IC INDUSTRIAL CORPORATION

10195

DATA SHEET

PETALITE

1. ANALYSIS

Li_2O	4.2%
K_2O	0.3
Na_2O	0.5
Fe_2O_3	0.04
SiO_2	74.0
Al_2O_3	16.5

2. APPLICATIONS

Petalite has the unusual property of yielding a very low thermal expansion product on firing. It does so without any change in volume having a specific gravity of 2.4 before and after calcination. When mixed with clay, it can be used to produce low expansion kiln furniture capable of withstanding severe thermal shock, thereby increasing the number of thermal cycles.

3. PACKAGING:

200 mesh Petalite is packaged in 25 KG bags

35 mesh Petalite is packaged in 50 KG bags

BILL: THOUGHT YOU'D LIKE [illegible]

BULLETIN 301

FOOTE MINERAL COMPANY

TECHNICAL DATA

PETALITE

GENERAL PROPERTIES

Petalite is a white lithium aluminum silicate mineral. Its analysis closely corresponds to the theoretical formula: $Li_2O \cdot Al_2O_3 \cdot 8SiO_2$.

Typical Analysis

	20 Mesh		*200 Mesh*	
	Molar Equivalent	*Typical Analysis*	*Molar Equivalent*	*Typical Analysis*
Li_2O	.904	4.4	.900	4.3
Na_2O	.019	0.5	.020	0.5
K_2O	.025	0.2	.026	0.2
CaO	.022	0.2	.023	0.2
MgO	.030	0.2	.031	0.2
Fe_2O_3	—	0.06	—	0.04
Al_2O_3	1.032	16.2	1.032	15.9
SiO_2	7.740	77.7	8.130	78.4

Particle Size:

On 20 mesh, 1-2%	On 200 mesh, 0.5-1%
Thru 200 mesh, 25-30%	Thru 325 mesh, 95%

Bulk Density:

Free Fall	68 lbs./cu. ft.	58 lbs./cu. ft.
Packed	95 lbs./cu. ft.	88 lbs./cu. ft.

True Density: **2.422**

Petalite is less soluble than either feldspar or nepheline syenite at equivalent particle size. This permits its use in considerable percentages (up to about 70%) in either body or glaze formulations without serious deflocculation problems.

Control tests on particle size, chemical analysis, color and fusibility assure uniformity of the product. Uses for the product fall into two separate categories:

1. As a simple, low-cost lithia source, petalite is well suited to many glass and glaze applications. It is relatively free of other oxides, having the highest Li_2O to Al_2O_3 ratio of any natural mineral. It is a much lower cost source of lithia than any commercial compound.
2. The thermal behavior of petalite makes it unique among minerals. Petalite finds use in:
   (a) low expansion ceramics having high thermal shock resistance.
   (b) low temperature compositions with long firing ranges, where petalite serves as a multiple flux component.
   (c) fast-fire, normal temperature porcelain and semi-vitreous bodies wherein the normal silica inversion is eliminated.

Thermochemical Behavior

When natural petalite is heated above 680°C., there is an irreversible crystallographic inversion from its alpha form into a solid solution of silica in beta spodumene. This unique structure has virtually zero thermal expansion and provides the basis for low expansion ceramic bodies of unexcelled heat shock resistance.

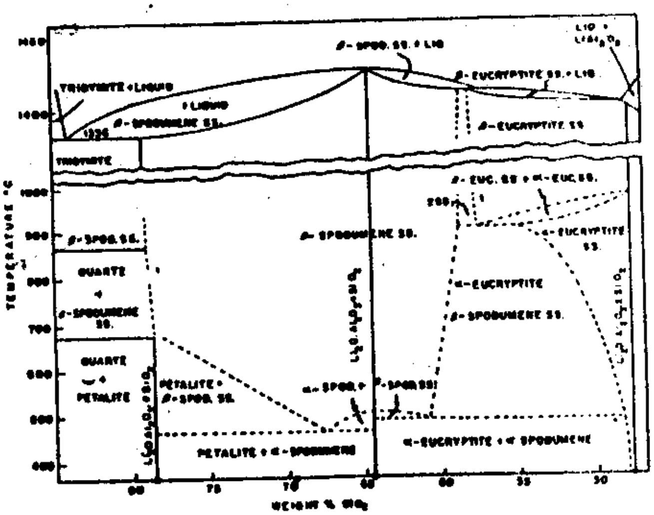

Figure 1

Diagram depicting phase-equilibrium relations along the join eucryptite ($Li_2O \cdot Al_2O_3 \cdot 2SiO_2$) — silica ($SiO_2$).

