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Stone Conservation in China-with focusing on carbonate stone conservation practice

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Abstract

China's cultural stone structures and objects are extremely multifaceted. The immovable of them can be broadly divided into three categories, first one is so called grottoes and inscriptions, which are built or crafted directly or indirectly into the geological bodies. The second one is stone structures of architectural heritage. The third one is ruins or tombs in underground. The grottoes are built predominantly in sedimentary stones, like sandstone, greywacke and limestone. The natural stones used as architectural materials vary also from region to region, due to locally available resources and petrology. The greatest building from natural stone is the Great Wall, in which the natural stones are used as foundation, gate and inscription materials. Limestone, marble especially dolomitic marble, sandstones, tuff and granite are most favorable stones for artistic objects. Due to the vast size of the country and the extreme differences in topography, stone structures are exposed to very diverse climatic conditions and the degradation of such structures varies significantly. Following the formation of China ICOMOS in 1993 various conservation principles, technical guidelines with the approval of State Administration for Cultural Heritage have been published. Those principles and guidelines provide an integrated and methodological approaches to the conservation and management of stone sites. The conservation researches have been cultivated by international cooperation especially with universities from Europe. In 2009 a national key pillar research project for stone conservation without international involvements has been launched using Yungang Grottoes as a reference object trying to understand both deterioration mechanism and technical options to prevent further decay. From 2008 at least 10 professional laboratories or institutes on stone conservation sciences, among them the Tongji Architectural Conservation Laboratory and Institute for Cultural Heritage Conservation Science at the Shanghai University are very active. Using two case studies of conservation practices, rescue intervention to preserve Huashan pictographs and conservation of a dolomitic marble statue in Shanghai as examples the paper shows difficulties and achievements for conservation of carbonate stones.

Keywords: cultural stone, carbonate stone, dolomitic marble, natural hydraulic lime, micro lime, conservation

Introduction

China's cultural stone structures and objects are extremely multifaceted. The immovable of them can be broadly divided into three categories（Li Hongsong, 2004）, first one is so called grottoes and inscriptions, which are built or crafted directly or indirectly into the geological bodies(Fig 1-1, 1-2). The second one is stone structures of architectural heritage, which are similar to the stone architecture in Europe (Fig. 1-3, 4, 5). The third one is ruins or tombs in underground (Fig. 1-6). The grottoes are built predominantly in sedimentary stones, like sandstone, greywacke and limestone. The largest site of first category is the Yungan Grottos. The natural stones used as architectural materials vary also from region to region, due to locally available resources and petrology. The greatest

building from natural stone is the Great Wall, in which the natural stones are used as foundation, filling, gate and inscription. Natural stones for traditional Chinese architecture are seldom used for entire masonry construction, but widely used for western influenced architecture, i.e. colonial style buildings constructed with Western architecture styles or a mix of Chinese and Western architecture styles.

