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# CERAMICS

## Introduction

To many people the word "ceramics" brings to mind the familiar wayside pottery with its assortment of stoneware mugs and pitchers, hand-thrown pots, and bright-colored tiles. The ceramic industry, however, includes a far more extensive field; it involves all the silicate industries, bringing into play physics, chemistry, geology, mineralogy, and applied engineering principles, as well as the skill and talent of the designer.

The word "ceramics" is derived from the Greek, "kerames", meaning "potter or pottery", and "kerames" is further related to the Sanskrit word meaning "to burn". Thus a ceramic product is one made of an earthy, non-metallic raw material, requiring a firing operation.

## History

Pottery is known to have existed eight to ten thousand years ago but information concerning ancient ceramic ware is meagre. The first evidences of clay work were found in the region of the Nile Valley in Egypt, where the products were sun-dried and consisted mainly of containers and adobe brick. It has been suggested that the discovery of applying higher temperatures to ceramic ware was accidental, but the date of any such discovery is unknown.

Since ancient time each civilization, including the Greek, Roman, Byzantine, Moorish, and Far-Eastern, has made its contribution to ceramics, but until the eighteenth and nineteenth centuries the main developments were of an artistic nature.

The Renaissance, however, produced Galileo, Copernicus, and Kepler, and with them the advancement of optical glass. About the same time Marco Polo was laying the cornerstone for trade with China, where the highest degree of perfection in the manufacture of porcelain had been attained. The Chinese had been most fortunate in finding a white-burning clay which became the envy of all Europe. It was then that imitations of the white Chinese porcelain began to appear. This was an important step, for with it came the creation of engobe ware, majolica, faïence, and soft-paste porcelain. During this period Holland was producing the blue and white Delft ware, and Germany was excelling in salt-glazed stoneware. The picture would not be complete unless we mention the fine English wares of Wedgewood and Spode. In considering the history of ceramics up to the nineteenth century, one can understand the natural association of art pottery with the word "ceramics".

It was not until the middle of the nineteenth century that the first refractories were manufactured on a commercial basis. Enamels applied to utilitarian products as well as the development of lime-gypsum type plasters are also of recent date. Within the past hundred years there has been continual development in such products as spark-plugs, enameled stoves and refrigerators, glass of all sorts, structural units, and abrasives.

## Clay

Of all ceramic materials clay is by far the most important. It has been defined as "an earthy or stony aggregate, consisting essentially of hydrous silicates and alumina, plastic when sufficiently pulverized and wetted, rigid when dry, and vitreous when fired at a sufficiently high temperature." Clay is not a pure mineral but rather an aggregation of minerals of which kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) is usually a primary constituent. Such minerals as montmorillonite, beidelite, and allophane are clay-like in character and are classified along with kaolinite as clay minerals. Bentonite, for instance, is a clay whose primary constituent is montmorillonite, but those clays used in the ceramic industry are mainly of the kaolinite variety.

Clay is formed by the decomposition of igneous rocks of which granite is a common example. Granite contains feldspar as an essential constituent and feldspar is the mineral from which clay is derived. Temperature changes, water, freezing and thawing, plants, wind, and glacial action disintegrate the original rock mechanically, while water, carbon dioxide, soil acids, and oxygen may react chemically with the rock. The resulting products are mainly kaolin (clay) and silica.

Clays vary both chemically and physically, and several different systems of classification have been set up. In the main the ceramist is acquainted with a few basic but decidedly different types of clays, and it would be well to consider here the more commonly used types.

The so-called common clay includes those varieties which fire to red or buff colors and are usually employed in the heavy clay products industry. The specific uses of common clay are for making common brick, structural units, sewer pipe, etc.

Refractory clays include those types which are capable of withstanding high temperatures. They are often referred to as fire-clays, but the specific uses of each clay usually result in such designations as pot clays, retort clays, and bond clays. Bond clays are very plastic and are generally of the ball clay variety, which is described below. The refractory clays are generally buff-burning, although some white-burning kaolins are employed in making fire-brick. Refractory clays are used mainly for fire-brick and refractory cements.

The whiteware clays are white-burning, light-colored, and fine-grained when fired in the range of cone 4 (2129°F.) These include the kaolins and ball clays and are used in suitable combination with feldspars and flint in the production of dinnerware and electrical porcelain.

