AR-1

THE MARKET POTENTIAL FOR ALASKAN CLAY PRODUCTS

By
Charles A. Beasley
Mineral Industry Research Laboratory

M. I. R. L.
Report No. 2

THE MARKET POTENTIAL FOR ALASKAN CLAY PRODUCTS

By Charles A. Beasley

Mineral Industry Research Laboratory
University of Alaska
College, Alaska 99735

THE MARKET POTENTIAL

FOR

ALASKAN CLAY PRODUCTS

submitted by

THE MINERAL INDUSTRY RESEARCH LABORATORY

of

the

UNIVERSITY OF ALASKA

to

the

ALASKA DEPARTMENT OF ECONOMIC DEVELOPMENT AND PLANNING

Juneau, Alaska

College, Alaska
January 1965

Charles A. Beasley
Assistant Professor
Mineral Economics

TABLE OF CONTENTS

LIST OF TABLES

FIGURES

APPENDICES

I

INTRODUCTION

This study was originally proposed to the Alaska Department of Economic Development and Planning as part of a continuing effort by the Mineral Industry Research Laboratory of the University of Alaska to strengthen and diversify the mineral industry of the state. While much attention has historically been focused upon exploration for new mineral deposits by various state agencies, the Mineral Industry Research Laboratory recognizes a distinct need to initiate a series of inter-disciplinary studies in mineral economics to describe the utilization environment for presently known mineral deposits. The purpose of such studies is to objectively describe the total geologic, mining, processing and marketing environments which exist for selected mineral commodities.

The intent of such investigation is to enable efficient planning and development by potential investors in mineral based enterprises, and permit optimum development and utilization of the resources of Alaska.

Study Background

The wide distribution of clay deposits and the seemingly simple processing procedures involved in the manufacture of clay products is traditionally responsible for the continuing interest in local manufacture of such products. In Alaska the added stimulants of expanding economic activity, accelerated construction programs due to the recent earthquake, and total dependence upon imported clay products are present. In addition, the joint occurrence in some localities of clay deposits and presently mined coal seams suggests that recovery of clay in the coal mining process could serve to stimulate coal production.

Although several previous attempts to manufacture clay products in the Anchorage area have ended in failure, renewed interest has recently been shown by private groups in re-establishing such an industry.

The Mineral Industry Research Laboratory feels that an objective inquiry into the market potential of clay products within the State is warranted by all the preceding conditions.

Study Objectives

The objectives of this investigations are:

(1) Determination of the entire range of Clay products currently marketed domestically.

(2) Identification of major clay products with present or future significance in Alaskan markets.

(3) Descriptions of the current competitive market environment in which these products must compete.

(4) Quantitization of the market size under present prices and the market increase to be expected under a more favorable price structure due to local manufacture.

(5) Correlation of the demand for finished products with the necessary quantity of clay production, as an indication of the size of mining operation needed.

(6) Determination of the beneficial effect of such clay recovery on the present production of coal which occurs associated with clay deposits.

II

GENERAL STRUCTURE OF THE CLAY PRODUCTS INDUSTRY

Since there are no clay products manufactured in Alaska it is requisite that an investigation into the feasibility of such manufacture begin with a summary of the structure of the industry, its production trends, and future outlook in the United States and Canada.

Industry Structure

The clay products industry in both the United States and Canada is a non-spectacular but very sound and stable industry. Although large multi-product companies do not exist, the industrial base is composed chiefly of many small to intermediate size firms with a limited but specialized range of products. In the United States 1,773 firms supplied structural, refractory, pottery, and related clay products in 1958.(1) In Canada 115 manufacturers supplied heavy clay, refractory and related products in 1961, with numerous additional firms supplying souvenir and art pottery objects. (2)

---

1) Last year reported by Statistical Abstract, 1963.

2) The Canadian Mineral Industry, 1961, Mineral Resources Division, Department of Mines and Technical Surveys, Ottawa, 1963.

The inherent low unit value and wide distribution of the basic clay raw material is chiefly responsible for the large degree of vertical integration characteristic of the industry. The mining of clay raw materials, manufacture of selected clay products, and marketing of these products on either a retail or wholesale basis by an individual company is common practice. Exceptions, however, include fabricators of complex technical ceramics and abrasives in which clay is but a minor constituent.

Production and Trade

Tables 1 and 2 illustrate the non-spectacular but extremely stable production position of the industry in the United States and Canada. It should be noted that while neither exports nor imports are an appreciable portion of total production in the United States, the clay and clay products imported into Canada in 1961 almost equaled the production from domestic sources. Apparent trends are decreasing imports and increasing exports for the United States and stable imports and slightly increasing exports for Canada.

Industrial Concentration

The widespread occurrence of common clay deposits precludes intensive geographic concentration of the industry. Such lack of concentration is supported by the production of clay in 1962 from 48 states, the District of Columbia, Puerto Rico, and widely throughout Canada. Alaska and Rhode Island were the only states not reporting production.

The more limited occurrence of higher quality clays enables designation of broad geographic areas which support specialty

Table 1

Salient Clay and Clay Product Statistics - United States

(thousand short tons and thousand dollars)

Item:	1958	1959	1960	1961	1962
Domestic clays sold or used by producers - - - - - -	43,750	49,383	49,069	47,389	47,797
Value - - - - - - - - - - - -	$ 143,487	159,659	162,411	156,829	163,012
Imports for consumption (clay)	162	176	160	156	132
Value - - - - - - - - - - - -	$ 2,900	3,288	3,103	3,055	2,540
Exports (clay) - - - - - - -	450	489	530	559	617
Value - - - - - - - - - - - -	$ 12,129	13,490	13,714	14,285	16,855
Clay refractories shipments					
Value - - - - - - - - - - - -	$ 162,887	178,632	178,836	166,628	166,095
Clay construction product shipments (Value - - - -	$ 459,700	522,700	488,500	480,300	510,500

Source: Minerals Yearbook, 1962.

Table 2

Salient Clay and Clay Product Statistics - Canada

(thousand dollars)

Item:	1958	1959	1960	1961	1962
Production (total clays-clay prod)	65,400	66,400	59,751	62,881	63,738 (e)
Clays and bentonites - - - - -			1,130	1,275	1,250
Total clay products mfg. from domestic clays - - - - - - -			58,621	61,606	62,488 (e)
Imports (total clays-clay prod.)	44,800	48,100	46,663	47,112	48,264
Clays - - - - - - - - - - - - - - -			4,258	4,682	5,577
Clay products - - - - - - - - - -			42,405	42,430	42,687
Exports: (totl clay-clay prod.)	4,200	5,100	5,265	5,796	5,423
Clays - - - - - - - - - - - - - - -			268	18	56
Clay products - - - - - - - - - -			4,997	5,778	5,367

(e) - estimated

Source: The Canadian Mineral Industry, 1961, Mineral Resources Division, Department of Mines and Technical Survey, Ottawa, 1963.

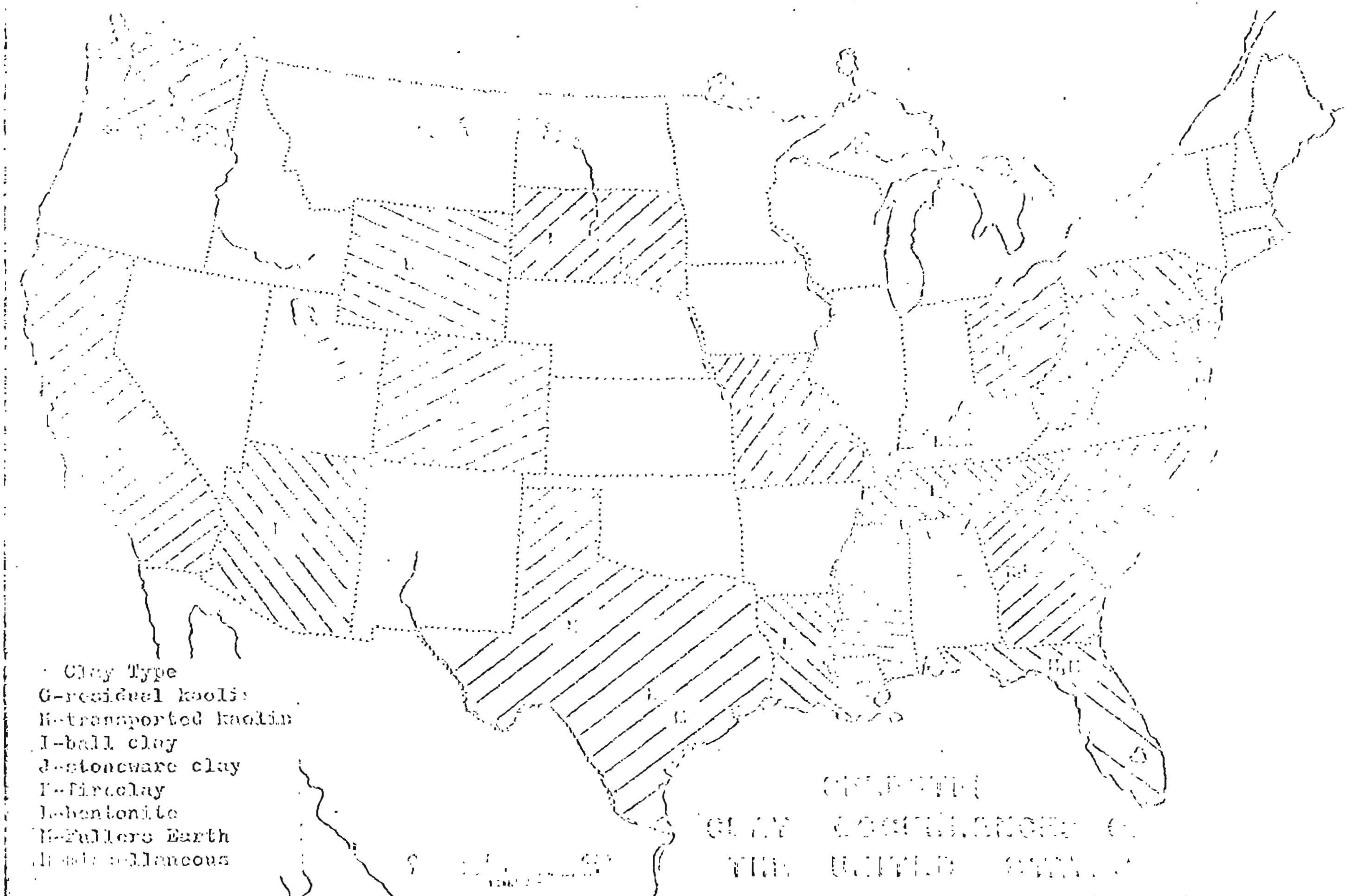
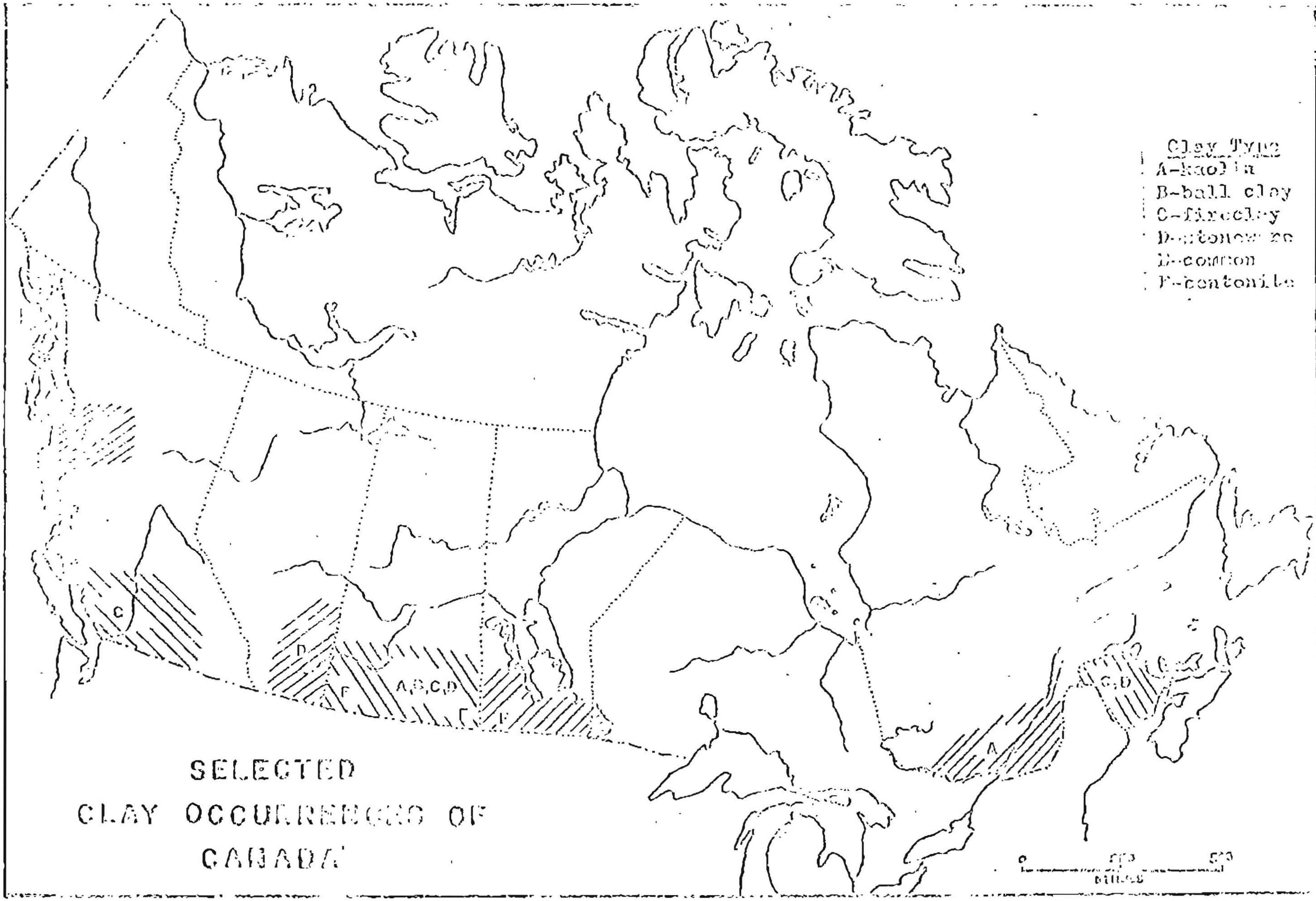

Clay Type
G-residual kaoli
H-transported kaolin
I-ball clay
J-stoneware clay
-fireclay
-bentonite
-Fullers Earth

Figure 1



Clay Type
A-kaolin
B-ball clay
C-fireclay
D-stoneware
E-common
F-bentonite
A
C,D
C
D
F
A,B,C,D
F
SELECTED
CLAY OCCURRENCES OF
CANADA
0
250
500
Miles

Figure 2

clay products manufacture. Figures 1 and 2 give these general production areas for both the U.S. and Canada.

Industry Prospects

The clay industry should continue the modest rate of expansion established during recent years. Although diverse growth trends may be expected for individual clay types possessing unique properties and uses, total clay production should continue to increase. A tendency to expand existing facilities rather than construct new facilities exists in the industry. This is evidenced by the recent expenditures for machinery and equipment as opposed to expenditures for new structures given in Table 3. The current trends toward increased automation and plant mergers should continue for some time into the future.

Table 3
Manufacturers Expenditures for New Plants and Equipment by Industry Subdivisions, 1958-1961

Time Interval and Item	Subdivisions: Total Stone, Clay and Glass Products	Structural Clay Products	Pottery and Related Products
1961:			
Total new expenditures	464,272	W	13,446
New structures and plants	96,593	W	4,826
New machinery and equipment	367,679	W	8,620
1960:			
Total new expenditures	537,650	37,021	11,628
New structures and plants	148,277	12,063	2,983
New machinery and equipment	389,373	24,958	8,645
1959:			
Total new expenditures	537,546	42,725	9,283
1958:			
Total new expenditures	443,178	32,152	10,648

W-withheld since estimate did not meet publication standards

Source: Annual Survey of Manufacturers, 1961, pp. 311.

III

CLAY PRODUCTS AND USES

The number and variety of clay products and the forms of clay utilization are myriad. The purpose of this section is to describe the entire range of clay products manufactured domestically without regard for economic significance, raw material availability, or existence of local markets. It will serve to inform those interested in clay industry development of the many product possibilities which exist. The approach utilized involves identification of the product, description of unique product characteristics, review of pertinent techniques of manufacture, and quantitization of the total domestic importance of the product or use when possible. The individual products or uses are catagorized and discussed as components of the general classifications given in Table 4.

Structural Clay Products

Structural clay products have an almost indeterminate history. With a known history of 12,000 years for certain type units, structural clay products have been a vital engineering material throughout the development of civilization.

Brick

Brick denotes a solid or cored masonry unit of clay or shale, formed commonly into a rectangular shape when plastic, and burned

Table 4

Major Clay Products and Uses

Structural Products	Refractory Products	Whiteware, Earthenware and Stoneware	Fillers, Coatings, and Extenders	Miscellaneous Uses & Products
Brick:	Brick	Whiteware	Fabrics	Ore, fuel, & feed pelletization
Common	Shapes	Tableware	Paint	
Facing	Mortars	Sanitary ware	Paper	Greases
Fire brick	Monolithics	Floor tile	Rubber	Medicines
Special shapes	Special Clays	Insulators	Pesticides	Cosmetics
Floor	Kiln-furniture	Wall tile	Plastic	Leather
Paving	Laboratory Ware	Electrical fixtures	Fertilizers	Soap
Sewer	Molding Sand	Refractory porcelain		Theraputic muds
Other		Chemical porcelain		Water clarification
Tile:		Technical products		
Structural		Earthenware and Stoneware		Leakage prevention
Partition		Household pottery		
Floor and wall		Sanitary ware		Adhesives
Roofing		Art-pottery		Seed coatings
Drain		Decorative ware		Cement manufacture
Architectural terra cotta				Masonry mortar
Sewer pipe				Concrete additives
Sewer liner plates				
Conduit				Radioactive waste disposal
Flueliner				
All-clay block				Aluminum ore
Lightweight block				Drilling-mud
				Petroleum refining

or fired in a kiln. Many types of texture may be imparted to brick by the forming die or by auxiliary attachments which cut, scratch or otherwise roughen the surface. Brick color is greatly variable and is chiefly a function of raw material composition and firing temperature. Brick may possess a natural unglazed surface or be glazed with a wide range of compounded ceramic coatings. Although many types of brick are manufactured, the following are of chief importance in structural applications.

Common brick - often termed building brick, common brick denotes a brick used for building purposes, not treated for texture or color. Individual brick may possess variable color and shape. It is used chiefly for back-up masonry or for exterior walls if uniform appearance is not requisite. The three grades are: SW - for exposure to heavy rainfall and freezing conditions; MW - for exposure to environments containing average moisture and minor freezing conditions; and NW - for exposures to minimum moisture and freezing conditions. Each grade possesses specified physical requirements.

Facing brick - Facing brick are manufactured specifically for utilization in exposed walls. They are commonly treated to obtain desired textures and colors and are generally more uniform in color and size than common brick. The grade catagories include the SW and MW catagories as for common brick in addition to the following: FBX - high mechanical perfection, narrow color range, minimum size variation; FBS - wide range of color and size variation; FBA - non-uniform color, texture and size.

Firebrick - Brick composed of refractory ceramic material which will resist high temperatures. Treated more extensively later under refractory products.

Special shapes - These denote all shapes made for a specific use but which are normally readily available from a majority of manufacturers. They include angle brick, arch brick and round column brick.

Floor brick - Floor brick is a dense, hard, abrasion resistant unit, commonly acid resistant and used chiefly as a finished floor surface for industrial applications.

Paving brick - Utilized where abrasion resistance is requisite, paving brick is a vitrified, dense, hard brick with high compressive strength. It must be noted that the importance of the unit has greatly diminished since the advent of the more common paving materials.

Sewer brick - A shale or clay brick with low absorption properties used in sewer, industrial waste, and storm water conduits. It exhibits high abrasion resistant qualities and is graded according to compressive strength and absorption properties.

