INDUSTRIAL MINERALS IN ARIZONA'S PAINT INDUSTRY

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ABSTRACT

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

The Arizona paint industry uses a larger variety of industrial minerals as extender pigments and functional fillers than any other Arizona industry. Minerals used include limestone, kaolin, silica, diatomaceous earth, feldspar, bentonite clay, talc, attapulgite clay, mica, pyrophyllite, barite, perlite, nepheline syenite, and pumice. More than 10 million pounds of minerals, with a value in excess of two million dollars, are imported by Arizona annually for use in manufacturing paint. Deposits of most of the minerals discussed in this report are known to exist in Arizona. Since a number of these minerals are not currently produced here, a market for local material exists.

The development of mines and the production of these minerals in Arizona would aid the state's economy. Additionally, these minerals could be available to manufacturers in Arizona, California, and other southwestern states at lower prices due to savings in transportation costs.

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Development Potential in Arizona

An 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.

Paint in General

The paint industry, more properly referred to as the coatings manufacturing industry, is an important consumer of ground industrial minerals in Arizona. Paint is generally divided into industrial coatings and architectural coatings (also known as "trade sales") coatings. Industrial coatings include such paints as automotive, highway striping, and appliance paints, while architectural coatings include interior and exterior house paint, whether used for homes, office complexes, or factories.

For the purpose of explanation, the composition of paint can be divided into a solid portion and a liquid portion. The solids are referred to as the pigment and the liquid portion is referred to as the vehicle. The pigment portion includes both hiding and extender pigments as well as any mineral matter used for flatting or other purposes. It is the pigment portion of the paint formulation and, more importantly, the extender pigments that are of interest to the potential development of mineral resources in Arizona.

The vehicle is the complete liquid portion of the paint. Normally it consists partly of non-volatile matter and partly of volatile matter. The non-volatile portion of the vehicle is the vehicle solids which is the binder or film former. The volatile portion is the solvent or diluent. The vehicle is nearly always a combination of manufactured organic chemicals with or without added water. Generally these chemicals do not contain industrial minerals.

Paints may also be classified as alkyd resin "oil" base or water emulsion resin "water" base (also called latex paint). Oil base paints use one or more hydrocarbon solvents, while water base paints use water as the solvent. Most paint is now formulated in dispersers (high speed mixers), while a small amount, especially some industrial paints, are still ground in pebble mills or sand mills. Dispersers do not cause any particle size reduction to the paint ingredients; therefore industrial minerals to be used in most paints must be supplied to the paint manufacturer to meet very rigid fine particle size requirements.

Pigments

Pigments are divided into hiding pigments and extender pigments. Hiding pigments are those that provide hiding ability and color. Extender pigments extend the hiding ability of the hiding pigments, add bulk to the paint formulation, and impart a number of other characteristics to both the liquid formulation and the final coating film.

Hiding pigments include both natural mineral pigments and manufactured organic and inorganic chemical compounds. They are further divided into color pigments and white pigments. The red, yellow, brown, orange and black iron oxides (minerals; hematite, limonite and magnetite) are the predominant natural mineral pigments used in paint. They may also be produced synthetically. Ultramarine blue was at one time ground lapis lazuli, but has long been made synthetically. Other inorganic color pigments are manufactured iron, zinc, chromium, cadmium, lead, or molybdenum compounds. Additionally, there are a large number of manufactured organic color pigments. The strongest white pigment is titanium dioxide an inorganic chemical manufactured from the titanium minerals rutile and ilmenite. Titanium dioxide is the most highly used hiding pigment in the paint industry. Other, less frequently used white pigments, are manufactured inorganic compounds of lead, zinc, or antimony.

The red iron oxide, hematite, a natural mineral color pigment, has been mined in Arizona for use in paint. Efforts in Arizona to produce red mineral pigment from hematite have not yet been fully successful. The intensity of marketing required, and the need to produce a product that meets industry approval cannot be over emphasized. Mean particle size, particle size distribution, purity, color strength, resistance to fad-

ing, and consistency from one production batch to another are very important.

Deposits of minerals that can be mined as hiding pigments exist in the state. Mica and pyrite have previously been mined for this purpose. Additionally, numerous deposits of "micaceous" hematite (specularite) and magnetite occur in Arizona.