Within the lithia-alumina-silica system there exists a broad area of low expansion body compositions. Negative expansions (the bodies actually contract upon heating) are encountered in certain areas.

Such bodies can, of course, be synthesized from pure chemicals — and a wide variety of expansion characteristics can thus be obtained. The advantage of petalite lies in the fact that it permits formulation of a relatively wide range of low expansion bodies at a fraction of the cost of bodies based on pure chemicals. Practical bodies based on simple clay-petalite mixtures can be formulated quite easily, and expansions can be obtained anywhere from about 4.5 x 10^{-6} linear [illegible] zero to slightly negative values.

While the refractory manufacturer will find these compositions of considerable interest, the average manufacturer of whiteware bodies cannot tolerate a very low expansion body, due to the requirements of glaze fit. Here a second effect is important.

E. J. Smoke* has shown that "the sudden thermal expansion at 1060°F. (573°C.) exhibited by quartz, when converting from its low temperature crystalline form to its high temperature form, can be eliminated."

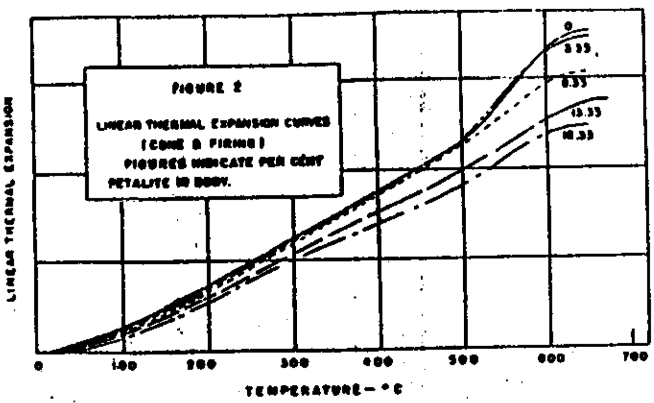

Figure 2

The incorporation of petalite in a conventional triaxial body tends to flatten out the quartz inversion "hump" (see Figure 2). Since the large volume change which accompanies the alpha to beta quartz inversion is a contributing factor in dunting, spalling or other types of thermal shock failure, it is apparent that repression of this inversion leads to improved thermal shock resistance, without imposing a serious glaze fit problem.

The advantages of a "straight-line" expansion curve are: (1) the tendency to dunt is lessened, and ware losses decreased; (2) the cooling cycle in the bisque firing cycle can be shortened, with an attendant increase in production; (3) for certain products, such as electrical porcelain, an improvement in thermal shock resistance is desirable in the finished product; and (4) the preheat portion of glost or refiring cycles can be shortened to normal bisque rates.

Development of special thermal expansion characteristics in ceramic bodies depends upon the development and retention of definite crystalline phases. This is accomplished largely through solid state reactions. Pure petalite theoretically melts at 1356°C. — the commercial mineral has a P.C.E. of cone 15. All evidence to date indicates that firing above cone 15 largely destroys low expansion crystalline phases, although it is also likely that some low expansion phases are reformed in the cooling cycle by crystallization from the glassy phase.

As a multiple flux component in low temperature bodies, it is expected that a majority of the petalite would go into solution in the glassy phase and that little or no recrystallization would occur.

Fluxing Properties

Because of its high P.C.E., petalite is not of interest as a principal flux in conventional whiteware bodies. It is not to be considered as a substitute for feldspar or nepheline syenite. However, it is of considerable interest as an auxiliary flux since it forms low melting eutectics with both feldspar and nepheline syenite. Unlike lime and magnesia, petalite can be employed to lower maturing temperatures without shortening the firing range.

Conventional semi-vitreous dinnerware bodies (normally maturing at cone 8) can be formulated to mature at cone 3 with equivalent properties; cone 10 sanitaryware bodies can probably be reduced to a cone 5 firing temperature or lower.

	Approx. P.C.E.
Pure petalite	15
45% petalite 55% F-4 feldspar	4
45% petalite 55% nepheline syenite	2
20% petalite 80% lepidolite	4
30% petalite 70% amblygonite	04

It has been long known that the lithium minerals exert powerful fluxing effects in ceramic bodies, and numerous investigators have studied the effects of spodumene and lepidolite upon the maturing temperatures and other properties of both vitreous and semi-vitreous bodies. The general procedure has been to substitute for a portion of the conventional flux constituent (feldspar or nepheline syenite) that amount of lithium mineral which will yield a eutectic combination. In this manner, firing temperatures may be reduced from five to six cones. This same procedure will apply to the use of petalite. Small additions of alkaline earth materials, such as talc or dolomite, exert a further fluxing effect permitting a further reduction in temperature.