Other brick - Many other types of brick products are manufactured including prefabricated brick panel units, small brick veneer units which can be nailed to wooden or equivalent bases, and acid brick used in the chemical industries. In addition, there are numerous brick designations which refer to the size of individual brick units rather than to unique utilization properties. Table 5 gives the more common designations of these units.

Table 5

Nominal Modular Sizes of Brick

Designation	Thickness (in.)	Face Demensions	
		Height (in.)	Length (in.)
Modular	4	2 2/3	8
Engineer	4	3 1/5	8
Economy	4	4	8
Double	4	5 1/3	8
Roman	4	2	12
Norman	4	2 2/3	12
Norwegian	4	3 1/5	12
King Norman	4	4	12
Triple	4	5 1/3	12
"SCR brick"	6	2 2/3	12

After: Technical Notes on Brick and Tile Construction, No. 10 A, Structural Clay Products Institute, Washington, D.C., Sept. 1963.

Tile

Structural tile - Structural tile denotes a hollow or cored burned clay building unit. The two main types of structural tile are designated load bearing or non-load bearing. Load bearing tile is used in masonry walls carrying superimposed loads. It must meet prescribed specifications concerning density, strength, durability and possibly appearance. Load-bearing tile is further divided into, (1) wall tile for the construction of exposed or faced load-bearing walls, (2) facing tile for exterior and interior masonry with exposed faces and, (3) glazed facing tile similar to face tile but having more stringent requirements concerning the exterior finish of the tile. Non-load-bearing tile is used for masonry walls carrying no superimposed load. It is classified as either furring or partition tile and used for lining the inside of exterior walls, for interior partitions or for fire-proofing of structural members.

The large number of structural tile sizes precludes their inclusion here, but they may be readily found in the technical literature.[3]

Structural floor tile - Structural floor tile denotes structural units used in roof and floor slab construction. Dependent upon the type of construction, the tile utilized may be either load bearing or non-load-bearing.

Floor and wall tile - Floor and wall tile are thin, flat, surfacing units used as a covering for floors and walls. Such units may be glazed or unglazed and different types vary in composition, degree of vitrification, and method of manufacture. They are commonly classed according to the degree of imperviousness of surface finish; from nonvitreous to semivitreous, vitreous, and impervious. The composition may be all clay or a mixture of ceramic materials in which clay is but one component along with a filler material (as silica or talc) and a flux or solvent (as feldspar).

The more common types of floor and wall tile are, (1) glazed interior tile, a non-vitreous tile with a blended composition of clay and other ceramic materials, (2) ceramic mosaic tiles, a vitrified unglazed unit with either a natural or blended body, (3) glazed weatherproof exterior tiles with near vitreous and very dense body, (4) quarry tile made from a natural clay or shale body, unglazed and highly imperious to abrasion and moisture.

---

3) Technical Notes on Brick and Tile Construction, Structural Clay Products Institute, Washington, D.C., 1963

(5) pavers similar to mosaic tile in composition but with a larger surface area, and (6) faience tiles manufactured from natural clays with widely varying degrees of vitrification and commonly surfaced with a colored glaze. A large number of sizes and shapes of tile accessories are available.

Roofing tile - Roofing tiles are available in a variety of shapes [(4)] varying from flat to s - curved units. Special shapes are required for fitting and weatherproofing of roofs. The tile is unglazed and produced in all the natural fired-clay colors.

Drain tile - Drain tile usually denotes a round, unglazed, and commonly perforated clay pipe, although other varied shapes are available. Such pipe may have bell and spigot or plain ends. As in sewer pipe, two strength-grades are available. Dependent upon type of usage the unit may be soft, medium, or hard-burned.

Sewer Pipe

Sewer pipe is a dense, vitreous common clay product normally manufactured in either standard or extra strength grades. The standard pipe has a bell molded on one end of each pipe section in the manufacturing process. Salt glazes are commonly used to decrease the absorption of liquids. The pipe is available in a wide range of lengths from 2 feet to 4½ feet, and in a range of inside diameters varying from 4 to 36 inches in 2 inch increments. A large variety of accessory fittings is available.

---

4) Bateman, John H., Materials of Construction, Pitman Company, New York, 1950.

Flueliner

Flueliner denotes a round or rectangular hollow unit used for lining masonry chimneys. Its function is to provide a smooth surface to eliminate soot accumulation and to insulate the surrounding chimney materials. It is available in a wide range of sizes. The units may possess either a salt glazed or natural finish.

All-clay block

The all-clay block is a recently developed structural unit similar to concrete block but employing an expanded shale aggregate and bonding clay body. It is claimed to be insulative, have high compressive strength, and be dimensionally stable. A natural or glazed finish may be employed and a number of surface textures can be achieved. The block was originally developed for the back-up rather than the facing market. Block appearance is supposedly equal to competitive concrete block.

Lightweight Aggregate Block

This structural unit differs from the all-clay block described above in that the aggregate is an expanded shale or clay, but the binding material is cement. It is used chiefly for nonload-bearing subfloors, walls, and roof decks. It absorbs sound, is insulative, fire-resistant and lightweight.

Sewer Liner Plates

Sewer liner plate units are used in lining large concrete sewers. They are manufactured with curved or flat cross-section.

Conduit

Conduits may be rectangular, multicellular units similar to structural tile or round units similar to sewer pipe. Frequently these units are salt glazed to decrease water absorption. Their function is to serve as ducts for installation of underground wire and pipe.

Architectural Terra Cotta

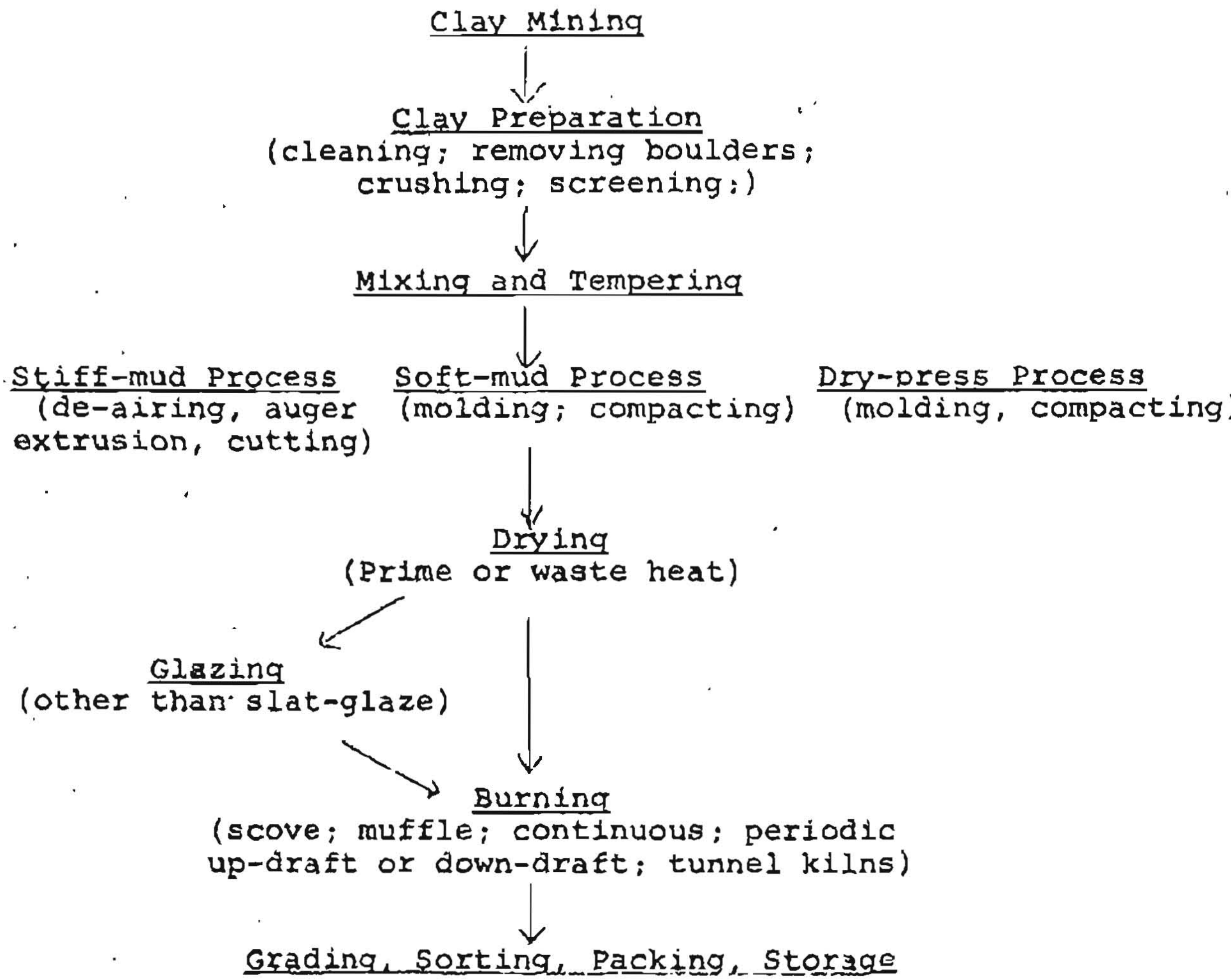
The term terra cotta has been used in many diverse and vague ways. It is more properly currently defined as a hard burned, glazed or unglazed building unit, plain or ornamental, with properties similar to that of burned brick but normally of a larger size than brick or facing tile. The common types are, (1) extruded terra cotta in ceramic veneer or anchor type, (2) handmade terra cotta with either open or closed back or solid slab, (3) prefabricated terra cotta paneling with lightweight concrete backing, and (4) ornamental or decorative units in varied colors, sizes and designs.

Manufacture of Structural Clay Products

Manufacture of the many structural clay products is similar enou to warrant common description of the processes involved. Figure 3 gives a general process flow-chart. Clay raw materials are obtained through either conventional underground or open pit mining methods. They may be prepared in a number of ways depending on the unique properties of the raw material and the expected end use. A common technique is to crush the material in roll or jaw crushers and screen to the desired size. For extremely fine grinding, "wet" or "dry" pans are used. These consist of heavy rollers which travel in a circle over either perforated or non-perforated steel or cast-iron plates.

Figure 3

General Flow-chart for Manufacture of Structural Clay Products



Three major forming methods are used for structural clay products. These are termed the stiff-mud, soft-mud, or dry-press processes. The stiff-mud process is employed with clays containing just enough water to impart plasticity. The clay is mixed in a wet-pan and/or pug mill and extruded through a forming dye. An auger is used to extrude products of uniform cross-section as brick, building tile, drain tile, and quarry tile. A plunger is used to extrude products with non-uniform cross-sections as sewer and conduit pipe. The extruded column is cut by a series of fine wires to produce the individual product.

The soft-mud process is used for clays whose moisture content precludes use of the stiff-mud process. Normally a pug-mill discharges the mixed and tempered clay into a series of molds where it is subjected to pressure from a plunger and vibrated to assure compaction. Sticking of the clay to the mold is eliminated by utilization of a water or sand coating on the mold. The process is applicable to many types of clay and has been used largely for manufacture of common brick.

The dry press process denotes forming by compressing relatively dry, granulated, non-plastic clays in steel molds. The resultant product is extremely uniform in size. The process has been used extensively for ceramic wall tile, floor tile, and face brick.

The formed products, with possibly the exception of those from the dry-press process, are subsequently transported to driers to remove as much moisture as possible before firing. Drying may be accomplished in the open air, in sheds, or in specially constructed driers. The heat employed may be either prime or waste heat. The process may be continuous or intermittant. The dried products are burned either to incipient or complete vitrification in various types of kilns. Kiln operation may be continuous or intermittant. Common types of intermittant kilns employed include scove, down-draft, and up-draft, while chamber, circle, and tunnel kilns normally utilize continuous operation.[(5)] Kilns may be fired by wood, coal, oil, or natural gas. Coal should be low in sulphur to prevent contamination of the ware. Oil and natural gas have high thermal efficiencies and provide a more easily controlled heat.

The surface of the clay product may be treated or natural. Surface treatment can be accomplished by utilizing ceramic or salt glazes applied either after the drying or during the burning process. Certain surface treatments require a two-fire process.

After firing, the clay products are slowly cooled to prevent cracking and deformation and are sorted and classed according to the color or magnitude of imperfection of the individual product.

It should be noted that the manufacture of the all-clay block and the lightweight aggregate block described previously departs somewhat from the general process. A rotary kiln or a traveling-grate sintering machine is used to expand the shale or clay for aggregate. For the all-clay block the raw bonding clay is mixed with the aggregate with sufficient water to achieve plasticity. The unit is molded in a vibratory concrete block

---

5) Norton, F. H., Elements of Ceramics, Addison-Wesley Press, Inc., Cambridge, Mass., 1952.

machine and the resultant block is kiln fired. The light-weight block also utilizes expanded shale but cement is used as the bonding material as in standard cement-block manufacture. Steam curing rather than kiln firing is used to dry, harden, and strengthen the finished block.

Refractory Products

In the broadest sense a refractory may be defined as a non-metallic material which is resistant to high temperatures. Usually it is requisite that such materials also be resistant to sudden temperature changes, mechanical abrasion, chemical corrosion, and load deformation while in a high temperature environment. Very few refractories are constituted wholly of clay raw materials, the majority being blends of ceramic raw materials and refractory metals, oxides, silicates, aluminates, carbides, etc., in which clay is but one component. Refractories have many diverse and specialized uses. These include utilization in equipment for metal refining and smelting, steam generation, production of glass, cement, and clay products, for fireplace and chimney construction, fireproofing of building walls, and numerous space age uses.

Refractory Brick and Shapes

There are many different types of highly specialized refractory brick and shapes. Brick normally denotes the common rectangular unit, while shapes are classified by their physical form as standard shape, rectangular tile, or special shapes. Such shapes are utilized for particular types of construction and other specific services. The major types of refractory brick which utilize at least moderate amounts of clay are given in Figure 4. Many other types of refractory brick are produced, however, which do not use clay as a raw material.

Figure 4
Types of Refractory Brick

Types	Classes	Major Constituents
Fireclay	(1) Superduty (2) High-duty (3) Medium-duty (4) Low-duty (5) Semi-silica	Flint and semi-flint plastic and semi-plastic kaolins (classes 1, 2, 3, normally clay blend, class 4 may be single clay, class 5 a silicious kaolin).
High-Alumina	Based on alumina content, 45-90 per cent	Diaspore bauxite; diaspore clay, bauxitic kaolin; kyanite; sillimanite; fused, sintered and calcined alumina; mullite.
Insulating	By maximum temperature of exposure	Diatomite; vermiculite; perlite; fireclay; kaolin; alumina mineral quartzite.

Refractory Mortars

Refractory mortars are used for bonding of refractory brick and shapes. Their composition is variable but should normally parallel that of the main structural units. Common constituents are refractory fire clays, blends of refractory bonding and calcined clays, alumina and silica mortar materials, and magnesite and chrome ore. Mortars are normally classed as heat-setting or air-setting, denoting the temperature range necessary to obtain a rigid or ceramic set.

Monolithic Refractories

Monolithic refractories include all those materials used to eliminate joints and achieve a homogenous surface over other structural units. Such materials may also serve a maintenance function and effect time savings in installation. They may be classified as plastic refractories, ramming mixes, gun mixes and castables. Plastic refractories are supplied as a stiff plastic for utilization without further preparation. The major raw material constituents include raw and calcined refractory clays, high aluminum materials, graphite and chrome-base materials.

Ramming mixes are composed largely of refractory fire clay, silica, alumina, periclase, dead-burned magnesite, chrome ore, silicon carbide and other materials. They are ground and graded by particle size. After appropriate preparation and placement they set upon drying or heating to form a monolithic structure.

Castables are composed of granular refractories including refractory clay, silicon carbide, chrome-magnesite mixtures, and insulating aggregate. They are mixed with a chemical binder to provide a hydraulic set at room temperature or a ceramic set at high temperatures. They are frequently poured or cast into place.

Gun mixes also contain granular refractory materials. They may be placed by a high pressure pneumatic "gun" in either wet or dry form. The mix may be air, hydraulic, or heat setting.

Special Clays

Special refractory clays and clay mixes include calcined flint clay and kaolin, ground gannister (crushed and screened quartzite), and highly plastic bonding clays.

Kiln Furniture

Kiln furniture denotes the many supports and containers used to hold ceramic ware during kiln firing. Saggers are refractory boxes used in the firing of whiteware products to both support the ware and protect it from direct contact with kiln gasses. The raw material used for manufacture of saggers includes plastic clay, fireclay, grog, and talc. Hand, slip casting, and machine press manufacturing methods are utilized. Slabs and posts are utilized for open-setting of wares that do not require protection from kiln gases. Raw materials used in their manufacture include fireclay, fused alumina, silicon carbide, and zircon.

Laboratory Ware

The most common usage of clay in laboratory ware is for the manufacture of crucibles. Clay crucibles are compounded from fireclay and grog and graphite crucibles are manufactured from plastic fireclay and flake graphite. Both types may either be pressed or made on a jigger machine.[6]

Foundry Molding Sands

In the shaping of metal by casting processes a clay and sand mixture is often utilized as the mold material. This molding sand may be a natural clay containing sand or a synthetic clay-sand mixture. The types of clay used in such mixtures include bentonite, plastic fireclays composed largely of kaolinite, and selected varieties of illite clays.[7] It is practically impossible to predict the exact behavior of clays for such use without an actual trial, due to the many complex properties required.

---

6) Explained later under ceramic manufacturing processes.

7) See Appendix A, Table I.

Refractory Manufacturing Processes

Many diverse and complex processes are utilized in refractory manufacture. Such processes may include power pressing, hydraulic pressing, impact and vibrating presses, piercing and forming, air ramming, extrusion processes, and hand molding. Detailed descriptions of these processes may be found in the technical literature.[(8)] After forming and drying, all products, except those chemically fused or bonded, are fired in either tunnel or periodic kilns to achieve the ultimate end properties.

The refractory mortars and other granular clay refractories are largely blends of calcined and raw clays and other ceramic materials. Calcining is commonly accomplished in a rotary kiln and the constituents are finely ground before being mixed in proportions necessary to achieve the desired end properties.

At the present time adequate supplies of relatively pure clays are abundant, so that beneficiation and use of submarginal clay is presently unnecessary.

---

8) Modern Refractory Practice, 4th Edition, Harbison-Walker, 1961

Fillers, Coatings, and Extenders

Fabrics

Clays are used in the textile industry for filling, sizing, and backing fabrics. The kaolinite, montmorillonite, and attapulgite varieties of clay[9] are used for such purposes. These clays must be fine-ground in preparation for such use.

Paint

Clay was originally used in the manufacture of paint as an extender. Recent developments have shown that clay may also provide desirable dispersion, viscosity, and oil absorption characteristics. Clays principally used include the kaolinite, montmorillnite, and attapulgite varieties. Their preparation may involve air or water-washing, chemical bleaching and fractionation.

Paper

Paper manufacturing processes require clay as a filler element and a component of the surface coating mixture. Normally the purest possible kaolin clay is required for such usage. The attapulgite variety has been used to a limited degree for coating purposes and the montmorillonite variety as a pulp additive.

Rubber

Clay fulfills multiple functions in rubber manufacture. It serves as a diluent, as an emulsion stabilizer, and as a reinforcing, stiffening, and thickening agent. Both kaolins and bentonites are used in compounding rubber. The total desirability

---

9) See Appendix A

of clay for rubber manufacture is dependent upon its particle size, shape, structure, and wettability.

Pesticides

Clay is used as a carrier and diluent in the manufacture of pesticides. Properties important for such usage include low moisture content, physical and chemical compatibility with the pesticide, free-flow characteristics and small particle size. Clays composed largely of kaolinite, attapulgite and montmorillonite are commonly used for this purpose.

Plastic

Clay is used chiefly as a filler in the manufacture of plastic. In addition it provides desirable flow characteristics, reduces shrinkage, produces a smooth finish, and increases strength and chemical resistance. Clay composed largely of kaolinite is used most extensively. Actual use tests are normally required to determine feasibility of clay usage.

