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A study of the composition of glass products based on multiple linear regression

Jianbo Han, Mingyue Li, Anan Lu, Wenbo Song, Lingyi Taishi

Tianjin University of Science and Technology, Tianjin, 300450, China

Abstract: *Ancient glass is highly susceptible to weathering by the burial environment, and during the weathering process, its composition ratios change. In order to grasp the pattern of compositional changes in the weathering of ancient glass products, this paper will analyse data on the characteristics of different glass products and the proportions of their chemical composition, discuss the relationships between the factors and promote the development of China's glass manufacturing industry. In this study, for the question of the relationship between weathering and type, decoration and color on the surface of glass, a chi-square test was used to calculate significant p-values of 0.0201, 0.0565 and 0.5066 in that order, and the following conclusions were obtained: there is a significant difference between weathering and type on the surface of glass products, and there is no significant difference with decoration and color; for the statistical pattern of the content of chemical components on the surface of cultural relic samples with or without weathering For the problem of predicting the content of chemical components before weathering, the data were divided into four categories based on the presence or absence of weathering and the type of glass, with silica content as the dependent variable and the rest of the chemical components as independent variables, and a multiple linear regression model was used to find the statistical law. The difference between the mean values of high potassium glass and lead-barium glass before and after weathering was used to predict the pre-weathering chemical content of the weathering points.*

Keywords: *Multiple linear regression, Classification of glass products, Chemical composition*

1. Introduction

The development of Chinese glass was closely linked to exotic cultures, and the Silk Road played a role in the spread of culture to the development of ancient glass in China [1]. The main raw material for glass was quartz sand, and other chemical components could be added to achieve certain effects in the process of making glass. However, ancient glass is highly susceptible to weathering due to the burial environment, and the proportion of its chemical composition will change during the weathering process [2]. Therefore, the analysis of the composition change law of ancient glass products has important research value for China's glass manufacturing industry [3]. This paper explores the relationship between weathering on the surface of glass artefacts and their glass type, decoration, and color, based on a batch of data relating to ancient glass artefacts in China; analyses the statistical pattern of chemical composition content on the surface of artefacts with or without weathering in conjunction with glass type, and predicts their chemical composition content before weathering based on weathering point detection data. For the question of the relationship between weathering on the surface of glass and type, decoration, and color, based on the data, we made a columnar table of whether the surface was wethered or not in relation to the type, decoration, and color of the glass in turn, based on which we applied a chi-square test, and then derived the relationship between surface weathering and each attribute. For the question of the statistical law of the content of chemical components on the surface of heritage samples with or without weathering, we divided them into four main categories based on the type of glass and whether it was weathered or not [4]. As the main chemical component of glass is silica, we set the proportion of silica as the dependent variable and the proportion of the remaining 13 chemical components as the independent variables, and then applied a multiple linear regression model to obtain four expressions, and tested the fit effect to This was used to derive statistical laws. For the prediction of thring chemical content of weathering points, we divided the raw data into four categories based on the presence or absence of weathering and the type of glass, and averaged the chemical composition of each category to find the difference between the mean values of high potassium glass and lead-barium glass before and after weathering, in order to predict the pre-weathering composition of weathering points [5].

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2. The fundamental of classification models

A columnar table of the presence and absence of weathering and each characteristic attribute was created in turn, based on which the p-values were calculated using a chi-square test. The data were classified, and after classification the statistical patterns for each category were calculated using a multiple linear regression model.

Step1: Solve for the actual and theoretical values in a series of tables

Suppose there are two definite class variables A with$B$, in a finite number of things, the A and B occur simultaneously a number of times A_1 that A occur and B the number of times that do not occur is A_2 , and$A$ does not occur and B occurs A_3 , and A does not occur and B The number of times it does not occur is A_4 , at which point the column table is drawn and then based on the A the probability of occurrence P_A , multiply the total number of occurrences of B by P_A to obtain the first theoretical value T_1 , and then multiply$B$ multiply the total number of times that does not occur by P_A to obtain the first theoretical value T_2, and the other two theoretical values are calculated using A The probability of non-occurrence is calculated in this way, to the point where two columns are obtained as follows in Table1 and 2.

Table 1: A Comparison with B List of actual values of events

B Events / A Events	B Occurrence	B No occurrence
A Occurrence	A_1	A_2
ANo occurrence	A_3	A_4

Table 2: A Comparison with B List of theoretical values of events

BEvents / AEvents	BOccurrence	BNo occurrence
AOccurrence	T_1	T_2
ANo occurrence	T_3	T_4

Step2: Cardinality solution

The cardinal values are solved for according to the following equation.

$$x^2 = \sum \frac{(A_i - T_i)^2}{T_i} \quad (1)$$

Step3: Using cardinality to calculate$p$ Value

Solving for degrees of freedom DF.

$$DF = (m-1) * (n-1) \quad (2)$$

Based on the calculated cardinality values and the degrees of freedom, check the cardinality table against the condition$p$ values.