An often-repeated comment by the paint manufacturers interviewed relates to the current shortage and high prices of titanium dioxide. Many asked about Arizona's potential to produce the product. Arizona does have occurrences of the titanium minerals ilmenite and rutile. Known placer concentrations of ilmenite and titaniferous magnetite have been described. Further, low, but possibly economically recoverable concentrations of rutile occur as a by-product in the state porphyry copper ores. Research may be justified to evaluate Arizona's titanium resources relating to their availability and acceptability to feed a titanium dioxide plant. Such a plant is a major industrial development and a decision to install such a plant is only slightly related to local availability of raw materials.

Arizona's Paint Industry

Arizona's paint manufacturing industry consists of 13 to 16 plants producing over 4 million gallons of coatings a year. These plants manufacture about 30 percent of the paint consumed in the state. Eight plants produce architectural water emulsion resin latex paints; 1 produces industrial coatings, and 4 produce some combination of coatings products. Specialty coatings such as swimming pool paint, highway striping paint, and antiskid floor paints are included. At least four of the plants are Arizona operations of larger national or southwestern-based paint companies.

Commodity	Quantity		Prices paid by consumers			
	Pounds	Tons	Minimum		Maximum	
			cents/lb	$/ton	cents/lb	$/ton
LIMESTONE	4,800,000	2,400	2.4	48	12	240
KAOLIN	2,000,000	1,000	6.7	134	48	960
SILICA	1,600,000	800	16.4	328	21.3	426
DIATOMACEOUS EARTH	810,000	405	27.6	552	29.6	592
FELDSPAR	490,000	245			16.6	332
BENTONITE CLAY	420,000	210				
TALC	400,000	200	5.08	102	18.8	376
ATTAPUGITE CLAY	140,000	70	10.4	208		
MICA	130,000	65	11.9	238	71	1420
PYROPHYLLITE	<100,000	<50				
BARITE	<50,000	<25			24.1	482
PERLITE	Combined total of 26,000 lb to avoid disclosing individual company data.					na
NEPHELINE SYENITE					18.2	364
PUMICE						na

Table 1. Industrial minerals used by Arizona's paint manufacturers – typical annual consumption.

Industrial Minerals in Paint

Arizona paint manufacturers consume at least 14 different industrial minerals as extender pigments or functional fillers. Table No.1 above lists all 14 by descending order of use.

Typical price ranges are given to help estimate the size of the market. 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 prices are for bagged material.

A majority of the industrial minerals used in paint manufactured in the state are described in the remainder of this chapter. All are very finely ground and must conform to detailed specifications. Some are interchangeable in certain uses.

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 paint industry are expected to provide sufficient technical data and support to consumers to tell them how to use their product.

Calcium Carbonate

The most used extender pigment in paint is calcium carbonate, primarily as fine ground white limestone or marble. All grades are finer than 325 mesh. Calcium carbonate supplies volume solids at a low cost; at about $1.35 per gallon, it is the cheapest ingredient in paint. It is used extensively in interior and exterior latex paints, particularly in pastel colors.

Dark color exterior paints can use only limited amounts because of calcium carbonate's tendency to "frost" or "chalk" when repeatedly wetted by rain or sprinklers. Such chalking gives the appearance of color fading, though in fact it is the calcium carbonate particles breaking down at the exposed surface and diluting the color pigment. In dark colored exterior latex paints ground silica or ground feldspars are used in place of a portion of the calcium carbonate.

Nearly all of the ground limestone used by Arizona paint manufacturers is imported from Lucerne Valley in southern California. The cost of shipping ground limestone from Lucerne Valley to Phoenix area manufacturers is approximately $25.00 per ton in bulk trucks.

Calcium carbonate for paint use is typically available in 5 or 6 average particle sizes:

0.75 microns
4 microns
5 microns
8 microns
10 microns
15 microns
(U.S. sieve mesh 325 is approximately 44 microns)

The Hegman grind gage is typically used to denote the largest size particle size in a particular grind. Hegman grinds of 3 and 4 are used in flat paints, 7 grind is used in full and semigloss paints. Whiteness is preferred to be 95 or better on the G.E. scale, but much material in the low 90's is used. If cheap enough, material with a brightness as low as the mid 70's can be used in some paints.