Fertilizers

Both liquid and solid fertilizers may contain clay. It functions as a diluent, soil stabilizer, prilling material, or suspending and stabilizing agent. The attapulgite variety has been used extensively in water suspensions and for prilling purposes.

Preparation of Filler and Coating Clays

The preparation of clays used as extenders, filler, and coatings is dependent upon individual end use. The two basic preparation methods most commonly used are air and water flotation.

Air flotation involves initial drying and crushing of the crude clay with subsequent separation of the desired fines by a high velocity air current. The fineness, color and impurity content of the clay determines the applicability of this method. Water flotation involves the separation of different size fractions of clay from water suspension. These fractions are then dried and possibly bleached to improve the brightness. Fractionating may involve utilization of settling tanks, hydroseparators or centrifuges. Filtering is accomplished with filter presses or drum separators, and drying by rotary or tunnel type driers.

Whiteware, Stoneware, and Earthenware Products

Although technically whiteware, stoneware and earthenware products are sufficiently diverse to warrant separate classification and discussion, their similar end use allows common treatment in this investigation. The terminology employed for designation of various ceramic dinnerware, art-pottery, and specialty products within the industry is overlapping and vague. Treatment of this subject requires construction of a common terminology which, though less than technically precise, allows common understanding of the product types involved. The discussion is largely summation of the work of McNamara.(10)

Whiteware

In its strictest sense, whiteware includes all ceramic products which develop a white-fired color. General usage, however, includes those non-white products (including fine earthenwares) made from similar raw materials by similar processes, and white bodies later covered by colored surface coatings. Whitewares are normally made from a mixture of clay, feldspar, and quartz. They are usually subdivided into the product catagories which are shown in Table 6 and discussed below.

---

10) McNamara, Ceramics, Vol III, Clay Products and Whitewares, Pennsylvania State College, State College, Pa., 1949.

Table 6

Classification of Whitewares

Vitreous Products	Semi-vitreous Products	Special Products
Tableware:	Tableware:	Refractory porcelain
Porcelain	Porcelain	Chemical porcelain
China	China	Technical products
Hotel china	Wall tile	
Sanitaryware	Electrical fixtures	
Floor tile	Fine earthenware	
Electrical porcelain insulators		

After: McNamara, Ceramics, Vol III, Clay Products and Whitewares, Pennsylvania State College, State College, Pa., 1949.

Vitreous Products

Porcelain - Porcelain denotes a vitreous whiteware produced by bisque (unglazed) firing at a low temperature followed by glazing at a high temperature. Porcelain products may be termed as "hard" or "soft", depending on their physical properties and chemical composition. Hard porcelain possesses a high scratch hardness and impervious body. The soft porcelains are softer in body and glaze but are translucent and resemble the hard product in appearance. A typical composition of hard porcelain includes clay substance (50%), feldspar (25%), and flint (25%). This composition may vary greatly depending on the chemical make-up of the raw materials. Hard porcelain may be glazed with either a feldspathic or calcareous glaze and decorated either underglaze or overglaze. It usually receives two firings in the manufacturing process. Soft porcelain may be designated as either "fritted porcelain" or as "bone china". Fritted porcelain is a fired mixture of finely ground frit and clay. It is not a product of major significance due to its difficult production processes.

Bone China - China is a term used to denote vitreous ceramic whiteware produced by bisque - firing at a moderate temperature, followed by glazing at a lower temperature. Although bone china is similar to hard porcelain in many properties it is less refractory and possesses lower strength, hardness and chemical durability. It also resembles fine earthenware but has a stronger body and glaze, increased brittleness, and high translucence. An average composition might include kaolin (30%), feldspar (35%), and bone ash (35%), although ball clay and flint may also be used. A softer glaze is utilized than for hard porcelains, but one which is more suited to a wider variety of underglaze and overglaze decorations.

Hotel and Restaurant China - Hotel china refers to a semi-translucent body with greater thickness, higher strength, and harder glazes than domestic china. The absorption characteristics are held to minimum values. It is made in three varieties to correspond to unique handling conditions. The highest grade of white-burning raw materials are used in its manufacture under a highly developed technology. Raw materials utilized might include a mixture of English china clay, Florida kaolin, ball clay, flint, potash, and soda feldspar, calcium carbonate, and magnesium carbonate. A refractory glaze is used to impart a hard and durable finish, and decoration is normally done underglaze as a protective measure.

Sanitary Ware - Sanitary ware refers to plumbing fixtures including sinks, lavatories, bath tubs, closet bowls, tanks and related products. Permanency and sanitary requirements make it requisite that such products possess a vitrified body and a hard glaze. The body and raw material requirements for sanitary ware parallel those for hotel china, with the exception of higher ball clay utilization. A typical body might include flint (30%), feldspar (26%), ball clay (18%), and kaolin (26%). While it is unnecessary to detail the production process it should be noted that the forming, drying, and firing problems are complex and require an advanced technology. The glazes employed may be of variable composition, colored or uncolored, but must be acid resistant and governed by the composition of the product.

Vitreous Floor Tile - Floor tile are thin, simply shaped, unglazed units, compounded of pure white bodies or colored whiteware bodies. They are highly vitrified to enable resistance to moisture, staining, and abrasion. An average body might include flint (25%), feldspar (30%), kaolin (19%), ball clay (15%), and magnesium carbonate (1%).

Electrical Porcelain Insulators - Electrical porcelain insulators denote the broad range of products of many sizes used for electrical fittings and insulation. Such products are compounded from a body similar to that used for hard porcelain, but may also contain quantities of kyanite, beryl, talc, zircon and other special ingreients. They may be glazed with a number of specialty glazes in order to increase their resistivity to weathering and thermal shock.

Semi-Vitreous Products

Tableware - Semi-vitreous tableware denotes both semi-vitreous porcelain and semi-vitreous china (semi-porcelain). These products are compounded from materials similar to those used for other whitewares with the possible exception of higher ball clay and lower feldspar content. An average composition might include flint (30-34%), feldspar (12-48%), English china clay (7-21%), kaolin (12-48%), ball clay (5-29%, and whiting (1-2%). Usually such bodies are not as finely ground as those for porcelain or hotel china.

Fine Earthenware - Fine earthenware denotes bodies compounded of white burning clays, flint and feldspar. The body is fired at a low temperature and a soft glaze is applied. The fired product is not translucent and is relatively absorbent.

Semi-vitreous Wall Tile - Semi-vitreous wall tile is a porous, low-strength product used largely for decoration. It is frequently glazed on the exposed side with either a transparent or colored surface coating. The higher grade tiles are compounded from a high talc body to gain resistance to moisture absorption and glaze cracking. An average body may include talc (38%), ball clay (22%), kaolin (6%), and flint (34%).

Stoneware

Stoneware is characterized by a hard, dense, impervious structure and possesses very low absorption values. The color is dependent on raw material impurities, but normally a light shade predominates. The two major classes of stoneware are "rough" and "fine". Rough stoneware is used in household pottery and sanitary ware while fine stoneware is used extensively for art pottery, decorative ware, and chemical stoneware. Unlike white-ware it is usually manufactured from a single light-burning low grade fireclay, although it can be compounded from a mixture of clay, flint, and feldspar. The composition of such blends may include clay (30-70%), quartz (30-60%) and fluxing oxides (5-25%). Moderately high firing temperatures produce the characteristic rugged, dense, body appearance. If vitrification is achieved in the firing process the need for glazing is precluded. A specially compounded slip glaze often is applied to obtain the typical chocolate color of household ware. A variety of other hard and soft glazes may be used for strictly decorative purposes and a feldspathic glaze may be utilized for chemical stoneware.

Earthenware

Earthenware is usually manufactured from a local clay rather than a blend of higher grade ceramic materials. An exception would be the fine-quality earthenware catagorized earlier as a semi-vitreous whiteware product. Earthenware products are normally fired at lower temperatures than stoneware or white ware products, and exhibit deep brown to light yellow colors. Table 7 summarizes the gradation of cermaic bodies from earthenware through whiteware based on color, firing temperature, and body composition.

Table 7

Ceramic Body Characteristics

Body Type	Firing Temperature (°C)	Fired Color	Body Composition							
			Water	Flint	Feldspar	Nepheline Syenite	Moderately plastic brick or low-refractory clays	Kaolin Clay	Ball Clay	Barium Carbonate
Earthenware	1000-1020	Dark Red	X	X			X		X	X
Low-fired porcelain	1145-1165	Cream	X	X		X		X	X	
Stoneware	1145-1165	Red or buff	X	X			X			X
Stoneware	1225-1250	Gray	X	X			X		X	
Semi-vitreous whiteware	1225-1250	White	X	X	X			X	X	
Porcelain	1225-1250	White	X	X	X			X	X	
High-fired porcelain	1450	White	X	X	X			X	X	

After: Norton, F. H., Elements of Ceramics, Addison-Wesley Press, Inc., Cambridge, Mass., 1952.

Manufacturing Processes

Limitations of space and original study objectives preclude comprehensive treatment of the many processes involved in the manufacture of the above products. It is possible, however, to indicate the major forming, drying, and firing processes involved.

Forming Processes

Soft-mud process - The requisite clay properties and general applicability of the soft-mud process was described earlier under structural clay product manufacture. "Hand molding" "modeling", and "jiggering", however, are more specialized soft-mud processes utilized in forming whiteware, stoneware, and earthenware products. Hand molding denotes actual hand working of wares usually by highly skilled artesians. It allows the use of raw materials which possibly could not be utilized in machine manufacturing due to unusual or unique properties. Hand molding may be used to fill stationary molds with raw materials by hand; to shape a clay mass which is revolving on a specially constructed wheel; or to construct an individual body without the aid of molds or machines. Such hand methods are largely employed now only by the artist-potter and do not lend themselves to mass-production objectives. Jiggering denotes a method of forming plates, cups, platters, and other dinnerware or pottery objects from a revolving mass of clay. The jigger machine utilizes the principle of the ancient potters wheel. A soft-paste clay blank is placed on or in a revolving base-mold and a pull-down profile tool is used to shape the upper surface of the spinning clay mass. Either hollow ware (as cups, bowls, vases, etc.), or flat ware (as dishes, shallow shapes) can be formed by this process.

Stiff-mud processes - The mechanics of the stiff-mud processes have also been previously discussed under structural clay product manufacture. Its major application for whitewares and stoneware is in the manufacture of flower pots and laboratory crucibles. The stiff-mud body is prepared in the pug-mill and extruded through a round die to form a blank. The blank is placed into a stationary mold and the product is formed by lowering a revolving core into the clay mass. The core forces the clay against the mold wall and produces the desired interior surface.

Dry-press process - This process is used largely for the manufacture of porcelain insulators, wall tile and other specialty products and shapes. It employs high grade clay mixtures. The mixtures may be prepared either by dry mixing of constituents or by wet-mixing. In finished form the raw material resembles a dust or damp powder. It is placed mechanically in a series of horizontal molds and a vertical plunger is lowered into the mold to create the necessary formative pressures.

Slip Casting Processes - Slip casting denotes the formation of a ceramic product by dewatering a liquid clay suspension in a porous mold. The raw materials are properly proportioned and mixed with an appropriate liquid. The resultant slip can be utilized to form any irregularly shaped object, either hollow or solid, by pouring it into a dry plaster mold. The mold absorbs water from the slip and builds up a layer of solid clay on the mold surface. After a short time interval the excess slip is drained out and leaves a hollow piece which can be removed from the mold after drying.

Drying Process

The drying of whiteware and stoneware products usually denotes a simple evaporation of water by the use of heat, although air drying alone may be utilized for certain products. The two most important types of driers are intermittant (as lofts and floors, compartment, chamber, or humidity cabinets), and continuous (as tunnel, mangle, rotary or drum driers). Hot floors are heated by hot air, gases or steam pipes; lofts denote large rooms heated by steam pipes placed around the walls or under the floor; compartment driers are total enclosures of varying size in which the temperature and humidity can be controlled; tunnel driers are long enclosures through which the ware is passed and in which humidity and temperature can be controlled; and mangle driers are small compartment type driers in which the drier shelves are suspended on endless chains and conveyed up and down through a baffled chamber.

Firing Process

Dependent upon the type of whiteware or stoneware product being manufactured either one or two firings may be utilized. The kilns used for such firing may be either intermittant or continuous. The updraft pottery kiln has been used extensively for whitewares but has been largely replaced by the tunnel kiln. The updraft kiln essentially is a round kiln of variable diameter with a somewhat conical upper chamber. The hot gases pass upward through the kiln and through the ware set in the chamber. The tunnel kiln allows optium utilization and control of kiln heat. It utilizes a zone of constant temperature through which the ware is passed on kiln cars. The ware may be placed in fire clay boxes to support and protect it from direct contact with kiln flame or gases or supported upon open refractory shelving. Open-setting is normally done only in "muffle" kilns in which combustion of the fuel occurs in a chamber separate from the one through which the ware is passed.

Glazing Process

Glazing of wares is necessary either to render them impervious to liquids or to enhance their appearance. Glazes may be grouped into three major catagories: salt, raw, or fritted. Salt glaze denotes the surface covering achieved by introduction of common salt into the kiln firebox. The resulting vapors react chemically with the surface of the ware and result in formation of a clear transparent coating on all exposed parts of the ware. Raw glazes are those compounded of insoluble components and thermally fused to the surface of the ware. Fritted glazes are prepared by mixing the appropriate materials in the raw state, melting the mixture, and grinding the resultant glassy material. This glassy material constitutes the principle component of the glaze slip later applied to the surface of the ware. Raw materials used as glaze components include silica, boric acid, alumina, lime, magnesia, lead oxide, potash, feldspar and soda. They can be mixed in varying proportions to obtain the desirable glaze characteristic. After appropriate compounding of the glaze it may be applied to the ware either by dipping, spraying, brushing, dusting or washing.

Miscellaneous Products

Pelletization of Ores, Fuels, and Feeds

Pelletization normally denotes the bonding of fine particles into units large enough for economical use. The clay raw material supplies bonding strength for the feed particles and also lubricates the pelletizing dyes. Bentonite is the clay type normally used for such purposes.

Greases

Clay is used to stabilize the gel properties of many lubricating greases. According to Grim[11] greases with superior properties may be produced since the adherence to metal is improved, the grease is more water repellent and it works well at temperature extremes. Montmorillonite clays have been used for this purpose and it may be possible that the attapulgite variety could also be so utilized. Preparation of clays for such

---

11) Grim, R.E., Applied Clay Mineralogy, McGraw-Hill Book Company Inc., New York, 1962.

usage involves washing of the clay to remove grit, followed by subjection to a cation-exchange reaction.

Medicine and Cosmetics

The major medicinal use of clays is as an intestinal absorbent. Its function is to absorb toxins, bacteria and other secretions and to impart a coating to the digestive tract. Both kaolinite and activated attapulgite varieties of clay can be used for such purposes. As a cosmetic product, clay finds use as a result of its softness, dispersion, gelling, absorption and other properties. Clays used for cosmetic purposes include the kaolinite, montmorillonite and attapulgite varieties.

Leather

Fine grained kaolin clays are used in leather manufacture. The function of the clay is to impart a smooth surface finish and light color.

Soap and Cleaning Compounds

The attapulgite and montmorillonite varieties of clay find use in the manufacture of soap due to their emulsifying, detergent and carbon affinity characteristics. The attapulgite variety and other calcined clays may be used as slightly abrasive polishing compounds.

Theraputic Muds

A less precise use but one which should be recorded is the use of muds containing clay minerals for the treatment of certain ailments. Normally utilized in the form of mud or organic-mud baths, the theraputic value possibly rests in the heat given the body or in the non-clay components of the mixture. While any type of clay may be utilized the bentonites would appear to be more suitable due to the high plasticity and water-holding capacity.

Water Clarification

Clay may be used to clarify drinking water, paper mill waste, sewage and other industrial waste products. After dispersal in the liquid to be clarified the clay particles collect colloidal materials that would not otherwise settle out. After collection of these materials, the clay itself is flocculated and removed from the water. Additional benefits as odor removal and softening properties may also be gained through such treatment. Bentonites and attapulgite varieties of clay have been used due to their high absorptive and dispersion properties.

Leakage Prevention

As a leakage prevention agent, clay is either used as a grouting material to stop or impede the flow of water through concrete and rock structures or as an impervious blanket in pond and ditch structures. In grouting it may be used in the form of a paste or slurry and in blanket applications may be applied in granular form. Sodium rich bentonites with high "gel" properties have been used extensively for this purpose.

Adhesives

The function of clay as an adhesive constituent is to serve as a diluent and to impart other selected properties to the adhesive material. Properties which may be influenced or controlled by clay constituents include the setting rate, bond strength, and suspension and viscosity characteristics. Although kaolinite type clays are commonly used in adhesives, specific properties of the illite, montmorillonite and attapulgite varieties may promote their use for specialized applications.

Seed Coatings

Powdered clay added to moistened seeds in a drum roller produces a coating which both protects the seed from direct applications of fertilizer and increases the seed size to allow mechanical planting. The montmorillonite clays have been used for this purpose.

Cement Manufacture

The silica and alumina content of portland cement is often obtained by addition of clays to the basic limestone raw material. While kaolinite clays containing only alumina and silica would be ideal, the feasibility of clay utilization is normally contingent only on the magnesia content since it affects the soundness of the resulting concrete. Illite and montmorillonite clays are also desirable due to their high silica and low iron and alkaline earth contents.

Cement Masonry Mortar

The chief function of clay in cement masonry mortar is to improve the plasticity and workability of the mortar and increase its resistance to drying when in contact with the masonry unit.

Many types of clays may be utilized for such purposes with the possible exception of the montmorillonite types. Their high water requirements for workability could result in a mortar of inferior strength.

Cement and Concrete Additives

It is possible to gain several desirable concrete properties by the addition of small amounts of selected clays to cement and concrete mixtures. These properties include workability, improved aggregate integration, decreased form-leakage, and increased permeability. Clay mineral composition is not stringent except that the montmorillonite clays tend to introduce undue strength loss because of high water requirements necessary to gain workability.

Radioactive Waste Disposal

One of the more recent areas in which clay would appear to have use is in the disposal of waste water and other solutions carrying radioactive material. Although still largely experimental the method of disposal would involve absorption of the toxic elements by the clay, followed by calcination of the clay at temperatures sufficient to vitrify the clay and fix the materials against leaching. The calcined material would then be buried. Montmorillonite clays were initially investigated but more recent work suggests that the kaolinite, attapulgite, and illite clay types may be better suited for such purposes.

Aluminum Ore

Since the use of clays as an ore of aluminum is still largely experimental, no attempt will be made to give a detailed coverage of the many processes involved. It is sufficient to note that since some clays contain an aluminum content of 30 to 40 percent, and conventional ores of aluminum are very limited in the United States, selected clay deposits could assume importance as sources of aluminum.

Petroleum Exploration and Refining

Clays have two important uses in the petroleum industry. The major use is as a component of the "drilling-mud" used for rotary drilling operations in petroleum prospecting. Clay is one constituent of this mud and must meet demanding requirements concerning gel strength and suspension viscosity. Drilling mud usage requires a type of bentonite clay in which the predominant clay mineral is sodium-rich montmorillonite. Such clays are capable of great volume expansion through the absorption of large quantities of water. The clay particles are of extremely small size and can remain in suspension indefinitely in water dispersions. The resulting colliodal "mud" is circulated through the hole during drilling operations to lubricate the drill bit, lift rock cuttings to the top of the hole, coat the hole walls, and provide gel strength to support the mud weighting material. The clays utilized in drilling muds do not occur widely, with most of the high quality material being obtained from eastern Wyoming and a limited number of other western states. Preparation of clay for such use involves drying, fine grinding and sizing.

Another use of clay in the petroleum industry is to decolorize, clarify, and remove gums from gasoline, lubricating oils, paraffin and other waxes. It involves a selective chemical and physical process in which the colored materials are attracted to the clay particles. Clays used for this purpose may be either naturally absorbent or capable of being made absorbent through subjection to leaching processes which change the molecular structure. The naturally active clays are known as "Fullers Earth" and do not occur widely in nature.