Using the processed data, the columns of each attribute were tabulated in turn, the results of which are shown below table 3, 4 and 5.

Table 3: List of surface weathering and types

Type / Weathered condition	High Potassium Glass	Barium lead glass	Total
Weathering	6	24	30
No differentiation	12	12	24
Total	18	36	54

Table 4: List of surface weathering and ornamentation

Ornamentation / Weathered condition	A	B	C	Total
Weathering	9	6	15	30
No weathering	11	0	13	24
Total	20	6	28	54

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Table 5: List of surface weathering and color

Color / Weathered condition	Black	Blue and green	Pale blue	Green	Light green	Deep Blue	Dark green	Purple	Total
Weathering	2	9	12	0	1	0	4	2	30
No weathering	0	6	8	1	2	2	3	2	24
Total	2	15	20	1	3	2	7	4	54

Based on the resulting column table, use the$matlab$ software, the solution was performed in turn$p$ values to obtain the significance of surface weathering in relation to glass, decoration and colour$p$ values are0.0201, and0.0565, and 0.5066 We conclude that there is a significant difference between surface weathering and type, and no significant difference between decoration and color.

3. Results

3.1 The establishment of simulation model

The large data prediction model for the user's electricity consumption is implemented in the Clementine software.

The multiple linear regression model equation is as follows.

$$y = k_0 + k_1x_1 + k_2x_2 + k_3x_3 + \cdots \quad (3)$$

Of these, thex_1 ,x_2 ,x_3...... are different characteristic variables, thek_1 ,k_2 ,andk_3 ...... are the coefficients before these characteristic variables, andk_0 are constant terms. Depending on whether they are weathered or not and the type of glass, we classify them into four main categories and for each category, we analyse them empirically.

3.2 Analysis of experimental results

The maximum number of transports in the results of the model in this paper is 2711 x 11 = 29,821, and the location of the power station can be set at 4.8, 4.9, 5 and 5.1 km from point P. The results are derived using a secondary simulated annealing algorithm, and the results obtained through the algorithm do not differ much from the first, so it is a little easier to use only one simulated annealing.

For each category, we applied a multiple linear regression model to derive statistical patterns, denoted by SiO_2 the proportion of the content of$x_i (i = 1,2, \dots\dots, 13)$ in the order of$N_{a2}O$,K_2O , , andC_aO, andM_gO , ,Al_2O_3 , , , ,Fe_2O_3 C_uO P_bO B_aO P_2O_5 S_rO S_nO_2 , , , andSO_2 The expressions for all sampling points for the unweathered properties of high potash glass are derived as follows

$$y = -33.1778x_1 - 2.0815x_2 + 12.8830x_3 - 50.8823x_4 + 15.0653x_5 - 20.0400x_6 + 3.2669x_7 - 3.1037x_8 + 4.9094x_9 + 13.6679x_{10} - 71.1899x_{11} + 49.7303x_{12} \quad (4)$$

The expressions for all sampling points for the weathering properties of high potassium glass were obtained as follows.

$$y = 101.5527 - 3.6392x_2 - 9.1297x_4 + 0.4279x_5 - 2.1206x_7 - 4.7531x_{10} \quad (5)$$

The expressions for all sampling points for the weathering properties of lead barium glass were obtained as follows.

$$y = 87.9657 + 0.2365x_1 + 4.7130x_2 - 1.3860x_3 - 3.2620x_4 - 0.5776x_5 + 0.2964x_6 - 0.2373x_7 - 0.8832x_8 - 1.0573x_9 - 0.8795x_{10} + 1.0652x_{11} + 1.7264x_{12} - 0.7156x_{13} \quad (6)$$

The expressions for all sampling points for the unweathered properties of lead barium glass were obtained as follows.

$$y = 98.8615 - 1.2768x_1 - 2.8311x_2 - 0.2970x_3 + 0.1906x_4 - 1.0167x_5 - 1.3140x_6 - 0.4961x_7 - 0.9909x_8 - 1.2565x_9 - 1.7238x_{10} + 0.6668x_{11} - 1.7303x_{12} - 0.3230x_{13} \quad (7)$$

Based on the four main categories, we solved for the mean value of each chemical composition for each category, followed by the difference value for each type of glass. Based on the difference values obtained, we predicted the content of each chemical composition before weathering for each weathering point. A small number of the predicted results had a negative proportion of chemical composition content, which is known to be unlikely to be negative based on the actual situation, so we modified the negative

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value to 0. Due to the large total number of weathering points and the 14 chemical compositions for each weathering point.

4. Conclusions

This paper provides a somewhat accurate and clever description of the study of the classification of ancient glass objects, using multiple linear regression to analyses the data and cleverly construct a classification model. Many graphs and charts are used to statistically analyses the characteristics of the data and to compare the characteristics of the different glass types more visually. For the problem of predicting the pre-weathering chemical content of weathering point test data, we divided the data in Form 2 into four categories based on the presence or absence of weathering and glass type, and averaged each chemical composition for each category. In addition, this model has implications for the planning and selection of industrial production of glass products.

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