大麦地岩画

Da Mai Di Rock Arts

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上海古籍出版社

序　言

陳兆復

當我打開巨型畫册《大麥地岩畫》彩圖卷的時候，不由得爲其宏偉的規模、豐富的内容、精美的裝幀和豪華的氣派所震撼了。此後還將連續出版拓片卷、臨摹圖卷，宏篇巨製，更可想見。這幾年，國内岩畫的畫册出得不算很多，但也出過一些了，却没有一本可以和《大麥地岩畫》這套巨型畫册媲美；就是在我看到的國外出版的岩畫圖書中，也很少有能與之相比的。我想，凡是看過這套畫册的人都會對編輯這部巨型圖册的主編謝玉傑先生、副主編李祥石先生、束錫紅先生和出版這部巨型圖册的西北第二民族學院、上海古籍出版社表示敬意。

我是在上世紀八十年代開始接觸到寧夏岩畫的。記得1985年夏天，我和蔣振明同志來寧夏考察岩畫，承蒙當時在賀蘭縣工作的李祥石先生熱情接待，親自帶領我們參觀了賀蘭山各山口的岩畫。但我接觸到中衛的大麥地岩畫却是後來的事。時間過去了五六年，1991年我應寧夏回族自治區領導之邀，參與組織“91國際岩畫委員會年會暨寧夏國際岩畫研討會”，這時我讀到了當時任寧夏社科院院長陳育寧先生的一份寫給自治區領導關于大麥地岩畫的報告，後來我又爲周興華先生的《中衛岩畫》寫過一篇序言，其實這時我並没有到過中衛，也没有看過大麥地岩畫。或許是由于這些機緣，我在1991年8月來到中衛，由周興華先生帶領參觀了黄河之北的大麥地、大通溝和黄河之南的香山等岩畫點。後來，大麥地被確定爲那次國際岩畫會議代表們參觀的一個岩畫點，有十幾個國家的一百多個岩畫學者參觀了大麥地岩畫。

大麥地，這個衛寧北山深處一片荒漠的山地，放眼望去，低矮的山梁連接着低矮的山梁，這裏了無人烟，稀稀落落地生長着些酸棗、駱駝刺等植物。我記得當時國際岩畫委員會主席阿納蒂教授對我説，到了這裏，使他想起了西亞的西奈半島，真是太像了。大麥地，又是一個很美的名字，她使人聯想到金黄的麥穗，聯想到喜悦的豐收，而這裏，今天那些在山梁上沉寂了幾千年的神秘圖畫，却因中外學者的到來而熱鬧起來了。後來周興華先生談起過那時的情景：有的説，“啊！這麼多岩畫！”有的説，“這裏應該保護起來，建立岩畫公園。”有的説，“我們國家的岩畫是罩住的，手都不能摸。你們中國的岩畫，怎麼允許人從上面走過呢？”數年後的1995年10月，在意大利都靈附近的史前藝術研究中心與博物館（CeSMAP）的展覽廳裏，我驚喜地發現一幅大麥地岩畫的拓片竟擺在一個非常顯要的位置上。大麥地在國際上已成爲一個響亮的名字了。

岩畫確是一個國際性的課題。最近，聯合國教科文組織官方網站上關于“世界遺産名録”指出：

“岩石上的繪畫和圖形，正如人們通常所説的岩畫，它們産生在人類還不知道如何讀和寫之前，是開始于智人出現的時候，它們提供了人類在文字發明之前極其重要的歷史資料。

這種藝術的圖像是一種普遍的人類遺産。全世界數百個巨大的岩畫點，裝飾着數千個形象，它們包含着數千年的藝術創造。從最初的狩獵—採集者開始，岩畫描繪出日常生活、信仰和不同發展階段人類的重大社會問題。它們也透露出流行的觀念和交流的動機。通過這種藝術，我們可以看出人類特性的本質：諸如知識、文化、藝術、想像和宗教等等。

迄今爲止，超過10萬件史前的藝術作品已被發現出來，並記録下來了。它們包括世界各地博物館、畫廊和私人收藏的小雕像，雕刻過的石頭和骨頭，有着裝飾的獸角和木頭。然而最大量的藝術品分散在五大洲70萬個岩畫點，估計約有兩千萬個或更多的形象和符號。到現在爲止，我們所知的史前藝術品99%是岩畫，其全部數量可能遠遠超過上面所估計的。”①

