COMMUNITY GEOTHERMAL TECHNOLOGY PROGRAM

HAWAII GLASS PROJECT

Conducted by

**Norman Miller
with Bill Irwin**

1988

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HAWAII GLASS PROJECT

Final Report

to the
Community Geothermal Technology Program

January 20, 1988

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Compiled by NORMAN MILLER
With BILL IRWIN

MASTER

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PREFACE

This is a report of work performed for the Community Geothermal Technology Program, a small grant program administered jointly by the Hawai'i Natural Energy Institute and the State of Hawai'i Department of Business and Economic Development.

This project was one of five funded under the pilot phase of the program. The grantees all began in 1986, and completed their work between October 1987 and April 1988. Funds for the pilot phase were provided by the U.S. Department of Energy and the County of Hawai'i.

The five Community Geothermal Technology Program projects were the first attempts to make direct use of geothermal heat and byproducts in Hawai'i. The success of these five grants has encouraged others to consider the use of geothermal energy in their businesses. A second round of grants was awarded in early 1988, and will demonstrate further applications of geothermal heat, brine and silica.

The opinions expressed in this report are those of the author, and are not necessarily shared by the program administrators, funding agencies, or others involved in the program. Responsibility for the accuracy of the data provided in this report lies with the author.

The enthusiasm, talents, and efforts of the grantees are much appreciated, and I look forward to continuing to work with them and with future recipients of grants from the Community Geothermal Technology Program.

A handwritten signature in black ink, reading "Andrea Gill Beck". The signature is fluid and cursive, with a long horizontal line extending from the left side of the first name.

Andrea Gill Beck, Administrator
Community Geothermal Technology Program

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INTRODUCTION

The primary purpose of this project was to develop a glass utilizing the silica waste material from geothermal energy production as the main ingredient, and as many other indigenous ingredients as possible. In addition, this glass should have those melting, working and cooling properties most desirable for hand production work, as well as be compatible with the colorants most commonly used by local artisans.

The secondary purpose of the project was to supply local artists with our developed batch (glass raw material mixture), have them each make one or more objects, and finally conclude the project with an exhibition of "Hawaiian Glass by Artists of Hawaii".

* * *

Quite frankly, we did not fully realize just how very ambitious an undertaking this would turn out to be. Just the design and construction of the necessary equipment was a major accomplishment in itself. Having done this for the amount of funds we had at our disposal is a minor miracle. But the fact is that we stuck with it and were successful well beyond our expectations.

We developed a glass composed of 93% indigenous Hawaiian materials. Its sole fault is a slight yellow/green color due to excessive iron contamination. Many of the artists thought it had working properties superior to the glass they regularly used.

We motivated and mobilized 24 artists who made 110 objects from our glass. We had a most successful, highly praised exhibition, and received much positive radio, TV, and newspaper coverage.

We found a definite market for art objects made from this material. In addition, by allowing the workshop to be used by local artists on a cost basis, and by planning classes and workshops for the future, we are being of service to the community.

DESCRIPTION OF WORK

PRELIMINARY:

Before work on the glass formula could begin, we had to design and construct the following:

1. Shed to house the facility. We constructed an open pagoda-like structure. As this was to be a permanent building on Bill Irwin's property, he added his own funds for some extra niceties, such as a shingled roof.

2. Heat hood to draw away and dissipate excess heat from the working area. This, we constructed of galvanized pipe and sheet roofing.

3. Power feed lines for propane and electricity with associated fusing, regulators, switches, safety devices, etc. For safety and convenience, the lines were dug underground.

4. Main furnace in which the raw materials are melted to form glass at 2600° F, which is then maintained at the working temperature of approximately 2100° F. Our design is a relatively simple square shaped crucible furnace. It is top fired with propane/forced air, and has a flat roof and burner block which we cast from high temperature material. When crucibles are changed out, the furnace must be dismantled 50%.

5. Burner assembly which we designed and made from pipe stock and fittings. Later we changed out the main furnace burner head and installed a commercially made ceramic one. A commercial electric blower unit is attached to a mixing pipe, and a gas cutout switch turns off the gas in the event of power failure. To meet safety regulations, we installed a useless pilot light assembly. As expected, this melted down immediately and was removed. [At these high temperatures, the whole interior of the furnace acts as a pilot light.]