IV

CLAY PRODUCTS WITH SIGNIFICANCE IN ALASKAN MARKETS

Significance Criteria

Establishment of a significance criteria is requisite for rational determination of those products with significant market potential in Alaska. The following list contains the major factors considered in determining the significance of each of the products given in the preceding section:

(1) Raw material availability - Only those products made wholly from the common clays or from specialty clays with proven Alaskan occurrence were considered significant. Those products were discounted in which clay was only a minor constituent in a blend of other specialty materials, not readily available in Alaska.

(2) Raw material tonnage - Since one of the major functions of the study is to stimulate mining activity and subsequently mining employment within the state, those products requiring very limited quantities of raw clay were not considered as significant as those requiring considerable tonnages.

(3) Previous production attempts - Those products with a history of production and sales within the state were rated more highly than those which have been traditionally imported. Product consideration was especially enhanced if the past venture was considered to have failed because of technical or financial difficulties rather than for complete lack of sales potential.

(4) Relationship between value and transportation cost- Those products for which freight cost constitutes a large share of total consumer cost were considered to have greater economic significance. This would tend to eliminate the high unit value, light-weight products and stress the heavy-weight products with low unit value.

(5) Production process - Products which require complex technical manufacturing processes, or highly specialized personnel not readily available in the state, were not considered to have great significance.

(6) Current and potential demand - The current level of consumption within the state, considered in the light of recent historical trends and future potential use, was a major determinant of significance. Some degree of importance was also attached to the trend of total consumption within the other states.

(7) Elasticity of demand - Those products for which demand increases as their prices decrease were considered more significant than those for which demand is independent of the price level.

(8) Competitive nature - The effect of local manufacture on competitive products now manufactured locally was heavily considered. Although such a consideration may be questioned, the function of this study is not to introduce competition within our already small economic base but to investigate the possibility of expansion of this base by the manufacture of products now being wholly imported.

Analysis of Product Catagories

While it is obvious that a detailed significance evaluation for each of the more than sixty uses or products given in Table 4 cannot be presented here, the more important conclusions can be summarized by product catagory.

Structural Products - The manufacture of structural products has the most marketing potential of any of the product catagories presented. Analysis of such potential is discussed in detail in Section V.

Refractories - The refractory products do not have major significance due to the extremely limited demand for such products in Alaska. Although a limited quantity of refractory brick have been previously manufactured from the clay deposit as Sheep Mountain and marketed to a power plant in the Anchorage area, there are no proven quantities of high grade refractory materials within the state.

Power generation plants and smaller heating plants constitute the major consumers of refractory products. Investigation has shown that most power generation plants currently use largely castables, silicon carbide, plastic refractories, and only small amounts of firebrick. These specialty products require higher grade raw materials than those known to occur locally and more complex manufacturing operations. Another factor which tends to limit market size is the practice of purchasing replacement bricks in various sizes and shapes whenever a new plant is installed, in order to overcome the high costs involved in intermittantly obtaining small quantities of non-standard shapes and sizes. Additionally, while replacement of brick on an annual basis by these plants requires only a small total tonnage, even this amount is composed of multiple sizes and shapes rather than a single product type. Average refractory consumption for a moderate size generation plant could be as low as one-half to one ton per year of all shapes and sizes. It should also be noted that gas turbine plants do not require boiler-refractories as do those plants with steam generating facilities.

Fillers, Coatings, and Extenders - The significance of utilization of local clays for these purposes is completely discounted by the lack of occurrence in Alaska of the fine quality kaolin clays required and the lack of any local market. These markets are located wholly in the lower states and are presently supplied by fine quality domestic clays located relatively close to the consuming industries (Figures 1 and 2).

Miscellaneous Products - Of the miscellaneous uses given in Table 4, only the utilization of clays in cement manufacture and as a constituent of drilling mud would appear to have potential in the foreseeable future.

The use of clay in cement is wholly dependent, however, upon the establishment of cement manufacturing facilities within the state. Clay is commonly used as a raw material in the manufacture of cement to supply the necessary silica and alumina content often lacking in the primary limestone raw materials. Clays appropriate for such usage occur locally throughout Alaska. The tonnage potential could vary widely depending on the quality of limestone actually used in such manufacture, but could approximate 25,000 tons per year for a 500,000 barrel plant appropriate for Alaskan needs.

The utilization potential of clay in drilling mud is more difficult to quantitize. Such usage requires a select variety of bentonite. While there are currently no proven deposits of such high-quality bentonites within the State, increased oil exploration activities could readily develop a market which would justify more intensive exploration efforts for such bentonites. The market would probably consist of sales of the raw clay to the major companies now supplying this market, since these companies also furnish the technical personnel to direct mud usage at the well site. A small local producer could not afford to supply these services which are an inherent part of the product.

The remainder of the miscellaneous products and uses have been discounted since they either, (1) require high quality specialty clays not presently known to exist in the State, (2) are utilized by industries which do not exist in Alaska and are supplied by producers of high grade materials located more favorably with respect the consuming industry, or (3) would involve insignificant demand quantities.

Whiteware and Stoneware - Selected products within this catagory have limited marketing significance and are analyzed in Section VI.

V

STRUCTURAL CLAY PRODUCTS

Product Specification

Selected structural clay products have been judged to have potential market significance contingent upon the ability of local manufacturers to meet identifiable production costs. A detailed description of the many structural clay products has been previously presented in Section III. Those products with Alaskan significance are limited to: (1) Common building brick, (2) Flueliner, (3) Hollow non-glazed structural tile, and (4) Sewer pipe and drain tile. Of these products common building brick would be the primary plant product. The remaining specified products, along with small amounts of refractory firebrick, are secondary products which could serve to more fully utilize plant capacity and defray the total fixed costs of production. The secondary products should not be heavily considered in determination of manufacturing feasibility due to either a more limited demand, increasing consumption trends of competitive products, or questionable raw material availability.

Significance Determination

Common building brick meets practically the total significance criteria previously established.

Previous Manufacture - There have been at least three significant attempts to manufacture common building brick in the Anchorage area within the past 20 years. These attempts have been summarized previously and will only be briefly acknowledged here.[12] [13]

In 1946, Clay Products of Alaska, Inc. was established in Anchorage. It began operation in May of 1947 and produced approximately 207,000 brick before operations were terminated due to technical forming and firing difficulties and inadequate capital. Of the total brick production, 25,000 were manufactured using clay from Sheep Mountain and were sold as firebrick. The remainder were common brick manufactured from clays from the immediate Anchorage area. The Anchorage Telephone Exchange was constructed with brick from this operation.

Basic Building Products, Inc. of Anchorage attempted to produce brick in the 1958-1959 interval. The kiln utilized had a capacity of 20-25,000 brick with a 6-day firing time. Regular, roman and firebrick were produced from clays mined at Sheep Mountain. The plant was abandoned after the 1959 season.

Atlas Brick and Tile Company established production facilities in Anchorage in 1960 to manufacture common, norman, and commercial building brick. The plant was to utilize clay from

---

12) Warfield, R.S., "Some Nonmetallic Mineral Resources for Alaska's Construction Industry", <u>Report of Investigation</u> 6002, United States Bureau of Mines, 1962.

13) <u>Minerals Yearbook</u>, Vol. III, United States Department of the Interior, 1959, 1960. (Other years summarized by private communication of Mr. Kevin Malone, U.S.B.M., Juneau, Alaska).

the Sand Lake area blended with a higher grade clay from Sheep Mountain, and had a capacity of 50 - 60,000 brick per day with a one to two week burn. Plans were to also manufacture sewer pipe, face brick, and flue lining. The operation was abandoned during the 1961-62 period due to inability to manufacture a brick of sufficient strength from the local Anchorage clays and the high cost associated with transportation of the Sheep Mountain clays to Anchorage.

Total clay production for the period 1940-1963 for the Cook Inlet-Susitna area was 2,865 tons valued at $17,694.(14)

Raw Material Requirements - The fact that brick has previously been manufactured and marketed in Anchorage leaves no doubt that adequate raw materials exist. It should be stressed, however, that research should be accomplished to determine the optimum forming and firing characteristics of the clay deposits in this particular region before any attempt to manufacture structural products is made. Difficulties encountered in the first manufacturing attempt and the subsequent failure of the last manufacturer to produce a satisfactory product underscore this need. Additionally, the extensive work done on other clay deposits in the railbelt area by the U. S. Bureau of Mines and sum-

---

14) Private Communication, Mr. Kevin Malone, Physical Scientist, U. S. Department of Interior, Bureau of Mines, Alaska Office of Mineral Resources, Juneau, Alaska.

marized in the technical literature[15] verify the existance of several other clay deposits in relatively accessible locations suitable for such use (Appendix B). The Healy clays in particular have been shown to be of major significance. The tonnage potential of these deposits is adequate to meet any expected requirements.

Value-Transportation Cost Relationship - The specified structural clay products are all heavy, low unit value materials. This characteristic accounts for the high freight cost necessary to transport these materials from the west coast to Alaska.

Production Process - The stiff-mud process could be used for each of these products. Although the manufacture of sewer pipe, as a secondary product, would require a different extrusion unit than the remaining products, the general process would remain the same. Such modification would not be critical in determining the manufacturing feasibility of the primary product.

Current Demand - It is recognized that current Alaskan markets for the selected structural products are somewhat limited. The opportunity for local manufacture is wholly dependent on the realization of increased markets to be expected at lower cost due to local manufacture. The potential markets for brick have been determined for three price levels and indicate appreciable demand elasticity (page 76).

---

15) Rutledge, R.A., R.C. Thorne and W.H. Kerns, "Nonmetallic Deposits Accessible to the Alaska Railroad as Possible Sources of Raw Materials, for The Construction Industry, Report of Investigations 4932, U.S. Dept. of Interior, 1953.

Domestic Competitive and Production Analysis

The feasibility of manufacture of structural clay products rests not only on current consumption and allowable production cost estimates, but upon analysis of the total competitive and production environment of the industry and identification of any factors which could affect it in the foreseeable future. Since there is no current manufacture of structural products in Alaska, examination must be made of the industry in the total United States to identify these characteristics. It should be stressed that although the Alaskan construction requirements differ somewhat from those of the other states, the same consumer trends and competitive pressures which bear on manufacturing feasibility in the states remain pertinent in Alaska.

Competitive Situation - Structural clay product manufacture traditionally has accounted for a large proportion of total domestic clay production. In 1962 it consumed 60 per cent of total clay production. The manufacture of structural products is obviously dependent upon the amount of building activity and the acceptance of such products by the consumer relative to alternate building products. Common brick and structural tile for masonry wall construction purposes have been subjected to increasing competitive pressures from wood, glass, concrete, plastic, and metal products. Especially damaging has been the trend toward prefabricated metal and fiberglass panels used in the "curtain-wall" type of construction.

Analysis of construction data shows that the amount of new construction put into place in the United States has increased consistently during the 1959-1963 period (Table 8). The production of clay structural products has paralled this increase, as has the output of the other major construction product groups (Table 9). It should be noted that the magnitude of increase has been greater for wood, cement, and gypsum products.

A more revealing comparison is that of the wholesale price indexes of these products for the same period (Table 10). Such comparison indicates that the rate of increase for the clay products has been higher than the rates of other major product groups with the exception of gypsum products and cement shingles. The wholesale price index for several products (as southern pine and plywood) has decreased over the same interval.

Another major competitive aspect which affects structural clay products is the high installation labor requirement. The relatively small size of the units involved and the amount of labor necessary to install the individual units compares unfavorably with the installation procedures and labor requirements of major competitive products. Not only are these labor requirements greater, but such skills command a higher rate of pay (Table 11). Although the average rates for the selected building trades shown indicate the pay differential is decreasing, the absolute rate for bricklayers is still appreciably higher than for the other labor catagories.

Table 8

New Construction Put Into Place in the United States 1959-1963

(Millions of Dollars)

Year	New Construction Put Into Place		
	Total	Private	Public
1959	55,305	39,235	16,070
1960	53,941	38,078	15,863
1961	55,455	38,299	17,156
1962	59,036	41,478	17,558
1963	62,770	43,789	18,981

Source: Construction Review, U.S. Department of Commerce, Vol.10, No. 2, February, 1964.

Table 9

<u>Construction Materials, Indexes of Annual Average Output, 1958-1963</u>
(1947-1949 = 100)

Year	Composite of Products	Lumber and Wood Products	Millwork	Iron and Steel Products	Portland Cement	Gypsum Products	Clay Construction Products
1958	126.4	122.0	108.4	129.8	155.3	172.5	132.3
1959	136.2	139.6	121.9	121.4	169.0	203.4	149.0
1960	130.2	127.0	95.3	128.6	159.0	188.8	140.9
1961	129.5	128.0	110.0	130.2	161.6	186.4	134.9
1962	134.5	134.6	107.2	131.6	167.6	203.3	139.2
1963	142.9	140.5	117.8	140.7	176.1	215.2	147.6

Source: <u>Construction Review</u>, U.S. Department Commerce Vol. 10, No. 2, February, 1964, pp. 49.

Table 10

Indexes of Wholesale Prices of Materials
Used in Construction by
Selected Groups and Commodities
(1957-1959 = 100)

Material	Year					
	1958	1959	1960	1961	1962	1963
All Construction Material	98.9	102.1	100.5	98.6	98.3	98.5
Lumber:						
Douglas Fir	95.0	108.3	99.0	94.9	97.7	101.5
Southern Pine	98.4	101.7	100.1	95.8	95.7	95.4
Selected Hardwoods	98.6	102.8	103.8	98.5	95.4	100.6
Plywood (group index)	98.9	103.0	97.8	95.7	92.5	93.5
Building Paper and Board:						
Insulation board	99.8	102.5	102.2	101.0	94.6	92.4
Hardboard	99.3	100.3	99.5	100.0	101.0	101.8
Metal Products:						
Structural shapes	100.6	102.8	102.8	102.8	102.8	103.6
Reinforcing bars	100.4	102.7	102.3	99.9	95.0	86.1
Aluminum siding				97.6	91.8	88.8
Plumbing Fixtures:						
Enameled iron	95.6	100.0	104.8	104.9	97.7	94.2
Vitreous China	95.7	101.4	102.5	100.5	91.0	88.0
Flat Glass:						
Plate	100.0	99.7	96.4	91.5	86.9	83.8
Window	100.0	99.8	96.7	97.0	100.6	105.4
Concrete Ingredients:						
Sand and gravel	100.3	101.2	101.8	102.4	103.4	104.8
Portland cement	100.5	101.5	103.5	103.3	103.1	101.5
Concrete Products:						
Building block	99.8	99.7	102.0	101.7	101.1	100 [illegible]
Concrete pipe	99.5	103.6	104.4	104.3	104.8	100.2
Redimix concrete	100.4	101.6	102.4	102.6	102.9	102.7

Table 10 (continued)

Material	Year					
	1958	1959	1960	1961	1962	1963
Structural Clay Products						
Group index	99.8	102.1	103.1	103.2	104.8	105.4
Building brick	99.4	101.9	103.5	103.8	104.9	106.1
Clay tile	99.8	101.4	103.4	104.1	104.6	104.7
Sewer pipe	99.2	102.8	104.0	104.8	105.6	105.9
Gypsum Products (group index)	101.0	101.8	101.9	103.8	105.0	105.4
Asbestos cement shingles	100.1	103.4	108.1	110.6	110.6	110.8
Asphalt floor tile	98.1	100.2	102.4	104.3	101.4	102.5
Vinyl floor covering	n.a.	100.3	101.5	105.0	99.2	99.7
Non-metallic insulation material	100.7	99.8	100.7	95.0	94.5	90.7

Source: Construction Review, Vol. 10, No. 2, United States Department of Commerce, September, 1964.

Table 11

Indexes of Union Hourly Wage Rates and Estimated Average Rates* for Selected Building Trades (1957-59 = 100)

Date	All Trades	Bricklayers		Carpenters		Building Laborers		Electricians		Painters		Plasterers	
	Index	Index	Rate	Index	Rate	Index	Rate	Index	Rate	Index	Rate	Index	Rate
July 1, 1957	95.5	96.4	3.77	95.4	3.29	94.7	2.35	95.5	3.50	96.4	3.17	96.8	3.65
July 1, 1958	99.8	99.6	3.89	99.8	3.46	99.4	2.48	100.6	3.68	99.9	3.27	99.9	3.74
July 1, 1959	104.7	104.0	4.04	104.8	3.63	106.0	2.62	103.9	3.80	103.8	3.38	103.2	3.88
July 1, 1960	109.0	107.1	4.18	109.0	3.77	110.9	2.78	109.3	4.00	108.3	3.54	107.5	4.01
July 1, 1961	113.3	111.1	4.33	113.3	3.94	116.4	2.95	113.6	4.17	112.3	3.67	109.9	4.17
July 1, 1962	117.5	114.5	4.45	117.4	4.08	120.2	3.07	119.5	4.38	116.5	3.80	113.4	4.27
July 1, 1963	121.7	117.8	4.59	121.6	4.23	124.6	3.16	123.2	4.53	121.8	3.97	116.1	4.38
July 1, 1964	n. a.	n. a.	4.74	n. a.	4.38	n. a.	3.29	n. a.	4.69	n. a.	4.11	n. a.	4.50

* Rate in dollars per hour

Source: Construction Review, Monthly Industry Report, Department of Commerce, August, 1964.

Alaskan Market Characteristics

Although the total competitive situation for the structural clay products in Alaska approximates that given for the total industry, certain unique characteristics exist which should be recognized.

Competitive Products - Competitive pressures for brick and structural tile in Alaska come not only from the products mentioned earlier, but from added sources. In the Fairbanks area, and to a lesser degree in the Anchorage area, log construction is very popular. The low initial cost and low maintenance requirements of log construction coupled with its esthetic appeal largely account for this popularity. A detailed examination of Alaskan construction characteristics and attitudes has been made and is included in detail in Appendix D.

Severe climatic conditions greatly affect the consumption of clay sewer pipe in the Anchorage-Fairbanks area. Both municipalities and their adjacent military installations have either implicit or explicit policy guidelines which favor competitive products. Wood-stave sewer pipe is usually specified for installations which must withstand freezing conditions. Galvanized pipe is used in utilidors because of the sanitary problems involved if the pipe were to rupture. While the technical feasibility of such restrictions may be questionable, they constitute market realities and are largely responsible for the limited consumption of clay sewer pipe in Alaska. The recent earthquake adversely affected the future market potential since it is felt in many areas that the inherent rigidity of clay pipe was responsible for a disproportionate amount of sewer installation damage. Additionally, the short length and necessary jointing procedure of clay pipe increase its installation cost and have helped make it susceptible to competitive pressure from asbestos cement and concrete pipe. It has encountered similar pressure from asbestos bonded corrugated metal for use in out-fall areas, unstable locations, and highway applications.

Flueliner and firebrick have traditionally been products with relatively inelastic demand characteristics, but recently both have been subjected to competitive pressures from prefabricated chimneys and fireplaces. Decreased installation cost again is the prime advantage. Prefabricated flueliner is supplied in short sections which simply screw together. The prefabricated fireplace units are all metal construction and require only face brick to cover the front portion of the unit.

Pricing Policy - The limited consumption of structural clay products is understandable through comparison of stateside prices for selected products with those in effect in the Anchorage-Fairbanks area. Table 12 gives representative prices for the Anchorage, Fairbanks and Seattle areas of roughly equivalent units. It can be seen that local contractor prices are two to three times the delivered contractor price in Seattle.