Ball clays are fine-grained and highly plastic. They usually contain a varying amount of organic material and for this reason tend to burn to a cream color. The ball clays are used principally as the plastic ingredient in ceramic bodies.

China clays are composed mainly of kaolinite. They are white-burning at high temperatures and light-colored in the raw state. At the same time they are coarser-grained and less plastic than ball clays. The residual kaolins like English china clay and North Carolina kaolin are less plastic but whiter than the sedimentary kaolins, of which Georgia and Florida kaolins are good examples. The china clays are used in dinnerware, wall and floor tile, insulators, etc., and may be sometimes classified under whiteware clays.

Sagger clays are used for kiln furniture (receptacles for holding and protecting ware to be fired) and consist of a mixture of sandy ball clays. Wad clays, which are used as separators between various pieces of kiln furniture, are also made up of sagger clays.

## Processes and Products

Although there is a wide variety of ceramic products, the fundamentals of ceramic production can be boiled down to a few processes. First the clay must be taken from the earth. In some cases it is necessary to remove some of the contained impurities, while

in others the clay may be used as it is found. The choice of procedure depends on the product to be made as well as the natural purity of the clay itself. Washing and screening are the principal methods of purification, although at times electrical methods are employed to remove the iron.

Preparation of the clay mix is the next step and the method used depends on the forming process to be used and the properties desired in the final product. The preparation of the clay consists of adding water and thorough mixing. In Table I the various forming processes are listed.

Table I

| Process | Percent Water | Forming Method |
|---|---|---|
| Casting | 20 - 40% | Poured into molds of Plaster of Paris |
| Soft-Mud | 30% | Thrown into wooden or metal molds |
| Stiff-Mud | 25 - 30% | Extruded from extrusion machine or jiggered |
| Dry-Press | 2 - 18% | Pressed to shape in a hydraulic press |

Cast ware is most dense; soft-mud and extruded or jiggered ware is intermediate; and dry press ware is most porous.

After the ware has been formed, it is then dried as it is essential that the mechanically contained water be driven off before the firing of the ware. Drying may be accomplished in various ways. Waste heat from cooling kilns is often utilized in drying, while common brick are frequently air-dried. In some instances special procedures make use of driers built specifically for the purpose.

Finally the ware is fired to a temperature which has been predetermined by experiment. Some clays have a wide maturing range which allows for a wide variation in firing to obtain a good product, although the heat treatment for a given product always is kept constant to insure uniformity. The firing is done in heated chambers called kilns, which may be updraft, down-draft, or horizontal-draft, periodic or continuous, depending on the type of firing to be done and the amount of ware to be produced.

This description covers briefly the fundamentals involved in producing most ceramic ware, but it must be remembered that a detailed procedure is required for each product. It must also be kept in mind that the above procedure does not apply to the glass, enameling, and abrasive industries.

The following is a classification of ceramic products according to Wilson:

Structural Ceramics

1. Common Brick
2. Paving Brick
3. Face Brick
4. Sewer Pipe
5. Drain Tile
6. Hollow Block
7. Terra Cotta
8. Conduits
9. Roofing Tile
10. Flue Lining
11. Floor Tile
12. Wall and Fireplace Tile

Refractories

13. Fire-clay Brick
14. Magnesia Brick
15. Silica Brick
16. Chromite Brick
17. Bauxite and Diaspore Brick
18. Special Refractories

**Pottery**

19. Tableware
20. Kitchenware
21. Art Pottery
22. Sanitary Ware
23. Stoneware
24. Chemical Porcelain and Stoneware

**Glass**

25. Household
26. Window
27. Bottle
28. Lighting
29. Optical Glass
30. Glazes, Enamels, and Artificial Stones
31. Quartz Glass

**Enameled Metals**

32. Household and Kitchen
33. Sanitary
34. Chemical
35. Advertising

**Abrasives**

36. Silicon Carbide
37. Aluminous Abrasives

**Cements, Limes, and Plasters**

38. Portland Cement
39. Building, Agricultural and Chemical Lime
40. Calcined Gypsum Products
41. Magnesia Cement
42. Dental Cement

**Insulation**

43. Electrical Insulators
44. Thermal Insulators

The broad range of ceramics is shown by the marked contrast between fine chinaware and common building brick, between the porcelain bathtub and the lining for a steel furnace, between the beer bottle and the lens for a large telescope, yet these are all ceramic products. As ceramics reaches into so many phases of our daily life, the growth of the industry in this country reflects the growth of industry in general and growth of population, as well as the development of suitable domestic sources of the raw materials necessary for its varied finished products.