Calcium carbonate has essentially no hiding power, that function being accomplished primarily by titanium dioxide. Precipitated calcium carbonate is a manufactured product that is becoming more popular in place of ground natural calcium carbonate. It is extremely pure, has tightly controlled particle size and shape, and some hiding power.

A typical specification for fine ground calcium carbonate is shown below:

Typical Chemical Analysis

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

Typical Particle Size Distribution

Retention on 325 mesh screen	Nil
Mean particle size	6 Microns
Percentage by weight finer than:	
Microns	%
30	99.8
20	97
10	75
6	50

Typical Physical Characteristics

Brightness	93
Gallons per pound	0.0445
Pounds per gallon	22.5
Specific gravity	2.71
Moisture	less than 0.20%
ph Factor	9.5
Oil absorption	11
Hegman grind	5-6

Kaolin

Kaolin, also known kaolin clay or kaolinite, and sometimes referred to as china clay or aluminum silicate, is an extender pigment that has some hiding power, more if calcined. It is second to calcium carbonate as an extender pigment in paint. Its hiding power is a result of the

delaminated clay particles piling up and overlapping. As an extender in paints it is chemically inert, has a high covering power, gives desirable flow properties, is low in cost, is white, and reduces the amount of expensive white and color pigments required. In addition, it has excellent suspension properties and is available in a wide range of particle sizes that can be used in many types of paints. For example, coarse-particle kaolins are used in paints where a dull or flat finish is required, and fine-particle kaolins are used in high-gloss paints.

Large quantities of calcined kaolin and hydrous kaolin are used in interior flat wall paints and in metal primers. Water-beneficiated grades of kaolin disperse easily in water and are, therefore, particularly suited to latex paints manufactured in high speed dispersers. Some kaolin is chemically treated to make it organophilic or hydrophobic and thereby suitable for use in exterior oil-base paints. Paint manufacturers are using calcined kaolin, because of its resistance to abrasion and dry covering properties, in increasingly large quantities. Calcined kaolin is an excellent extender for titanium dioxide, the leading paint pigment, particularly in latex types. Its use reduces costs and simplifies the formulation of the paint.

Nearly all of the kaolin clay used by Arizona paint manufacturers is imported from the Georgia/Florida area of the southeastern United States. The cost of shipping kaolin clay from the southeast U.S. to Phoenix area manufacturers is approximately $90.00 per ton in truckload quantities.

A typical specification for fine ground kaolin is shown below:

Typical Chemical Analysis

$Al_2 0_3$	38.8 %
$Si0_2$	45.2%
Na_2O	0.05-0.3 %
$Ti0_2$	0.6-1.7%
CaO	0.02%
Fe_2O_3	0.3-0.9%
MgO	0.03 %
K_2O	0.05-0.2%
Loss on ignition	13.6-14.2%

Typical Particle Size Distribution

Retention on 325 mesh screen	0.15%
Mean particle size (Equivalent Spherical Diameter)	4.8 Microns
Percentage by weight finer than:	
Microns	
20	99+
10	85
5	50
2	21

Typical Physical Characteristics

Physical form	Highly Pulverized Powder
Brightness	79-82
Gallons per pound	0.047
Pounds per gallon	21.5
Specific gravity	2.58
Moisture	less than 1.0%
ph Factor	3.5-5.0
Oil absorption	30-35
Hegman grind	4+
Refractive index	1.56
Bulk density (Loose)	24 lbs/cu ft
" " (Tamped)	45 lbs/cu ft

Silica

Fine ground quartz, or ground microcrystalline silica, is used as an extender pigment, particularly in exterior latex paints. Its high purity and neutral ph make it virtually non-reactive with other chemical compounds. In paints it provides flatting with uniformity of gloss and sheen over surfaces of varying porosity and texture, while providing uniform suspension and complete pigment dispersion. Ground silica is non-chalking and unaffected by exposure to ultraviolet light and therefore improves the weatherability of exterior paints when used in place of some of the calcium carbonate.

Nearly all the ground silica used by Arizona paint manufacturers is imported from Illinois. The cost of shipping ground silica from Illinois to Phoenix area manufacturers is in the range of $50 to $70 per ton in truckload quantities.