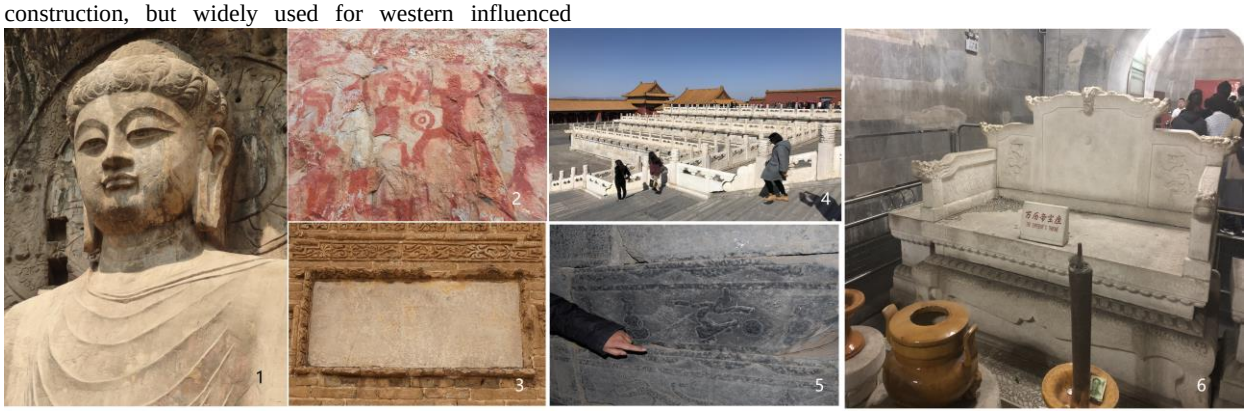

Figure 1 representative carbonate stone monumments which are listed as UNESCO cultural heritage in China (1=Longmen Gottos, buddha stutue caved in dolomitic limestone; 2= Huashan pictographs on limestone cliff; 3= lime stone inscription in the Great Wall; 4=carviong of football play on the surface of limestone pagoda of Han Dynasty; 6=Empery tom of Ming Nasty in Beijing) , Source: Dai Shibing

Approaches in stone conservation in China – researches and education

The fisrt state owned reseach institute for stone conservation in China was the former China National Institute of cultural Properties (now China Academy for cultural heritage), founded in 1935. The most important grottoes were rescued through grouting and anchoring during in 1960-1970's. The national reseach base for stone conservation was awarded to the former Xi'an Conservation Centre (now Shan'xi Academy for Cultural Heritage Conservation in 2007. Following the formation of China ICOMOS in 1993 various conservation principles, technical guidelines (series of WW/T) with the approval of State Administration for Cultural Heritage (SACH) have been published. Those principles and guidelines provide an basic integrated and methodological approaches to the conservation and management of stone sites.

The conservation researches have been cultivated 1990's by international cooperation especially with universities and conservation centres from Europe. A few chinese-german cooperation reseach projects in cultural heritage conservation were sponcored by federal government of Germany from 2006 to 2015. However in 2009 a national key pillar research project for stone conservation without international involvements has been launched. The scopes of the researches are focusing on conservation of sandstone monuments in grottoes, inclusive non-destructive investigation methods, comprehensive exploration technology of water source of grottoes,the stability of gelogical bodies, cleaning of soilings, conservation and repair work of deteriorated stone. Such comprehensive reseach projects helped understand both deterioration mechanism and technical options under Chinese administration system to prevent further decay.

From 2008 at least 10 new professional laboratories or institutes on stone conservation sciences have been set up. In 2008 the Architectural Conservation Laboratory of Tongji (tongji-acl) was set up within the faculty of architecture, which focuses on problems and conservation practrices of bult stone heritage. In 2017 a new Institute for Cultural Heritage Conservation Science at the Shanghai University was founded under the surpport of SACH and Shanghai municial Government to focus on stone conservation sciences.

In 1989 the conservation subject for Bachelor Degree was firstly offered by the Xibei University, today, almost 35 universities in China offer study programmes in cultural heritage related fields, inclusive built heritage conservation programme. The education in the field of material conservation is however very limited to very few places. As a result, there is a lack of professional conservationists in China who are trained to assess materials and to analyze symptoms and causes of deterioration. Recently few courses and workshops cover the issues of stone conservation

practices (Fig 2) to bridge the gap between university education and practical implementation.

Figure 2 workshop of lime for cultural heriatge conservation organized by UNESCO world heritage reseach and training centre (WHITRAP) in Suzhou in 2018 , Source: Dai Shibing & WHITRAP-Suzhou)

Deterioration of stone monuments and practical conservation intervention

All ICCOMOS-ISCS defined deterioration can be found in chinese stone monuments. However, the causes of deterioration are more complicated. The stone materials in grottoes are more affected by quality of the stone materials itself, but also by condensation or geological water comparing to architectural stone elements or ornaments. The stone in underground are suffered by biological colonization, condensation, delamination cuased by fluctuation of temperature .

There are obviously accelerating deterioration of stone monuments in China (Fig. 3) in the recent decades. Figure 3 shows the inscription was in relatively good condtion after app. 70 years although they were carved in clay rich sandstone, but heavely deteriaoration occued in last 12 years, this inscription need to be rescued immideately. The causes are not clearified. This may be related to climate changes, air pollutions and lack of maintenaces.

From 2008 a few national conservation projects were lauched. Among them the No. 1 stone conservation project was the conservation of Thousand-hand Bodhisattva in Dazu. This ten years conservation project was organized directly by the State Administration of Cultural Heritage with contribution of over ten research institute and universities. After complishement there were debates on the final appearance.