The dollar value of ceramic products in the United States has increased many fold during the past fifty years. The growth of the glass and refractories industries has been especially marked.

In Oregon and the Northwest in general, the ceramic industry is in its infancy. With ceramic materials, as with other non-metallics, local or nearby markets are all-important. In general, such materials will not stand high transportation costs. Therefore, Northwest markets for ceramic products are essential. Industrial growth and the resulting growth in population appear to be assured for the Pacific Northwest. Consequently the ceramic industries in Oregon and Washington will surely grow and expand.

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Esther W. Miller

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# FEDERAL GOVERNMENT REGULATIONS AND THE SMALL MINE OPERATOR

by

A. M. Dixon

There is a lack of materials for all industrial and civilian needs due to the enormous war demands. Therefore, governmental regulation of supply and demand is essential in order to conserve materials and to distribute them to the operations most important in the war program. These regulations seem burdensome and at times unnecessary, but it should be remembered that maximum war production is all important and that all efforts and regulations are concentrated to that end.

Large mining companies are able to maintain a department concerned solely with governmental regulations. The small mine operator, however, must look after such matters himself and is sorely beset at times to know what to do in order to keep his mine a going concern. Most of his problems have to do with procurement, and this article outlines procedures to follow in order to obtain supplies. It also briefly summarizes functions of the various federal agencies in relation to the mineral industry.

All mining operations, including those of sand and gravel, and non-metallic mining as well as metal mines come under W.P.B. Preference Rating Order P-56. The Mining Division of the War Production Board administers priorities to the mining industry. The definition of a mining enterprise is very broad, encompassing all metal, coal, and non-metal underground and surface mining, and exploration. There are also numerous other industries which exploit mineral resources such as sand and gravel, crushed rock, salt production, diatomaceous earth, silica sand, etc. Production of raw material is covered through all processing stages until a salable commodity or product for shipment to a smelter or to a consumer is produced. (i.e. Copper is covered from its natural occurrence underground through mining, milling, and concentrating; sand and gravel are covered through mining, washing, and grading processes until ready for delivery; lime, cement, gypsum, and similar non-metallics are covered through packaging.) However, "hot-mix", concrete mix, fabrication of wallboard from gypsum and the like are not covered by Preference Rating Order P-56.

Priorities are obtained by the following procedures:

(Please note that Controlled Materials Plan Regulation 5 does not apply to mines, and controlled materials cannot be obtained under said regulation.)

1. Preference Rating Order P-56, as amended May 5, 1943, provides:

   a. A rating of A-2 for maintenance, repair, and operating supplies for all mines (no special applications or serial number required). If higher ratings are required, Form WPB-2910 (metal mines) or WPB-1915 (non-metallic mines) should be filed. Never use WPB-541 (PD-1A) unless it is so specified by a particular restricting order as an "E", "L", or "M" order.

   b. Substantial enterprises may be granted serial numbers permitting a quarterly dollar and weight value quota for maintenance, repair, and operating supplies for high priority -- currently AA-1. Applications for serial numbers should be made on Form WPB-1212 for metal mines; on Form WPB-2758 for non-metallic mines; and on Form WPB-2784 for coal mines. The completed forms should be sent to the State Emergency Coordinator of Mines for his certification (in Oregon, Mr. E. K. Nixon, Emergency Coordinator of Mines, Woodlark Building, Portland, Oregon) or to the Regional Technical Advisor, or direct to the Mining Division, Washington, D. C. Form WPB-2952 should be used for core or churn drilling. Quarterly quota applications are made on Forms WPB-2937, WPB-2938, and WPB-2939, formerly the PD-400 series, A, B, and C for metal, coal, and non-metallic mining operations, respectively. These quarterly quotas allot controlled critical materials with a high priority rating to the mining operation. Failure to submit quarterly quota forms will result in cancellation of the mining operation serial number.