6. Re-heating furnace ("glory hole") is a circular drum furnace offering intense localized heat of about 2800° F and controlled oxidation/reduction conditions. This is used for selectively heating or softening work in progress. It is also very important for color work and for testing glass compatibility. Like the main furnace, it uses propane and forced air with similar burners and devices, but is side fired, forcing the flame to

circumvolve within the drum. We designed a special system of doors to regulate the size of the front opening.

7. Annealing kiln ("lehr") provides controlled cooling down of finished pieces, providing stress free stability at room temperatures. It is also important for testing the sagging and melting points of glass. Our design is an electric top loader with three sets of nichrome elements. We could not afford automatic control devices, and so instead use a thermocouple, manual switching and patience.

8. Crucibles to contain the raw materials and resultant glass. These must be able to withstand the direct flame of the burner as well as the extreme thermal shock of heating up and cooling down, while not leaching undesirable elements into the glass. Developing the glass formula required many individual test firings, and each group of tests required a fresh crucible. Altogether we used 6 test crucibles and 3 full sized ones. As commercial crucibles were prohibitively expensive, we had to design and make our own.

Our first attempt was a conventional clay based type ordered from a local ceramicist. This lasted about 30 seconds. So we made our own from a high temperature casting material, which everyone, including the manufacturer, advised us was not at all suitable. It worked for us, thus proving once again that . . . "naivete' can work wonders".

SILICA PROCESSING:

At the geothermal plant, the silica bearing waste water is routed into a settling tank, which is an arrangement of baffles constructed in concrete. This engineering marvel no doubt works well in theory, but not so well in the real world. As a result, it is in and out of operation, and the bulk of the silica is dumped here and there (mostly there) into the beautiful, once natural surroundings behind the plant. Added to it now and then,

are various other wastes and contaminants - known and unknown. We had to find the least contaminated silica, starting in the settling tank and later venturing out into deeper and deeper hot water in the dump ponds behind the plant. As will be explained later, this silica had to be just at the right stage of crystallization for our use. Then through trial, error and much labor, we developed home made methods of dealing with it.

GLASS FORMULA:

Once the shop and furnaces were completed, and the problems of crucibles and silica processing were taken care of, we were able to concentrate on making a usable glass, which was, after all, the main purpose of the project. Our working procedure, our problems, our results . . . all this and more, are explained in detail later in this report.

RESULTS

SILICA

When the silica first settles down from the waste water, it is in a fine jelly-like condition. In time it crystallizes more and more. It is necessary to wash the silica with fresh water in order to remove the salts and other water soluble contaminants. When too fresh, the silica would run off with the wash water, and when too old, it would have been necessary to mechanically grind the larger crystals. The older silica is usually overly contaminated as well. For these reasons, the silica we needed had to be at an early stage of crystallization and have just enough structure to sink of its own weight in the wash water.

We shovelled the silica onto a sieve set over our wheelbarrow and washed it through with fresh water. When the suitable material within reach or wading distance was depleted, we used a scoop made from a large plastic flower pot on the end of a pole.

It should be noted that several of the chambers in the settling tank were contaminated from the iron pipes running through them. Any contact with iron will contaminate the silica. Also, much of the outside settling pond area was too shallow, making the material unusable as it was too difficult to separate from the fine cinder dust mixed in with it.

Drying the washed silica proved to be a major undertaking. What we ended up with was a large sheet of salvaged stainless steel which we supported on blocks so that we could put a large propane burner underneath. In other words, a giant outdoor hot plate barbecue. About a week's worth of shovelling and turning would get us a barrel of silica (if it didn't rain) which after a half day's laborious manual sifting became usable.

GLASS FORMULA:

BACKGROUND

Basically a glass consists of three main groups of ingredients:

1. Glassformer which is almost always silica.
2. Fluxing Agent which lowers the melting temperature to a practical range - most commonly soda ash or potash.
3. Stabilizing Agent which gives the glass weather and chemical resistance - most commonly used are calcium (lime) and lead.

The most common type of glass is composed of silica, soda ash and calcium and is known as "soda-lime glass". So called "crystal glass" is made from silica, potash and lead.

High temperature chemistry differs radically from common normal temperature chemistry. For example, this glassformer, flux and stabilizer categorization, while forming the most common theoretical model, is really an over-simplification of what actually goes on, much of which is still not fully understood. The boundaries between the categories are indistinct and an ingredient may be a flux in one circumstance, a stabilizer in others, or even all three at the same time.

