

A Study of Producing Ceramic Glaze Utilizing Shihmen Reservoir Silt

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Abstract. This study is based on the Shihmen Reservoir silt, where the largest quantity of silt is deposited and is located right next to the National Taiwan University of Art, and with combinations of other simple components, like various kinds of clay, plant ashes or other raw materials, to produce quality glazes that can perform artistic charm and give great additional values. The development of the new glaze formula is processed by the “Triangular Coordinate Method” to organize and distribute proportions of the raw materials and through the practical reconcile and firing experiments to acquire the suitable formulas. This study has successfully produced glazes such as the Oil-spot Glaze, Red Iron Glaze, Red Iron Crystalline Glaze, Golden Black Glaze, Golden Purple Glaze, Amber Glaze, Yellow Glaze, Beige Glaze and Celadon Glaze. In some of these glazes, the employment proportion of the silt can reach up to the range of 80% to 90%. In general, to employ the Shihmen Reservoir as a type of raw material can not only be practical, but possess many distinctive qualities.

Keywords: Shihmen Reservoir silt, Triangular coordinate method, ceramics glaze.

1 Introduction

The landforms in Taiwan are mostly distributed with steep slopes and, in addition to the abundant annual rainfall, severe surface overland flows are caused during the rainy season. In the past three decades, due to the destruction of the upstream reservoir, the erosion of the soil has been increasing each year. According to statistics, the deposit silt in the reservoir has accumulated 14 million cubic meters, which has reached the exact effective volume as the Meandear Reservoir. For the time being of the 70 reservoirs, the volume of deposit silt adds up to a total volume of 470 million cubic meters, which is more than the amount of water that the Feitsui Reservoir can hold[14]. Therefore, the dredging process for the reservoir silt becomes an exceedingly important job; on the other hand, how to find a way to process or reuse the great quantity of deposit silt is also an inevitable issue to achieve.

The silt from the Shihmen Reservoir comes from the debris that washed out from the watershed, which turns out to be the same source of raw material used in the ancient times in China, where they use the deposit silt distributed around the valleys[6]. Therefore, exception of the particular geology status, the chemical compositions of the

silt, that origin from the reservoir, mostly qualifies all the requirements for the glaze. Presently, the chemistry analysis for the Shihmen Reservoir silt shows[2], that besides the slight lower value of the CaO (can be resolved by adding limestone), the chemistry composition of the silt is very similar to the famous kilns that were well know through out history of China.

The reservoir silt contains large amount of iron oxide, therefore, the employment of the material can only be used to perform maroon or black color glazes. Although the glazes has color limitations, to make capital of the crystalline effects can also perform varieties of glazes. Notable example like the black glazed tea cup from Jianyang Kiln in the Sung Dynasty, the different crystalline effects, including the Yao-change, Hare-fur, and Oil-spot Glaze, shows unique artistic charm[7, 8, 12, 13, 15]. Therefore, the employment of the reservoir silt to the aspect of ceramic glaze has great potentials and can also bring in great additional value effects.

2 Research Purposes

This project is based on the Shimen Reservoir silt, where the largest quantity of depositing silt is located and is located right next to the National Taiwan University of Art, and with combinations of other simple components, like various kinds of clay, plant ashes or other raw materials, to produce quality glazes that can perform artistic charm and give great additional values. Meanwhile, it can also reduce the amount of other raw material put into use, providing another method to resolve the reservoir silt, therefore, contributing to environmental issues. Furthermore, the follow up of this study may also combine with production of tea cups for the “Longquan Tea” in the Longtan area to create a distinctive feature as a cultural creative product for the local region. The importance of this research reflects on the following aspects:

- a. Cultural aspect: to continue traditional culture of the Chinese glaze for the “slip glaze” system.
- b. Environmental aspect: the employment of reservoir deposit silt into the glaze, besides reducing the dependency for raw material, can resolve difficult preparation issues for the reservoir silt to obtain the double benefit towards the recycling of waste resources. Moreover, the process of producing glaze is also friendly to the environment.
- c. Economy aspect: the high efficiency of employing the Shihmen Reservoir silt into glaze can reduce production cost and create great economy effects.

3 Literature Review

Up until today, there has not been any correlated research studies that uses the reservoir silt as an ingredient for ceramic glaze, therefore, this issue intends to possess innovation and seeks as a challenging task to explore.