Simple Petalite-Clay Bodies

Bodies made from simple combinations of clay and petalite are principally of interest as heat shock resistant refractories for service to cone 13. Such bodies have a wide useful range of low expansion compositions, some of which in fact display negative expansion. In general, such bodies are useful within the same temperature range and for the same applications for which cordierite bodies are currently employed. However, petalite bodies show two outstanding advantages over commercial cordierite bodies: the thermal shock resistance is substantially greater, zero expansion bodies being quite feasible; the firing range is considerably longer, thus eliminating one of the principal drawbacks to cordierite.

Ceramic Age, December 1954, "Thermal Expansion Properties of Some High Silica Bodies in the System Lithia-Alumina-Silica."

Figure 3 shows diagrammatically thermal expansions for the general petalite-clay range.

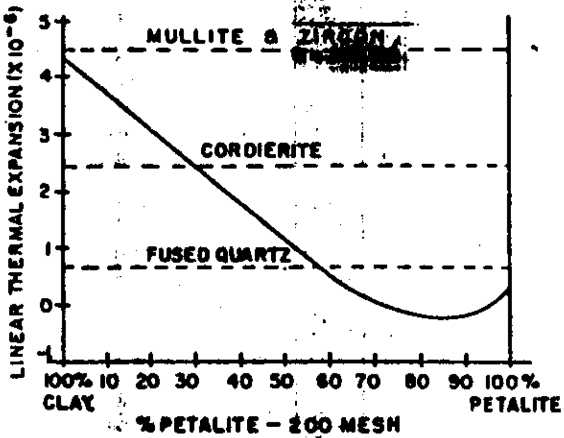

Figure 3

Further work has demonstrated that the use of a good grade of china clay increases the refractoriness of these compositions, so that cone 12-13 bodies appear to be commercially practical. Such bodies can be fired to technical vitrification.

Freedom from impurities is essential where maximum refractoriness is desired. For this reason, additions of grog, or other refractory constituents, should be confined to materials which contain only Al_2O_3 and SiO_2. Materials containing alkaline earth oxides, such as talc, dolomite and the like, must be excluded.

Fired strengths of the refractories are generally comparable to cordierite compositions, but are largely dependent upon the clays used and degree of vitrification desired. Porous bodies (5-15% absorption) will have moduli of rupture in the range 1500-5000 psi. Vitrified bodies will have moduli up to 14,000 psi.

Thermal stability of the refractory in use at high temperature dictates that the reactions be carried as close to completion as possible. For this reason, coarse materials, such as grog, must be used cautiously, since further reactions may take place once the refractory is placed in service.

For general utility, a body composed of 45% 200 mesh petalite and 55% china clay will yield excellent thermal shock properties. Laboratory specimens have been quenched from 2300°F. to room temperature without damage to the refractory.

Bodies of the type described in Table I should find many applications in the field of low temperature refractories. These would include saggers, setters, cranks, and other refractories common to dinnerware and wall tile manufacture. Petalite bodies can be fired to vitrification at about cone 13, offering potential uses in unglazed technical porcelain — electrical and chemical porcelain, pyrometer tubes, etc. In the field of structural clay products, flue and incinerator liners, low temperature refractory brick and car tops offer possibilities.

An interesting and unique property of these low expansion bodies lies in their ability to be welded. Thus, two ceramic parts may be joined by fusion, either through furnacing or through torch heating. This property should prove useful for a number of new products and processes, hitherto unattainable by conventional means.

TABLE I

Petalite-Clay Body Compositions

	P-1	*P-2*	*P-3*	*P-4*
Petalite (200 mesh) ...	35%	55%	65%	90%
China clay ...	—	45	35	10
Plastic fireclay	65	—	—	—
Properties:				
At Cone	6	13	13	11
Absorption ..	18.5%	2.8%	9.8%	27.9%
Modulus of Rupture	1575 psi	5900 psi	2775 psi	2750 psi
Linear Thermal Exp. x 10^{-6} (25-600°C) ..	1.49	0.787	0.163	—0.010

Vitreous Bodies

In the manufacture of vitreous sanitaryware, electrical porcelain and china, if heat shock failure is not a cause of costly losses, the avoidance of it is the limit to otherwise faster firing schedules. Petalite, in improving thermal shock resistance, permits faster schedules.