Changing a certain property of the glass is therefore not as simple as adding a little more of this, or less of that. Rather it is a matter of very complex sets of inter-relationships with fuzzy borders and indistinct characteristics. The technical literature is mostly dated and of limited usefulness. Frankly, with all the research being done, it is apparent to me that the field of glass still contains as much secrecy and proprietary knowledge today as was common 1000 years ago.

RESULTS

Our research was more a matter of "feel" than technology. For this reason I cannot offer the scientific precision that some of you might expect.

In our experiments, we ended up trying adaptations of three different base formulas as starting points. The first was copied from a book; the second was adapted from that used by Mr. Hugh

Jenkins at Punahou High School in Honolulu; and the final one we adapted from a commercially produced glass marketed to the art glass industry. In each case we began by adapting the formula to our local ingredients, adjusting for the known and guessing for the unknown contaminants. When unsatisfactory for one or another reason, we changed things around and tried again, then again & again - until we gave up and began all over with the next base formula.

We obtained a usable glass almost right away, but I didn't like the "feel" of it, and so we went on and on until it felt right. We have a glass of most excellent qualities.

Our glass contains:

72% Silica waste material from geothermal production.

13% Soda ash which is produced by Brewer Co. on Oahu
as a by-product of chlorine extraction from
sea water.

8% Ground coral from Kawaihae deposits which is mined
for use in agriculture. (see appendix)

93% MATERIALS OF HAWAIIAN ORIGIN

7% imported ingredients

100%

CORAL

We had the choice of Kawaihae, Kona Coast or Mauna Kea Beach deposits. As the promised cooperation from the University of Hawaii in the form of chemical analysis was like pulling teeth from an unwilling patient, we relied instead on our more trustworthy methods of guesswork. We chose the Kawaihae. As it turned out, it was the correct choice since the much too late (and incomplete) analysis showed that the Kawaihae had the highest calcium content. It also showed a strontium content which was a surprise, but probably beneficial, as well as more alumina than we had guessed.

SODA ASH:

We purchased commercial soda ash together with our imported chemical order. Only later discovering that it is locally available. As the local product and the imported are both the same pure chemical, it would make no difference in the glass.

COMPATIBILITY:

Glass, being a liquid, expands and contracts within the normal room temperature range. This can be measured and is expressed as a "coefficient of expansion" (C of E). When two different glasses are fused together, their C of E's must be fairly closely matched, for if one glass expands or contracts more than the other, they will break apart. Our glass is designed for art purposes, and must have a C of E comparable to that of the colored glass most commonly used by artists for decorative purposes. This is produced by Kugler Company in Germany and has a C of E compatibility range of 83×10^{-7} to 86×10^{-7} .

A precision test for C of E requires equipment beyond our means. A simple test involves heating together two small bits of each glass and pulling them out to a thin rod, so that each glass ends up one over the other. Upon cooling, the rod will remain straight if the glasses are compatible, and curve one way or the other if not. One can in this way, with sufficient accuracy judge the difference in points. It is also possible to obtain a rough estimate of the C of E by computing the molecular weights of the ingredients according to a special table of equivalency factors.

The figures we obtained by computing according to equivalency factors were much out of bounds and did not match up with the physical tests, which are the ones that count. This indicated the presence of some unknown substance in our mixture. Certain elements have a great effect on C of E while others have little or none. Our guess is sodium. This will be discussed some more in this report under "problems".

DECOLORIZATION:

Once we managed to adjust our formula so that the C of E of the glass fell within the required range, and we were certain that our adjustments didn't appreciably alter the glasses' desirable properties, the final step was to make the glass as clear and colorless as possible. Without decolorization, the glass would have a sharp blue-green color due to traces of iron and possibly chromium.

Decolorization is a two stage process - chemical and physical, accomplished almost always through trial and error. Chemical decolorization involves the addition of certain oxidizing agents such as nitrates of sodium and potassium or oxides of arsenic and antimony. These cause the iron to change from ferrous form which has a blue-green color to its ferric form with a yellow-green color easier to deal with. Physical decolorization involves the masking of the yellow-green ferric color as well as the green of chromium with other coloring agents.

We used a combination of manganese and cobalt oxides. This process has limits and in our case, we could not achieve total clarity. We chose instead to cut back so that the remaining color was more pleasant.

It is an interesting historical fact that the method of decolorization was a closely guarded secret first discovered in ancient Rome. The secret was lost for nearly 1000 years to be re-discovered in Venice during the middle ages.