As for the present employment for the reservoir silt, the most successful employing method is using it as a light weighted aggregate for architectures. So far the Chaio Tung University, Chung Hsing University, Kaohsiung University of Applied Sciences, China University of Science and Technology, Cheng Kung University, Meihou University,

Chung Hua University, Taipei University of Technology has all processed related research and discussions with positive outcomes[1, 3, 4, 5, 9, 10, 11, 14]. According to research: "Employing the fired reservoir silt as an architectural material results in light weighted aggregate that has inner voids and a solid case, light yet receiving an appropriate intensity, which can be made into concrete that is not as heavy; moreover, it is also usable for garden planting. As light weighted, seismic, insulating, and fireproofing as the concrete is, Europe, America, and Japan has already been employing these lightweight concrete to structural or non-structural constructions in the early 20th century." "Employment of the lightweight concrete to architecture can not only increase the insulation for the house, but also cuts back on the consumption for energy resources, therefore, the material demonstrates the concept of 'Green Buildings'. In addition, firing the reservoir silt to make lightweight aggregates not only can consume deposits to increase the water storage capacity for the reservoir, but also supply the insufficiency of the sandstone resource. As the results serve multiple purposes, the employments of this material marked a significant milestone." The manufacturing development and applications of the lightweight concrete, made from the reservoir silt, has aroused the attention to the industries. On the contrary, the difficulty of obtaining space and establishment for the lightweight concrete factory, the manufacturing process has not been able to take on the practical full-scale production.

The reproduction and research on the black crystalline glaze involves ceramic artists and scholars, which relative results are quite significant. Plenty of ceramic artists focused on the reproduction and development for the black glaze of Jian Kiln; many like the Japanese artists, which includes Ken Andou, Yashushi Oketani, Hirage Kazumichi, Kyousuke Hayashi and Sugihara Motoo, Taiwanese artist, involving Yu-ting Chiang, Chun-ho Li, Kun-ho Chen, Liang-yang Shao, Chin-ying Liao, and Chinese artists, such as Hsaio-hu Mau, Ta Li, Jian-hsing Sun, Wen-tan, and Ping-lung Tsai, all contributed effort to this aspect. But as to experimental results for these artists are mostly considered as a piece of their art creation, therefore, techniques are often held on to the artists themselves. As for academic studies, research content mainly focused on the glaze ingredient analysis, microstructure discussions and so on, but as to the issue of how it is produced and fired, we may still find many questions waiting to be resolve. The physical chemistry process of black crystalline glaze that happens during firing has always been a typical problem of thermal chaos. The glaze which has the exact ingredients may perform an entirely different visual effect due to various firing processes and the different atmospheres within the kiln. According to current reproduction results, the Hare-fur and Oil-spot Glaze have been successfully reproduced, yet the Yao-change Glaze still has efforts to be made for improvement.

As for the present reproduction status for the Jianyang Black Crystalline Glaze, people in China still use traditional ball clay, stone glaze, and plant ashes from the local region. On the contrary, the Taiwan region has a shortage on ball clay and natural resources; therefore, the glaze production relies upon the imports of raw materials or chemical materials. Materials which the Japanese use are more diverse, but some do claim that the source of the materials origin from the Jianyang region. The current overall results show that the reproductions made from China and Japan are more

exquisite than Taiwan, which speculates the possibility of the resource origin being an obstacle in the production process of the black glaze. As mentioned earlier, the formation of the reservoir silt and the silt glaze (the deposit fine soil between the valleys) used in the Jianyang area are quite similar, on the other hand, the ingredient analysis on the two had also come out only in small differences, thus, the reservoir silt indeed is a quality source for the Jianyang Black Crystalline Glaze study. In general, this research is highly innovative and the results are worth expecting.

4 Research Methods

4.1 Research Aspects

This project that is correlated to the glaze research aspect is divided into two portions; the first aspect is to develop a new glaze and the second aspect is the reproduction of the specified glaze.

The development of the new glaze formula is processed by the “Triangular Coordinate Method” to organize and distribute proportions of the raw materials and through the practical reconcile and firing experiments, we will be able to acquire the suitable formulas (Fig. 1, 2) [16]. This process often comes up with unexpected results, providing a unique style of glaze. The using the existing Seger Value of the specified glaze reproduction, like Tea Glaze, Red Iron Glaze, and famous glazes known through out the history of China, are all calculated into weight values of the relative raw materials, then by processing the expansionary experiment of the “Triangular Coordinate Method” to obtain the most suitable formula (Fig. 3,4). This method not only can effectively acquire the specified glaze, but also can lead to unpredictable results.

