INDUSTRIAL MINERALS IN ARIZONA'S CULTURED MARBLE INDUSTRY
Including Cultured Onyx and Granite, and Dense Filled Counter Top Materials

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ABSTRACT

This report briefly describes Arizona's cultured marble manufacturing industry, and in more detail, the specifications and quantities of industrial minerals consumed.

The Arizona cultured marble industry is an important user of minerals as fillers and pigments. The primary filler used is calcium carbonate in the form of ground limestone or ground marble. Perlite and silica are also used. Potential use exists for feldspar, magnesite, and brucite More than 28 million pounds of minerals with a value in excess of two million dollars are imported by Arizona annually for use in manufacturing cultured marble and related products. Since a number of these minerals are not currently produced here, a market for local material exists.

DEVELOPMENT POTENTIAL IN ARIZONA

The opportunity for development of Arizona mineral deposits exists because few of these minerals are currently mined in Arizona despite the likelihood that significant deposits occur within the state. Further, there are additional markets in the Southwest and potential export markets.

Detailed information on deposits of industrial minerals in Arizona may be obtained from the Arizona Department of Mines and Mineral Resources.

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CULTURED MARBLE IN GENERAL

Cultured marble is an imitation stone. For the purpose of this report the cultured marble industry includes the other imitation stone materials of cultured onyx and cultured granite, and dense fill counter top materials such as DuPont's Corian. All cultured marble type materials are hardened cast mixtures of plastics resins and inert fillers, with color pigmentations and patterns, made to resemble natural stone. The inert fillers are typically calcium carbonate. The most common cultured marble product is the bathroom vanity top with or without a lavatory bowl.

Cultured marble products reproduce the appearance of quarried stone, some with startling success. While cultured stone's most common application is the bathroom vanity top with or without a sink unit, the concept is also used in bathtubs and wall panels, whirlpools, and kitchen counters, and as luxurious window sills, archways, and other detailing in homes and commercial buildings.

Good quality cultured marble has distinct advantages over natural stone for many applications. It is lighter, lower in cost, easier to clean, less brittle, and less subject to staining. Color and hardness can be controlled in the manufacturing process, and the material can be cast into almost any shape, allowing customized designs and seamless construction.

Cultured marble consists of a polyester resin system, highly filled with inorganic particulates, cast into a structural and decorative unit. The specific combination of resin and filler materials for a product is called its matrix. The matrix formula and method of mixing are unique to every manufacturer.

A lightweight cultured marble is made to reduce the weight of large cultured marble fixtures. Fixtures such as bathtubs are quite heavy and may weigh as much as 600 pounds. The handling and installation of such a large, heavy item is difficult and can subject construction/installation workers to possible injury. Using a low density filler, such as popped perlite or hollow glass spheres, the item is produced with a 33 percent reduction in weight.

Cultured onyx is the industry name for a premier segment of cultured marble. Onyx is made with a larger percentage of polyester resin than other cultured marbles. By using water white resins and pure white hydrated alumina, onyx manufacturers seek to replicate the delicate veining and translucence of polished stone.

Cultured granite is a product similar to cultured marble and cultured onyx, but made to look like quarried and polished granite. Like the marble and onyx products it is highly filled, but the filler is, in part, of a granular nature. The granular filler may be actual rock chips, color-coated rock chips, or chips of colored polyester resin.

In the casting process, the mold is first coated with a thin polyester gel, generically called "gel coat" that serves as a waterproof surface on the finished piece. The cultured marble mixture is then poured into the mold. If the finished piece is to include a sink, the backside of the sink portion of the mold, called the "hat," is placed and filled with the mixture. After several hours of chemical curing and a cool down period, the product is removed from the mold, trimmed, cleaned, ground, and buffed.

As a rule, the cultured marble companies in the United States tend to be small shop operations, formed by independent entrepreneurs to serve local or regional markets. The first shops began in Southern California, Florida, Texas, and other fast growing locations in the late 1960's. Today manufacturers can be found in all parts of the country. Despite their small size, many operations have instituted rigorous quality controls and subscribe to the formal annual testing and certification procedures conducted by the Cultured Marble Institute. Standards are in place for quality of workmanship, structural integrity, thermal shock resistance, color-fastness, cleanability and wear, and cigarette burn resistance.