Table II illustrates two of the approaches to this petalite application. Their development has been restricted to normal clay choice or content. Such bodies are similar to commercial bodies in working properties and shrinkage. There is little or no change in the maturing temperature or range. Fired strengths are increased. While body cost may be increased, creditable studies have shown a substantial net saving in manufacturing cost, through increased kiln output.

TABLE II

Experimental Sanitaryware Bodies

	Percent by Weight	
	R-1	*R-2*
Ball Clay	30.0	20.0
China Clay	20.0	30.0
Nepheline Syenite	10.0	10.0
Petalite (200 mesh)	10.0	10.0
Flint	12.5	11.2
Pyrophyllite #16	12.5	15.0
Milled Zircon	5.0	—
A-2 Alumina	—	3.8

	Modulus of Rupture	*% Firing Shrinkage*	*% Absorption (Kerosene)*	*Linear T.E. x 10^{-6}*
R-1				
Cone 8 ...	13,560	9.26	0.30	6.11
10 ...	13,457	9.28	0.30	5.75
13 ...	8,783	8.25	0.26	n.d.
R-2				
Cone 8 ...	9,608	9.50	3.04	n.d.
10 ...	11,165	10.4	0.21	6.05
13 ...	10,767	9.87	0.50	5.56

Semi-Vitreous Bodies

Semi-vitreous bodies can be co[illegible] on a multiple flux principle, using combinations of petalite with either feldspar or nepheline syenite. As is the case with all lithium minerals, petalite is a potent flux for the feldspathic minerals and forms low melting eutectics.

In the case of petalite, a combination of approximately 45% petalite with 55% feldspar, or nepheline syenite provides a low melting flux which can be substituted for the normal flux portion of a semi-vitreous body, thereby reducing maturing temperatures from cone 9 to cone 5 or 6. Inclusion of a small quantity of talc serves to lower maturing temperatures perhaps a cone or two further.

When so employed, the petalite is substantially taken into solution and there is no lowering of thermal expansion, since only crystalline phases of petalite possess low expansion properties. However, it is interesting to note the effect of using petalite as a replacement for potters flint. It will be apparent that, when such a substitution is made in any appreciable quantity, part of the petalite will remain out of solution, while a portion of it will act as a flux. To the extent that the petalite remains out of solution, lowered expansion will result—suggesting that petalite can be used effectively to produce a type of heat shock resistant ovenware.

With such bodies, one may obtain "straight line" expansion at normal maturing temperatures, or normal expansions with lower maturing temperatures or concessions in between. Lower maturing petalite bodies requiring little or no glaze adjustment offer a particularly attractive opportunity.

A body series evidencing the effect of petalite when added at the expense of flint is shown in Table III. Note the decreasing difference between the linear thermal expansion to 400°C. from that to 650°C. with increasing petalite addition. This illustrates the lessening of the normal expansion accompanying the silica inversion. Also, that the expansion over the lower temperature range is slightly increased. This is ideal for good glaze fit.

Glass and Glazes

Petalite, being a simple oxide source of lithia finds ready application in many glass and glaze compositions. Commercial and research experience has demonstrated the ability of lithia to improve surface, flow, bubble count and brilliance in many glazes. Certain applications indicate lithia has a beneficial effect on colors. Foote research has developed a wide range of glaze compositions which are available for customer evaluation.

The Product

Foote petalite products were developed following an exhaustive study of mine selection, blending technique and general process controls. This provides uniform high quality products closely approximating the theoretical pure mineral and assurance of freedom from contamination.

Foote Research and Development Laboratories maintain continued programs in glass, porcelain enamels, whitewares and refractory specialties.

Petalite is ground at Foote's modern grinding facility at King's Mountain, N. C. This unit is fully equipped for the unprecedented and exacting use tests that are a vital part of finished product control.

Our growing list of published data and commercial experience is available through our technical sales-service department.