EXHIBITION:

At the beginning of our project we made preliminary arrangements for an exhibition at the Volcano Art Center on the Big Island, tentatively set for June 1987. We could not make any arrangements in Honolulu due to the fact that it was not possible to say which (if any) of the artists would participate, or for that matter, even if we could make glass from the material. In fact, we encountered much scepticism.

Through posters, announcements in publications and word of mouth, we discovered and contacted most of the artists.

Once our glass formulation was finalized, we processed as much silica as we could and mixed up about 500 pounds of batch (glass raw material mixture). Arrangements were made with the glass facilities at U. H. - Manoa and Punahou High School in Honolulu and the batch was shipped over. The batch was melted to glass at these locations and the participating artists were scheduled over a three day period. Our facility in Pahoa was also made available, and a number of artists made their pieces there.

The exhibition date was changed for August. However, due to shortcomings in the publicity arrangements as well as the difficulties of the artists due to the vacation period, this was changed at the last minute to October.

The exhibition, "Hawaiian Glass - by Artists of Hawaii" was held October 4 - 23, 1987 at the Volcano Art Center. In addition a partial exhibition was on display the month of December, 1987 in Mayor Dante Carpenter's office in the County building in Hilo.

The following 24 artists participated:

1. Robert Bento	Kailua, Oahu
2. Marijke Christanson	Honolulu
3. William Cooper	Honolulu
4. Jerry Crosby	Big Island
5. Terrence Fowler	Honolulu
6. Jeff Gaskell	Honolulu
7. Ann Ingemarsson	Pahoa
8. Bill Irwin	Pahoa
9. Hugh Jenkins	Honolulu
10. Wayne Kawamoto	Honolulu
11. Steven R. Lee	Honolulu
12. Bill Lowry	Honolulu
13. Chris Lowry	Honolulu
14. Norman Miller	Pahoa
15. Rick Mills	Honolulu
16. Lee Miltier	Honolulu
17. Babs Miyano	Honolulu
18. David Musgrove	Honolulu

19. Zora Newhold	Honolulu
20. James Rhodes	Keaau, Big Island
21. Bud Sprindt	Lihue, Kauai
22. Linda Stevens	Pahoa
23. Charles Vannatta	Honolulu
24. Lisa Yoshihara	Honolulu

The full exhibition consisted of 110 pieces as follows:

18 sculptural pieces

8 goblets

15 bowls

11 vases

2 plates

12 perfume bottles

2 paper weights

and jewelry consisting of:

18 pairs ear rings

18 ornaments

6 pins

SPECIAL PROBLEMS

1. INSURANCE was difficult to obtain, causing the project to be delayed by four months.

2. SILICA PROCESSING was a major problem in general. > {previously}
3. LACK OF COOPERATION WITH ON-TIME CHEMICAL ANALYSIS > {discussed }

4. UNKNOWN INGREDIENTS IN SILICA caused difficulty with formula adjustments. It was known to us that sodium hydroxide was being regularly dumped into the waste water ponds and we had to take care due to its caustic nature. We naturally chose that silica which appeared the least contaminated, and counted on our washing process to remove any hydroxide as well as soluble salts from the sea water. However, our difficulties with compatibility adjustment made us suspect the presence of some form of sodium, in some way bound with the silica. A complete chemical analysis would give the answer.

5. CRUCIBLES: Hot glass is corrosive to almost anything other than platinum. For this reason, all bricks, liners and crucibles must be composed of materials that will decompose into the glass without appreciably altering the formulation or add defects such as stones or undissolved particles. Our crucibles were home made from a high temperature casting material not really suitable for use with glass. We believe it to be mainly alumina that is added and we did some more of our famous guesswork to adjust accordingly. It is conceivable that leaching from the crucible material added to our CoFe adjustment problems, although there is nothing in its chemical make-up that as far as we know could do this.

6. MAIN FURNACE BURNER HEAD disintegrated into the glass and was replaced with commercial ceramic burner head.

7. GLORY HOLE could not reach the required temperature and had to be re-done in a makeshift fashion. It worked for the project and we will reconstruct it with our own funds later on.

8. LEHR was and still is plagued by breakdown and a major headache. Much good work was lost and much time wasted. We managed to limp along with it and will re-construct it on our own.