The cultured marble industry has gone through tremendous growth since its beginning in the late 1960's. Through a steady evolution in processes and materials, cultured marble manufacturers have turned out ever more elegant and durable products. Architects and builders have expanded the commercial and residential applications of cultured marbles into sophisticated new areas. Now, with heightened consumer interest in luxurious appointments for new and remodeled bathrooms and kitchens, the demand for cultured marble products is climbing sharply. Cultured granite and cultured onyx as the premier product segments of cultured marble, are enjoying an increasing percentage of the market.

In the twenty-plus years of the cultured marble industry there has been, and continues to be, an overall trend toward improved control of raw materials and processes. Significant progress has been made in resin materials, resulting in better background color and translucency in cultured onyx. Manufacturers have become more sophisticated in their management and documentation of key processes such as the formulation of the resin matrix, mixing methods, mold preparation, gel coating, and casting and curing procedures. Demand for higher quality and more consistent quality filler minerals has resulted from this increased sophistication. In addition, improvements in mold designs have resulted in better size matching and have expanded the range of shapes and sizes into which the material can be cast.

Industry efforts to develop dependable and beautiful cultured marble products have won consumer confidence. The Cultured Marble Institute estimates that cultured marble accounts for over 50 percent of the bathroom lavatory market and about 10 percent of the bathtub and bath wall panel market. The bathtub market has been growing rapidly, spurred by demand for whirlpools and other high-end fixtures.

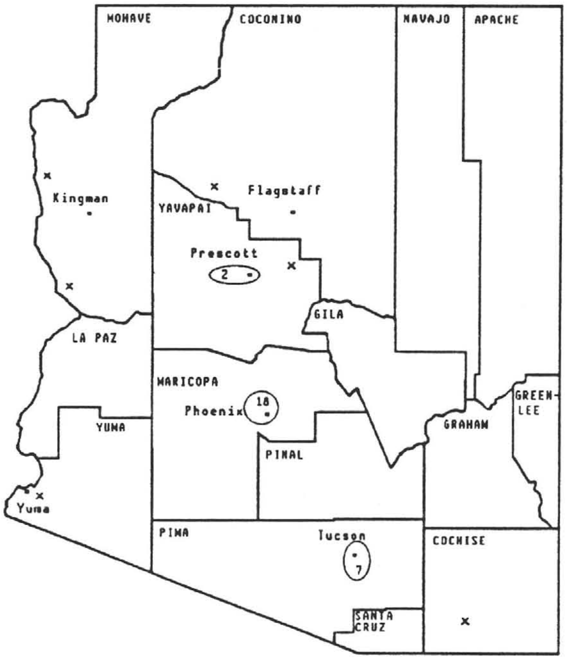
ARIZONA'S CULTURED MARBLE INDUSTRY

Arizona's cultured marble manufacturing industry consists of about 35 plants producing nearly 40 million pounds of material a year. These plants are all custom manufacturers and account for nearly all of the custom material installed in Arizona. Ready made bathroom counter tops and bathtubs sold in chain store home improvement centers are imported into Arizona, primarily from Southern California. Arizona cultured marble producers range in size from a single person operation, producing and installing less than 4,000 pounds of cultured marble fixtures, to the largest, with over 200 employees and producing over 4,000 tons of cultured marble products. Most, but not all, of the Arizona manufacturers produce some cultured onyx, with the product typically representing 10 to 20 percent of their business. A lesser number produce cultured granite. Cultured onyx and cultured granite are considered premium products and sell at higher prices.

The cultured marble industry is a volatile segment of the residential and commercial construction industry. The manufacture of cultured marble type products is labor intensive and start up costs for a small manufacturer are limited. Thus manufacturers may begin or go out of business as the market fluctuates.

The year 1990, for which this data was compiled, represents a year for which the Arizona residential and commercial construction industry was in the middle of a slowdown phase. It represents neither a peak or a low in the cycle.

Locations of cultured marble plants in Arizona.



MAP SYMBOLS

x - Single plant

(3) - Areas/cities with number of plants indicated.

INDUSTRIAL MINERALS IN CULTURED MARBLE

Table 1 lists the typical quantities of industrial minerals consumed by Arizona's cultured marble manufacturers on an annual basis for 1989-1990. The data for this table and for Table 2 was compiled from personal interviews with all but one of the State's manufacturers. Totals include estimates for that one manufacturer.