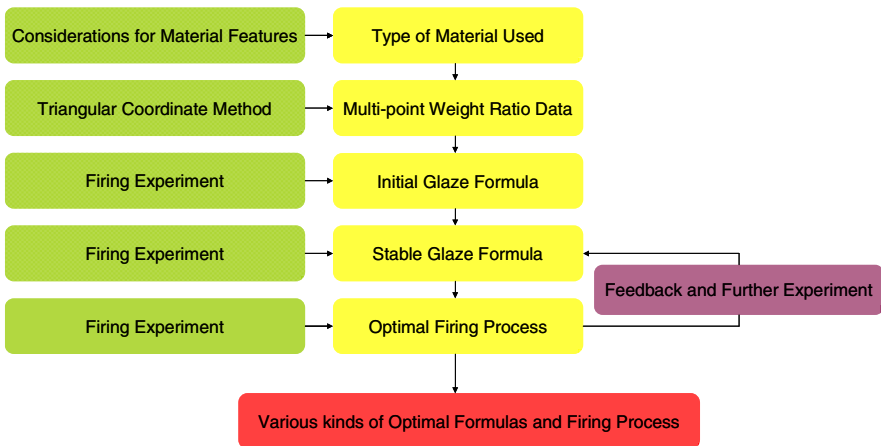


Fig. 1. Experiment Proportion of the Organized Raw Material

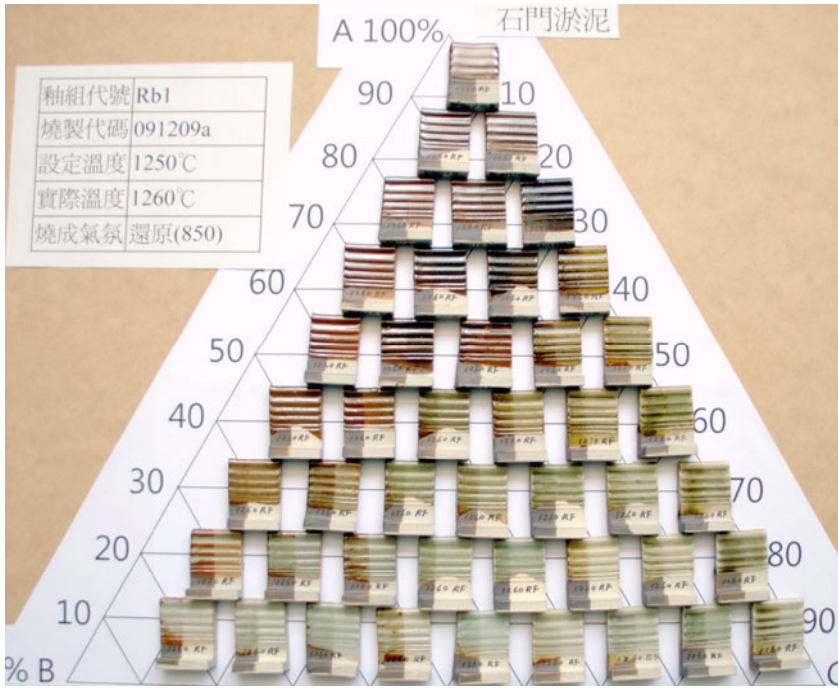


Fig. 2. Examples of the Organized Raw Material Experiments

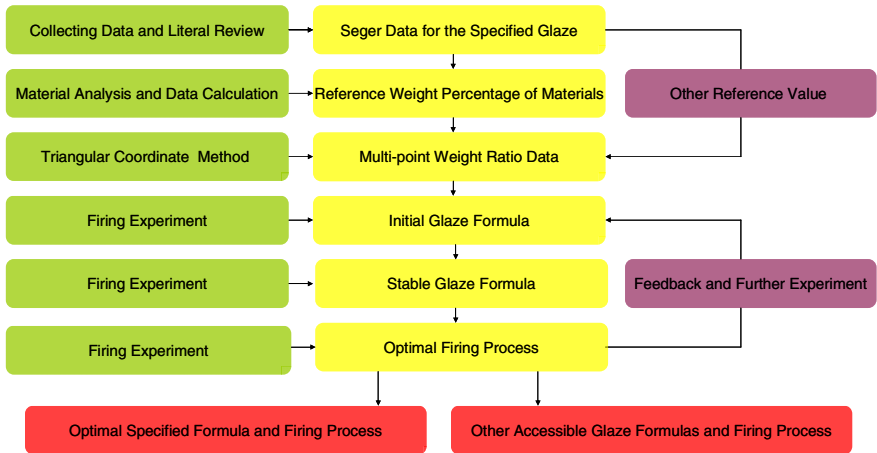


Fig. 3. Recovery Process and Method of Specified Glaze

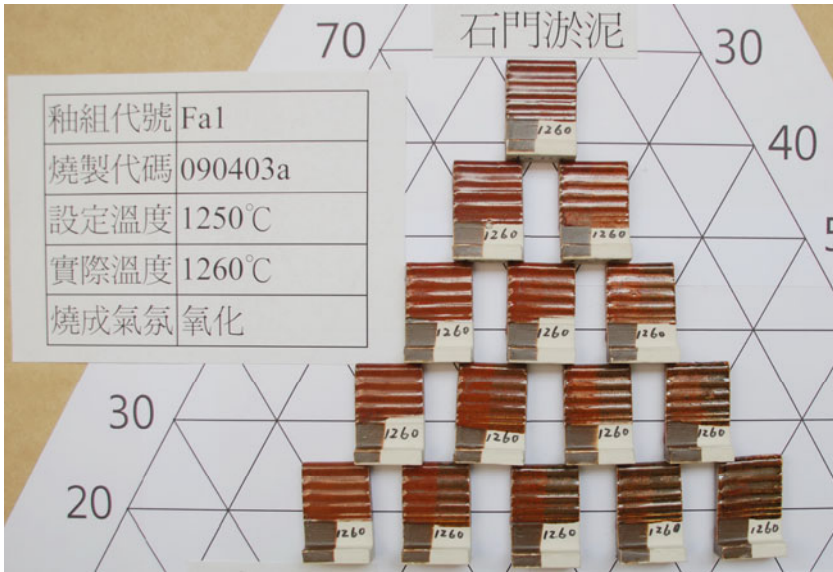


Fig. 4. Examples of Specified Glaze Experiments

4.2 Executive Procedures

- a. Reservoir silt preparation process:
Mining → Screening → Drying → Pluverizing → Calcining.
- b. Reservoir silt ingredient analysis: Using the ingredient analysis as the data source for the “Triangular Coordinate Method” calculation.
- c. Based on “Triangular Coordinate Method” to create 4 test tiles for each formula at the first phase, and then processing the experiments by firing each individual through different temperatures or diverse kiln atmospheres.
- d. Selecting the best test tiles to make discussions and perfection experiments, including adjustments of the formula, the firing temperatures, and the firing process.

5 Discussion and Conclusion

The result and contribution of this research is to provide the ceramic design industry, ceramic industry, ceramic art or schools on how to effectively employ the waste resource as a replacement of the raw materials, moreover, to resolve the important issues concerning environmental destruction and energy depletion.

5.1 Research Results

