Composition Analysis and Identification of Ancient Glass Products Based on OLS

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Abstract. In order to explain the relationship between surface weathering and its glass type, decoration and color, this paper adopts multiple linear regression for research and analysis. The test results show that the pattern B is easier to weather than the pattern A and C when other factors remain unchanged, and the type of high potassium is more difficult to weather than the type of lead barium when other factors remain unchanged.

Keywords: OLS, glass composition identification, Cluster analysis.

1. Introduction

The ancient Silk Road is of great significance in the world, serving as a bridge between Eastern and Western cultures [1-2]. Glass is an important material evidence of trade between early ancient China and foreign countries [3]. In the early days of the Silk Road, many bead-shaped ornaments in my country were made of glass by people in West Asia and Egypt and then traded. The glass produced in ancient my country was also produced in the country after mastering foreign technology. It is made from local materials, so the glass produced in my country is similar in appearance to the glass products from foreign trade, but the chemical composition is different [4]. The main raw material of glass is quartz sand, and its main chemical composition is silica [5]. Because the melting point of pure quartz sand is very high, in order to reduce the melting temperature, it is necessary to add a co-solvent to it during refining [6]. Commonly used co-solvents in ancient my country includes plant ash, natural caustic soda, saltpeter and lead ore, and limestone (the main component is calcium carbonate) is added as a stabilizer, and limestone becomes calcium oxide after calcination. The main chemical composition is related to the co-solvent [7]. Different co-solvents have different chemical compositions. For example, lead-barium glass uses lead ore as a co-solvent, and its content of lead oxide and barium oxide will be very high [8]. Weathering can cause changes in the compositional proportions of ancient glass products, which can affect the correct judgment of their categories. By studying the chemical composition of ancient glass artifacts [9]. This paper conducts research based on the sample data of glass cultural relics provided by a website. Potassium glass is fired with plant ash as a co-solvent, so it has a high potassium content [10-11]. Ancient glass is susceptible to weathering by the burial environment. During weathering, internal elements are exchanged with environmental elements, so that the proportion of components changes, which will affect the judgment of its category.

2. The basic fundamental of OLS

paper selects the glass cultural relic data provided by a certain website for research. Based on the existing data, descriptive statistics are carried out, and the processing results are shown in Table 1.

Since some samples have missing colors in the original data, the descriptive statistics are shown in Table 1. There are 58 samples observed for weathered and unweathered, type and decoration, and only 54 samples are observed for color, among which the decoration (d1, d3), type (c1, c2), color (b2, b7) has a larger share, and color (b4, b6, b8) has a smaller share. The overall introduction of the indicators is shown in Table 2.

Table 1. Descriptive statistics

variable	Obs	Mean	Std. Dev.	Min	Max
a1 (surface weathering == no weathering)	58	0.414	0.497	0	1
a2 (surface weathering == weathering)	58	0.586	0.497	0	1
b1 (color == light green)	54	0.056	0.231	0	1
b2 (color == light blue)	54	0.37	0.487	0	1
b3 (color == dark green)	54	0.13	0.339	0	1
b4 (color==dark blue)	54	0.037	0.191	0	1
b5 (color == purple)	54	0.074	0.264	0	1
b6 (color==green)	54	0.019	0.136	0	1
b7 (color == blue-green)	54	0.278	0.452	0	1
b8 (color==black)	54	0.037	0.191	0	1
c1 (type == lead barium)	58	0.69	0.467	0	1
c2 (type == high potassium)	58	0.31	0.467	0	1
d1 (decoration==A)	58	0.379	0.489	0	1
d2 (decoration==B)	58	0.103	0.307	0	1
d3 (decoration==C)	58	0.517	0.504	0	1

Table 2. Introduction to the overall situation of indicators

variable type	variable name	illustrate
Qualitative Indicators (Dependent Variables)	surface weathering	There are two categories: Weathered and Unweathered
Qualitative Indicators (Independent Variables)	color	There are eight colors: light green light blue, dark blue, purple, green, cyan, black
Qualitative Indicators (Independent Variables)	type	There are two types: high potassium, lead barium
Qualitative Indicators (Independent Variables)	Ornament	There are three types: A, B, C

According to Table 2, the independent and dependent variables of the regression equation can be obtained. It is assumed that the independent variable $X = \{x_1, x_2, x_3\}$ and the dependent variable are weathered and satisfy the following linear relationship:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \mu \tag{1}$$

where μ is the perturbation term that cannot be detected but has completely random properties.

3. Results

3.1. The establishment of simulation model

Statistical law is the overall law of random events. It is not a simple superposition of the characteristics of a single random event, but the inevitability of an event system. The law that acts on a large number of accidental events as a whole expresses the essence and inevitable connection of the whole of these things. First, the regression coefficients before the five independent variables in the regression equation are tested and found $P = 0.0 < 0.05$, so the null hypothesis is rejected at the 95% confidence level.