Table 1. Industrial minerals used in Arizona's cultured marble industry
(Typical annual consumption)

Commodity	**Quantity** (short tons)
CALCIUM CARBONATE	12,700 tons
PERLITE	50 tons
MANUFACTURED LIGHTWEIGHT FILLER	50 tons
HYDRATED ALUMINA	1,000 tons

The cultured marble product is primarily made up of calcium carbonate mineral filler bonded together with polyester resins. Mineral pigments, typically paint pigments and white titanium dioxide, are added for color and pattern. Rock chips may also be added for special effect. To obtain the translucence required for cultured onyx, hydrated alumina is used as the filler instead of calcium carbonate. Calcium carbonate is used in the form of ground white limestone or ground white marble. Hydrated alumina is a manufactured product made from alumina recovered from ores of aluminum.

Although calcium carbonate is the primary filler used for cultured marble, there may be other usable minerals. Any properly ground, water resistant, white to slightly gray-white mineral of relatively low abrassiveness that is compatible with the resins used, could be substituted for calcium carbonate. Any substitute mineral considered would have to be available at a comparable price or provide some significant physical or marketing advantage.

Some manufacturers are attempting to produce a light weight matrix using either hollow glass microspheres or expanded popped perlite in place of some of the calcium carbonate. Their objective is to produce an item weighing up to 33 percent less. Those manufacturers interviewed that were producing a light weight product were either using glass spheres with success or experimenting with perlite as a less expensive alternative to the spheres.

Hydrated alumina is used in place of calcium carbonate in the matrix when producing cultured onyx. The primary difference between cultured onyx and cultured marble is the translucence of the finished onyx product. The use of hydrated alumina instead of calcium carbonate as the filler is the most important manufacturing feature in obtaining translucence. Characteristics of hydrated alumina that enhance translucence are probably its index of refraction, particle size, and color when encapsulated by resins. The particle size distribution and index of refraction for a hydrated alumina blend used for cultured onyx is given in Table 2.

Table 2. Properties of hydrated alumina as a cultured onyx filler

Property		Quantity
Median particle diameter (microns)		35
% less than 10 microns		4
Bulk density - loose (gm/cm^3)		1.0
Bulk density - packed (gm/cm^3)		1.2
Specific gravity (gm/cm^3)		2.42
Surface area (m^2/gm)		0.5
Index of refraction		1.57
Screen analysis (Tyler Standard Screen)		
Retained on	Percentage	
100 mesh	0 - 1	
200 mesh	5 - 10	
325 mesh	30 - 65	

Hydrated alumina may have a natural mineral substitute. Nearly any ground natural mineral that could sustitute for hydrated alumina is likely to be available at a lower price. Thus there should be considerable incentive to find such a mineral. Possible substitutions to consider include: feldspar, nepheline syenite, fluorite, silica, and brucite. Some of the cultured onyx manufacturers have expressed a willingness to experiment with any mineral material submitted to them.

The industrial minerals used in cultured marble manufactured in the state are described in the remainder of this chapter. All must conform to detailed specifications. Most are finely ground. Larger mineral particles are used in cultured granite and for special effects in cultured marble.

Price ranges are given when available to help estimate the size of the market. All prices include freight delivered to the user unless otherwise specified. Lowest prices are often those paid by warehouses and the largest bulk users while the highest prices are often in quantities of single pallet loads or single bags. Most material is supplied in 50 pound bags and most, but not all prices, are for bagged material.

Those interested in developing new sources of these minerals should be fully aware of the idiosyncrasies of the industrial minerals industry. Suppliers of minerals to the cultured marble industry are expected to provide sufficient technical data and support to consumers to tell them how to use their product. Past attempts to produce mineral fillers in Arizona suitable for use by cultured marble manufacturers have failed. Product quality and cleanliness have been the obvious problem areas, but lack of understanding of the consuming industry is often the real problem.

CALCIUM CARBONATE

Calcium carbonate accounts for over 95 percent of the mineral filler used by Arizona's cultured marble manufacturers. It makes up 60 to 80 percent of the cultured marble matrix. Calcium carbonate supplies volume solids at a low cost.

Calcium carbonate for cultured marble use is available in several particle sizes and from a number of mining companies/suppliers. A dozen or more different sizes and specifications are used by the Arizona industry. Table 2 lists quantities of calcium carbonate used by product size specifications.

Manufacturers pay anywhere from a little less than 3 cents a pound ($60.00 per ton) to nearly 8 cents a pound ($160.00 per ton) for calcium carbonate delivered to their plants. All but one or two Arizona users receive their material in 50 pound bags. Sources of calcium carbonate currently used in Arizona are Lucerne Valley and Salinas in California and Wheatland, Wyoming. Transportation costs from mines in California to users in Arizona range from $30 to $45 per ton. Transportation from mines in Wyoming range from $50 to $80 per ton. Each Arizona cultured marble manufacturer has a favorite blend and source; price is less a factor than is the user's contentment with their current source.