TABLE III

	PS	S-1	S-2
WWG Petalite	—	3.33	8.33
F-4 Feldspar	12.00	12.00	12.00
Potters Flint	33.33	30.00	25.00
China Clay	24.67	24.67	24.67
Ball Clay	30.00	30.00	30.00
Properties:			
At Cone	8	8	8
Firing Shrinkage, %	6.1	7.0	8.3
M. of R. psi	3850	3990	4900
Absorption % Water	12.0	8.5	6.0
Linear T.E. x 10^{-6} (25-650°C.)	7.9	7.6	7.1
Linear T.E. x 10^{-6} (25-400°C.)	6.3	6.5	6.7

HAMMILL & GILLESPIE, INC.
ESTABLISHED 1848
Importers, Exporters & Manufacturers
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TELEPHONE: (201) 994-3650 TELEX: 139114 (HAMGIL LVON)

NON-METALLIC MINERAL PRODUCTS AND CHEMICALS
NATURAL, PROCESSED AND SYNTHETIC

MATERIAL SAFETY DATA SHEET

To comply with OSHA'S Hazard Communication Standard, 29 CFR 1910.1200

SECTION I. IDENTITY OF PRODUCT AND IMPORTER OR PRODUCER

Trade Name: PETALITE
As Marked on Bag: 033 Petalite
Chemical Name: Lithium Alumino Silicate
CAS Number: 1302-66-5

Importer/Producer Name and Address:
INDUSTRIAL CORPORATION
P.O. BOX 477
LIONVILLE, PA 19353

Telephone Number:
For Emergency and Information
215/269/9228

Distributor Name and Address:
HAMMILL & GILLESPIE, INC.
P.O. BOX 104
LIVINGSTON, NJ 07039

Telephone Number:
For Emergency and Information
201/994/3650
Date Prepared: 4/15/91

SECTION II. HAZARDOUS INGREDIENTS & OCCUPATIONAL EXPOSURE LIMITS

QUARTZ (Respirable) < 11% by dry weight
CAS # 14808-60-7, Much is not fine enough to be normally respirable
OSHA PEL's
8-hr TWA: 0.77 mg/m³ (Total Respirable Dust)
8-hr TWA: 2.31 mg/m³ (Total Airborne Dust)
ACGIH TLV, 1989-90
TLV-TWA = 0.1 mg/m³ (Respirable Dust)

SECTION III. PHYSICAL DATA

Physical State: Solid
Fusion Range: 1160-1175°C
Specific Gravity: 2.4
Solubility in Water: None Soluble
% Volatile (Below 100°C): None
Vapor Pressure: Not Applicable
Odor and Appearance: Off White powder, odorless

SECTION IV. FIRE AND EXPLOSION HAZARD DATA

Non-flammable and Non-Explosive

SECTION V. REACTIVITY DATA

Stability: Chemically Stable
Incompatibility (Materials to Avoid): None Known
Hazardous Polymerization: Will Not occur
Reactivity, and under what conditions: None Known

SECTION VI. HEALTH HAZARD DATA

OCCUPATIONAL EXPOSURE LIMITS: See Section II

CARCINOGENICITY: Quartz has not been classified as a carcinogen by NTP or OSHA. IARC has indicated that "there is limited evidence for the carcinogenicity of crystalline silica to humans."

SUMMARY OF RISKS:

Short-term: Exposure to crystalline or amorphous quartz may lead to dryness of skin and mucous membranes.

Long-term: Prolonged exposure to respirable quartz may cause silicosis.

FIRST AID:

Eyes: Flush thoroughly with water. Ingestion: No known hazard.

Skin: Wash off with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as required.

NOTE: For all cases above, consult physician if conditions persist.

SECTION VII. SPILL, LEAK AND DISPOSAL INFORMATION

Action to be taken in case material is released or spilled:

Clean up and collect, minimizing excessive dust. Use a dustless system, such as wet sweeping or a vacuum, to maintain airborne dust levels below the Permissible Exposure Limits (See Section II)

Waste disposal method:

Any approved solid waste disposal, including burial. Comply with Federal, State and local regulations.

SECTION VIII. SPECIAL PROTECTION INFORMATION

Respiratory Protection: If dust concentrations exceed recommended Permissible Exposure Limits, use NIOSH approved dust respirators. If spraying coatings use NIOSH approved dust/mist respirators.

Ventilation: Local exhaust or other ventilation that will reduce dust concentrations to less than Permissible Exposure Limits is recommended. Use adequate ventilation if spraying coatings.

Eye Protection: Wear tight fitting goggles if high dust concentrations exist.

Other Protective Equipment: None required

Other Comments: Impervious gloves or clothing may be worn to minimise skin irritation. Never eat, drink, smoke or wear contact lenses in work areas.

SECTION IX. SPECIAL PRECAUTIONS

Minimize dust generation and exposure. Do not breathe dust.