



# Visualization Analysis of Chinese Unearthed Tomb Murals Data Based on Big Data Technology

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**Abstract.** The unearthed tomb murals in China depict the splendid culture of each historical period of our country with the cultural symbols with the characteristics of The Times. They are the precious cultural heritage for the inheritance and study of the development history of the Chinese national civilization. However, because the tomb murals are buried deep underground, they can only be found through archaeological excavation, and it is difficult to preserve the murals after they are excavated, which makes it impossible for the majority of scholars to directly observe and study the murals, leading to the difficulty in recognizing and understanding the precious cultural information in the tomb murals. Currently using big data technology, data visualization tomb murals can be converted to works of art, from the perspective of informatization, digital parsing the connotation of the information of the tomb murals and cultural heritage, to help the visitor information from multiple dimensions to fully understand and cognitive tomb murals in the gorgeous Chinese traditional culture and strong artistic appeal.

**Keywords:** Chinese excavated tomb murals · Big data · Visualization · Cultural heritage information

## 1 Introduction

There are many kinds of murals in ancient China. According to their forms of expression, they can be mainly divided into three types: color painting, relief carving and line carving; according to their existing forms, they can be divided into tomb murals, cave murals, temple murals and so on. Among them, the numerous number of existing Chinese tomb murals, the wide range of distribution, the huge volume, the long history of evolution, is incomparable to the other two kinds of murals. With the gradual development of the excavation and protection of cultural relics in China, more and more tomb murals have emerged from the dust and appeared in front of us. Since the 20th century in our country ancient mural tomb, discovered in time span almost throughout the whole process of the feudal society in China, from the qin and han dynasties to the late Ming dynasty, from the nobility, next to the civilian population, tomb fresco, with its rich subject matter content, perfecting the system of image painting not only reflects the achievements of painting

art in our country, it also reflects the inheritance of national culture from generation to generation. The tomb murals in China are the inheritance of Chinese civilization and the construction of another cultural development history of the Chinese nation. They are a unique and precious cultural wealth of our country [1].

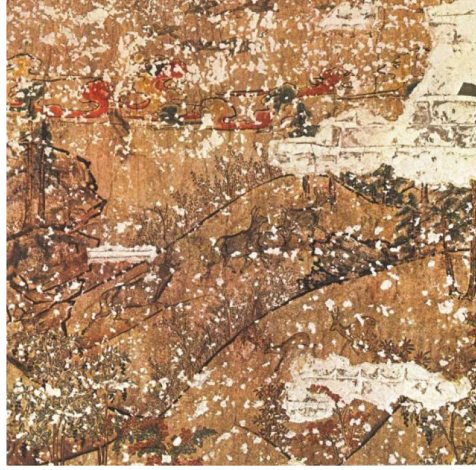
## 2 Difficulties in the Study of Tomb Murals Unearthed in China

The unearthed tomb murals have high cultural and artistic value, but the existing technical means are difficult to balance the two aspects of cultural relic protection, research and exhibition. The reasons are as follows: First, the tomb murals are huge. For example, Tang Que Lou Tu (280cm vertical and 280cm horizontal), unearthed from the tomb of Prince Yide in Gan County, Shaanxi Province in 1971, as shown in Fig. 1. Second, the tomb murals belong to cultural relics with special materials, and the pigments used in painting are all mineral pigments. The bottom white ash layer (background color) of the picture is made of hydrated lime, which exists in the closed and anoxic environment of the tomb for a long time. When unearthed, it is easy to be oxidized and weathered, resulting in discoloration. As shown in Fig. 2, the frescoes of Four Seasons Landscape in Qing Tomb of Liao Dynasty were moted and seriously damaged. All of these pose challenges for cleaning, cutting, repairing, packaging, transportation and exhibition of murals unearthed from tombs. As a result, the exhibition rate of murals in excavated tombs is low, and it is difficult for visitors to understand the cultural connotation of murals in a short time, and the information acceptance of the public is generally not high [2].