A major concern of all manufactures is the cleanliness of the calcium carbonate. Any form of color contamination is a problem. Dark particles are a particular nuisance as they show up in the finished product looking like pieces of dirt embedded in the marble. Although natural marble always contains natural imperfections and included particles of other minerals, purchasers of cultured marble products expect them to be perfect.

There are a number of possible sources of dark particle contamination. The limestone or marble deposit may contain dark material that can range from small dark inclusions to major dark structures. Selective mining is required to avoid both. Wear particles of clean metal or rust, scale, and corrosion particles from machinery can be a form of contamination. Metal and rust particles are denser than the cultured marble matrix and sink to the bottom of the mold. When the curing process is complete these particles are exposed on the finished surface. An especially frustrating form of contamination is particles of rubber worn off conveyor belts. Such particles swell upon contact with the polyester resin.

Three forms of white calcium carbonate are used by cultured marble manufacturers. All are probably interchangeable. They are: naturally precipitated limestones, crystaline marble, and white dolomite (that contains some magnesium carbonate). Some manufactures have expressed a preference for ground crystalline marble because of its lower resin absorbtion as they can therefore use less $1.00-a-pound resin and more 8 cent-a-pound filler for the same piece of work. Other basis for choices have been slight differences in color of the matrix, availability of a particular particle size, and perceived or real concerns about contamination and availability.

Table 3. Calcium carbonate materials used in Arizona's cultured marble industry.
Typical annual data for 1989 - 1990

Material Used	Short Tons
Minus 30 mesh	4338
Minus 100 mesh	919
Minus 325 mesh*	867
Supplier mixes	3761
Marble chips and sand - various size ranges	2778
Miscellaneous - data not available or specified	51
TOTAL	12,714
* U.S. sieve mesh 325 is approximately 44 microns	

A typical specification for fine ground calcium carbonate used in the manufacture of cultured marble is shown below:

Typical Chemical Analysis (Calcium Carbonate)

$CaCO_3$	minimum	97-98 %
$MgCO_3$		1 %
Acid insoluble		2 %

Typical Particle Size Distribution

Retention on 325 mesh screen <1 %
Mean particle size 10 Microns
Percentage by weight finer than:

Microns	%
44	90
20	50
15	40
5	13
2	8

Typical Physical Characteristics

Dry brightness	91
Gallons per pound	0.0445
Pounds per gallon	22.5
Specific gravity	2.71
Moisture	less than 0.20 %
pH	9.5
Oil absorption	8

A typical specification for coarse ground calcium carbonate used in the manufacture of cultured marble is shown below:

Typical Chemical Anaysis

$CaCO_3$	minimum 97 %
$MgCO_3$	1.7 %
SiO_2	1.0 %
Al_2O_3	0.5 %
Fe_2O_3	0.05 %
Moisture	0.2 %
Loss On Ignition	42.8 %

Typical Particle Size Distribution
Percentage by weight retained on:

U S Mesh	%
30	1.0
40	12
50	28
70	42
100	64
200	74

Typical Physical Characteristcs

Brightness	84
Tapped Density lb/cu ft	112
gm/cc	1.79
Apparent Density lb/cu ft	77

SILICA

Fine ground quartz, ground microcrystalline silica, and clean fine quartz sand have been mentioned as a possible filler for cultured marble products by a few of the manufacturers interviewed. In particular, it is believed that quartz is being using as the filler for a polyester resin-mineral filler matrix for outdoor cultured marble statuary.

There are advantages and a possible disadvantage to the use of ground silica in some cultured marble applications. Its high purity and neutral pH make it virtually non-reactive with other chemical compounds. Ground silica is non- chalking and unaffected by exposure to ultraviolet light. Its use in the cultured marble matrix could improve the weatherability of products that are exposed to sunlight, rain, landscape watering, and treated water used in decorative fountains and swimming pools. In such applications it would replace some or all of the calcium carbonate. A disadvantage to the use of ground silica is its abrassiveness on mixing and handling equipment during the manufacturing process.

A typical specification for fine ground quartz, ground microcrystalline silica, or clean fine quartz sand would require a very clean product devoid of any mineral material that might cause discoloration of the matrix. Depending on application either milky white or water clear material would be needed. Applications could require particle sizes as large as 16 mesh or as small as 10 microns.