從這些話語裏，我們可以看出岩畫研究在整個人類文化史的研究上將佔有多麽重要的位置！大麥地衹不過是寧夏衆多岩畫點中的一個，我想如果全國各個重要的岩畫點都能出版這樣巨型的畫册，這將是一個規模多麽宏大的書庫啊！由于各地的岩畫都在迅速地遭受各種因素的破壞，比如，1985年我曾在賀蘭山的小西伏溝的一塊巨石上，拍下一幅有五六十個圖形的非常精美的岩畫；但今年有人再去的時候，拍回來的却是一片碎石堆。因此，除加强對岩畫點的保護之外，采用多種方法將各地的岩畫記録保存下來，並將這份寶貴的遺産留給子孫後代，實在是當務之急，從這方面説，《大麥地岩畫》這套巨型畫册的出版是具有里程碑意義的。

二〇〇四年十一月一日

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① 聯合國教科文組織官方網站（http://whc.unesco.org/sites/rock-art.htm）：《世界遺産名録中的岩畫點》。中譯文見“陳兆復岩畫網”（http://chenzhaofu.nease.net/sjgk/worldlist00.htm）。

Preface

by Chen Zhaofu

When I opened Da Mai Di Rock Arts, I was absolutely astonished by its grandiose dimension, abundant connotations, attractive design and luxurious style. After the publishing of this collection of colored photographs, the collection of rubbings and facsimiles will continue to be printed, which altogether will certainly be a magnificent pursuit of publicizing and preserving of rock arts. In recent years, some collections of rock arts, not many, have been published in China, but none of them can be comparable to Da Mai Di Rock Arts, and even among the foreign publications that I have seen, this one is unparalleled. I think those who have viewed the collection will certainly have the idea to show respect to those who edited and published it, i. e. , Mr. Xie Yujie, the chief editor, Mr. Li Xiangshi and Shu Xihong, the sub-editors, the Second Northwest University of Nationalities (SNWUN) and Shanghai Chinese Classics Publishing House.

It was in the 1980s that I became acquainted with the general Ningxia rock arts (while Da Mai Di is a specific area in Ningxia). In the summer of 1985, Mr. Jiang Zhenming and I went to Ningxia to investigate the rock paintings and drawings there. We were welcomed with great hospitality and were guided by Mr. Li Xiangshi, who was then working for the government of Helan Prefecture, to visit the remained rock paintings and drawings in Helan Mount, but till then, I still had not got to know Da Mai Di rock arts. In 1991, gladly accepting the invitation of the leaders of Ningxia Hui Autonomous Region, I participated in the organization of the 1991 Annual Meeting of International Rock Art Committee and the Seminar of Ningxia International Rock Arts. At that time, I was fortunate enough to know a report about Da Mai Di rock arts written by Mr. Chen Yuning, the then president of Ningxia Social Science Academy, to the leaders of the Autonomous Region. Later, I wrote a preface for Zhongwei Rock Arts, collected and edited by Mr. Zhou Xinghua, but even till that moment, I still had not been to Zhongwei, not to speak of viewing Da Mai Di rock paintings and drawings. Maybe because of "yuan" (the very special Chinese term borrowed from Buddhism which is almost equivalent to "luck" and here referred to the things mentioned above), in August 1991, under the tour guide of Mr. Zhou Xinghua, I finally got the opportunity to visit the rock art sites in Da Mai Di and Da Tong Gou, both in the area north of the Yellow River, and in Xiangshang Mount, in south. Later, Da Mai Di was decided as a rock art site on the visiting agenda of the delegates of that annual meeting and hundreds of rock art experts from more than a dozen of countries and regions visited it.

Da Mai Di, a bleak mountainous desert in the inner area of North Weining Mount, is desolate and uninhabited. There, low ridges stretch as far as we can see and some xerophytes (such as Ziziphus jujubes and Alhagi pseudalhagi) scatter over the area. During that visit, Prof. E. Anati, the chairman of International Rock Art Committee, told me that the scenery of Da Mai Di made him think of Sinai Peninsula in West Asia. Da Mai Di, a beautiful name which means "the area of barley" in Chinese, associates itself with golden wheat and gratifying harvest. That day, those mysterious paintings that had laid serenely for thousands of years were revitalized due to the visit of those scholars both at home and abroad. According to the description of that situation made by Mr. Zhou Xinghua, some of the scholars exclaimed, "Ah, so many rock paintings!" Some suggested, "A rock art park should be established to preserve the precious relics here." Also, some asked, " In our country, rock paintings and drawings are so well-preserved that they are covered and people are not allowed to touch them, but how can you bear the stamping of these relics?" Several years later in October 1995, I was amazed to find that a rubbing of Da Mai Di rock painting was put in a very significant position in the exhibition hall of the Center of Study and Museum of Arts of Prehistory (CeSMAP) near Torino, Italy, which is a strong evidence that Da Mai Di has become a prominent name in the community of rock art studies.