COMMERCIAL APPLICATIONS

MACHINE GLASS:

The feasibility of machine glass was investigated as a possible spin-off of this project and rejected. The following are a few of the reasons:

1. The quantity of silica available now and in the near future would be sufficient only for relatively small scale production, which is not cost effective.
2. The cost of materials is not the major expense involved in glass manufacturing.
3. The high cost for local energy greatly over-rides the expense of shipping in imported wares.
4. Even with lowered energy costs, the extremely high start up costs coupled with tough competition for a small market, makes it a questionable investment.
5. Automatic glass machinery must be run continuously 24 hours a day. Shut downs and start ups add greatly to expenses. The bulk of production would be for custom designed ware such as trade beverage bottles. These factors demonstrate that it is an especially difficult industry to speculate in.

ART GLASS:

We found a definite market for hand produced art and novelty glass made from this material.

However, the uncertain supply of uncontaminated silica as well as the difficulty involved in silica processing are very serious handicaps.

In addition, the user fee charged at the well for wet, unprocessed silica amounts to 4 times the cost of imported ready to use silica when purchased in small quantities. In large quantities, it would be about 40 times.

FISCAL REPORT

item	grant money	cost share	total
Shed for furnaces and equipment	249.52	350.00	599.52
Materials for gas & electric utilities	399.09	---.--	399.09
Installation fee for gas tank	195.00	---.--	195.00
Annual rental fee for gas tank	54.00	---.--	54.00
Glass working tools and supplies	569.61	---.--	569.61
Materials to construct furnaces, lehr & hood	1711.53	353.17	2064.70
Refractory materials for furnaces, lehr & crucibles	1994.46	---.--	1994.46
Chemicals for glass making	1177.51	271.03	1448.54
Propane fuel	1671.17	---.--	1671.17
Research Literature	84.69	---.--	84.69
Shipping and packing expenses	206.36	---.--	206.36
Telephone	24.77	---.--	24.77
Travel expenses	669.38	---.--	669.38
Exhibition and publicity expenses	517.91	---.--	517.91
Insurance	419.00	---.--	419.00
Facilities use fee (for silica)	200.00	---.--	200.00
TOTAL	10144.00	974.20	11118.20

INCOME

Grant money	9525.00
Facilities use fee	200.00
insurance reimbursement	419.00
	<hr/> 10144.00

1st grant payment	5835.00
2nd grant payment	3607.00
Balance due glass project	702.00
	<hr/> 10144.00

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BIBLIOGRAPHY

Kulasiewicz, Frank
"Glassblowing: The Technique of Freeblown Glass",
New York: Watson-Guptill, 1974

Littleton, Harvey K.
"Glassblowing: A Search for Form",
New York: Van Nostrand Reinhold, 1972

Phillips, Phoebe (ed)
"The Encyclopedia of Glass"
New York: Crescent Books, 1981

Scholes, Samuel R.
"Modern Glass Practice",
New York: McGraw-Hill, 1952

Toolet, F. V. (ed)
"Handbook of Glass Manufacture", 2 volumes,
New York: Glass Publishing Co., 1960

Weyl, Woldemar A.
"Coloured Glasses",
London: Wm. Dawson and Sons, 1959

* * *

Hermelin, Carl F.
"Fakta om Glas",
Växjö, Sweden: Glasförskningsinstitutet, 1966

Magnusson, John
"Glas: Glasets Egenskåper och Tillverkning"
Stockholm, Sweden: Liber Läromedel, 1971

Simmingssköld, B.
"Råvaror för Glassmältning",
Växjö, Sweden: Glasförskningsinstitutet, 1963

Westholm, Ingwald
"Glas Arbetsteknik",
Kalmar, Sweden: Länsskolnämnden, 1977

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THE GLASS MAKING FACILITY
(Left to right) Main furnace, glory hole,
and lehr. Glassblowers bench in foreground.

GATHERING HOT GLASS

SILICA DUMP PONDS BEHIND THE PLANT
(above and below)

CRYSTALLIZED SILICA IN SETTLING TANK

DIGGING SILICA OUT OF SETTLING TANK

HAULING IT AWAY

DIGGING IT OUT

ZORA NEWHOLD, Honolulu
"Handle Bowl"
Freeblown form with applied handles
and sandblasted design.

ZORA NEWHOLD, Honolulu
"Flame"
Sculpture of joined
blown pieces with
attached glass chips.
Sandblasted design.

BILL & CHRIS LOWRY,
Honolulu
Bowl with sandblasted
design.