Table 12

Estimated Contractors Prices - Selected Structural Products
Fairbanks, Anchorage, and Seattle
(dollars)

Item	Anchorage (3) Description	Price	Fairbanks (3) Description	Price
Brick				
Common	Std. common, 3 1/2 x 2 5/8 x 8"	0.18	Inca Select, 3 3/4 x 2 1/4 x 8"	0.24
Norman	Red, smooth, 3 3/4 x 2 1/2 x 11 1/2	0.30	Clay City, 3 1/2 x 2 1/2 x 11 1/2"	0.54
Roman	Red, 3 1/2 x 1 5/8 x 11 1/2"	0.30	Red, 3 1/2 x 1 1/2 x 11 1/2"	0.25
Firebrick	Columbia X, 2 1/2 x 4 1/2 x 9"	0.45	Columbia X, 2 1/2 x 4 1/2 x 9"	0.52
Concrete	Grey, 2 1/4 x 4 x 8"	0.08	Grey, 2 1/4 x 4 x 8"	0.11
Sewer Pipe	4" dia, 9#/ft. per ft.	2.10	4" dia. 9#/ft, per ft.	2.25
Concrete Pipe	4" dia. 21#/ft., per ft.	1.00	4" dia. 21#/ft., per ft.	1.50
Structural Tile	(1)	----	Glazed, 4 x 12 x 12"	1.33
Flueliniing	8 x 8", 18#/ft. per ft.	1.65	8 x 8", 16#/ft. per ft.	2.00

(1) Not available
(2) Delivered contractor price, Greater Seattle-Tacoma area, and price to put on dock for water shipment. (Cars or vans loaded in plant yard at 1/2 delivery charges.)
(3) FOB customers truck at plant.
(4) Estimate

Source: Average prices based on information supplied by Concrete Products of Alaska, Inc., Fairbanks and Anchorage plants; Anchorage Sand and Gravel Company, Anchorage; Alaska Brick Company, Inc., Anchorage; and Mutual Materials, Seattle.

Table 12 - continued

Item	Seattle Description	Price
Brick		
Common	Utility, 3 3/4 x 2 1/4 x 8"	0.06
Norman	3 1/2 x 2 1/2 x 11 1/2"	0.125
Roman	3 1/2 x 1 1/2 x 11 1/2"	0.08
Firebrick	Skagit-X, Superduty, 9"	0.20
Concrete	(1)	____
Sewer Pipe	4" dia. 8#/ft, per ft.(4)	0.33
Concrete Pipe	(1)	----
Structural Tile	Partition, 4 x 12 x 12"	0.27
Fluelining	8 x 8" per ft.	0.65

Depending on the individual dealer, price breaks may be available for contractors or may be tied to the quantity of products purchased. Stateside manufacturers may make prices available to local dealers and distributors which allow for resale at the factory price plus freight to the dealers area. Contractor discounts from local dealers are variable for individual products but approximate an average of 10 percent. Carload-lot orders may carry factory discounts. Damage or loss in shipment may be collectable by the consumer from the carrier, or covered by allowance of a small price discount per unit if purchase is made in larger quantities.

Product Distribution - Distribution of the structural products may be either through local retail outlets or by direct shipment from the manufacturer to large consumers. Often such consumers buy only "shortage" items from local outlets. Some evidence exists of military purchases direct from stateside manufacturers rather than local dealers due to the specification of products manufactured by a given company rather than specification of product characteristics. All of the major suppliers in the Anchorage-Fairbanks area carry structural clay products as secondary products only. Concrete block is often the primary product.

Transportation - The structural clay products are transported to Alaska by commercial van or rail barge or steamship lines from pacific northwest ports. They move from the Anchorage area to Fairbanks by rail. Distribution throughout the immediate marketing area is by truck but there is usually no major long distance transport of such products by truck due to their heavy, low unit value characteristics.

Transportation costs of such products are extremely high and constitute a large portion of the delivered cost to the Alaskan consumer. Table 13 gives estimated freight rates for selected structural clay products from Seattle to specified Alaskan ports. Although transportation costs may decrease if excessively large quantities are moved, the rates given adequately reflect the magnitude of cost involved. It should be noted that new transportation concepts, as through shipment of railroad car lots of commodities without rehandling, may cut current transportation costs appreciably.

The present low consumption of clay products in Alaska does not allow direct shipment from Anchorage to other Alaskan ports. Such shipment by commercial carriers would involve product transport to Seattle and then back to Alaskan ports on regularly scheduled carriers. This would obviously preclude competition of products manufactured in the Anchorage-Fairbanks area with those originating in the Pacific northwest. Either company owned transportation units or sufficient sales volume would be necessary to overcome this transportation handicap. A minimum of 200 tons per movement would be necessary to establish direct shipment to Southeastern ports by commercial carriers. This quantity currently exceeds the entire yearly consumption of most ports as shown in Table 15.

Table 13

Estimated Freight Rates, Seattle to Various Alaskan Ports (1)

(Dollars per CWT)

Destination	Products and Rates			
Seattle To	Brick (Building fire, paving except glazed or enameled)	Tile (Building and partition)	Tile (Facing, flooring and quarry)	Drain Ti and Sewer p
Anchorage (2)	2.44 (6)	2.88 (7)	2.43 (7)	3.08
Fairbanks (2)	2.94 (6)	3.51 (7)	2.84 (7)	3.88
Ketchikan (2)	1.65 (9)	3.18	2.12	3.18
Wrangell (2)	1.63 (9)	3.60	2.13	3.60
Petersburg (2)	1.61 (9)	3.60	2.10	3.60
Juneau (2)	1.83 (9)	3.84	2.36	3.84
Haines (2)	2.13 (9)	4.32	2.39	4.32
Skagway (2)	1.54 (9)	3.90	2.28	3.90
Sitka (2)	1.67 (9)	4.12	2.23	4.12
Valdez (3)	1.96 (9)	2.35 (7)	2.04 (7)	2.35 ([illegible])
Cordova (2)	1.63 (9)	1.63	1.63	1.93 ([illegible])
Cold Bay (4)	2.10	2.10	2.56	2.56
Nome (5)	2.92	2.88	3.42	3.42

(1) All tariffs used are listed in bibliography
(2) Includes all wharfage and handling (van rate) except as otherwise noted, except unloading at destination.
(3) Includes all wharfage and handling but would have $0.10/cwt allowance for shipper load and secure to pallets.
(4) Includes wharfage at Seattle (loose) but excludes wharfage at Cold Bay.
(5) Includes wharfage at Seattle (loose) and literage to beach.
(6) 40,000# minimum (7) 36,000# minimum (8) 26,000# minimum.
(9) Allowance of $0.15 per cwt for using carrier pallets, shipper loader.

Compilation assistance by the Institute of Business, Economics, and Government, University of Alaska.

Current Consumption

Present consumption of the structural clay products under existing prices is greatly limited. Table 14 gives the consumption of selected groupings of structural clay products in the Anchorage-Fairbanks marketing area for 1961 through 1963. Since no reliable statistical summaries of consumption exist, the given quantities were determined by compilation and analysis of exterior and interior transportation data and dealer sales information. The tonnage units are the primary values and have been converted into equivalent structural units only to show the physical significance of such tonnage. A breakdown of the markets between Anchorage and Fairbanks shows Anchorage to be the major marketing area since Fairbanks consumes approximately only 33 percent of the total brick, 23 percent of the total flueliner, and negligible amounts of sewer pipe and structural and drain tile. Table 15 provides a more general product consumption estimate for the total state.

Potential Consumption Under More Favorable Price Levels

The present level of consumption of the structural clay products within Alaska has been shown to be limited. Of more importance to the potential manufacturer is the determination of expanded market levels possible under more favorable prices due to local manufacture. This expected market expansion for building brick has been determined through an extensive attitude survey of homeowners in the Anchorage-Fairbanks area. This entire survey is presented in detail in Appendix D. The survey enabled determination of:

Table 14

**Estimated Consumption of Selected Structural Clay Products
Anchorage-Fairbanks Marketing Area
1961-1963**

Products and Units	1963		1962		1961		Average, 1961-1963	
	Units	Tons	Units	Tons	Units	Tons	Units	Tons
Brick:								
Common and face (3.5# brick equivalents)	202,857	355	246,857	432	242,285	424	230,857	404
Firebrick (6.25# brick equivalents)	69,760	218	36,800	115	39,360	123	48,640	152
Structural and Partition Tile (10#, 4x6x12" equivalents)	39,200	196	47,600	238	56,800	284	47,800	239
Sewer Pipe and Drain Tile (Foot equivalents, 10" dia. standard strength, 30#/ft.)	19,066	286	65,866	988*	28,533	428	37,800	567
Flueliner (Equivalent feet, 8x8" - 18#/ft.)	25,000	225	25,666	231	27,333	246	26,000	234

* Reasons for this exceptionally high tonnage not accounted for.

Source: Compiled from transportation data and dealer sales information.

Table 15

Clay Product Shipments Total
Alaska - 1963
(tons)

Harbor	Product Catagory		
	Clays and Earths	Brick and tile	Clay Products (Not elsewhere classified)
Ketchikan	--	20	3
Wrangell	--	5	-
Petersburg	--	2	-
Sitka	--	8	-
Juneau	--	72	2
Skagway	--	1	-
Cordova	--	4	3
Valdez	1	--	-
Seward	133	847	50
Anchorage	--	81	-
Whittier	--	--	-
Kodiak	--	11	-
Nome	--	72	-
Naknek River	--	21	-
Other ports, south-eastern	--	1	-
Aleutian Island ports	--	24	1
Southerly side of Alaskan Penninsula	--	9	-
Total	134	1178	59

Source: Waterborne Commerce of the United States, Part 4, Department of the Army, Corps of Engineers, 1963.

(1) The relative usage of the various types of building materials.

(2) Attitudes concerning the desirability of these materials.

(3) The effect of the recent earthquake on consumer attitudes toward various building products.

(4) The home-heating market potential of selected fuels.

(5) Attitudes concerning the desirability of these fuels.

(6) Changes within the home heating market to be expected in the immediate future.

The market expansion possible at various allowable increases in total home building costs is given in Table 16. The maximum allowable selling price of brick which would enable establishment of these individual market levels is given in Figure 5. The given demand curve represents the expected annual market levels obtainable at specified selling prices. Calculation of the maximum allowable price per brick is included as Appendix C. It is evident that sizable demand elasticity exists for the structural clay products. It should be noted that the given market expansion considers only an increase in private construction quantities. Corresponding increases in government and business construction could create appreciably larger markets.

Manufacturing Feasibility

No attempt will be made to estimate production costs at the various market levels due to the variety of equipment, kilns, fuels and manufacturing techniques which could be utilized. It is left for the potential manufacturer to determine if the requisite sale price levels could be met, using his proposed equipment

Table 16

Building Brick Market Potential For
Given Allowable Increases In Total Building Cost
(single dwelling units; Anchorage-Fairbanks area)

Allowable Home Cost Increase	Number of Additional Homes That Would Have Utilized Brick, 1963+		Market Expansion In Number of Building Brick++		Total Market Potential, Actual Use Plus Market Expansion*		
	Anchorage	Fairbanks	Anchorage	Fairbanks	Anchorage	Fairbanks	Total
10%	124	8	669,600	43,200	804,338	110,819	915,657
15%	46	3	248,400	16,200	383,638	83,819	467,457
20%	28	2	151,200	10,800	286,138	78,419	364,857

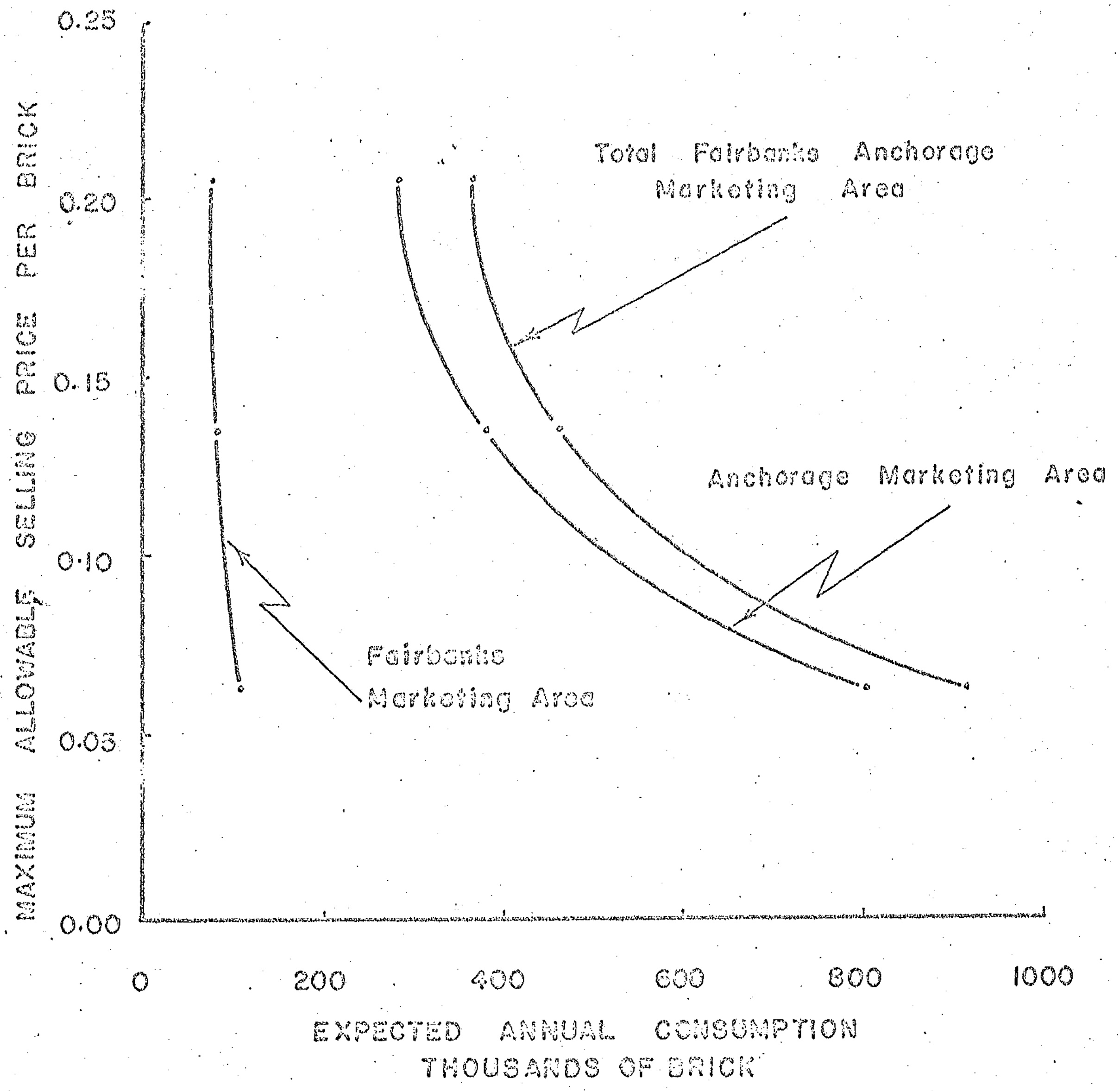
\+ In the city proper only, based on home-owner survey and building permits issued in 1963.

++ Assuming "average" house of 40' x 25' area, 8' wall height, 6.5 brick per ft., 20% allowance for wall openings, 5400 brick/house.

* Sum of actual 1963 usage of 3.5# brick equivalents and market expansion possible under more favorable price structure.

EXPECTED ANNUAL CONSUMPTION OF BRICK AT SPECIFIED PRICE LEVELS*

ANCHORAGE AND FAIRBANKS MARKETING AREAS



*Based on private building sector only. Excludes potential increases in government and industrial construction sectors.

Figure 5

and operating techniques. Analysis of Tables 17 and 18 show the most feasible location of a manufacturing plant is dependent upon the clays to be utilized. If the Healy clays are to be utilized, the manufacturing plant should be located in the Healy area in order to allow lowest cost distribution to the Fairbanks markets. The cost of distribution to Anchorage markets would be identical whether manufacture using Healy clays occurred in Healy or Anchorage. Intangible considerations include the lack of gas availability at Healy for kiln firing and a more restricted labor market. Coal for kiln firing is available however in the immediate area.

If local Anchorage clays were to be utilized the plant should be located in Anchorage. The lower quality clays involved, however, would necessitate preliminary studies to determine optimum forming and firing conditions. Gas is available in the immediate area and could be beneficial in achieving optimum firing conditions, especially if tunnel kilns were deemed necessary to overcome the unique clay firing characteristics. The Anchorage market potential so far exceeds that of Fairbanks it would seem to preclude consideration of manufacture in the Fairbanks area.

Table 17

Estimated Transportation Rates For Raw Clay
(Dollars per CWT)

Destination Anchorage To	Rate and Minimum Weight
Healy*	30,000# - 0.76
Sheep Mountain+	40,000# - 0.56
Homer+	40,000# - 0.92
Isabell Lake+	40,000# - 1.07

* Rail rate
\+ Truck rate

Table 18

Estimated Transportation Rates For Selected Clay Products

(Dollars per CWT - 30,000# minimum)*

Destination Healy To	Brick (Building, fire, paving, except glazed or enameled)	Tile (Building and partition)	Tile (Facing, flooring, quarry)	Drain Tile and Sewer Pipe
Anchorage	0.76	0.76	0.76	0.76
Fairbanks	0.42	0.42	0.42	0.42

* Not including loading or unloading charges.

Compilation by the Institute of Business, Economics and Government, University of Alaska.

VI

EARTHENWARE AND STONEWARE PRODUCTS

Significance Determination

Of the many whiteware, stoneware and earthenware products described previously, only earthenware or stoneware art-pottery, novelty, and souvenir products are judged to have potential significance. These products may be manufactured from moderately impure brick or low-refractory clays. Previous work by artist-potters in the Anchorage-Fairbanks area indicates that appropriate clays occur locally for the manufacture of these products. Clays from the Healy area have been shown to be especially suitable for such use. The manufacturing processes necessary for production of limited quantities of such products are not excessively complex and a relatively small capital investment would be required for small-scale production. Current local demand is acknowledged to be limited but the market potential is excellent.

Competitive Environment

It should be noted that large scale manufacture of common tableware or other ceramic products mass-produced by stateside of foreign manufacturers is not advocated. Rather, a small line of high quality, well-designed art pottery, novelty products, and souvenirs with an Alaskan motif could have significant market potential. Such products could be relatively expensive and still command a sizable market share. This type of product is now supplied Alaskan markets by manufacturers located in the lower states and in Japan. The Japanese products have created increasingly competitive pressures for domestic suppliers.

Product Consumption

Accurate consumption levels for individual product types are difficult to determine due to the lack of published summary statistics, the natural hesitance of local dealers to divulge confidential statistics, and joint treatment of all ceramic products in dealer records. Table 19 indicates the estimated consumption of selected whiteware and stoneware products in the Anchorage-Fairbanks area during 1963. It is an admittedly conservative estimate derived from measurement of approximately 80 percent of the Fairbanks market with projections for Anchorage based on comparative retail trade volumes and population in the respective trading areas. This procedure was necessitated by the physical destruction of many Anchorage dealer facilities by the recent earthquake.

Although Table 19 indicates very limited current consumption levels, purchase of novelty andsouvenir products has been greatly discouraged in the past because manufacture of these products has been outside of Alaska. In 1963, an estimated

96,000 tourists visited Alaska and spent 1.7 million dollars on gifts.[16] The magnitude of this potential tourist market could be appreciable if attractive, locally manufactured products were available.

Table 19

Consumption of Selected Whiteware, Earthenware, and Stoneware Products

Anchorage-Fairbanks Area, 1963

Product	Estimated Wholesale Volume-Dollars
Whiteware, earthenware and stoneware (novelties, souvenirs, garden-ware, art-pottery)	127,000
Chinaware	120,000

Manufacturing Cost

The available markets, and consequently production costs, are a function of the artistic and creative ability of the artist-potter, the quality of the product, and the efficiency of the marketing procedure. Knowledgeable major dealers in Alaska feel that for a local manufacturer to be competitive in the art-pottery line the cost of manufacture would have to average less than 30 cents per pound.

---

16) Private communication from Mr. Donn Hopkins, Director Division of Planning and Research, Department of Economic Development and Planning, State of Alaska.