This study has successfully produced glazes such as the Oil-spot Glaze, Red Iron Glaze, Red Iron Crystalline Glaze, Golden Black Glaze, Golden Purple Glaze, Amber Glaze, Yellow Glaze, Beige Glaze and Celadon Glaze. In some of these glazes, the

Image			
No. Title Fire Temperature Maturation Range Quantity of Silt	db100-a3 Golden Oil-Spot 1290°C OF 1260~1300°C 65%	rc105 Leopard Oil-Spot 1290°C OF 1250~1290°C 80%	rc105 Purple Temmoku 1290°C OF 1250~1290°C 80%
Image			
No. Title Fire Temperature Maturation Range Quantity of Silt	da138-1 Black Temmoku 1270°C RF 1240~1280°C 50%	da112-1 Golden Purple 1270°C RF 1240~1280°C 50%	fa119 Iron Red Crystalline 1265°C OF 1230~1270°C 40%
Image			
No. Title Fire Temperature Maturation Range Quantity of Silt	rb149 Light Celadon 1270°C RF 1240~1280°C 10%	rb149 Light Yellow 1270°C OF 1240~1280°C 10%	dc118 Amber 1280°C RF & OF 1240~1290°C 50%

employment proportion of the silt can reach up to the range of 80% to 90%. In general, to employ the Shihmen Reservoir as a type of raw material can not only be practical, but possess many distinctive qualities:

- a. Reservoir silt glaze is classified in the category of natural silt glaze, which involves more variety of trace elements and people generally consider it as a support to the performances of the glaze color and texture. According to practical results, we find that even though the Shihmen Silt Glaze production carries a smooth surface, it still preserves a reserved, implicit sheen and possesses a fine variation effect.