BABS MIYANO, Honolulu
"Prayer Box Song"
Sculpture consisting of
blown bowl with reeds,
plate glass and brass
fittings.

BABS MIYANO, Honolulu
"Notes From a Dream"
Two piece sculpture with blown
colored bowl and candcast base.

RICK MILLS, Honolulu
Large freeblown bowl
with colored inclusions.

HUGH JENKINS, Honolulu

Sculpture of joined blown pieces
with internal forms. Cut & polished.

Sculpture of blown piece
with internal forms.
Cut and polished.

ROBERT BENTO
Honolulu
Wine goblets, free
blown with pulled
stems.

STEVEN R. LEE, Honolulu
Blown Bowl with trailed decoration.

Blown bowl with applied
color.

DAVID MUSGROVE, Honolulu
"Wind Vase." Blown vase with
applied handles. Sandblasted

JEFF GASKELL, Honolulu
Blown form with copper cast
& wire inclusions, applied
color.

LNN MILLER, Honolulu
Blown form with wire mesh
inclusions and applied
colors.

BILL IRWIN, Paho
"Re-Creation of Atlantis Spaceport"
Investment cast glass.

NORMAN MILLER, Pahoa
Perfume bottle with applied color.

ANN INGEMARSSON, Paho
"Bouquet"
Diamond drill hand engraving.
Perfume bottle by NORMAN MILLER
blown with applied & included colors.

VOLCANO ART CENTER EXHIBITION

Hawaiian Glass

- #1. Rick Mills NFS
- #2. Norman Miller "Threads" NFS
- #3. Terrence Fowler "Phoenix Going Through the Motions" NFS
- #4. Zora Neuhold sandblast bowl 185.00
- #5. Zora Neuhold sandblast plate 300.00
- #6. Zora Neuhold handled bowl 520.00
- #7. Norman Miller 12 perfume bottles 2 paperweights 100.00 each
- #8. Norman Miller bowl 100.00
- #9. Norman Miller bowl 125.00
- #10. Bill Lowry vase NFS
- #11. Bill Lowry bowl NFS
- #12. James Rhodes vase NFS
- #13. James Rhodes vase NFS
- #14. Bill and Chris Lowry bowl with sandblasting NFS
- #15. Bill Lowry vase NFS
- #16. Ann Ingemarsson "Hibiscus" 150.00
- #17. William H. Cooper vase NFS
- #18. Steven R. Lee bowl NFS
- #19. William H. Cooper vase NFS
- #20. Steven R. Lee bowl NFS
- #21. Steven R. Lee bowl NFS
- #22. Babs Miyano "Notes From A Dream" 375.00
- #23. Babs Miyano "Prayer Box Song" 1500.00
- #24. Terrence Fowler "From A Pure Heart To A Pure Soul" 3350.00
- #25. Hugh Jenkins sculpture 600.00
- #26. Hugh Jenkins sculpture 400.00
- #27. Hugh Jenkins sculpture 1000.00
- #28. Jeff Gaskell sculpture 180.00
- #29. Lee Miltier sculpture 125.00
- #30. Bill Irwin "Bubblelicious" 200.00
- #31. Bill Irwin cast plaque NFS
- #32. Bill Irwin "Greco Punk Vase" 150.00
- #33. Bill Irwin vase 50.00
- #34. Bill Irwin "Post-Nuclear Glassware" 80.00
- #35. Charles Vannatta sculpture 750.00
- #36. Zora Neuhold "Flame" NFS
- #37. Wayne Kawamoto "Persimmon" NFS
- #38. David Musgrave "Wind Vase" 300.00
- #39. Robert Bento 8 goblets 28.00 each
- #40. Lisa Yoshihara "The Tale Of Two" NFS
- #41. Bud Spindt "Twist and Spout" 800.00
- #42. Marijcke Christianson/Terrence Fowler "Ride the Wind" NFS
- #43. Bill Irwin "Raincloud" 300.00
- #44. Bill Irwin "Re-Creation of Atlantis Spaceport" 350.00
- #45. Ann Ingemarsson "Volcano" 80.00
- #46. Ann Ingemarsson "Orchids" 40.00
- #47. Norman Miller bowl 150.00
- #48. Ann Ingemarsson "Hawaiian Fish" 180.00

Hawaiian Glass

by Artists of Hawaii

The first glass created from materials of Hawaiian Origin.