VII

AFFECTS OF CLAY PRODUCTS MANUFACTURE ON THE ALASKAN COAL INDUSTRY

When this study was initially proposed to the state, it was felt that extraction of clays closely assoicated with clay deposits now being mined in Alaska could stimulate coal production within the state. Such stimulatory effect could result from the sale of larger quantities of coal at lower prices, made possible by the added profitability of clay sales. Investigation has proved this original premise to be fallacious for two reasons.

The total tonnages of clay required to supply both a structural products and ceramic pottery manufacturer would be limited. Assuming a conservative 20 percent loss factor for clay used in both types of operation, the total annual clay requirements would approximate 1,000 tons.[17] Even if the total income from this tonnage was deducted from the sales price of only 50 percent of the annual coal production of the Nenana area, the decrease would be less than a penny per

17) Assumes capture of 50 percent of the market for art-ware, novelty and souvenir items in the Anchorage-Fairbanks area, and production of 400,000 common brick.

ton.[18] Such a decrease would be totally insignificant.

Analysis of the consuming sectors which comprise the Alaskan coal market, and the results of a survey of homeowner attitudes toward coal utilization, indicate that coal usage rates are not a direct function of price. Military purchases, which accounted for 66 percent of total coal production in 1962 and 1963, are predicated only on procurement of a fixed number of heat units and do not directly reflect price. This same purchase basis is followed to a large extent by both private and industrial consumers. In addition, the previously mentioned survey (Appendix D) showed conclusively that the convenience and cleanliness characteristics of fuels cannot be overcome by lower coal prices.

It is therefore apparent, from consideration of the expected profitability and demand inelasticity, that production of the required amounts of clay could not possibly stimulate coal production in Alaska.

---

18) Assuming a clay cost of $1.50 to $2.00 per ton, FOB mine, based on cursory examination of coal operations in the Healy area and discussions with management personnel.

VIII

SUMMARY AND RECOMMENDATIONS

Summary

This study has identified two clay products with current marketing significance, four secondary products with lesser significance, and two uses with appreciable future potential.

The manufacture of common building brick is judged to have major significance, contingent upon the ability of local manufacturers to meet identifiable maximum price levels. The necessary facilities could be used with minor modifications to manufacture flueliner, structural tile, firebrick, and drain tile as secondary products. The quantities of common brick which could be sold at specific price levels has been determined for the private construction sector for the Anchorage area. The demand elasticity for this product is felt to be applicable to other structural clay products.

The manufacture of earthenware and stoneware art-pottery, novelties, and souvenirs has also been judged to have potential. Although current demand for such products is limited, a large tourist market exists for a locally manufactured, well designed product with an Alaskan motif.

Utilization of clays in petroleum exploration and cement manufacturing operations could have future significance. Increased drilling operations could warrant more extensive exploration for bentonite clays, while the clay tonnages required to supply a future cement manufacturer could be appreciable.

Recommendations

Full realization of either the structural or ceramic products markets would appear to warrant additional investigation.

To rationally develop a sound structural clay products industry it is requisite that technical studies be undertaken to determine the forming and firing characteristics of clays in the Anchorage and Healy areas.

Manufacture of art-pottery products, especially if accomplished by Alaskan natives to achieve authenticity, would necessitate two preliminary programs. A technical study would be required to locate readily accessible clays of appropriate quality, and a training program should be established to develop and refine the unique talents of the artist - potters necessary for such manufacture.

APPENDICES

Appendix A

Summary of Clay Origin, Type, Mineralogy, and Properties

Definition

Technically clay has been defined as a natural, earthy, fine grained material, composed chiefly of hydrous aluminum silicate minerals of colloidal or near colloidal particle size. (1) It generally becomes plastic when wet, rigid when dry, and vitreous when subjected to high temperatures. Clay may occur in the form of a paste, laminated rock or soft solid.

Origin

Most clays have occurred as a result of weathering or chemical decomposition of aluminum bearing rocks. If the residue from these processes remains in place the resultant clay deposit is known as a "residual" deposit. If, however, the decomposition products are transported to another depositional area by wind, water, or glaciers, the deposit is termed a "transported" clay. The chief exception to this simple origin classification is the formation of clay within the earths surface through alteration of rock by hot acqueous solutions.

---

1) Bates, R.L., Industrial Rocks and Minerals, Harper and Brothers, New York, 1960.

Since residual deposits largely take the form of the source rock, they may occur in a variety of forms varying from near-vertical dikes to horizontal deposits of great area. Depositional depths depend only on the amount of weathering, and the extent of deposits of transported clays is largely a function of the depositional environment. Such deposits are often described, based on the depositional location, as (1) lake clays - formed in restricted interior basins (2) swamp clays - formed in coal swamps by fine stream material or through the action of organic compounds on peat formations, (3) stream clays - deposited either in protected environments or on flood plains, (4) estuarine clays - mechanically deposited in restricted ocean arms, and (5) lagoon deposits - laid down in areas adjacent to Ancient Seas. In addition, glacial erosion with subsequent deposition of melt water material, and wind transportation of fine clay particles has also resulted in clay deposit formation.

<u>Clay Minerals</u>

The fine crystalline clay particles are known generally as hydrous aluminum or magnesium silicates. Certain minerals have been identified and grouped by physical properties as shown in Table I.

Table I

Clay Minerals

Mineral Name	Composition
Kaolin group:	
Kaolinite	$Al_2(Si_2O_5)(OH)_2$
Halloysite	$Al_2(Si_2O_5)(OH)_2$
Livesite	$Al_2(Si_2O_5)(OH)_2$
Dickite	$Al_2(Si_2O_5)(OH)_2$
Nacrite	$Al_2(Si_2O_5)(OH)_2$
Anauxite	$Al_2O_3 3SiO_2 2H_2O$
Allophane	$Al_2O_3 \cdot nSiO_2 nH_2O$
Montmorillonite group:	
Montmorillonite	$(Al, mg)_2Si_4O_{10}(OH)_2$
Biedellite	$Al_2(Al,Si)_4O_{10}(OH)_2$
Nontronite	$(Al,Fe,Mg)_2(Al,Si)_4O_{10}(OH)_2$
Hectorite	$(Mg,Li,Al)_3Si_4O_{10}(OH)_2$
Saponite	$Mg_3(Al,Si)_4O_{10}(OH)_2$
Hydromica (illite)	Variable
Magnesium silicate group:	
Sepiolite	$H_4Mg_2Si_3O_{10}nH_2O$
Attapulgite	$Mg_5Si_8O_{20}(OH)_2 8H_2O$

Source:

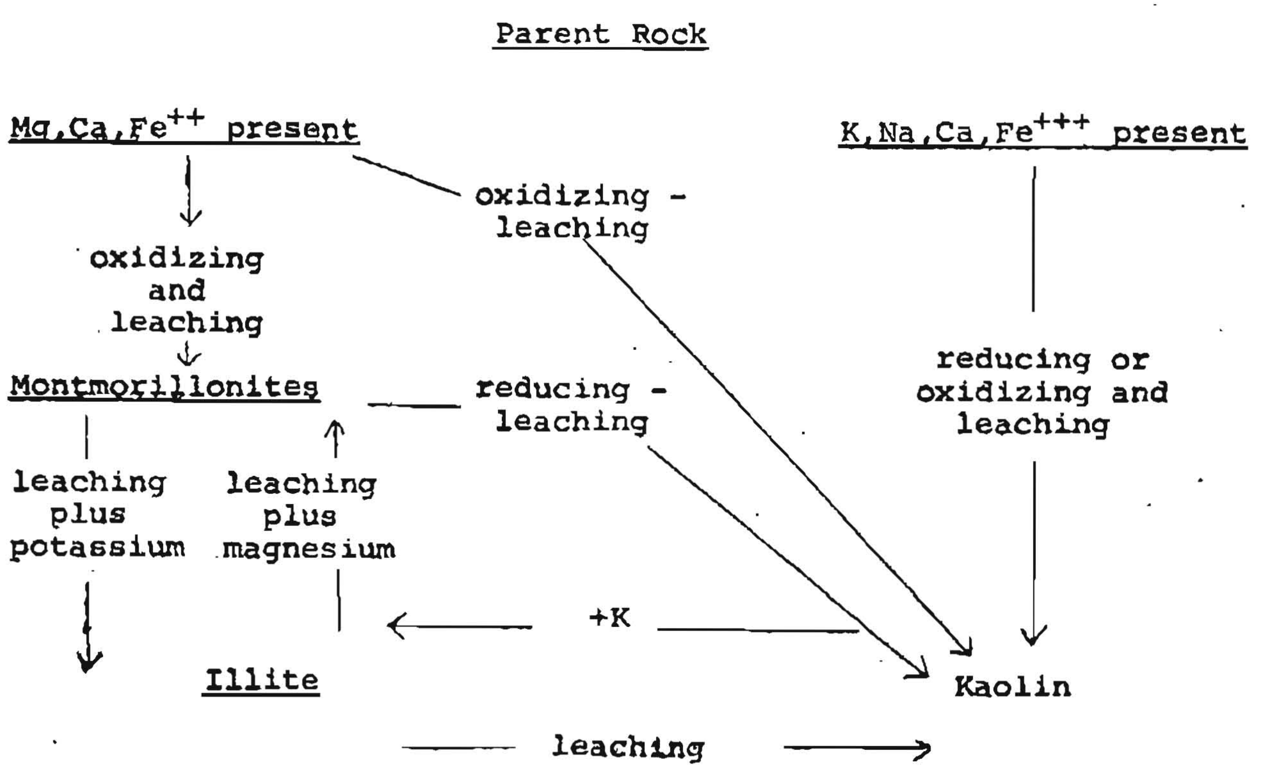
Mineral Facts and Problems, Bulletin 585, Bureau of Mines, 1960, pp. 202.

According to Bates[1] the mineral structure of clay consists of two different types of atom layers. These layers occur in different positions and combinations of aluminum, iron, or magnesia atoms embedded in oxygen or hydroxl atoms. If magnesia

1) Bates, R.L., Industrial Rocks and Minerals, Harper and Brothers, New York, 1960.

is present the resulting sheet is termed the 'brucite' structure. A 'gibbsite' structure denotes a sheet in which aluminum is the embedded material. The second type of atom layer is composed of silicon, oxygen, and hydroxl atoms and is termed the silicon tetrahedral sheet. The general formula for the brucite structure is $Mg_3(OH)_6$, for the gibbsite structure $Al_2(OH)_6$, and for the silican tetrahedral sheet is $Si_4O_6(OH)_4$.

The clay minerals, however, are not fixed but may react to changes in composition, temperature, and hydrogen ion concentration in their immediate environment. Such clay mineral instability and sensitiveness to environmental conditions is illustrated by the following chart.



Source: Problems of Clay and Laterite Genesis, American Institute of Mining and Metallurgical Engineers, 1952.

Similar groups of minerals may differ very little chemically but possess entirely different crystal lattices. The montmorillonite group varies from the kaolin group in crystal form and structure constituents, and mode of formation. The basic structure of the kaolinite group is a two layer lattice consisting of a gibbsite sheet plus silica, while the general structure of the montmorillonite group is a three layer unit consisting of a gibbsite layer sandwiched between two silica tetrahedral layers. The illite structure is a unit containing a gibbsite sheet enclosed between two silica tetrahedral sheets in which some substitution of alumina for silica has occurred. An exception to the general clay mineral structure is that of attapulgite, which is a chain-type rather than a layered structure.

Nonclay Minerals

Clay deposits often contain quantities of mineral impurities which influence the clay properties, value, and usage. Some of the more common minerals which occur with clay, their composition, form, and influence are given in Table II.

Clay Types

Table III summarizes the chief clay types, their use, and chief characteristics as set forth by Bateman.[2]

---

2) Bateman, A. M., Economic Mineral Deposits, Second Ed., John Wiley and Sons, New York, 1950, pp. 699.

Table II

Composition and Influence of Nonclay Minerals

Impurity	Composition	Influence
Quartz	SiO_2	Decreases plasticity and shrinkage and imparts refractory properties
Rutile	TiO_2	Titanium acts as flux at higher temperatures
Limonite	Hydrous iron oxide	Iron lowers fusion temperatures, acts as a flux and strong coloring agent
Siderite	$FeCO_3$	
Pyrite	FeS_2	
Gypsum	$CaSO_4$	- - - - - - - - - -
Feldspar	Aluminum silicates with K, Na, and/or Ca	Aluminum imparts refractoriness; silica increases plasticity
Muscovite	Aluminum silicates with K and (OH)	
Calcite	$CaCO_2$	Flux

Source: Bateman, A.M., Economic Mineral Deposits New York: John Wiley and Sons, 1950, pp. 699.

Table III

Clay Types

Clay Type	Chief Use	Major Characteristics
Kaolin	whiteware, porcelain fillers, paper	High-grade, fine-grained, white burning, limited occurrence
Ball	Whiteware	White-burning, good quality, sedimentary, plastic, refractory, limited occurrence
Fire	Refractories	Include all refractory clays with exception of kaolin and ball clays. Normally sedimentary, possibly nonplastic endure high temperature.
Stoneware	Stoneware	Dense-burning, semi-refractor
Paving and sewer pipe	Sewer pipe	Fair quality, variable color
Brick and tile	Brick and Tile	Common, low-value clay, fires to cream or red color
Bentonite	Filtering, drilling-mud, bleaching agent	May be swelling or non-swelling, bleaching or non-bleaching. Swelling and bleaching types of limited occurrence.
Fullers Earth	Filtering	Absorptive properties, limited occurrence.

Source: Bateman, A.M., Economic Mineral Deposits. New York: John Wiley and Sons, 1950, pp. 698.

Clay Properties

Although desirable clay properties vary widely and depend chiefly on end us, it is possible to note selected properties relevant to all clays.

Plasticity is the characteristic which enables shaping of raw clay before burning. A highly plastic clay is termed "fat" clay, while a non-plastic clay is termed "lean" clay. The degree of plasticity is a function of mineral particle size, shape and distribution, as well as colloidal content and the nature and amount of water contained in and surrounding the mineral particles. It can be influenced by both blending and preheating processes.

The fusibility of clay is significant since it helps determine the degree to which a clay can be utilized in refractory applications. To determine its refractory properties the behavior of the clay is compared to the behavior of a standard specimen of known quality. Such behavior usually consists of subsequent stages of compaction, vitrification and fluidity. The entire temperature range of the process is significant as well as the absolute temperatures at which each stage occurs.

Many clays contain small quantities of inorganic compounds which are detrimental to clay usage. Such compounds may be the product of reactions between the kiln gases and clay raw materials, or weathering of associate minerals. These compounds are termed soluble salts and are objectionable since they may cause formation of a white coating on the fired clay product, interference with glaze application or disintegration of the product. They can often be combated by the addition of barium compounds which convert the compounds to insoluble salts.

The firing changes which clays undergo are also significant. Properties which may be affected include color, specific gravity, porosity, hardness, volume, thermal conductivity, electrical resistivity, and others. The color of fired clays is usually determined by the amount and type of clay constituents, with iron compounds, titanium oxide, and lime having major influence. Volume changes in clay are important and may occur due to exposure to heat source, flow deformation under load at elevated temperatures, or elastic expansion and contraction. The relative significance of each type of volume change is dependent on the desired product. Such changes in dimension may be due to the volatilization of certain constituents or a change in clay porosity. Uncontrollable shrinkage normally precludes the use of the clay in fired products.

The strength-hardness characteristics and requirements of clay are highly variable and are largely a function of product end-use. Green strength denotes the ability of a body to withstand handling when in a moist state, while dry strength refers to its resistance to handling and the forces encountered in its utilization. Bonding strength refers to the inherent ability of the clay to hold together non-plastic material particles. Strength characteristics may be determined under tensile, compressive, abrasive or impact conditions.

Clays may contain water in two distinct forms. Mechanically held water normally denotes that water which evaporates at room temperature, that water contained in the interparticle spaces, and the thin molecular film of moisture on the individual particle. Chemically held water refers to that moisture in combination in the hydrous aluminum silicates which evaporates at relatively high temperatures.

Although many additional properties could be described, it is preferable to indicate those above properties relevant to major end uses. Generally, the properties important in ceramic usage are plasticity, fired color, dry and fired strength, drying and firing shrinkage and vitrification range. Properties important in refractories include all those given for ceramics plus the ability to withstand elevated temperatures, resistance to spalling, peeling and fluxing, and electrical resistivity. Cement manufacture requires given chemical properties, lightweight aggregate products demand definite firing characteristics, filtering and decolorizing uses require high sorption and ion-exchange activity, and filler and paper usage necessitate definite grain texture and color characteristics.

Appendix B

Alaskan Clay Deposits of Possible Economic Significance

by J. E. Wallis, Mineral Industry Research Laboratory

Summary

Alaska has relatively few high-quality clay deposits with major economic significance. The majority of the known deposits are suitable only for the production of the heavy clay products. The clay deposit at Sheep Mountain with proper preparation is capable of producing refractory products. The Healy deposits are suitable for use in the manufacture of art-pottery objects and cement, as well as the structural clay products. Montmorillonite from the Isabel Lake deposit may be suitable for use in drilling mud. Common clays from many points in the immediate Anchorage area should be suitable for structural clay products, but could require strict control of the manufacturing process.

Deposit Descriptions

The following deposits have been indexed on the map shown as Figure I by letters corresponding to those by which the deposit is designated. Their descriptions have been summarized largely from recent U.S. Geological Survey materials.[1]

---

1) Mineral and Water Resources of Alaska, United States Geological Survey and State of Alaska Department of Natural Resources, U.S. Government Printing Office, Washington, 1964.

Anchorage Area - A

Marine clays of estuarine origin are exposed along the sea-cliff on Knik Arm from Point Woronzof to the mouth of the Eagle River. The clay is blue to gray in color, sticky when wet and contains silt laminations. Auger holes indicate approximately 49 feet of clay above, and 75 feet below extreme high tide. Clay thickness in the Government Hill area averages 10 feet. The deposits in the vicinity of the Elmendorf Reserve average 20 feet in thickness and are overlain by 20 to 25 feet of gravel till.

A very impure clay is located about 11 miles from Anchorage at the intersection of Edmonds Creek and the Potter Highway. The deposit is covered by gravel and has a maximum depth of around 14 feet.

Sheep Mountain - B

Sheep Mountain is located on the Glenn Highway 113 miles northeast of Anchorage. The clay occurs mixed with gypsum rock; is sticky and plastic, with a color range from grey to yellow. Some of the clay from this area has been used in the manufacture of brick and firebrick. The clay possesses good working characteristics and excellent fired strength.

Millers Landing - C

This deposit is located in the Homer area just south of Millers Landing. It is a blue clay which occurs near the top of the kenai coal bearing formation, and is exposed as an outcrop in the bluff along Kachenak Bay.