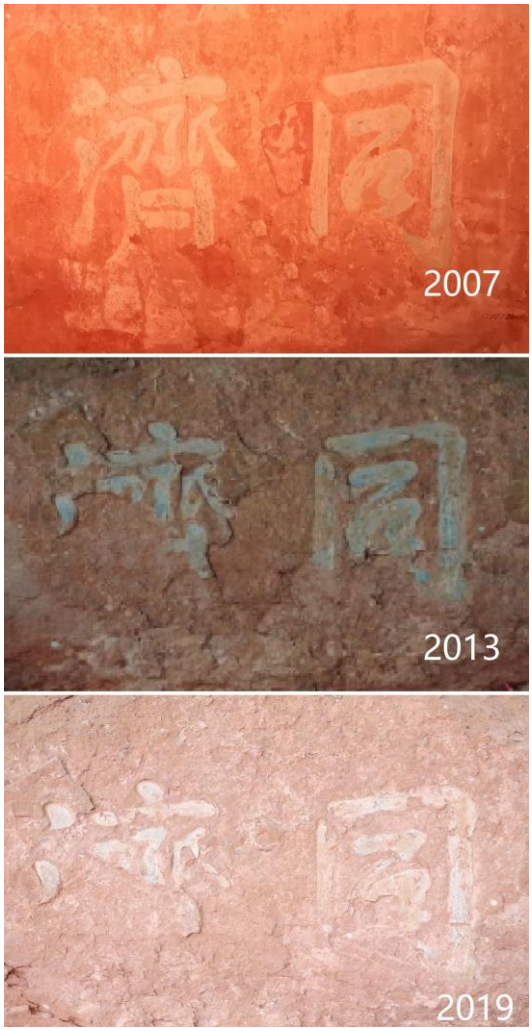

Figure 3 inscription of Tongji (同济) carved on 7 July 1938 on sandstone cliff as the University of Tongji moved from Shanghai to west as the Japan invated China. , Source: Dai Shibing & Tang Yongjing

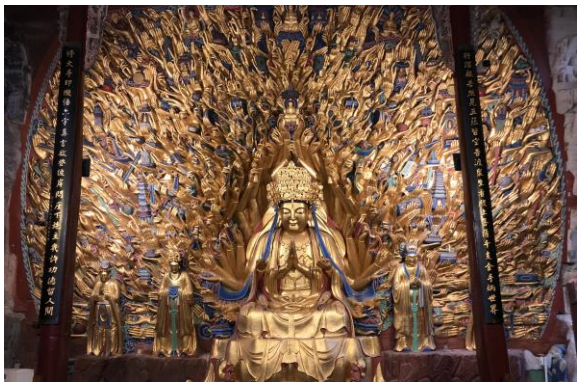

Figure 4 Thousand-hand Bodhisattva in Dazu three years after restoration , Source: Dai Shibing

Carbonate stone monuments

Carbonate stones are most preferable natural stone for art, recording (inscription) and construction. The widly use of limestone has to do both with geological occurrence, and with mechanical, phys-chemical propties of limestone. The limestone and marble are avaible all over in China except along the southen China coastal regions. The preliminary researches show that all limestone used for construction are very dense, the water absoption of limestome is less than 1wt%. Those stone can be well worked, polished and carved due to medium hardness. It is also durable in pre-industrial time. After weathering the lime stone can show unimaginable shapes, parttens and forms so lime stone is most used deorative stone (it is called Taihu Stone) in Chinese garden (Fig 5).

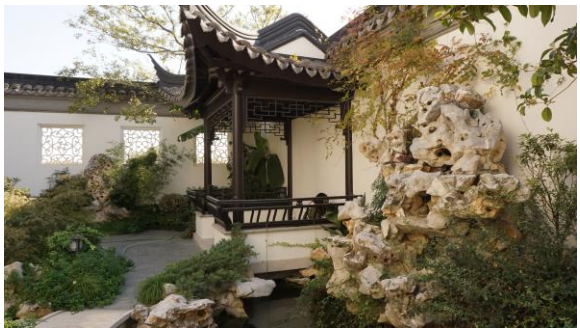

Figure 5 lime stone is one of the decorated components in Chinese Garten (hier duplication in new construction). , Source: Dai Shibing

But the carbonate stone monuments are suffering severe damages especially in the industrial pollution (Fig. 6). Besides cracking, new formation of water soluble salts cause not only the material lose of the carbonate stone, but also damages to historic adjointing materials. Special conservation need to be developed for carbonate stone conservation.