Waste Silica from the Geothermal Well
Coral from Kawaihae deposits

Curated by Bill Irwin and Norman Miller

October 4 - October 23, 1987

Reception: Sunday, October 4 • 1 p.m. - 4 p.m.

*Research project partially funded by the
Community Geothermal Technology Program*

Featuring Volcano Prints by Louis Pohl

"HAWAIIAN GLASS - BY ARTISTS OF HAWAII"

* * * geothermal waste silica becomes fine art * * *

24 artists exhibit at the Volcano Art Center, October 4-23, 1987

More than an art show, this is a landmark event introducing the first glass ever to be made from indigenous Hawaiian materials. All of the works exhibited are made from this Hawaiian Glass.

The world of glass is, above all, a world of light. Glass has fascinated us for many thousands of years, and even today, when glass is so commonplace that we surround ourselves with it, it has not lost its special appeal.

Glass is not only one of our most beautiful and versatile materials, it is also one of the most unusual substances in nature. Glass is a liquid, and has no freezing point, melting point or crystal structure. Glasses can be made to be: heat conducting or insulating; electric conducting or insulating; as hard as gemstone or as soft as cotton; to resist chemicals or even to dissolve in plain water. Corning Glass Works tests 200 glasses each week.

Most common household and art glass is of the "soda-lime" type. Our Hawaiian glass is of this type and contains 72% geothermal waste silica, 7% crushed coral from the Big Island, 14% soda ash - available on Oahu as a by-product of chlorine extraction from seawater and 7% imported materials.

In a geothermal well, the extreme pressure and temperature of the fluids leach silica from the surrounding rock. After the heat is extracted for energy, the waste water is pumped into holding ponds where the silica slowly settles to the bottom. Silica is the basic stuff of rocks, sand as well as lava and composes fully one fourth of the earth's crust.

* * * * *

Norman Miller and Bill Irwin, artist/researchers from Pahoa on the Big Island built the equipment and developed the glass in a project funded under the Community Geothermal Technology Program (C.G.T.P.).

All of the works exhibited were made at three locations using the Hawaiian glass developed and supplied by the two researchers.

The majority were made at the University of Hawaii at Manoa's glass facility in Honolulu. While few people here are even aware of its existence, the UH-Manoa glass facility has an excellent reputation and counts among its alumni several of the most notable glass artists in the U.S.A..

Other works were made at Punahou School's first rate glass facility in Honolulu. Punahou is one of the only two high schools in the country offering a glass blowing program.

The remainder were made at Miller and Irwin's studio in Pahoa.

* * * * *

More information on the Hawaiian glass can be obtained by contacting Norman Miller at 966-8805 or Bill Irwin at 965-8530. Information on the C.G.T.P. grant program can be obtained through the Energy Extension Service at 961-7558.

THE HISTORY OF GLASS

The making of glass is an ancient art with origins in the earliest civilizations. Youthful Hawaii has never before had a man-made glass of its own. Only our volcano makes glass here. The only glass melted in Hawaii is done by artists . . . with imported ingredients.

* * * * *

<u>YEAR</u>	<u>GENERAL HISTORY</u>	<u>GLASS HISTORY</u>
<u>B.C.</u>		
50,000	Stone age.	Ornaments & tools of natural glass.
10,000	Plants & animals domesticated.	Man-made glass as ceramic glaze in middle east.
4,000	Bronze age.	Glass beads and jewels.
1,500	Moses, alphabet, compass.	Fused glass vessels in Egypt.
<u>A.D.</u>		
0	Jesus.	Phonecians (Syria) invent glass blowing.
0-400		Rome as glass center, clear glass.
475	End of Roman Empire	First window glass.
1200-	Printing press, Columbus.	Venice as glass center, Clear glass
-1500	Arabs invade Europe.	re-discovered, Silvered mirror, flat glass in England.
1609		Glass made in America.
1650		Lead (flint) glass in England.
1850	Queen Victoria, telegraph, photography.	Pressed glass in U.S.A..
1899	Motion pictures, radio.	Automatic bottle machine, pyrex.
1914-	First World war.	
-1918		
1931	Great depression.	Fiberglass, glass building blocks.
1934		Corning makes 5 meter mirror for Mount Palomar telescope.
1939-	Second World war.	
-1945		
1987	Irangate, Reaganomics.	First glass of Hawaiian material developed by Norman Miller and Bill Irwin in Pahoa.