2. Form WPB-617, application for permission to begin construction, should not be filed unless so recommended by the field representative of the Mining Division since certain types of construction of new facilities or expansion can sometimes be more expediently authorized under P-56 insomuch as mines are exempt from cost limitations under L-41 where the construction is an integral part of the mining operations. However, in the case of bunk houses, residences, and cook shacks, these are not considered directly connected with the mining operation and authority for such construction is obtained from the Federal Housing Administration field offices having jurisdiction over the location. Mill buildings are considered directly connected with the mining operation. If construction of mining facilities is to be done under P-56, the entire project must be presented to the proper section of the Mining Division, War Production Board, Washington, D. C. Usually, materials are secured by filing a supplementary quota request (Form WPB-2937, metal mines) and application for new material and equipment on Form WPB-2910.

3. Mines may receive emergency priority assistance from the War Production Board field offices. This is the only type of direct priority assistance field offices can give to mines and this is usually only in the case of actual breakdowns which are real emergencies.

4. The Mining Division maintains an expediting unit which gives assistance in obtaining material urgently required for important operations.

5. Under the Access Roads Section of the Mining Division, recommendations are made for construction of roads to mining enterprises where there is shown to be an actual need for the road and that a substantial tonnage of critical metals or minerals can be produced. To initiate an access road to a mineral deposit, Form PR-DA-3 should be obtained from the Public Roads Administration, completely filled out, and returned to them. Most mining properties in this area are located in the National Forest Reserve and when such is the case, the Public Roads Administration works in close cooperation with the Forest Service.

Detailed information concerning access roads within the National Forest can usually be secured from the District Engineer of the Forest Service.

The Public Roads Administration may have the Forest Service build the road after it has been approved or it may be built directly by PRA. After an application has been submitted to the Public Roads Administration and an estimate for the cost of construction submitted to the District Engineer, he will then secure a report from the United States Geological Survey or the United States Bureau of Mines. This report will then be forwarded to his superiors and the Public Roads Administration will send the application to the War Production Board, Washington, D. C. for approval.

Rationing of gas and tires for passenger cars, as well as food, is controlled by the Office of Price Administration, and County Rationing Boards have jurisdiction over these matters. Allotments of gas and tires for trucks, together with purchase of new trucks, are under jurisdiction of the Office of Defense Transportation.

Operating labor problems are in the province of the War Labor Board. Matters connected with hiring labor are under the jurisdiction of the War Manpower Commission and the United States Employment Service.

Use and purchase of explosives are controlled through the issuance of explosives licenses usually handled by County Clerks of the counties in which the mines are located. Regulations governing sale and storage of explosives are made and supervised by the United States Bureau of Mines. Bureau safety engineers make periodic inspections in order to check closely possession and storage of explosives, and on recommendation of the safety engineers, an explosives license may be cancelled. Such cancellation is made if there is evidence that a licensee is not storing, using, or properly safeguarding explosives in his possession.

The Metals Reserve Company, a subsidiary of the Reconstruction Finance Corporation, was formed to expedite production of needed minerals and also to provide a direct market for many of these minerals. The Metals Reserve Company pays through established smelters a premium price on domestic production of copper, lead, and zinc in excess of monthly quotas established by the War Production Board and the Office of Price Administration. A ceiling price for these metals was established by the OPA. The premium payment is the difference between the unit ceiling price and 17¢ per pound f.o.b. Connecticut Valley, copper; 9½¢ per pound New York, lead; and 11¢ per pound East St. Louis, zinc. In order to establish quotas and hence make producers eligible for premium prices, all cases are reviewed by the Metals Reserve Company with the advice of the War Production Board.

The Metals Reserve Company has established ore purchasing depots at various points and will buy directly or through agents certain minerals and ores such as mica, chrome, manganese, tungsten, tin, antimony, molybdenum, quicksilver, and beryllium.

The Reconstruction Finance Corporation makes mining loans and maintains field offices with technical personnel who make examinations of mining properties in conjunction with loan applications.

The United States Bureau of Mines, through its regional offices, examines mines and prospects which may qualify for exploration by the Bureau. Approved projects generally take the form of drilling, trenching, or at times underground work in order to show extent and quality of the ore deposit. Usually, such projects include metallurgical testing work.