A typical specification for fine ground silica or quartz is shown below:

Typical Chemical Analysis

$Si0_2$	98.6 %
$Al_2 0_3$	0.70 %
Na_2O	0.03 %
TiO_2	0 .05 %
CaO	0.04 %
Fe_2O_3	0.05 %

MgO	0.04 %
K_2O	0.05 %
Loss on Ignition	0.44 %

Typical Particle Size Distribution

Retention on 200 mesh screen	0.06%
Mean particle size (Equivalent Spherical Diameter)	4.8 Microns
Retention on 325 mesh screen	1.20 %
Retention on 400 mesh screen	2.30%
Retention on 500 mesh screen	4.70 %

Typical Physical Characteristics (Silica)

Brightness	85
Gallons per pound	0.045
Pounds per gallon	22.1
Specific gravity	2.65
Moisture	0.25 %
ph Factor	6-7
Oil absorption	27-31
Hegman grind	4+
Refractive index	1.54-1.55
Bulk density (Loose)	27-29 lbs/cu ft
Hardness (MOHS)	7.0
Specific surface area	5.2 m^2/gm

Diatomaceous Earth

Diatomaceous earth is an extender pigment primarily used as a flatting agent. Because of the physical structure of the individual particles making up diatomaceous earth, they lay in a random, three-dimensional pattern that stiffens, reinforces and improves the durability of the filled paint system. The variety of shapes also provides low density and high absorption. The effective density of diatomaceous earth fillers is among the lowest of any mineral fillers at 1.98 to 2.33 grams per cubic centimeter. Diatomaceous earth occupies up to 30 % more volume per pound than most other filler minerals. This advantage is critical in those applications requiring light weighting.

A typical specification for fine ground diatomaceous earth or diatomite is shown below:

Typical Particle Size Distribution

Retention on 325 mesh screen	3.0%
Mean particle size (Equivalent Spherical Diameter)	5.2 Microns

Typical Physical Characteristics

Color	Cream
Brightness	72
Specific gravity (Effective)	2.2
Moisture	6.0%
ph Factor	6.5-8.5
Water absorption (weight %)	250
Oil absorption (weight %)	180
Hegman grind	4
Specific surface area	4.5 m^2lgm

Bentonite Clay

Bentonitic clays are used as thixotropic agents due to their gelling ability. Bentonite is typically classified as an additive instead of an extender pigment. Its use inhibits running or sag in the application of the coating.

Attapulgite Clay

Attapulgite clay is used as a thickener and/or thixotropic agent that aids in spreadability of the final product and the holding of ingredients in suspension.

Nearly all of the attapulgite clay used by Arizona paint manufacturers is imported from the Georgia - Florida area. The cost of shipping attapulgite clay from the southeast U.S. to Phoenix area manufacturers is approximately $90.00 per ton in truckload quantities.

Feldspar and Nepheline Syenite

Both feldspar and nepheline syenite are used by some paint manufacturers as a substitute for ground silica in those paints requiring an economical replacement of calcium carbonate in exterior applications.

Fine ground feldspar and nepheline syenite are used as an extender pigment, particularly in exterior latex paints. As with ground silica, it provides flatting with uniformity of gloss and sheen over surfaces of varying porosity and texture, while providing uniform suspension and complete pigment dispersion. Ground feldspar is non-chalking, unaffected by exposure to ultraviolet light, and contains very little free silica. Ground nepheline syenite contains no free silica. Both improve the weatherability of exterior paints when used in place of some of the calcium carbonate.

All of the ground feldspar and nepheline syenite used by Arizona paint manufacturers is imported from the east coast of the U.S. or eastern Canada. The cost of shipping ground feldspar and nepheline syenite to Phoenix area

manufacturers is in the range of $80 to $110 per ton in truckload quantities.

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

Typical Physical Characteristics

	Nepheline Syentite	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/Ib)	0.0459	0.0463
Apparent built density (lb/cu ft), loose	58	40
Apparent bulk density (lb/en ft), packed	70	60
Moisture content (%)	0.1	0.1
Refractive index, average	1.53	1.53
Hardness (MOHS)	5-6	6-6
Particle shape	Nodular	Nodular

Talc

Talc is a common extender pigment. Its platy grain structure improves the covering ability of the paint.