- b. From present observation of the experimental results, the combination of the reservoir silt with feldspar, limestone, rice husk ash, and a few other materials, can create a diversity of tone, sheen, and crystalline effects for a quality glaze. And through the manipulation of the atmosphere in the kiln, whether by oxidation firing or reduction firing, we can retrieve more variation for the glaze to perform full extent.
- c. Based on experiment statistics, the maturation temperature of the glaze, which mainly contains reservoir silt, has quit a large range (from 40~50°C or higher), therefore, uneven temperature within the kiln seldom becomes a cause for failure.
- d. On the aspect of material preparation, to employ the reservoir silt to the ceramic industry can almost leave out traditional process of water tossing, the screening procedure only needs to eliminate a small portion of sand grains. According to practical executing experiences, the Shihmen Reservoir silt has more than 95% of the content that can be taken into good account, moreover, the preparation procedures are not as complicated. If mass production is possible to achieve, the prime cost of the silt will be much more efficient to the economy benefit.
- e. As for the succeeding glazes, with the formulas, which uses the similar modern raw material that relates to the calculation of the “Seger Method”, we can find the conclusion where the Shihmen Reservoir Silt Glaze can reduce the needs of diverse raw materials, furthermore, making significant impact on narrowing down the time and labor cost.

5.2 Promotion and Employment Values

a. Research Contributions

1. To arouse the industry with the idea of local waste resources by combing local resources with the creative industry; further on, expanding the horizons of culture and economy.
2. To find another solution for the prompt depositing silt and, meanwhile, reduce the ceramics dependency for natural ore. By this way, we can fulfill actual environmental protection and become a classic industrial icon.
3. Transforming the waste materials into beautiful ceramic decorations, therefore, stressing both environmental protection and aesthetic values to full extent.
4. Using Taiwan raw materials to create a local ceramic industry feature.
5. To establish a new employment for the traditional industry, developing a broader possibility either for production techniques or marketing demands.

b. Employment Strategy I: Creating Local Creative Merchandises

1. Tourist Souvenirs: To develop a series of goods which will unite with tourist attractions and sells within souvenir shops. Ceramic industry has always been closely related to the natural environment resource, examples such as ball clay resources and fuel resources. Employing the Shihmen Reservoir silt to ceramic craft, can not only provide environmental value, but is also an intimate combination with the features of the local raw material. Slogans such as “Take the.....soil home!” or “Sending you a handful of the.....soil” will be quite an attractive souvenir to take home.

2. Longtan Tea Ware: The Shihmen Reservoir is located next to the Longtan Town, which is well known for its Longtan Tea. Uniting the sophisticated Shihmen silt tea ware with the famous “Lontan Tea” will absolutely make great improvements to the quality of diet as well. In general, to create a series of creative culture product that involves a local look.
3. Shihmen Fish Tableware: The Shihmen has a very famous reputation for its fish dish, but has also faced a severe problem of competition. Many restaurants have superior cooking expertise, but compromises with unattractive or even extremely poor quality tableware. If it is possible to create exquisite ceramic tableware with the employment of the Shihmen Reservoir silt, the quality of diet will then be enhanced, promoting a higher enjoyment level for the gourmet feast.

c. Employment Strategy II: Development of Merchandise with Quality Glaze

1. Reservoir silt glaze is classified in the category of natural silt glaze, which involves more variety of trace elements and people generally consider it as a support to the performances of the glaze color and texture. According to practical results, we find that even though the Shihmen Silt Glaze production carries a smooth surface, it still preserves a reserved, implicit sheen and possesses a fine variation effect. On the contrary, the performance of modern material, such as stains, provides more of a cold, monotonous sense of feeling. Therefore, the successful results in this research is proven to be worthy of developing a series of distinctive products which emphasizes the beauty of the glaze.
2. Ceramic is multidisciplinary aspect of professional knowledge and techniques, including chemistry, physical thermodynamics, aesthetics, and artistic techniques. Although modern ceramic artist are expertise in sculptural creations, exploring the ceramic aspect from a different point of view, finding the perfect glaze for their creation is frequently quite a difficult task to achieve. “Shihmen Slip Glaze” can be a cooperation project with these artists, either developing or producing ceramic art works with the reservoir silt, but still emphasizing each individual artistic statement and style. Therefore, creators may resolve their desire for certain glaze and can put more focus into their creation. In short, the coordinated relationship rests in harmony.

Acknowledgment. This study was partly sponsored with a grant, NSC98-2410-H-144-002, from the National Science Council, Taiwan.

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