Fig. 6 typical deteriration of dolomitic marble through industrialization (hier Na_2SO_4 dusts attacked dolomitic marble), , Source: Dai Shibing

Case study 1: Surface refitting of Huashan pictographs

The Huashan pictographs are the largest display of rock paintings within the 38 sites of the "Cultural Landscape of Huashan Pictographs along Zuojiang River". The pictographs were painted between Zhou Dynasty and Han Dynasty (5th century B.C. to the 2nd century A.D.) on limestone cliffs.

The Huashan pictographs are symbols of the ancient Luo Yue culture, the ancestors of the Zhuang ethnic group. They are important cultural relicts of the Zhuang culture and being one of the world's largest preserved displays of historic rock art therefore they have high historic and artistic value.

In 1988 the site listed as "Important Units of Cultural Relics under the National Protection" by the State Council.

Damage symptoms of the Huashan Pictographs are typically cracking and loss of paints. Crack width, direction and form are varying. Calcium and clay/mud sediments can be found inside the cracks. Loss of paints is not only related to cracking but also to disolving due to condensation. To rescue such cultural heritage, bonding mortars and injection grouts based on natural hydraulic lime (NHL2) have been developed in 2007. NHL-Bonding agent is composed of NHL2 and additives like redispersable acrylic resin (less than 1wt%). It's role is to reatach delaminated limestone pieces (pls. s. middle of Fiigure 7). To seal cracks, the formulation is to adjust with liemstone powder according to the widness of cracks. 15-20wt% of 1-2mm limestone particles can be added into NHL-bonding agent to seal crack width larger than 5mm. Injection grout based on NHL2 and superplasticizer is to fill holeness. It has good bonding properties even to clay contaminiated cracks. After setting it has high water absorption capacity (over 40wt%) to absorp condensation, which is believed to be main damaging factor for paint fading of pictographs. Both modified NHL-bonding agent and injection grout have low shrinkage, but similar thermal expension coeeficient as that of limestone. They show also higher water absorption and higher water vapour permeability than that of limestone. Because the Huashan pictographs is located in subtropical climate, the frost resistance was not tested.

Fig 7 Detachment od limestone and fading of paints of Huashan Pictographs , Source: Dai Shibing

After over 2years site evaluation this rescue measurement was implemented from 2009 to 2012. Successful conservation has contributed that Huashan Pictographs was inscribed as Cultural Heritage on the World Heritage List in 2016. Other pictographs along the Zuojiang Rivers are being conserved with same concept from 2018.

Case study 2- conservation and maintenance concept of the Song's dolomitic marble statue in Shanghai

Madam Song Qinglin was honorary Chairlady of Peoples' Republic of China. The marble statue of Song Qing-ling stands in the memorial square of Song Qing-ling cemetery in Shanghai, China. The statue has been inaugurated in 1984. The statue is composed of 4 pieces of Hanbaiyu, a valuable and famous artistic natural dolomitic marble from Fangshan, Beijing.

The statue was painted white using various polyurathan-modified acrylate paints until 2010. In 2010 it was decided to stripp old paints and sealed with water repelling clear sealer with intention to prevent further weathering of the marble from acid rains. This measurement was completed in september 2012. From 2014, there have been many micro cracks(Fig 2) occoured on the surface, especially on the head of the statue(Fig. 2). In May 2018 the architectural conservation laboratory of Tongji University was asked to carry out dianostic investigation and to work out conservation and maintenance concept.

Under the in-situ microscope, over 30 micro cracks were identified and labeled. The crystal fabric on the surface is becoming loosen with different degrees, even small marble pieces are pelling off. Mineralogically it consists of approximately 92-97% dolomite($CaMg(CO_3)_2$), minor quartz and muscovite have also been identified. This composition is same as the typical dolitic marble found in Fangshan near Beijing. Epsomite have been idenfied in the marble dusts.