FELDSPAR AND NEPHELINE SYENITE

Both feldspar and nepheline syenite might be usable by some cultured marble manufacturers as a substitute for hydrated alumina in cultured onyx. They might also be usable in applications as a replacement for silica. Translucence and other optical properties need to be investigated for these applications. It is expected that either feldspar or nepheline syenite would be chemically inert in typical resin systems used in making the cultured onyx matrix.

Like silica, ground feldspar is non-chalking and unaffected by exposure to ultraviolet light and weather. Also like silica, its use in the cultured marble matrix could improve the weatherability of products that are exposed to sunlight, rain, landscape watering, and treated water used in decorative fountains and swimming pools. In such applications it would replace some to all of the calcium carbonate. Like silica, a disadvantage to the use of ground feldspar and nepheline syenite is its abrassiveness (though not as hard as silica) on mixing and handling equipment during the manufacturing process.

Typical specifications for fine ground nepheline syenite and feldspar are shown below:

Typical Physical Properties

	NEPHELINE SYENITE	FELDSPAR
Brightness (green filter)	94	95
Oil absorption (rub-out) ASTM D-281-31	22-23	18-19
Hegman grind	3 - 4	3 - 4
pH	9.9	9.3
Coarseness (microns)	44	44
Mean particle size (microns)	7.5	8
% finer than 74 microns (200 mesh)	100	100
% finer than 44 microns (325 mesh)	99.98	99.95
% finer than 30 microns	98	94
% finer than 20 microns	92	88
% finer than 10 microns	65	60
% finer than 5 microns	37	30
Surface area (m^2/g)	0.9-1.0	1.0-1.3
Specific gravity	2.61	2.60
Weight per solid gallon (lb/U.S. gal)	21.7	21.6
Bulking value (U.S. gal/lb)	0.0459	0.0463
Apparent bulk density (lb/cu ft), loose	58	40
Apparent bulk density (lb/cu ft), packed	70	60
Moisture content (%)	0.1	0.1
Refractive index, average	1.53	1.53
Hardness (MOHS)	5 1/2-6	6-6 1/2
Particle shape	Nodular	Nodular

MICA

Mica could be used as a special effect pigment in cultured marble to impart a reflective sparkle and provide luster effects. The cultured marble systems would take advantage of the ground mineral's platy structure. Such effects are currently supplied by plastic "glitter." Thin laminar mica flakes between 40 and 16 mesh and of a bronze or golden color would probably be most usable. Many of the smaller cultured marble producers have expressed a willingness to experiment with nearly any filler or pigment.

PERLITE

Perlite is ground, expanded, and sized when used as a light weight filler to produce a lighter weight cultured marble. As previously discussed, large cultured marble fixtures such as bathtubs are quite heavy.

Most manufacturers of lightweight cultured marble use hollow glass beads. A few use sized, popped perlite. They are attempting to produce a light weight matrix using either the hollow glass microspheres or the expanded popped perlite in place of some of the calcium carbonate. Their objective is to produce an item weighing up to 33 percent less. Those manufacturers interviewed that were using perlite were experimenting with it as a less expensive alternative to the spheres. Perlite used in cultured marble must be very white when expanded and expand into competent "popped" particles.

CONCLUSIONS

Arizona's cultured marble industry uses a large quantity of industrial minerals, primarily limestone, as fillers. Nearly all of these are currently imported into Arizona. Deposits of these minerals, in particular, limestone, marble, dolomite, and perlite are known in Arizona. Occurrences of mica, feldspar, silica, and brucite, minerals that might also be used in cultured marble, are known in Arizona. The consumption of these minerals in cultured marble together with other industries might be sufficient to justify a small specialized multimineral producer operating a number of small mines, each producing a specific mineral, but utilizing a common grinding/processing plant. The calcium carbonate and additional minerals that might be used in cultured marble have nearly the same specification as those used in Arizona's paint and wallboard joint cement industries. Thus a multimineral producer could produce for more than one Arizona industry. Further, Southern California is a large market for industrial minerals in wallboard joint cement, paint, glass, asphaltic roofing materials, and other industries. It is expected that investigation of other industries in Arizona and Southern California will yield consumption data that will produce totals of sufficient quantities to justify development of new mines in Arizona.

Detailed information on deposits of industrial minerals in Arizona may be obtained from the Arizona Department of Mines and Mineral Resources.