Waste silica from a geothermal well becomes fine art

By Maxine Hughes
Tribune-Herald

Twenty-five artists have submitted art objects made from Hawaiian glass to be exhibited at the Volcano Art Center Oct. 4-23. A reception, open to the public, is set for 1-4 p.m. Oct. 4.

This will mark the very first time fine art glass has been made from waste silica from the Puna geothermal well, and coral from Kawaihae as the main ingredients, according to the originators, Norman Miller and Bill Irwin of Pahoa.

Miller and Irwin's "Hawaii Glass Project" was one of five selected in January of 1986 for funding in the inaugural phase of the Geothermal Technology Program.

The program offers small grants to individuals, small businesses and non-profit organizations for research and development projects utilizing geothermal heat or by-products.

Miller and Irwin, artists/researchers, said they built the equipment for the glass project and developed the glass at their studio in Pahoa. They also are curators for the show.

All of the work to be exhibited was made at three locations using the Hawaiian glass developed and supplied by the researchers. The majority was made at the University of Hawaii at Manoa's glass facility in Honolulu, which has an excellent reputation out-of-state and counts among its alumni, several of the most notable glass artists in this country, Miller said.

Other objects were made at Punahou School's first rate glass facility in Honolulu. Punahou School is one of only two high schools in the country offering a glass blowing program, Miller adds.

The remainder of the work to be exhibited was made by Miller and Irwin in their studio.

Among the many artists represented in the show are Hugh Jenkins, founder of and the principal instructor at the Punahou High School glass facility. He has exhibited widely in Hawaii and on the mainland.

Another is Zora I. Newbold, assistant instructor at Punahou, and a recognized artist with many exhibitions to her credit. Rick Mills, one of Hawaii's top glass artists, with many exhibitions — most recently at the American Craft Council Museum in New York City.

Babs Miyano, well known for her work in glass and mixed media, also has exhibited extensively.

Miller received his glass training in Sweden, where he attended

—T-H photos by Larry Kadooka

GLASS BLOWING — Norman Miller, left, is blowing a bubble of glass while Bill Irwin is transfer another bubble to Miller's piece so it can be softened and fashioned into a bowl.

Orrefors Glass School's two-year residency program. He has worked in glass factories and studios in Europe as well as the United States. Miller was born in New York City, and since living on the Big Island has been an entrepreneur involved in a number of business projects.

Irwin is an artist-craftsman best known for his laminated designs in woodwork and his contemporary furniture. He also has been working with glass using the techniques of casting, sandblasting and sculpture. Irwin is active with local and statewide artists' and craftsmen's organizations.

Because the glass used for the objects in the show is the first to be made from indigenous Hawaiian raw materials, and the quality of the glass art, there has been some preliminary discussion on having the show travel to other Big Island districts, and the Neighbor Islands.

The public is invited to view the glass show at the Volcano Art Center.

For more information call Miller at 966-8805 or Irwin at 965-8530.

ANOTHER STEP IN PROGRESS — Miller is heating an art object in the 'glory hole' in another piece of equipment.

CHEMICAL ANALYSIS: CALCIUM CARBONATE SAMPLES

for the Hawaii Glass Project

SAMPLE A (Coral samples from the Kona Coast)

as metal	as metal carbonate
Ca: 34.0% $\pm$ 0.2%	CaCO ₃ : 84.91%
Mg: 0.925% $\pm$ 0.011%	MgCO ₃ : 3.21%
Sr: 0.624% $\pm$ 0.001%	SrCO ₃ : 1.05%

SAMPLE B (Deposit from Mauna Kea Beach area)

as metal	as metal carbonate
Ca: 29.19% $\pm$ 0.46%	CaCO ₃ : 72.90%
Mg: 1.546% $\pm$ 0.036%	MgCO ₃ : 5.36%
Sr: 634 $\pm$ 3 ppm.	SrCO ₃ : 0.11%

SAMPLE C (Kawaihae coral deposit)

as metal	as metal carbonate
Ca: 35.913% $\pm$ 0.208%	CaCO ₃ : 89.69%
Mg: 0.159% $\pm$ 0.005%	MgCO ₃ : 0.55%
Sr: 0.757% $\pm$ 0.001%	SrCO ₃ : 1.28%

Remainder = alumina silicates (basalt fragments)

Analytical technique: ICP/AES
4/28/87 E.D.C.

END

**DATE
FILMED**

3 / 22 / 94