Nenana - D

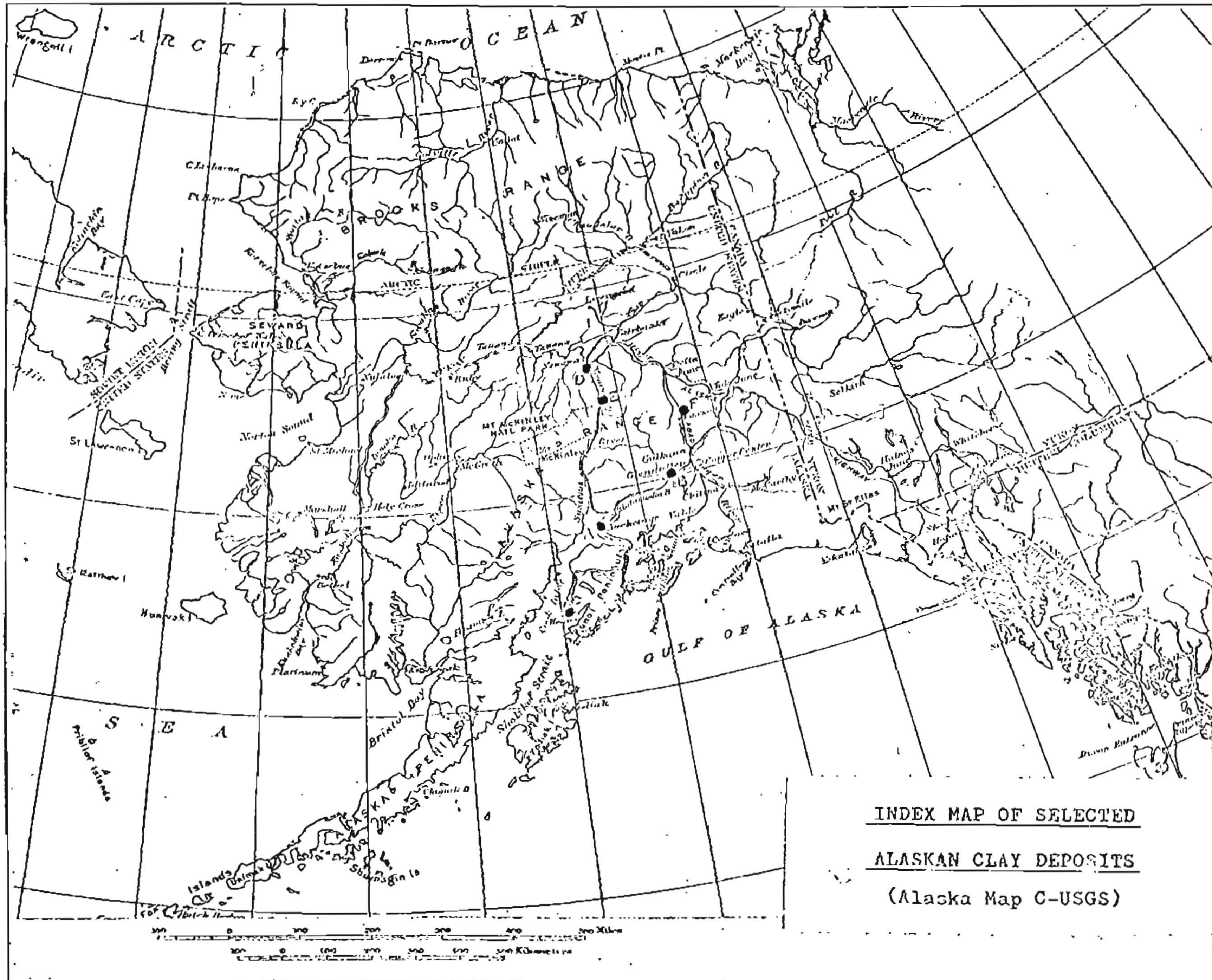
Lenticular, flat lying clay deposits occur about three miles south of Nenana along the Alaska Railroad. Definite clay units varying in color from tan to gray are identifiable. Preliminary tests indicate the clay to be suitable for common brick and tile.

Healy Creek - E

Healy is located at mile 351 on the Alaska Railroad. It is accessible by road and railroad from Fairbanks and by railroad from Anchorage. Two major beds of clay and claystone suitable for structural clay products are identifiable in the coal bearing formations on Healy Creek. One is a dark brown claystone about 100 feet in thickness and the other consists of a green claystone approximately 130 feet in depth. Clays suitable for art-pottery objects also occur in the same general area.

Isabel Lake - F

Isabel Lake is located roughly six miles northeast of Summit Lake on the Richardson Highway. Montmorillonite clay, possibly of drilling-mud quality, occurs over a large outcrop area. Detailed deposit information has not been published.



INDEX MAP OF SELECTED ALASKAN CLAY DEPOSITS

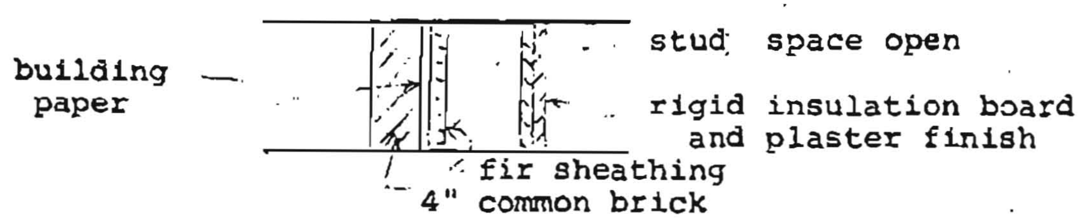
(Alaska Map C-USGS)

Appendix C

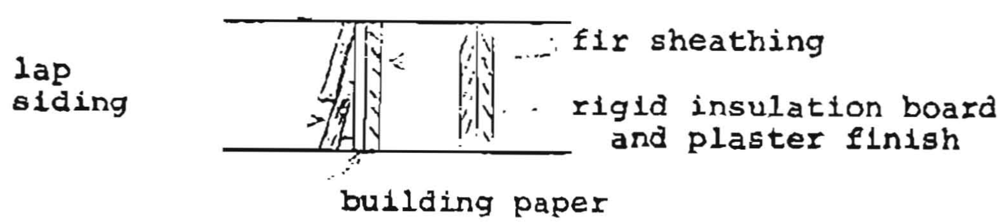
Cost Comparison of Basic Wall Types to Determine the Maximum Brick Cost Necessary to Realize Allowable Increases in Total House Construction Cost

A. Types of wall utilized in comparison:

a. Frame wall, brick veneer - 4" common brick building paper, 25/32" fir sheathing, 2"x4" studs, 1" rigid insulation board and plaster finish interior, stud space open, U factor of .15



b. Frame wall, 2"x4" studs - yellow pine lap siding, building paper, 25/32" fir sheathing, 1" rigid insulation board and plaster finish interior, stud space open, U factor of .15.



B. Cost assumptions - Siding vs brick veneer only - remainder of wall similar construction

1. Wood Siding Cost Approximations

Material - - - - - - - - - - -	$0.275/ft^2$
Labor - - - - - - - - - - - -	$0.275/ft^2$
Painting - - - - - - - - - -	$0.150/ft^2$
Total	$0.700/ft^2$

2. Brick veneer cost approximations

Material (6.2 common std. per ft^2, 1/2" joints @ 0.18 ea.) - - - - - - - -	$1.116/$ft^2$
Labor -	1.000/ft^2
Mortar -	0.175/ft^2
Total	$2.291/$ft^2$

* Common std. in Fairbanks would be 24¢.

C. Siding cost allowable for various total home cost increases.

1. Assume following percentage base costs for construction cost of "average" brick veneer house* (1 story, single family, 1000-1250 ft^2, 5 1/2 rooms, no basement, 1 bath).

(a) Structure and finish (Foundations, walls, partitions, floors, ceiling, roof, windows) Percent of Total Cost - -	84
(1) Average for exterior wall masonry component** - - - - - - - - - - - - 8%	
(b) Heating and ventilating - - - - - - - - - - - - - -	6
(c) Plumbing -	8
(d) Electrical -	2
Total	100%

* Building Cost Manual, Joint Committee on Building Costs of Chicago Chapter of American Institute of Architects and The Appraisers Division of the Chicago Real Estate Board John Wiley and Sons, New York, 1957, example 113B.

** Average of exterior masonry component of 11 different types of masonry structures, Engineering News Record, "Where the Building Dollar Goes" (March 1964, December 1963, September, 1963).

2. Allowable increase in exterior wall component of total cost.

(a) Let X = allowable increase in exterior wall component
W = wall component portion of total cost
S = (Structure and finish component of total cost)-(Wall component)
H = Heating and ventilating component
P = plumbing component
E = electrical component

(b) For 10% allowable increase in total house cost

$X(W) + S + H + P + E = 110$
$X(8) + 76 + 6 + 8 + 2 = 110$
$X = 2.25$ multiplier to determine allowable exterior masonry cost.

(c) For 15% allowable increase in total house cost.

$X(W) + S + H + P + E = 115$
$X(8) + 76 + 6 + 8 + 2 = 115$
$X = 2.88$ multiplier to determine allowable exterior masonry cost.

(d) For 20% allowable increase in total house cost.

$X(W) + S + H + P + E = 120$
$X(8) + 76 + 6 + 8 + 2 = 120$
$X = 3.5$ multiplier to determine allowable exterior masonry cost.

3. Allowable brick veneer cost per square foot.

(a) For 10% total house cost increase
($0.70 x 2.25) - - - - - - - - - - - - - - - - $ 1.57/ft^2
(b) For 15% total house cost increase
($0.70 x 2.88) - - - - - - - - - - - - - - - 2.02/ft^2
(c) For 20% total house cost increase
($0.70 x 3.5) - - - - - - - - - - - - - - - - 2.45/ft^2

D. Maximum brick cost to enable wall construction at allowable total cost increase.

1. 10% cost increase
(Total Cost Allowable - (Labor) - Mortar) ÷ No. of brick/ft^2 = maximum cost per brick

$$\frac{\$1.570 - 1.000 - 0.175}{6.2} = \frac{0.395}{6.2} = \underline{\$0.064}$$

2. 15% cost increase

$$\frac{\$2.02 - 1.00 - 0.175}{6.2} = \frac{0.845}{6.2} = \underline{\$\ 0.136}$$ maximum cost per brick

3. 20% cost increase

$$\frac{2.45 - 1.00 - 0.175}{6.2} = \frac{1.275}{6.2} = \underline{\$\ 0.206}$$ maximum cost per brick

Appendix D

Survey of Homeowner Attitudes Concerning Building Materials and Fuels in The Anchorage-Fairbanks Area

by Dr. Kenneth Martin, Director, Counseling and Testing, University of Alaska

Purpose

The objective of this survey was to determine basic homeowner attitudes concerning the relative desirability of selected building materials and fuels. The total purpose was to gain information that would reinforce the data gathered from other sources to determine the market potential of clay structural products in Alaska, and the relationship between coal consumption and coal price.

Method

Because of time limitations and monetary restrictions, questionnaires were utilized to survey the property owners of Alaska's two major marketing areas, Anchorage and Fairbanks.

The list of property owners used for the survey was determined by the tax rolls of the two cities. The tax rolls of both cities were stratified according to the subdivisions of the cities. After eliminating the commercial establishments, a sample of 635 names was drawn, 350 from Fairbanks and 285 from Anchorage. The smaller number from Anchorage was due to sampling of larger population increments and availability of only 80 percent of the Anchorage tax rolls at the time the questionnaires were mailed. Fortunately, the majority of the property in the missing rolls was the commercial property in downtown Anchorage. With this exception, each section of both cities was represented in proportion to the number of property owners in each subdivision.

Data Analysis - Building Materials

Of the 635 questionnaires distributed for the study, 6.3 percent were unclaimed by the addressee. This figure was constant for both marketing areas, as shown in Table I. The completed and returned questionnaires represented a 42.0 percent return for the total sample. The Anchorage return was 51.3 percent in contrast to the Fairbanks return of 34.4 percent. It can only be hypothesized that the larger return from Anchorage was due to a greater interest in home construction material brought about by the recent earthquake.

Table II shows the distribution in terms of percent of responses received from Anchorage and Fairbanks and the two areas combined to the question, "Which type of house construction do you prefer for your locality?" The number of responses exceeded the number of respondents in both cases, indicating that for some persons one type of construction is equivalent to another. The respondents were given six options from which to choose: wood frame, concrete block, stucco, brick, brick and wood and log. Wood frame and log accounted for 79 percent of the total responses and brick and wood accounted for 9 percent of the total responses. The majority of the respondents from each marketing area indicated that wood frame construction was the type of construction preferred by most homeowners. The most noticeable difference between the two marketing areas was the greater preference for log construction in the Fairbanks area - a difference of 20.2 percent.

The respondents were queried as to the reasons they preferred a certain type of home construction. Table III shows the responses in relation to preference for certain types of home construction. Where multiple responses were given but not ranked by order of preference the respondents were eliminated from the table. The reasons most often given for preference of frame construction were low initial cost, general appearance and low heating cost. The reasons most often given for preference of log construction were general appearance, low initial cost and low heating cost in that order. However, a comparison of the two distributions revealed that those preferring log construction indicated low initial cost, general appearance and low heating cost to be of equal importance whereas those preferring frame construction judged low initial cost to be two to three times as important as lower heating cost or general appearance.

General appearance was the reason most often given for preferring brick and wood. Low maintenance cost was the reason most often given for preferring either concrete block, stucco, or brick construction.

Comparing the two marketing areas by the reasons most often utilized to explain their preferences, the respondents from the Fairbanks area gave greater emphasis to low heating cost than did the Anchorage respondents irregardless of the type of construction. The differences in the distribution probably reflects the difference in climate and price of fuel between the two areas.

Table IV shows the type of materials used in the construction of the houses in which the respondents were presently living. The responses indicated that 90.5 percent of the Anchorage respondents and 84.1 percent of the Fairbanks respondents reside in homes of wood frame construction and that no respondent in either area lived in houses utilizing brick as a major structural feature. The difference in the two areas with regard to preference for log construction was somewhat reflected in Table III. Ten percent of the respondents from Fairbanks indicated a log residence as opposed to 4.4 percent of the respondents in Anchorage. For the total sample, 5.2 percent reported that concrete block and stucco was the type of construction used in their present homes.

The respondents were queried as to whether the recent earthquake had affected their preferences for building materials. Table V shows the relative numbers offered. While 87.6 percent of the respondents from both areas replied in the affirmative, a larger percentage of the Anchorage respondents indicated that their preferences had been affected. In the Anchorage area 94.2 percent indicated their preference was affected as opposed to 79.6 percent of the Fairbanks respondents. The responses indicating an aversion to certain types of construction were tabulated and a percentage distribution developed. Table VI shows the distribution of "least preferred" responses as a percentage of total responses received. Concrete block, stucco and brick construction received 93.3 percent of the "least preferred" responses in the Anchorage area as opposed to 78.4 percent in the Fairbanks area. Attitudes toward log construction were least affected in both marketing areas.

Table VII shows the percentage of Anchorage residents who would have purchased a brick home of similar size at a higher cost if one had been available. Because of apparent misinterpretation of the question by the Fairbanks' respondents, similar data was unavailable on that marketing area. The data shows that 31.4 percent of the Anchorage respondents would have purchased a brick home at a higher cost had it been available. Table VIII shows the percentage of increase they would have been willing to pay compared to the type of house in which they are presently residing. Of the respondents who lived in wood frame homes 64.3 percent would have paid ten percent more, 21.4 percent would have paid fifteen percent more, and 14.3 percent would have paid twenty percent more for a home utilizing brick construction. Only one respondent who lived in a concrete block home would have purchased a brick home at an increase in price.

Table IX compares the assessed valuation of the Anchorage respondents' present home with their willingness to pay for a brick home at a specified increase in price. Of the ten respondents whose homes were assessed at ten thousand dollars or less 40 percent would have paid 10 percent more, 40 percent would have paid 15 percent more, and 20 percent would have paid 20 percent more. Of the twenty respondents whose homes carried an assessment between ten and twenty thousand dollars, 70 percent would have been willing to pay an increase of 10 percent, 15 percent would have been willing to pay an increase of 15 percent, and 15 percent would have been willing to pay an increase of 20 percent. Of the eleven respondents whose homes carried an assessed value of twenty-one to thirty thousand dollars, 72.7 percent would have paid an increase of ten percent, 18.1 percent would have paid an increase of 15 percent and 9.2 percent would have paid an increase of 20 percent. Two respondents whose homes were assessed at $31,000 or over would have paid more for a brick home - one would have paid 10 percent more and the other would have paid 15 percent more.

Conclusions - Building Materials

Wood frame construction predominates in both areas as a present residence and as a preferred residence. Low initial cost and general appearance were the attributes most generally considered in defining a preference for such construction. Log construction appears to have an appeal to respondents from both areas but the Anchorage respondents are less inclined to this type of construction than the Fairbanks residents. One-fourth of the Fairbanks respondents indicated a preference for log construction as opposed to only 5 percent of the Anchorage respondents.

Distributors of building materials should be aware of the effect of the earthquake on attitudes towards certain types of construction. With regard to the type of materials most affected, 92 percent of the Anchorage responses and 78 percent of the Fairbanks responses judged concrete block, stucco and brick to be the least preferable. Of this total, concrete block was affected to a greater extent than brick or stucco. Dealers in these materials should promote an educational campaign directed toward creating a more realistic attitude toward these materials.

Assuming the figures from this sample are representative of the two areas, brick appears to have a market providing the price can be lowered appreciably and the attitudes can be modified. Although the earthquake appeared to have affected the attitudes toward the use of brick in home construction, a market still exists for brick home construction and the use of brick as trim. Promotional literature prepared by brick dealers could emphasize the improvement in general appearance and the low maintenance cost to reinforce the attitude presently held by the respondents.

Data Analysis - Fuel

The results dealing with the portion of the questionnaire concerned with fuels will also be reported here. The respondents were queried as to their fuel preferences, the reasons for this preference, the type of fuel presently being utilized, past conversions, intention of conversion, and attitudes toward coal as a fuel.

The respondents were given four choices with which to indicate their fuel preferences: gas, oil, coal and electricity. Table X shows the percent distribution of the responses among the four choices for each marketing area and for the total sample. The distribution of responses indicates that the respondents were answering in terms of the fuels available in the marketing areas at the time of the survey. The Anchorage responses indicating preference for heating fuel were distributed as follows: 46.7 percent for gas, 27.7 percent for electricity, 24.1 percent for oil, and 1.5 percent for coal. The respondents in the Fairbanks area indicated their preference to be as follows: 36.3 percent for oil, 35.4 percent for electricity, 17.7 percent for gas and 10.6 percent for coal. The difference in the order and magnitude of the responses for the Anchorage area suggest that if fuels are equally available, natural gas would predominate with electricity and oil having a smaller market.

Table XI shows the reasons given by respondents for preferring specific fuels. Since multiple responses were obtained from the respondents on each fuel, the table represents a tabulation of attributes ascribed to each fuel by the respondents preferring the fuel. The respondents were least concerned with burning efficiency regardless of the fuel preferred. The factors of cleanliness and convenience were the reasons most often given for preferring gas and electricity in Anchorage and oil and electricity in Fairbanks. With regard to the respondents that preferred coal, cost was the primary reason for their choice. Of the four reasons permitted the respondents, cleanliness was given first consideration followed closely by convenience with cost in the third position and burning efficiency given only minor consideration.

The respondents were surveyed as to the type of fuel they were presently using. As can be seen in Table XII the Anchorage responses indicated 61.3 percent were using oil, 35.0 percent were using gas, 1.5 percent were using electricity and 0.7

percent were using coal. The classification, "other", resulted from 1.5 percent of the respondents indicating that they were using wood as a heating fuel. The respondents from Fairbanks indicated that 76.2 percent were using oil, 18.7 percent were using coal, 1.9 percent were using bottled gas, and 0.9 percent were using electricity. Some respondents indicated that they were using either city steam or wood for heating purposes and represented 2.3 percent of the respondents in the Fairbanks sample.

Table XIII shows the percentage distribution of respondents who indicated their intentions of converting to another fuel. For the total sample 17.5 percent of the Anchorage respondents indicated that they were considering conversion as opposed to 12.4 percent of the Fairbanks respondents. Table XIV compares the fuel preference of those considering conversion to the type of fuel they are presently using. All of the Anchorage respondents who indicated that they were considering converting to another fuel were using oil at the time of the survey. The fuel preferences for this group were distributed 58.3 percent for gas and 41.7 percent for electricity. Of the Fairbanks respondents considering converions, 57.2 percent were using oil and 42.8 percent were using coal. The preferences of the respondents were distributed as follows: 50.0 percent preferred electricity, 28.6 percent oil and 21.4 percent preferred gas. Of the respondents who were considering converion and using oil, the greatest number preferred electricity and of the respondents using coal, the greatest number preferred oil.

Table XV shows the effect of a decrease in the price of coal on the type of fuel presently being used. In the Anchorage area 2.3 percent of the non-coal users would consider using coal if the price were to decrease. None of those using electricity would consider changing but 2.4 percent of those using oil would change and 2.3 percent of those using gas would change. The responses from the Fairbanks area indicated that 21.4 percent of the respondents would consider either changing fuels or continue using coal assuming a decrease in price. A large portion, 99.2 percent of the respondents presently using coal would continue using it and 12.0 percent of those using oil would consider changing. None of the Fairbanks respondents using gas or electricity would consider changing to coal if the price were to decrease.