In view of the above problems, the traditional passive museum display mode of Chinese excavated tomb murals can not meet the needs of visitors, but also increase the difficulty of museum protection of excavated tomb murals. This calls for a new way to balance these contradictions. This requires that the unearthed tomb murals should



**Fig. 1.** Tomb of Prince Tang Yide Tang Que Tower



**Fig. 2.** Landscape Map of Four Seasons -- Autumn in Qing Tomb of Liao Dynasty

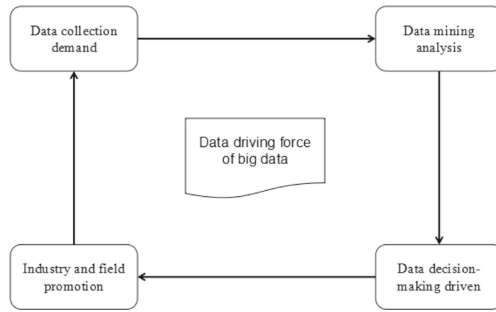
be exposed to visitors and researchers as much as possible, so as to make the ancient cultural relics warm and vibrant and create a more profound cultural experience.

With the support of big data technology, the cultural information of tomb murals is transformed into digital information and data symbols and combined with data visualization technology to vividly display the creation age, attribute state, simulated reproduction process, and the story content covered in the tomb murals. An ancient solidified tomb mural is clearly analyzed with dynamic data, which enhances the readability of tomb mural information. At the same time, it also provides a new digital protection strategy for the protection of the unearthed tomb murals.

### 3 Big Data Technology and Data Visualization Analysis

By the end of 2020, the global data volume has exceeded 50ZB, and China's data production accounts for about 23% of the global data production, ranking first in the world. Such a huge amount of data will certainly promote the development and change of various industries and fields, but the more key is how to dig out valuable information data from the data. Through the construction of a specific data system, high-value data information groups are built into a closed-loop data driving force, as shown in Fig. 3, and combined with general domain knowledge to continuously drive the sound development of the industry and the field [3].

Data visualization is an important means to simplify data volume and reduce the complexity of data application under big data technology. Under big data technology, data visualization should go through the process of data acquisition, data storage, data analysis, data sharing, data search and data visualization. Data visualization collects, analyzes and mines the original and disorderly data quickly by means of tables, charts, images, animations, 3D modeling and so on, and then presents the data results vividly and interestingly. Data visualization not only changes the appearance of the complex



**Fig. 3.** Data driving force closed-loop diagram

data and information, but also makes the insights behind the data and information appear in front of us, allowing us to easily accept and feel the original complex and profound connotation.

At present, the research and application of data visualization in China is still in the primary stage, and the main direction of the research is focused on the visualization of data charts. Universities, institutions and many enterprises are also involved in it. Although there have been some achievements in the research and application of combining data visualization with the digitization of cultural relics, the research on digital protection and data visualization of unearthed tomb murals is still a blank. The research of data visualization based on Chinese excavated tomb murals involves the intersection and integration of multiple fields and different disciplines, such as archaeology, history, information science, design science, conservation and restoration of cultural relics. Only through the cooperation of various parties can we make a comprehensive and systematic analysis and study of the tomb murals unearthed in China. Based on the data information visualization design of excavated tomb murals in China, this paper puts forward the reconstruction of digital simulation of tomb murals, and shows the contents of tomb murals digitally, so as to completely solve the practical problems of protection, research and exhibition of tomb murals.

#### 4 Research on Data Visualization of Tomb Fresco

Data collection is the primary task of data visualization research on Chinese excavated tomb murals. For the special type of tomb mural, we should first understand the various original data contained in the tomb mural itself, that is, to determine the data object of data visualization research. Research on the data object determines the fundamental direction of data visualization design, and it is also the core content of the digital display of tomb mural. Due to the particularity of excavated tomb murals, the relevant data are of high complexity and have no annotated format of data information. Therefore, it is necessary to analyze and summarize the non-structural data information from all dimensions to facilitate the subsequent visualization design of tomb murals data.

## 4.1 Historical Background

The history of Chinese tomb murals almost runs through the whole process of China's feudal society, which can be divided into three stages. The first stage is the Han, Wei, Jin, Southern and Northern Dynasties. Tomb murals emerged from the late Western Han Dynasty to the Eastern Han Dynasty. In some places, it was common for the families of the powerful and powerful to have lavish burials. There were not only burial goods in the tombs of the dead, but also murals painted on the tomb walls. The second stage is from the Sui, Tang and Five Dynasties to the Yuan Dynasty. This stage was the flourishing period of model murals. Due to the strong national strength of the Tang Dynasty, the style of generous burial was well continued. There were a large number of tomb murals unearthed and the artistic creation level was very high, which reached the peak of development. During the late Tang Dynasty and the Song Dynasty, the tomb murals began to change from the aristocracy to the common people, with various contents and themes and widely used. The murals in Liao's tombs in the same period of history were the last brilliant stage of tomb murals in China's history. Especially in the process of Liao's continuous southward movement and learning from the Central Plains, the tombs of Khitan noblemen of Liao Dynasty were close to those of the Han noblemen at that time. The frescoes in Liao Tombs show the freedom and unrestrained of the Khitan people of Liao, and also reflect the new height of the integration of national cultures. The third stage is the Ming and Qing Dynasties. At this time, the wind of heavy burial was no longer prevalent, and the tomb murals also developed into a period of decline. The number of tomb murals unearthed here decreased sharply, and the development stagnated [4].