Rock art study has indeed become such an important international project that the official website about the List of World Cultural Heritage of United Nations´ Educational Science and Cultural Organization (UNESCO) pointed out that:

"Prehistoric paintings and drawings on rock surfaces, known as ŕock art´, were produced by people who did not know how to read or write as we understand it. Having begun with the appearance of Homo sapiens, it thus offers by far the most important record of the history of human beings before the invention of writing."

"This art form illustrates a common human heritage. Decorated with thousands of figures, the hundreds of large rock art sites recorded around the world embrace thousands of years of artistic creation. Ever since the time of the first hunter-gatherers, rock paintings and drawings have depicted daily life, beliefs and important questions at the different levels of development in human society. They have also revealed prevailing conceptual and communicative motivations. Through this art, the essence of fundamental human characteristics such as knowledge, culture, art, imagination and religion were made visible. "

"Over 100,000 prehistoric works of art have so far been discovered and recorded. hey include figurines, stone slabs, engraved bones and decorated horn and wood belonging to museums, galleries and private collections. However, the majority of this artistic output, spread across the five continents, consists of about 700,000 sites with rock paintings and drawings containing an estimated 20 million or more images and signs. To date, over 99% of known prehistoric art is, in fact, rock art. The total number of items could be much higher."①

From these words, it is obvious that rock art study occupies an important position in the study of anthropology, ethnology and the history of culture. Da Mai Di is only one of the many rock art sites in Ningxia. It will be an incredibly tremendous library of precious records if the paintings and drawings of every important Chinese rock art site can be published like Da Mai Di Rock Arts. Unfortunately, all these are under severe and accelerating demolition due to various causes. For example, in 1985, I photographed a very exquisite rock painting with more than 50 images on a megalith in Xiao Xi Fu Gou, Helan Mount, but now what remains there is only rubbles and ashes. Therefore, in addition to the strengthened physical protection of rock paintings and drawings, it is urgent to record and preserve them with a variety of methods and only in this way can we pass them on as a precious heritage to our offspring. From this perspective, the publication of Da Mai Di Rock Arts will be a milestone in the process of awakening consciousness of preserving and recording.

Translated by Liu Mingming

① http://whc.unesco.org/sites/rockart.htm

地衣測年法在大麥地岩畫中的應用

李祥石　束錫紅

地衣,顧名思義就是覆蓋于大地的美麗衣裳。這個"衣裳"不是布的,也不是土的,而是一種特殊的植物,它廣泛生長于世界的各地,它色彩斑斕,家族繁盛。我國已知的就有200個屬近2000種,世界上則約500個屬26000餘種,它們生活在岩石、樹木、古建築之上,以鮮艷的色彩點綴着大地,以頑强的生命迎接着一個又一個世紀,它可以説經歷了滄海桑田的巨變,目睹人類從野蠻到文明的巨大變化,它纔是真正的歷史的"見證人"。

地衣是一種特殊的植物,是兩種生物的複合體:由緑色或藍緑色的藻細胞和無色的真菌絲組成了複合的共生體。真菌雖然與藻類共生,實際上佔主導地位的却是真菌。真菌與藻類的聯合是相依相合互濟互利地聯合,地衣的共生菌是依賴于藻的光合作用提供的有機營養,共生菌的某些分泌物反過來可增進藻細胞的光合作用,進而有利于共生藻的生存。還有,交織如網的菌絲包裹藻細胞,起到了保護和固定藻細胞的作用,使藻細胞免受自然力或有害物質的傷害。更爲重要的是菌絲組織使光照强度適當減弱以利于依賴弱光照生存的共生藻生長,減少藻細胞内部的水份蒸發,有利于提高抗旱能力。

地衣具有多種顔色、多樣的生長形態、特殊的内部結構以及其它生物無可比擬的生命力。地衣内的化學成分主要有:核酸、蛋白質、胡蘿蔔素、多元醇、游離氨基酸、維生素等等。

地衣生存中所需要的有機物來自體内共生藻的光合作用,其光合作用速率遠比高等植物低,提供給共生菌的有機物很少,這就是地衣生長緩慢的主要原因。

地衣有以下幾大特點:

1. 耐旱性。地衣同其它植物一樣是需要水的,離了水則無法生存。但是它需要水極少,有的地衣在乾燥的環境中含水量小的時候在2.0%—14.5%,這就充分説明了它能耐受嚴酷的乾旱。

2. 對温度不敏感。地衣同别的生物一樣也需要温度,但地衣有着異乎尋常的耐受性。地衣可以忍受極熱的高温,一般在50—69℃的條件下仍然存活;另外地衣又能忍受極冷的低温,許多地衣在-183—-268℃的環境中也不會死亡。因此,在我國北部的廣大地區甚至海拔數千米的高山地區地衣都能怡然自得地生活着。

地質年代:地衣測年的研究及原理

地衣測年的首創者是奥地利學者伯斯切爾 R. E. Beschel在1950年用地衣研究全新世的冰川及冰緣沉積物的年代。之後許多學者將這一方法運用于地質、地貌、氣象、冰川、地震、古建築、岩畫、考古等多方面,解决了許多無法考證的年代測定。

地衣測年的依據是,當冰川退縮時,冰緣沉積物形成並穩定之後,其上生長了地衣,隨着時間的延長,時間越久,個體地衣就越大,因此就用附着于某些基物上最大地衣的直徑或面積推算出基物面形成的年代。選擇測年的地衣要求很嚴格,要求其生長有規律,形狀規整,生長期長,分佈廣遠,對生長基物的化學性質没有選擇,對生長地的氣温、水量、海拔高度没有要求等,這樣的地衣才適用于測年。在成千上萬種地衣中優選出能測年的地衣則屈指可數的。經過人們的篩選,通常用于測年的地衣有近40種,我國的學者一般是用麗石黄衣[①]。

地衣用肉眼就可以鑒别年限。年輕的麗石黄衣呈淺黄色或深黄色,個體呈圓形或橢圓形,邊沿清晰;年長的麗石黄衣中心部分生長密集,向四周擴張部分較稀疏,顔色呈黄棕色;死亡的麗石黄衣呈褐色。藉助顯微鏡,可以對地衣進行更仔細觀察,可以看到麗石黄衣呈紫色的基本色,藻細胞、橢圓對稱形孢子,呈單一相互分隔的菌絲。地衣測年由于被測物所處的自然地理環境不同和地衣本身生長速率的差異,其測定結果不盡相同。到目前爲止,各國地衣測年的時間局限在地質時代的全新世之内,距今1萬年左右。但前國際岩畫委員會主席阿納蒂(E. Anati)説澳大利亞用地衣測到數萬年,不知采用何種地衣,用何種方法測算的。大麥地岩畫用麗石黄衣測年最早爲13241年。

國内最先利用地衣進行岩畫斷代的是王維斌,他在1985年6月完成的論文《新疆可可托海一二臺斷裂强震復發週期研究》中用麗石黄衣對岩畫進行了斷代研究。此後,1987年夏國家地震局地殼應力研究所謝新生、蕭振敏先後測定了新疆阿爾泰山岩畫和寧夏賀蘭山紅果子溝,作者曾協助他們進行賀蘭山山口岩畫的地衣測年研究,得益匪淺,并且在後來地衣測年法的研究中不斷得到他們熱情的支持,許多資料是他們直接提供的。

麗石黄衣爲鱗殼狀,表面呈橙黄色或橙紅色,在强紫外綫的地區爲銹紅色,背陰處爲緑黄色。背陰的濕度和光照環境較之向陽面更利于地衣生長,利于藻類的光合作用,藻類能提供給真菌較多的有機物。地衣中心部分常隆起懸空,底部呈淡白色,無假根。子囊盤稠密,圓盤狀,直徑爲0.5—2mm。

子囊盤遇氫氧化鉀(鹹)變爲紫紅色,含麗石黄衣酸。共生藻爲球藻,無粉芽。地衣體周邊緊貼基物,生長于各種岩石表面上[②],不能作片狀剥離。

寧夏賀蘭山與北山地區有多種地衣生長。經過調查,賀蘭山地區麗石黄衣相對減少,地衣的發育有明顯的差異,一般生長在海拔1300—1500米的山坡上。麗石黄衣在多種岩石上都能生長,對岩石的化學性質没有選擇。在調查中常常可以見到麗石黄衣中間部分或邊緣部分懸空生長,説明麗石黄衣與岩石基物僅僅是依附關係,並不需要基物提供營養。我國學者陳昌

