885, the Austin & Northwest Railroad enabled the quarry to ship the huge granite blocks to Austin. Over three years, 15,700 loads of Sunset Red were extracted and shipped to Austin for the new Capitol. With the railroad and its location on the Colorado River, Marble Falls was poised to become a commercial center. Adam Johnson had shown remarkable foresight.



There is a popular misconception that a rail line was constructed just for the Granite Mountain operation. However, it should be noted that by 1884 the Austin & Northwestern Railroad had already existed for three years, having been chartered in 1881 to lay track to Abilene. By 1882, it had only made it to Burnet, when its assets were auctioned off to a New York group. All that was required to service Granite Mountain was a 15 mile spur, continuing into Marble Falls, constructed under the charter of the Granite Mountain and Marble Falls City Railroad. At first, the railroad was narrow-gauge, but it was converted to standard gauge by the time it reached Llano in 1892. It became part of the Southern Pacific line until 1986, when it was abandoned and taken over by Capitol Metro. Freight service is now run by the Austin Western Railroad.

LONE STAR ENGINE PULLED 15,700 CARLOADS OF GRANITE



Convict Labor

Convicts were used as labor both to build the rail line to Granite Mountain (and later into Marble Falls) and to mine the granite from the mountain. A deal was cut with the director of Texas Prisons in which there were restrictions on the hours worked, numbers of prisoners which could be used, the kinds of skills required, and the supervision and control of the prisoners on the site. Three hundred state prisoners were assigned.

The state convicts were virtually all black or Hispanic, and they were not only men but also boys as young as twelve. The 19th century did not have a juvenile court system, so adolescents were lumped in with older men.

The state prisoners completed the fifteen-mile narrow gauge railroad from the granite quarry to Marble Falls in November of 1885 and room and board facilities for the convicts were established at the quarry. Convicts stayed at the site and were fed meager diets of cornbread, salt pork, and coffee. Police with dogs guarded the workers at night.

Blocks were cut using the feather-and-wedge method and mule-drawn flat cars were used to haul the blocks to the dressing and shaping grounds at the quarry. "Breaking rocks in the hot sun" became a reality for these three hundred prisoners -- only these were gigantic boulders.



"Convicts were perfectly satisfied and everything moves along smoothly, all reports and marvelous flim-flams to the contrary. Out of 300 men employed, only 7 are sick, which speaks well for the sanitary condition of the camps, and care shown in securing comfort for all engaged in the quarries." AUSTIN DAILY STATEMAN: Grand Jury Inspection Report

Union Disputes

Another problem developed during construction: there was no money available to hire skilled quarrymen to cut and finish the pink granite. The solution again was simple—use convicts from the prison system. The state felt it couldn't afford in-state stone masons and quarreled with the stone-cutters union. Although the granite itself was free, the cost of shaping and shipping the granite made it more expensive than earlier estimates for limestone.

The net result was that Texas imported Scottish stone masons and ran into great interference from the union – a conflict that would later result in a court case and fine paid by the state. Their recruitment, it turned out, was a violation of the Contract Labor Act of 1885. From the prison walls of Huntsville to Hadrian's Wall in Scotland, the use of Texas state prison convicts had national and international repercussions, stimulating a debate over whether convict labor should be used when there were law-abiding citizens ready to do the work.

Capitol Completed

The capitol was opened to the public on April 21, 1888 and dedicated during May 14-19 of that year. On completion, it contained 392 rooms, 18 vaults, 924 windows, and 404 doors. Today, the Texas Capitol has the largest square footage of all state capitol buildings and is second in size only to the US Capitol in Washington. The Texas State Capitol is 308 ft tall, 19 feet more than the US Capitol.

Final construction of the building required an estimated 4,000 railroad cars of granite, 11,000 railroad cars of limestone and other materials. The total cost of the Capitol was \$3,744,630.60 with Texas paying only about \$500,000, thanks to an epic land swap, the use of convict labor, and the deal with Granite Mountain.