## 4.2 Draw the Process

The main structural levels of the tomb murals unearthed in China can be divided into the foundation support layer, the ground support layer and the paint layer. The ground battle layer began to appear in the Eastern Han Dynasty, and then became the unified production standard in the Tang and Song Dynasties. It appeared for the purpose of preserving the murals for a longer time and not easy to damage and fall off. With the development of tomb murals, the production technology of tomb murals is becoming more and more perfect, and the materials and pigments are becoming more and more exquisite. The drawing process of tomb murals is generally drafting, coloring and drawing lines. First, use light lines to draw the outline and layout, then color, and finally use dark lines to enhance the color contrast of the picture.

## 4.3 Color Use

In the tomb murals unearthed in China, the use of color is very rich, which not only conforms to the requirements of The Times, religion and mythology, but also reflects the identity, status and class norms of the tomb murals owner. The use of color in tomb frescoes is a unique painting language, which has obvious style and characteristics of The Times, and also reflects the level of pigment production and the development of chemical technology at that time from the side. This is also the reason why color

**Table 1.** Mineral pigments of tomb frescoes in different periods in ancient China

Mineral color	Han Dynasty	Wei, Jin, Southern and Northern Dynasties	Sui and Tang Dynasties	Song and Liao Dynasties
Red	Cinnabar, Lead paint	Iron red	Iron red, Cinnabar, Lead paint	Iron red
Black	Ink	Ink	Ink	Ink
Yellow	Vanadinite, Goethite	Pyromorphite	Lithargite (PbO), Iron yellow, Orpiment	Iron yellow
Green	Stone green	Stone green, Atacamite, Antofagastite, Brochantite	Stone green	
Blue	Azurite, Lapis lazuli	Azurite, Lapis lazuli	Azurite, Indigo	
White	Calcium carbonate, Quartz, Gypsum, Kaolin, Lead white	Calcium carbonate, Quartz, Talc, Dolomite	Calcium carbonate, Quartz, Kaolin, Lead white	Calcium carbonate, Quartz, Mica
Purple	Copper silicate		Barium violet iron ore	

becomes an important part of the data information of tomb murals. Table 1 shows the mineral pigments of tomb frescoes in different periods in ancient China.

#### 4.4 Subject Matter

The themes and contents of the tomb murals unearthed in China are constantly updated and enriched with the development of The Times. From the Qin and Han dynasties, the themes of tomb murals were mostly the images of mortals rising to immortals, the sun, the moon and the stars, clouds, thunder and lightning, gods and monsters from four directions, and the twenty-eight stars. Even in the Tang and Song dynasties, the tomb owners' official experiences, major historical and political activities, or big battles and wars are often presented. The other part focuses on the daily life of the tomb owner, such as dwellings, fields, gold and silver possessions, banquets, dances and music, which can be reflected in the tomb murals. However, the tomb murals of the Khitan nobles in the Liao Dynasty mainly focus on the life of nomadic people in the north. For example, a large number of travel and return pictures have been found, which are not found in other dynasties.

## **5 Design and Construction of Information Visualization Model for Tomb Fresco**

### **5.1 Collection of Information and Data of Tomb Murals**

The data information of tomb murals unearthed in China is different from other data statistics. The data information contained in tomb murals should be collected and classified in combination with the characteristics and historical background of tomb murals themselves. Through the analysis and processing of big data technology, the aggregated data of tomb murals can be divided into the following three categories.

#### **5.1.1 Statistics**

The data information of tomb murals unearthed in China is multi-dimensional, so the dimensions and directions of statistics are also many. For example, count the number of murals in the tomb from the perspective of historical development; The number of murals in the tomb is counted from the division of different regions; From the archaeological excavation of the number of statistics tomb murals and so on. With the help of the data collection and statistics function of big data technology, the statistical data of tomb murals are presented in multiple dimensions. Table 2 shows the distribution of murals in tombs in different dynasties.