篤認爲地衣是自養植物,從空氣中和自身殘骸分解中獲取營養。麗石黄衣面積較大者中有的連成一片(或一體),有的中心部分(長子囊盤部分)經常死亡,殘留部分呈環形,個體越大,時間越長,其環形的寬度越窄。

中國北部麗石黄衣測年通用模式

麗石黄衣(Xanthoria elegans(Link)Th. Fr)可生長于我國北方各種氣候環境的各種岩石上,具有廣泛的使用價值和測定年代的科學意義。

(1) 麗石黄衣喜歡弱光。在光綫較弱的背陰處以及水分蒸發少的向陽基物上,生長很好。

(2) 麗石黄衣喜歡空氣濕度較大的環境,在水系附近生長較好,中國北部尤其西北部空氣比較乾燥,麗石黄衣遠未達到水飽和,因此,這一地區濕度越大,它生長越好。

(3) 通過不同平均氣温地區麗石黄衣直徑比較發現,平均氣温對它的生長有影響,但遠没有濕度對它的影響大。

由于麗石黄衣的年代同它的生長地的氣候有一定的關係,因此對麗石黄衣的直徑和面積作逐步回歸分析如下:

$$T(x_1,x_2,x_3,x_4,x_5) = +A_1x_1+A_2x_2+A_3x_3+A_4x_4+A_5x_5$$

上式:

x_1 代表地衣産地附近的年平均氣温,

x_2 代表 >0℃的年平均積温,

x_3 代表 >10℃的年平均積温,

x_4 代表年平均水汽壓,

x_5 代表麗石黄衣直徑 D 或面積 S,

T 爲麗石黄衣年齡函數。

2 結果是:

$$T(x_4,x_5=D)=242.1324-65.2438x_4+12.9098D,$$

$$K=13.5\%;$$

$$T(x_4,x_5=S)=343.1940-28.9404x_4+0.0885S,$$

$$K=14.6\%。$$

K 爲相對誤差;

上兩式表明麗石黄衣的生長僅與時間和平均水气壓密切相關。

根據謝新生、蕭振敏《中國北部地衣測年研究》對麗石黄衣研究,其生長模式有以下參數選擇③:

1. 基物:麗石黄衣的生長與基物的化學性質没有生理上的關係,不需要基物提供營養,而是菌、藻在合適的水份、陽光下互利互惠共生。因此,測年模式可排除基物。

2. 温度:地衣生長的適應温度範圍很寬,可以説凡有生物的地方都有地衣。植物學家們認爲年平均積温對植物的影響比年平均氣温大,因此,取積温作地衣生長模式參數之一。

3. 濕度:水是一切生物新陳代謝的必要條件。地衣依靠吸收空氣中的水份生長。降雨的水份對地衣影響不大,特别是北方地區,許多地方常年乾旱少雨,因此,空氣中的濕度對地衣的生長至關重要,是地衣生長模式的重要參數之二。

4. 地衣直徑及其地衣面積:爲了測定年代,將地衣生長時間作爲因變量,地衣直徑、面積參數作爲自變量。這是地衣生長模式的參數之三。

中國北部不同自然區麗石黄衣區域生長模式

綜上所述,麗石黄衣的生長與氣候關係密切,將幅員遼闊、氣候複雜的中國北部根據"中國自然區劃圖"劃分爲四個自然區,這四個自然區的麗石黄衣區域直徑模式 T(D)和面積模式 T(S)分别爲:

1. 暖温帶半濕潤區麗石黄衣生長模式:

$$T(D)=0.1142D^{1.894},K=17\% \quad (1)$$

$$T(S)=38.2590+0.0838S,K=13\%; \quad (2)$$

2. 中温帶乾旱區麗石黄衣生長模式:

$$T(D)=2.8609D^{1.304},K=12.3\% \quad (3)$$

$$T(S)=254.7117+0.0934S,K=17\%; \quad (4)$$

3. 中温帶濕潤區麗石黄衣生長模式:

$$T(D)=0.1663D^{1.884},K=20\% \quad (5)$$

$$T(S)=74.6639+0.1061S,K=20\%; \quad (6)$$

4. 中温帶半乾旱區麗石黄衣生長模式:

$$T(D)=0.9155D^{1.491},K=20\% \quad (7)$$

$$T(S)=63.5375+0.0902S,K=16\%。 \quad (8)$$

以上模式中 D 爲地衣直徑,S 爲地衣面積,K 爲相對誤差,T 爲麗石黄衣年齡函數。

其中模式 2、4 適合于中國北部有氣候資料的麗石黄衣測年。賀蘭山地處我國中温帶乾旱區,這一區域包括内蒙古東西部、河套、灌區、阿拉善高原區,地域遼闊,海拔約 1000—1500 米,年降水量爲 50—400mm,大于 10℃積温爲 2600—3000℃左右。