In order to conserve manpower and critical materials, gold mines (non-essential) were closed in October, 1942, according to W.P.B. Limitation Order L-208. This order is still in effect. All requests for relief from this order should be made to the Deputy Administrator, Limitation Order L-208, Mining Division, War Production Board, Temporary "R" Building, Washington, D. C.

The Mining Division of the War Production Board maintains an office at 822 Bedell Building, Portland, Oregon with a Regional Technical Advisor in charge, who serves the mining industry in relation to the war effort, particularly to assist in clarifying priority problems.

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## WHAT'S DOING IN THE DEPARTMENT THIS SUMMER

All work of the Department is aimed directly or indirectly at aiding the war effort. During the summer, a considerable portion of the Department's activities has been in connection with the exploration of Coos Bay coal. Three staff members are putting in full time in the district. The job is in charge of John Eliot Allen, chief geologist. Dr. Ewart Baldwin is assisting largely in geologic investigations. Ralph S. Mason takes care of the drilling, purchasing, and supervising of labor. Although the general geology of the Coos Bay district is known, having been published in folio style by the U. S. Geological Survey forty years ago, it has been necessary to work out detailed geology to assist in the current exploration. Stratigraphic studies which should correct minor errors in the older work are under way. In planning the drilling and exploration, emphasis has been placed on finding stripping coal in deference to the manpower situation and because strip or open pit coal can be produced for next winter's use.

Ray C. Treasher, field geologist with headquarters at Grants Pass, has been dividing his time among quicksilver, coal, antimony, copper, and other strategic properties, and has completed in preliminary form compilation of a geologic map of the entire southwest quarter of the State.

N. S. Wagner, field geologist at Baker, has been putting most of his time on an antimony report which, when completed within the next month, will cover all known antimony prospects in the State. He has also been spending some time on base metal properties in the Blue Mountains and on optical calcite in Malheur County.

Dr. H. C. Harrison has kept the M - G set in the spectrographic lab singing full time and overtime on everything from the elements of deep-seated ores to the contents of the stomachs of poisoned cows. Most interesting are Harrison's studies of soil deficiency elements having a bearing on war food production and his analysis of alloy metals. Esther Miller, our ceramic engineer, assists Harrison in the spec lab, is accumulating data and equipment for clay testing, and doing some certain research.

Dr. Wallace D. Lowry, assistant geologist, after winding up in succession a vanadium problem in Coos County and a report on optical calcite in southeast Oregon, has been working the past month on foundry sands. We hope to produce a high enough grade foundry sand to cut down long rail shipments of this product from the middle west to Portland.

L. L. Hoagland has been doing all of the chemical and other analyses possible in our consolidated laboratory at Portland, although handicapped by difficulty of getting contractors to complete the plumbing, electrical and ventilating laboratory facilities.

Mrs. Owen and Mrs. Priestaf run the multigraphing or "printing" part of the establishment, take care of the library, file publications and keep the card indices.

F. A. Steeble handles the accounting, all orders and requisitions, payrolls, and the equipment inventory of the Department.

June Roberts, secretary, does a large part of the typing of the Department and has charge of the correspondence files.

Mrs. Furniss, stenographer, takes care of her share of the correspondence, mailing of bulletins, and desk inquiries.

F. W. Libbey, mining engineer, is acting director in Mr. Nixon's absence. Libbey proof-reads and edits manuscripts, edits the "Ore.-Bin" material, assembles mineral production statistics, and handles many mail and personal inquiries.

Mr. Nixon, in addition to administration, has been giving considerable time to mineral industry phases of the Department's activities. He also handles the largest percentage of the Departmental correspondence. He tries to spend at least one-third of his time in the field.

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## CLEARING HOUSE

78-CH Mrs. Rena L. Culbertson, 703 Oak Street, Hood River, Oregon, wishes to sell one 5-ton "Champion" type quicksilver retort 36 inches in diameter by 8 feet long. Everything complete, price $1500 cash, located on property about 25 miles east of Prineville. Other equipment for sale includes a drill, cars, rails, compressor, and other machinery. The mine, formerly operated by Staley and Culbertson, is also for sale.

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