#### **5.1.2 Linked Data**

The tomb murals unearthed in China are the product of the development of Chinese culture and a symbol of the continuation of Chinese civilization. They are an indispensable part of the inheritance of the whole traditional culture. Therefore, the study of tomb murals can not be analyzed and understood solely in terms of time series or spatial layout. At the same time, it is necessary to combine the data information such as the production process and color selection of the tomb murals, and conduct a research on the integrity and unity of the data information of the tomb murals from the global perspective. For example, the tomb murals of the Western Han and Eastern Han dynasties carry on the soul concept, the belief of the immortals, the theory of Yin and Yang, and the connection between heaven and man in the pre-Qin period, and have a direct impact on the religious ideas of the Wei, Jin, Southern and Northern Dynasties as well as the Tang and Song dynasties. As well as the inheritance and promotion of the production technology of tomb murals in different periods, the influence of chemical technology in different times on the color use of tomb murals and so on.

#### **5.1.3 Content Data**

The most intuitive data information of Chinese excavated tomb murals is the data of content, which includes the content and theme of tomb murals. The story content depicted in the tomb murals concentrates a lot of life scenes, spiritual beliefs, ideological pursuits and religious myths of the ancient people, and the collocation of colors further increases the abundance of the story content. Visualized analysis and research of content data is

**Table 2.** Distribution of murals in tombs in different dynasties

Time	Western Han	Xinmang	Eastern Han	Wei, Jin, Southern and Northern Dynasties	Sui	Tang	Five Dynasties	Liao	Song	Jin	Yuan	Ming	Qing	Total
Shaanxi	4	3	2	14	8	105	1		2	3	2			144
Henan	5	3	13	7		5			29	7	6	1		76
Shanxi		1	2	10		10		17	11	13	7			71
Hebei			5	13			1	11	7	6	1			44
Liaoning			12	12				17		1	1			43
Inner Mongolia			6	1				29			5			41
Shandong			5	5	1				5	5	9	1		31
Gansu			4	22					1	1				28
Jilin				21		5								26
Beijing		1		2		6		8			2		1	20
Fujian									8		2			10
Xinjiang				6		3								9
Jiangsu			1	1			2		2					6
Ningxia				3	1	2								6
Hubei						5			1					6
Sichuan			2			1	2							5
Zhejiang						2	1							3
Guangdong	1					1								2
Yunnan				1										1
Chongqing						1								1
Jiangxi									1					1
Heilongjiang						1								1
Total	10	8	52	118	10	147	7	82	67	36	35	2	1	575



A. Tomb No. 2 of Liao-Baoshan -- Lady's Psalm (partial)      B. Tomb of Princess Yongtai of Tang Dynasty - Lady of the Palace (partial)

**Fig. 4.** Chinese tomb mural



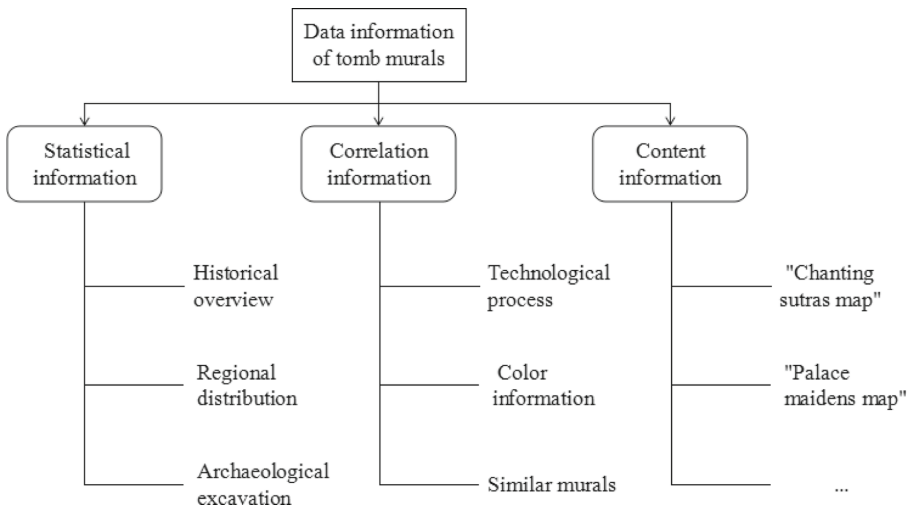


Fig. 5. Visualization architecture of tomb mural information

helpful to quickly understand the data information of the content of tomb murals and to analyze the profound connotation of tomb murals.