Most of the ground talc used by Arizona joint cement manufacturers is imported from Montana. The cost of shipping ground talc to Phoenix area manufacturers is approximately $55 per ton in truckload quantities.

A typical specification for fine ground talc is shown below:

Typical Chemical Analysis

SiO_2	61.2%
MgO	31.7%
Al_20_3	0.7 %
GaO	0.19%
Fe_2O_3	1.1%
Acid solubles	1.9 %
Loss on ignition	5.0%

Typical Particle Size Distribution

Retention on 325 mesh screen	nil
Mean particle size (Equiv. Spherical Diameter)	2 microns

Typical Physical Characteristics

Dry Brightness (G.E.)	90.5
Gallons per pound	0.0445
Specific gravity	2.70
ph Factor	8.8
Oil absorption	50
Hegman grind	6+
Bulk density (Loose)	6.7 lbs/cu ft

Wollastonite is not currently (1989) used in Arizona's paint manufacturing industry although some are considering its use. Wollastonite is primarily an asbestos replacement. It will provide paint film reinforcement, sag resistance, resistance to cracking, and corrosion resistance.

Mica

Most Mica (wet ground -325, -160, and -100 mesh) is used in paint systems that can take advantage of the ground mineral's platy structure and high aspect ratio (area: thickness). Its particle shape acts to form a barrier in paints and coatings. The smooth surfaces aid in lubrication and luster effects.

Most of the ground muscovite mica used by Arizona joint cement manufacturers is imported from North Carolina or the New England States. The cost of shipping ground muscovite mica from these locations to Phoenix area manufacturers is at least $100 per ton in truckload quantities.

A typical specification for fine water ground muscovite mica is shown below:

Typical Chemical Analysis

Theoretical chemical formula $H_2KAlS(SiO_4)_3$

Typical Physical Characteristics

Color	White and lustrous
Particle Shape	very thin and platy
Nominal particle size	-325, -160, -100 mesh respectively
Chemical activity	Essentially inert except to H_2
Loss on ignition	4-5 %
Pounds per gallon	23.57
Gallons per pound	0.0424
Specific gravity	2.8-3.0
Moisture	0.25 %
Oil absorption	54
Refractive index	1.58
Bulk density (Apparent Loose)	10 lbs/cu ft
Hardness (MOHS)	2.5

Pyrophyllite

Pyrophyllite is used in paints in the same manner as mica.

Perlite

Perlite is used in an expanded, then a ground form, as a lightweight filler. Perlite used in paints must be very white when expanded and expand into competent “popped” particles.

Barite

Barite (called bayrtes in the paint industry) is referred to as a “very hard” extender pigment of very low oil absorption. It is most often used in epoxy-based paints. It also provides excellent water resistance and is used in outdoor paints to protect metal.

All of the ground barite used by Arizona paint manufacturers is imported from Alberta, Canada or the east coast of the U.S. The cost of shipping ground barite to Phoenix area manufacturers is in the range of $65 to $110 per ton in truckload quantities.

A typical specification for fine ground barite is shown below:

Typical Chemical Analysis

Barium Sulfate	minimum 97%
Free Silica	0.03 %
Iron Oxide	0.50%

Typical Particle Size Distribution

Retention on 325 mesh screen	trace
Mean particle size	3 Microns

Percentage by volume finer than:

Microns	%
16	100
11	100
8	95
6	87
4	71
3	51
2	29

Typical Physical Characteristics

Brightness	93
Specific gravity	4.35+
Oil absorption	10 - 10.5
Hegman grind	6.5-7
Color	white

Conclusions

Arizona’s paint industry uses a large variety of industrial minerals, all of which are imported into Arizona. The consumption of a few of these minerals with special properties might be sufficient to justify a small, specialized producer. In general the Arizona paint industry alone does not use a sufficient quantity of industrial minerals to justify development of a producer. Southern California is however, a large market for industrial minerals in paint. Further, very favorable freight rates are available from Arizona to southern California. It is hoped that the investigation of the paint industry in southern California and other Arizona industries 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 Department of Mines and Mineral Resources.