Table XVI shows the percentage of conversion within the past three years for the two marketing areas. The Anchorage responses indicated that 35.8 percent of the respondents had converted within the same period of time.

Table XVII indicates the direction and number of the changes that took place. Of the Anchorage respondents who did convert, 89.8 percent changed from oil to gas, 4.1 percent changed from coal to oil, 4.1 percent changed from oil to electricity, and 2.0 percent changed from gas to oil. Of the respondents in Fairbanks who converted, 71.4 percent changed from coal to oil, 21.4 percent changed from gas to oil and 7.2 percent changed from coal to electricity.

Conclusions - Fuels

The expressed preference for a specific fuel appeared to be dependent upon the type of fuels available in a particular marketing area, but a hierarchy of preference could be established. For the Anchorage area, gas was the most preferred followed by electricity and oil with coal given very little consideration. For the Fairbanks area, oil and electricity were equivalent in overall preference followed by gas with coal receiving the least number of preferences. In ascribing reasons for their preferences the respondents emphasized the factors of cleanliness and convenience as being the most important. Gas was described as having more of the four advantages than any other fuel and coal was described as having only one major advantage - lower cost. Oil and electricity were viewed as having the advantages of convenience and cleanliness but without the advantages of lower cost and burning efficiency.

With regard to the type of fuel in use the majority of the respondents in both areas were using oil, however, the Anchorage respondents indicated that approximately 35 percent were using gas as a heating fuel. How the present status would be affected by future conversions was answered somewhat with information on intention of conversion and past conversions. Seventeen percent of the Anchorage residents were considering conversions and the past trends indicated that the majority of those using oil would convert to gas and those using coal would convert to oil. Twenty percent of the Fairbanks residents were considering conversion and the past history of conversions indicated the majority of these would be from coal to oil with approximately twenty-one percent of those planning conversion from bottled gas to oil.

Although the attraction of coal as a fuel was based on cost, it would not appear that reducing the price of coal would attract many new customers. Approximately 2 percent of those using oil or gas would consider changing in Anchorage and 12 percent of the Fairbanks' respondents using oil would consider changing.

It is interesting to note that the history of past conversions indicates that the hierarchy of fuels established through preferences was a true hierarchy. In the majority of cases when conversion took place, the change was to the next fuel level on the hierarchy.

Table I

Disposition of Questionnaires

Source	Number Distributed	Number Unclaimed	Percent Unclaimed	Number of Possible Returns	Number Returned	Percent of Possible Returns
Anchorage	285	18	6.3	267	137	51.3
Fairbanks	350	22	6.3	328	113	34.4
Total	635	40	6.3	595	250	42.0

Table II

Preference for Types of Residential Construction

(Distribution of Percents)

Source	Number of Responses	Type of Construction						
		Wood Frame	Concrete Block	Stucco	Brick	Brick and Wood	Log	Total
Anchorage	149	75.2	3.3	5.4	1.3	9.4	5.4	100
Fairbanks	127	51.9	9.3	.8	3.8	8.6	25.6	100
Total	276	64.5	6.2	3.3	2.5	9.0	14.5	100

Table III

Reasons For Preference of Construction vs. Types of Construction Preferred

(Distribution of Responses)

Source	Reasons for Responses	Types of Construction: Wood Frame	Concrete Block	Stucco	Brick	Brick and Wood	Log	Total
Anchorage	Low Initial Cost	61	1	3		3	3	71
	Low Maintenance	14	4	4	3	5	5	35
	Low Heating	23	1		2	1	2	29
	General Appearance	47	1	3	2	10	8	71
Total		145	7	10	7	19	18	206
Fairbanks	Low Initial Cost	31	3	1	1		17	53
	Low Maintenance	7	7	1	7	3	9	34
	Low Heating	15	5	1	2	3	17	43
	General Appearance	22	2	1	5	9	15	54
Total		75	17	4	15	15	58	184

Table III - continued

Source	Reasons for Responses	Types of Construction: Wood Frame	Concrete Block	Stucco	Brick	Brick and Wood	Log	Total
Total	Low Initial Cost	92	4	4	1	3	20	124
	Low Maintenance	21	11	5	10	8	14	69
	Low Heating	38	6	1	4	4	19	72
	General Appearance	69	3	4	7	19	23	125
Total		220	24	4	22	34	76	390

Table IV

Type of Construction of Present Residence

(Distribution of Percents)

	Type of Construction						
Source	Frame	Concrete Block	Stucco	Brick	Brick and Wood	Log	Total
Anchorage	90.5	2.9	2.2			4.4	100
Fairbanks	84.1	3.5	1.8			10.6	100
Total	87.6	3.2	2.0			7.2	100

Table V

Percent Distribution of Responses Showing Whether Attitudes Toward Building Material Were Affected by the Earthquake

Source	Affected	Unaffected	Total
Anchorage	94.2	5.8	100
Fairbanks	79.6	20.4	100
Total	87.6	12.4	100

Table VI

Percent Distribution of Responses Indicating The Types of Construction That Were Least Preferred In View of the Recent Earthquake

Source	Number of Responses	Type of Construction: Wood Frame	Concrete Block	Stucco	Brick	Brick and Wood	Log	Total
Anchorage	169	2.4	50.9	13.0	28.4	4.7	.6	100
Fairbanks	120	10.8	41.7	17.5	19.2	6.7	4.1	100
Total	289	5.8	47.1	14.8	24.8	5.5	2.0	100

Table VII

Interest of Anchorage Respondents in Brick Construction at Increased Cost

(Distribution of Percents)

Number	Would have purchased	Would not have purchased	Total
137	31.4	68.6	100

Table VIII

Anchorage Respondents Who Indicated Interest in Brick Construction: Type of Present House vs. Allowable Percent Increase

(Distribution of Percents)

Type of Present House	Number	Percent Increase Willing to Pay 10%	15%	20%	Total
Wood Frame	42	64.3	21.4	14.3	100
Concrete Block	1		100.0		100

Table IX

Percent Distribution of Anchorage Residents Who Indicated Interest in Brick Construction: Assessed Value of Present Home vs. Percent Increase Willing to Pay

Assessed Value of Present House	Number	Increase Willing to Pay 10%	15%	20%	Total
0-10,000	10	40.0	40.0	20.0	100
11-20,000	20	70.0	15.0	15.0	100
21-30,000	11	72.7	18.1	9.2	100
31,000 up	2	50.0	50.0	--	100

Table X

Percent Distribution of Fuel Preference

Source	Number	Type of Fuel Preferred				
		Gas	Oil	Coal	Electric	Total
Anchorage	137	46.7	24.1	1.5	27.7	100.0
Fairbanks	113	17.7	36.3	10.6	35.4	100.0
Total	250	33.6	29.6	5.6	31.2	100.0

Table XI

Distribution of Responses Indicating
Reasons for Preference vs. Type of Fuel Preferred

Source	Reasons for Preference	Type of Fuel Preferred				
		Gas	Oil	Coal	Electric	Total
Anchorage	convenience	30	21	--	23	74
	cost	38	12	2	4	56
	cleanliness	45	3	--	36	84
	burning efficiency	25	4	1	5	35
Total		138	40	3	68	249
Fairbanks	convenience	7	33	--	25	65
	cost	8	7	12	4	31
	cleanliness	16	27	--	35	78
	burning efficiency	6	8	1	3	18
Total		37	75	13	67	192
Total	convenience	37	54	--	48	139
	cost	46	19	14	8	87
	cleanliness	61	30	--	71	162
	burning efficiency	31	12	2	8	53
Total		175	115	16	135	441

Table XII

Percent Distribution of Responses Concerning Type of Fuel Presently Being Used

Source	Type of Fuel					
	Gas	Oil	Coal	Electric	Other	Total
Anchorage Number = 137	35.0	61.3	.7	1.5	1.5	100.0
Fairbanks Number = 113	1.9	76.2	18.7	.9	2.3	100.0
Total Number = 250	20.0	68.0	8.8	1.2	2.0	100.0

Table XIII

Intention of Conversion - Percent Distribution

Source	Percent not considering conversion	Percent considering conversion
Anchorage Number = 134	82.5	17.5
Fairbanks Number = 108	87.6	12.4
Total	84.8	15.2

Table XIV

Fuel Preference vs. Type of Fuel Presently Used For Respondents Considering Conversion

(Percent Distribution)

Source	Fuel Preference	Type of Fuel Presently Used: Gas	Oil	Coal	Electric	Total
Anchorage Number = 23	Gas		58.3			58.3
	Oil					
	Coal					
	Electric		41.7			41.7
Total		--	100.0		--	100.0
Fairbanks Number = 14	Gas		14.3	7.1		21.4
	Oil		7.1	21.4		28.6
	Coal					
	Electric		35.8	14.3		50.0
Total		--	57.2	42.8	--	100.0
Total Number = 37	Gas		42.1	2.6		44.7
	Oil		2.6	7.9		10.5
	Coal					
	Electric		39.5	5.3		44.8
Total		--	84.2	15.8	--	100.0

Table XV

Attitude Toward Use of Lower Priced Coal vs. Type of Fuel Being Used

(Distribution of Percents)

Source	Attitudes Toward Coal	Type of Fuel Presently Using: Gas	Oil	Coal	Electric	Total
Anchorage	Yes	2.3	2.4			2.3%
Number = 130	No	97.7	97.6		100.0	97.7
Total		100.0	100.0		100.0	100.0
Fairbanks	Yes		12.0	99.2		21.4
Number = 98	No	100.0	88.0	.8	100.0	78.6
Total		100.0	100.0	100.0	100.0	100.0
Total	Yes	2.1	7.3	99.2		11.8
Number = 228	No	97.9	92.7	.8	100.0	88.2
Total		100.0	100.0	100.0	100.0	100.0

Table XVI

Conversions in Past Three Years

Source	Converted	Did not convert	Total
Anchorage	35.8	64.2	100.0
Fairbanks	12.4	87.6	100.0
Total	25.2	74.8	100.0

Table XVII

Three Year History of Conversions vs. Type of Fuel Being Used

(Distribution of Percents)

Source	Fuel Converted From	Type of Fuel Presently Using: Gas	Oil	Coal	Electric	Total
Anchorage	Gas		2.0			2.0
Number = 49	Oil	89.8			4.1	93.9
	Coal		4.1			4.1
	Electric					---
Total		89.8	6.1	---	4.1	100.0
Fairbanks	Gas		21.4			21.4
Number = 14	Oil					---
	Coal		71.4		7.2	78.6
	Electric					---
Total		---	92.8	---	7.2	100.0
Total	Gas		6.4			6.4
Number = 63	Oil	69.8			3.2	73.0
	Coal		19.0		1.6	20.6
	Electric					---
Total		69.8	25.4	---	4.8	100.0

Appendix E

Individuals Contacted in Informal Interviews

Mr. James A. Williams
Director, State Division of Mines and Minerals
Juneau, Alaska

Mr. Leo Saarela
Regional Mining Supervisor
Branch of Mining Operations
United States Geological Survey
Anchorage, Alaska

Mr. Don Hopkins
Director, Division of Planning and Research
Dept. of Economic Development and Planning
Juneau, Alaska

Mr. Jared A. Herdlick
Chief, Alaska Office of Mineral Resources
U.S. Bureau of Mines
Juneau, Alaska

Mr. Kevin Malone
Physical Scientist
U.S. Bureau of Mines
Juneau, Alaska

Mr. Robert Bettisworth
Masonry Contractor
Fairbanks, Alaska

Mr. Lloyd Burgess
Burgess Construction Company
Fairbanks, Alaska

Mr. E. S. Philleo
Philleo Engineering and Architectural Service
Fairbanks, Alaska

Mr. Martin Jasper
Mining Engineer
Division of Mines and Minerals
Anchorage, Alaska

Mr. John Burdick
Assistant Professor Civil Engineering
University of Alaska
College, Alaska

Mr. William J. Mead
President
Engineers Ceramics Company
Bartlett, Illinois

Mr. Robert Chapman
U.S. Geological Survey
College, Alaska

Mr. George Schmidt
Bureau of Land Management
Anchorage, Alaska

Mr. James Flood
Alaska Brick
Anchorage, Alaska

Mr. Frank Loe
Vice President
Magnet Cove Barium Corp.
Houston, Texas

Mr. Stan Stanfill
Staff Assistant
Chugach Electric Assn., Inc.
Anchorage, Alaska

Mr. Douglas Culp
Chief Engineer
Usibelli Coal Mining Co.
Usibelli, Alaska

Mr. Charles Tryck
Architect
Anchorage, Alaska

Mr. Thomas J. Smythe
Senior Community Planner
Alaska State Housing
Authority
Anchorage, Alaska

Mr. Ross Miller
Area Industrial Development
Officer
Bureau of Indian Affairs
Juneau, Alaska

Mr. R. S. Ludwig
Mechanical Superintendent
United States Smelting,
Refining and Mining Co.
Fairbanks, Alaska

Mr. Douglas Huber
Chief Engineer
Evan Jones Coal Mine
Anchorage, Alaska

Mr. W. H. Joy
Electrical Superintendent
Municipal Utilities System
Fairbanks, Alaska

Mr. Hugh Mathieson
Evan Jones Coal Mines
Anchorage, Alaska

Mr. William Waugaman
General Manager
Usibelli Coal Mines Inc.
Fairbanks, Alaska

Mr. R. F. Hilton
Chief, Land Section
Bureau of Land Management
Fairbanks, Alaska

Mr. W. G. Hackney
Concrete Products of Alaska
Fairbanks, Alaska

Mr. William Race
Mining Engineer
State Division of Mines and Minerals
Juneau, Alaska

Mr. R. E. Melbo
Executive Assistant
U.S. Army Engineer District, Alaska
Corps of Engineer
Anchorage, Alaska

Mr. Daniel Jones
Manager, Land Office
Bureau of Land Management
Fairbanks, Alaska

Mr. Clyde W. Humphrey
Manager, Ceramic Division
The Fate-Root-Heath Company
Plymouth, Ohio

Builders Brick Company
Seattle, Washington

Mr. Pat Cook
Chief Engineer
Alaska Railroad
Anchorage, Alaska

Mr. Joseph Usibelli
President of the Board of Directors
Usibelli Coal Mines Inc.
Fairbanks, Alaska

Mr. W. D. McKinney, Jr.
Office Manager
Sea-Land Service
P.O. Box 1961
Anchorage, Alaska

Mr. F. W. Hoefler
Assistant General Traffic
Manager
Alaska Railroad
Anchorage, Alaska

Mr. Edward R. Sanders
Managing Director
Alaska Carriers Association,
Inc.
1701 E. 1st Avenue
Anchorage, Alaska

Mr. Clyde S. Courtnage
Director Anchorage Field
Office
U.S. Dept. of Commerce
306 Loussac-sogn Building
Anchorage, Alaska

Mrs. Joan Movias
Port of Anchorage
Box 400
Anchorage, Alaska

Mr. Kenneth Sheppard
Concrete Products of Alaska
Box 679
Anchorage, Alaska

Mr. Levake Renshaw
Chief of Design and Public
Works
Anchorage, Alaska

Mr. Dale Teel
Vice President and General
Manager
Anchorage Natural Gas Corp.
Anchorage, Alaska

Mr.D. L. Allen
General Traffic Manager
Alaska Railroad
Anchorage, Alaska

Mr. A. L. Jess
Chief, Design Branch
Engineering Division
U. S. Army Engineering District
P. O. Box 7002
Anchorage, Alaska

Mr. Frances B. Mayer
Architect
210 Loussac-sogn Building
Anchorage, Alaska

Capt. A. E. Harned
Port Director
Port of Anchorage
Box 400
Anchorage, Alaska

Mr. C. V. Chatterton
District Superintendent
Production Department
Standard Oil Company of California
Anchorage, Alaska

Mr. Gerald Earp
Sales Manager
Alaska Aggregate Corporation
Anchorage, Alaska

Mr. Jack Harrison
Vice President
Anchorage Sand and Gravel
Anchorage, Alaska

BIBLIOGRAPHY

Books and Reports

American Institute of Architects, Building Cost Manual. London: John Wiley and Sons, 1957.

Bacha, C. P., Schwalje, J. L. and Del Mastro, A. J., Elements of Engineering Materials. New York: Harper.

Bateman, Alan M., Economic Mineral Deposits. New York: John Wiley and Sons, Inc., 1950.

Bateman, John C., Materials of Construction. New York: Pitman Publishing Company, 1950.

Bates, Robert L., Geology of the Industrial Rocks and Minerals. New York: Harper and Brothers, 1960.

Browne, Ralph, Anchorage, An Analysis of its Growth and Future Possibilities. Juneau: Alaska Development Board, 1953.

Cooper, George H., Building Construction Estimating. New York: McGraw - Hill Book Company, 1959.

Federal Housing Administration, Heat Loss Calculations, Technical Circular 7. Washington: U.S. Government Printing Office, 1956.

Garve, T. W., Factory Design and Equipment and Manufacture of Clay Wares. Wellsville, New York: Randall Publishing Co., 1950

Gillson, Joseph L., Ed., Industrial Minerals and Rocks. New York: American Institute of Mining and Metallurgical Engineers; 1960.

Grim, Ralph E., Applied Clay Mineralogy. New York: McGraw-Hill Book Company, 1962.

Harbison-Walker Refractories Company, Modern Refractory Practice. Cleveland: The William Feather Company, 1961.

Kingery, W.D., Editor, Ceramic Fabrication Processes. Cambridge, Mass.: The M.I.T. Press, 1963.

Lovejoy, Ellis, Fundamentals and Economics in the Clay Industries. Wellsville, New York: Randall Publishing Company, 1947.

McNamara, Edward P., Ceramics, Volumes II and III. State College, Penn.: School of Mineral Industry, 1949.

Norton, F. H., Elements of Ceramics. Mass.: Addison-Wesley Publishing Company, 1952.

__________, Refractories, Third Ed. New York: McGraw-Hill Book Company, 1949.

Parmlee, Cullen W., Ceramic Glazes. Chicago: Cahners Publishing Company, 1959.

Salmang, Herman, Ceramics. London: Butterworths, 1961.

Stratton, Mary Chase, Ceramic Processes. Ann Arbor, Michigan Edwards Brothers, Inc., 1941.

United States Bureau of Mines, Mineral Facts and Problems, Bulletin 585. Washington: U.S. Government Printing Office, 1960.

United States Geological Survey, Mineral and Water Resources of Alaska. Washington: U.S. Government Printing Office, 1964.

United States Bureau of Mines, Minerals Yearbook, Volume III. Washington: U.S. Government Printing Office, 1963-1960.

Van Vlack, Lawrence H., Physical Ceramics For Engineers. Mass.: Addison-Wesley Publishing Company, Inc., 1964.

Wass, Alonza, Building Construction Estimating. New Jersey: Prentice-Hall, Inc., 1963.

Periodicals

Ceramic Data Book. Suppliers catalogues, buyers directory, engineering data. Chicago:, Cahners Publishing Co., 1963-64 and 1964-65.

Brick and Clay Record. Journal of the brick, refractories, clay pipe and expanded aggregate industries. Chicago: Cahners Publishing Company, Year 1964.

Tariff Reference

The Alaska Railroad Freight Tariff	No.	5-O
The Alaska Railroad Freight Tariff		16-F
The Alaska Carriers Association Freight Tariff		1-A
Alaska Steamship Company Tariff		832
Alaska Steamship Company Seattle Terminal Tariff		732
Alaska Dock (Juneau) Terminal Tariff		16
Conway Dock (Sitka) Terminal Tariff		13
Haines Terminal and Highway Co. (Haines) Tariff		11
Ketchikan Wharf Tariff		25
Public Dock (Petersburg) Tariff		11
Pacific and Arctic Railway and Navigation Co. (Skagway) Local Freight Tariff		
Wrangell Wharf Company		7
Alaska Steamship Company Tariff		846
Alaska Steamship Company Tariff		841
Lomen Commercial Company Tariff		25
Alaska Steamship Company Tariff		845
Cordova Wharf		16
Alaska Steamship Company Tariff		795
Valdez Dock Company Terminal Tariff		20