Figure 4-A is the large Liao Dynasty mural tomb No. 1 and No. 2 at the south foot of Baoshan, Dongsha Ritai Township, Alukeerqin Banner, Chifeng City in 1994. In the stone chamber of the second tomb of Baoshan, exquisite frescoes such as “Phoning the Sutra”, based on the stories of the Han nationality, have been unearthed [5].

Figure 4-B is the Palace Maid Graph unearthed in 1960 on the south side of the east wall of the front chamber of Princess Yongtai’s Tomb. There are 9 people in the figure, and the figures are quite clear. The first one combs his head with a single knife and a half bun, looks ahead, crosses his arms in front of his abdomen, and moves forward with his chest straight, with a magnificent and elegant appearance [6].

## 5.2 Visualized Data Information Architecture of Tomb Murals

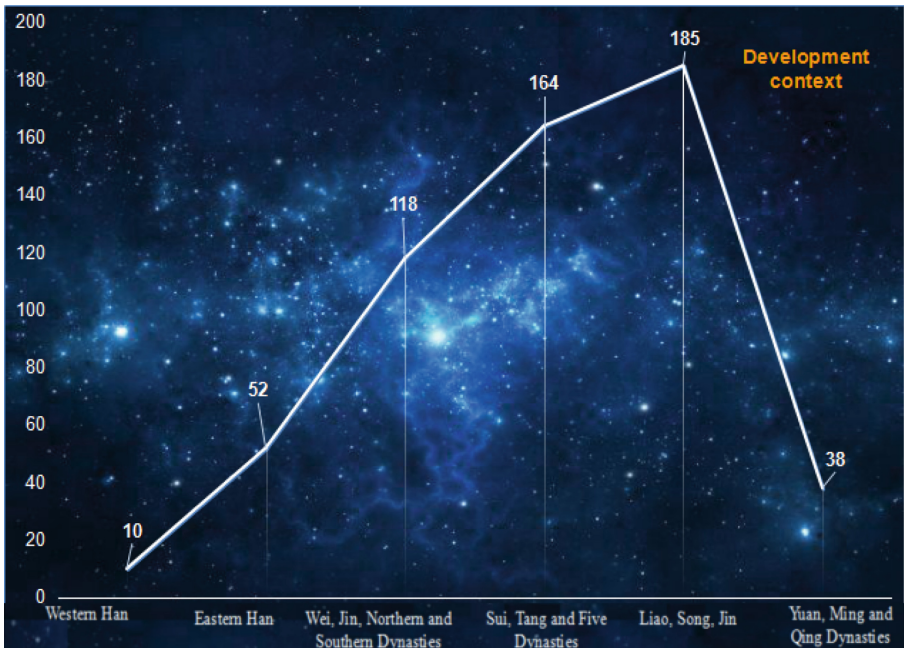
Visualization design of data information for Chinese excavated tomb murals. They are statistical data visualization, associated data visualization and content data visualization respectively. Statistical data visualization mainly shows the production of tomb murals and the process of archaeological excavation from the historical time sequence. Linked data visualization can connect the tomb murals of the same region, the same content and theme, and the same style with horizontal data information, so as to expand the data information exchange of tomb murals. Content data visualization can reproduce the story content of the tomb murals in a virtual way, create on the basis of the basic story content, reconstruct the information elements, and enhance the cultural feelings of visitors and researchers. Figure 5 shows the architecture diagram of the tomb mural information visualization.

### 5.3 Visualization Design of Data Information of Tomb Murals

#### 5.3.1 Visualization of Statistical Information

The function of this part is to show the development process of tomb murals from rise to decline through the statistical data of tomb murals unearthed throughout the country. At the abscissa end, the time or historical dynasty is taken as the axis, and the vertical axis shows the specific statistical data in the form of line chart. At the same time, the company menu can be provided to facilitate the jump of detailed data of each dynasty. According to the statistical data, the mural excavated tomb in China is divided into three data sets according to time and region, which are dynasty, region and specific mural excavated tomb. As shown in Fig. 6, through the display and comparison of statistical data, we can clearly have a systematic understanding of many tomb murals in China.

Tomb murals unearthed in China are widely distributed in 22 provincial and municipal units throughout the country, especially in areas where dynasties are frequently replaced in Shaanxi, Shanxi, Henan, Hebei and Liaoning. As for the regional distribution of tomb murals, the display form of scatter diagram is adopted. According to the distribution quantity of tomb murals in different regions in different times, the circles of different sizes are used to represent them. At the same time, it is also convenient to jump the detailed data of each dynasty through the line-up menu. This is shown in Fig. 7.