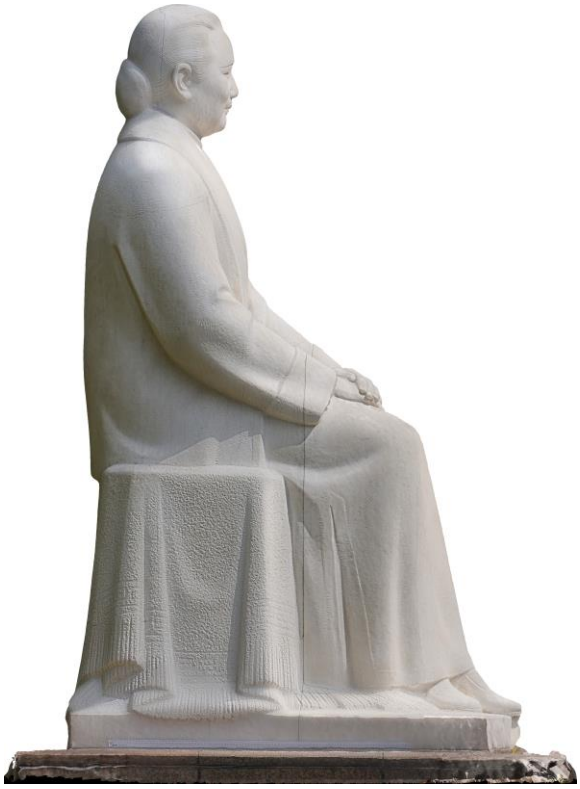

Figure 8 west view of the Madam Song's Statue (@Tangzhong)

Figure 9 typical macro defects of the dolomitic marble of Madam Song's Statue in Shanghai, Source Dai Shibing

Non-destructive ultrasonic technology, IR-scanning, water absorption, sanding test with tesa-film were applied to evaluated the conditions. The water repllent effect is gone. Surface consolidation tests with micro lime (dispersed Ca(OH)2 with partical size of 0.2-3 μm in ethanol) and low concentrated ethyl silicate show satified results. The pull-off strength of micro lime on fresh cracked dolimitic marble can rearch 0.1-0.3 Mpa in 14 days.

Based on other test results, a conservation concept has been worked as follows:

(1) Preconsolidation with micro lime to fix peelling of the dolomitic marble surface and to kill algae

(2) Desanilation with poultice based on cellose and clay minerals

(3) Crack injection with micro lime

(4) Surface consolidation with low concentrated micro lime and thinned ethyl silicate 1 week after application of micro lime (the thinned ethyl silicate is composed of 1 part of pure ethyl silicate, 2 parts of ethanol)

(5) No water reppelling agent will be applied.

For the maintenance, bird shits shall be cleaned with deionized water and neutralized with thinned micro lime.

A monitoring program especially to control cracking has been also worked out. This concept has been approved by authories and is being implemented from December 2019.

Conclusion and discussion

China's cultural stone structures and objects are extremely multifaceted. Carbonate stones (lime stone, marble and dolomitic marbel) are mostly used stones for religious gottoes, building and construction, inscription and so on. They are in danger not only due to special geological enviornments, like grottoes and caves, underground tomes and ruins, but also due to strong air pollutions. Special cares are needed to conserve or restore destroyed monuments, as the same time sustainable maintennace for carbonate stones. The two case studies show that using traditional materials, like natural hydraulic lime, or calcium hydrate dispersed in alcohol, with help of modern chemistry, may provide solution for conservation.

However more researches are needed. First of all the deterioration mechanism under modern air pollution and how this deterioration affects durability of the stone monuemtn itself, also to the adjointing historic materials and conservation effectivness. Due to the vast size of the country and the extreme differences in topography, stone structures are exposed to very diverse climatic conditions and the degradation of such structures varies significantly. The second is the reseach on the sustaibale conservation and maintenance concept. The third one is the montiroing. Some of the carbonate stone monuments which are expose directly to weather in the region Nanjing, southen China, have been conserved with synthetic resin and achieved satified results. All those need to be evaluated

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