3.2. Analysis of experimental results

calculation results of the model in this paper, the regression analysis results based on OLS are shown in Table 3.

Table 3. Results of regression analysis based on OLS

a2	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
b1	-0.322	0.38	-0.85	0.401	-1.088	0.444	
b2	0.232	0.29	0.80	0.427	-0.353	0.818	
b3	0.03	0.338	0.09	0.93	-0.652	0.712	
o	0	0	0	0	0	0	
b5	-0.155	0.364	-0.43	0.672	-0.89	0.579	
b6	-0.655	0.486	-1.35	0.185	-1.636	0.326	
b7	0.381	0.295	1.29	0.204	-0.215	0.976	
b8	0.601	0.379	1.58	0.12	-0.164	1.367	
o	0	0	0	0	0	0	
c2	-0.797	0.147	-5.42	0	-1.094	-0.501	***
o	0	0	0	0	0	0	
d2	1.018	0.209	4.86	0	0.596	1.44	***
d3	0.257	0.142	1.80	0.078	-0.03	0.544	*
Constant	0.399	0.273	1.46	0.152	-0.153	0.95	
Mean dependent var	0.556		SD dependent var		0.502		
R-squared	0.553		Number of obs		54		
F-test	5.319		Prob > F		0.000		
Akaike crit. (AIC)	56.237		Bayesian crit. (BIC)		78.116		

***p<0.01, **p<0.05, *p<0.1

Significance test is carried out according to the regression coefficient obtained in Table 3. It can be seen that the variables c2 (type = high potassium) and d2 (texture = B) therefore reject the null hypothesis at the 95% confidence level. a2 (surface weathering == weathering) has a significant effect.

According to the research on the polyline of the aggregation coefficient, it is found that the downward trend of the polyline slows down when it is classified, so the cluster analysis of high potassium glass is set to 3. At the same time, when the value is from 1 to 5, the degree of distortion is the largest, and when it exceeds 6, the degree of distortion gradually weakens.

Table 4 is the clustered data of high potassium after clustering into the first group, and Table 5 is the clustered data of lead and barium clustered into the first group.

Table 4. Category 1 sample SiO_2 content and weathering table

Cultural relic sampling point	Silica SiO2	Whether weathering is quantitative	Classification
01	69.33	unweathered	1
03 Part 2	61.71	unweathered	1
04	65.88	unweathered	1
05	61.58	unweathered	1
06 part 1	67.65	unweathered	1
06 Part 2	59.81	unweathered	1
13	59.01	unweathered	1
14	62.47	unweathered	1
16	65.18	unweathered	1

Table 5. Cluster 1 sample lead oxide *PbO* and *BaO* content and weathering table

Cultural relic sampling point	Lead oxide PbO	barium oxide BaO	Whether weathering is quantitative	Classificat ion
02	47.43	0	weathered	1
19	42.82	5.35	weathered	1
30 parts 1	39.22	10.29	unweathered	1
30 parts 2	37.74	10.35	unweathered	1
34	46.55	10	weathered	1
36	41.61	10.83	weathered	1
38	49.31	9.79	weathered	1
39	61.03	7.22	weathered	1
40	70.21	6.69	weathered	1
41	44.12	9.76	weathered	1
43 part 1	59.85	7.29	weathered	1
43 Part 2	44.75	3.26	weathered	1
49	34.18	6.1	weathered	1
50	44	14.2	weathered	1
51 part 1	40.24	8.94	weathered	1
51 Part 2	51.34	0	weathered	1
52	47.42	8.64	weathered	1
54	55.46	7.04	weathered	1
54 Severely Weathered Points	58.46	0	weathered	1
56	41.25	15.45	weathered	1
57	45.1	17.3	weathered	1
58	39.35	7.66	weathered	1

For classification 2, the content is significantly higher than that of classification 1 and classification 3, while the content is significantly lower than that of series 1 and is comparable to that of series 3. At the same time, the clustering results of classification 1 show that most of its samples are Weathering, by comparison, it can be concluded that lead-barium glass is more easily weathered when the content is large and the content is small.

Regarding the content of classification, it is obvious compared with classification 2. The content of classification 1 and classification 3 is significantly lower than that of classification 1. According to Table 5, it can be concluded that high-potassium glass is more easily weathered when the content is more, and when the content is less High potassium glass is not easy to weather.

4. Conclusions

This paper analyzes the relationship between the weathering on the surface of glass cultural relics and its glass classification, decoration and color; analyzes the statistical law of the chemical composition content of weathering on the surface through the glass type, and conducts modeling processing based on the weathering point detection data. This paper describes the classification research of glass cultural relics accurately and subtly to a certain extent, and establishes multiple linear regression to analyze different types of cultural relics. Under the condition that other factors remain unchanged, the decoration of B is more likely to wind than the decoration of A and C. The type of high potassium is more difficult to weather than the type of lead barium when other factors remain unchanged. In addition, this model also has certain reference significance for the production planning and selection of glass products.

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