**Fig. 6.** A line chart of the historical period of murals unearthed from Chinese tombs

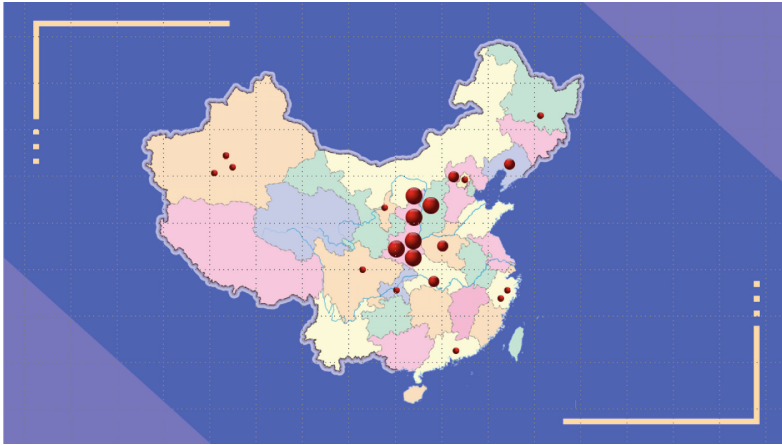


Fig. 7. Regional distribution of tomb murals unearthed in China



Fig. 8. Flowchart of making tomb murals in China

### 5.3.2 Visualization of Association Information

Combining with the mural “The Lady in Court” on the south side of the east wall of the front chamber of Princess Yongtai’s Tomb in Tang Dynasty, this paper analyzes the production process of the tomb mural layer by layer and displays it in the form of color cards. Through switching the color cards, we can see the production methods and material selection of the bottom layer of different mural paintings. This is shown in Fig. 8. In the color layer map, the part of the mural in the picture can be enlarged or reduced, and the detailed information of the color materials used in the tomb mural can be displayed in the pop-up mode of text labels. Through the production process and color selection of the tomb mural, the era and background of the appearance of the mural are combined to form an interrelated data set, which can better make the data information of the tomb mural form an organic whole and improve the visual experience.

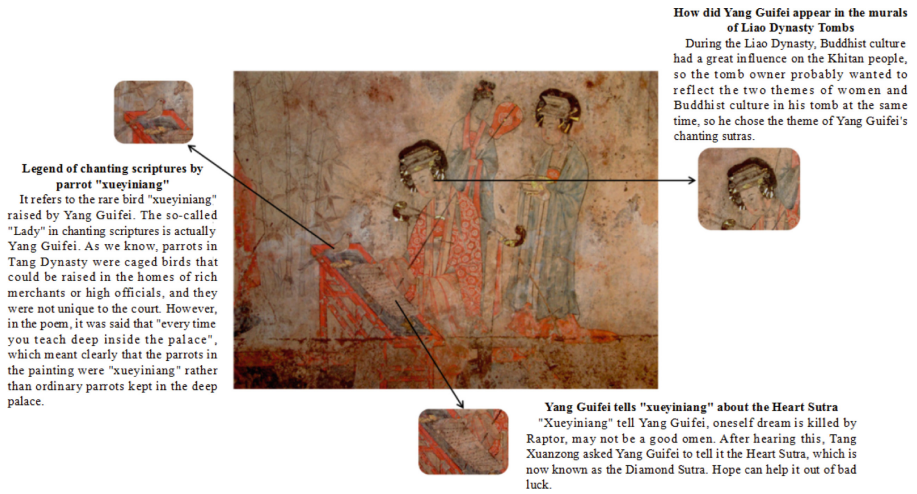


Fig. 9. Flowchart of the production of tomb murals in China

### 5.3.3 Content Information Visualization

Due to the long time buried in the ground, many of the murals unearthed in China will be damaged or incomplete due to natural causes. However, the content information visualization of the tomb mural needs to re-present the most complete and true original appearance of the mural, especially the hidden story content of the tomb mural. For example, the Psalm of Scriptures, as shown in Fig. 9, contains information that is visually expressed in a storytelling way.

## 6 Conclusion

Data information contained in tomb murals unearthed in China, through data visualization design, allows more people to quickly obtain the history and culture behind tomb murals. The application of high and new technology expands the study of tomb murals from scattered data points to the whole world. Relies on and big data technology to comb and display the data information of the tomb mural, and clearly analyzes an ancient solidified tomb mural with dynamic data, which enhances the readability of the tomb mural information. At the same time, it also provides a new digital protection strategy for the protection of the unearthed tomb murals.

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