依據謝、蕭提供的數據,作者在賀蘭山紅果子溝北側的麥鲁井岩畫點發現較大個體的麗石黄衣。這些麗石黄衣都生長在花崗岩上,均爲橢圓或圓形,形體較規則,便于測量。在測量時測得地衣長軸 b 和短軸 c,其直徑爲:$D=\sqrt{ab}$,然後進行運算。④

大麥地岩畫麗石黄衣測定

1990 年 10 月自治區文物管理委員會在大麥地調查岩畫時測定 4 組麗石黄衣,編定爲第 1 至第 4 組,當初由于計算失誤,先校正如下:

1 組:長軸 640mm,短軸 220mm,直徑 375.2mm,面積 110564.5mm²。

2 組:長軸 420mm,短軸 340mm,直徑 377.9mm,面積 112161.5mm²。

3 組:長軸 510mm,短軸 390mm,直徑 446mm,面積 156228.3mm²。

4 組:長軸 710mm,短軸 330mm,直徑 484mm,面積 183984.2mm²。

2003 年 5、6 月間,西北第二民族學院對大麥地岩畫區又進行了一次較爲認真的岩畫調查,在岩畫區共收集死亡的並附着于岩畫上的麗石黄衣 6 組,編定爲第 5 至第 10 組,測得年代如下:

5 組:長軸 500mm,短軸 300mm,直徑 387.3mm,面積 117810.7mm²。

6 組:長軸 450mm,短軸 360mm,直徑 402.5mm,面積 127239.4mm²。

7 組:長軸 630mm,短軸 600mm,直徑 614.8mm,面積 296864mm²。

8 組:長軸 420mm,短軸 310mm,直徑 360.8mm,面積 102240.5mm²。

9 組:長軸 310mm,短軸 150mm,直徑 215.6mm,面積 36507.9mm²。

10 組:長軸 800mm,短軸 640mm,直徑 715.5mm,面積 402076.9mm²。

	長距	短距	直徑	面積	乾旱帶年齡	乾旱帶年齡 + A	半乾旱帶年齡 - A	半乾旱帶年齡	乾旱帶年齡 + B	半乾旱帶年齡 - B
1	640	220	375.2	110564.5	6506.4	7306.7	5706.1	6307.9	7569.5	5046.3
2	420	340	377.9	112161.5	6567.5	7375.3	5759.7	6375.7	7650.8	5100.6
3	510	390	446.0	156228.3	8151.5	9154.1	7148.9	8162.4	9794.9	6529.9
4	710	330	484.0	183984.2	9068.6	10184.0	7953.2	9220.7	1064.8	7376.6
5	500	300	387.3	117810.7	6781.4	7615.5	5947.3	6613.6	7936.3	5290.9
6	450	360	402.5	127239.4	7130.5	8007.6	6253.4	7004.3	8405.2	5603.4
7	630	600	614.8	296864.0	12388.3	13912.1	10864.5	13172.3	15806.8	10537.8
8	420	310	360.8	102240.5	6182.7	6943.2	5422.2	5950.4	7140.5	4760.3
9	310	150	215.6	36507.9	3159.2	3547.8	2770.6	2761.4	3313.7	2209.1
10	800	640	715.5	402076.9	15097.8	16954.8	13240.8	16515.1	19818.1	13212.1

由于自然界的巨大變化包括地理環境、氣候條件，自然生態也必然隨之變化，這是不以人的意志和願望變化的。加之，寧夏衛寧北山大麥地特殊的自然條件，麗石黄衣的生長也必然受到影響。因此，我們將大麥地的生長年齡列出兩組數據，即乾旱帶和半乾旱帶的年代，爲的是更能接近實際自然環境。

從 1990 年 10 月測定的 4 組大麥地岩畫年代以上表“半乾旱帶年齡 - A”爲主，早期在 7149 年—7953 年，中期在 5706 年—5760 年。

2003 年 5、6 月間測定的範圍要比 1990 年 10 月大得多，因此，這一次測定的要準確一些。還有，這一次測的早期年代又遠遠大于上一次，在 10865 年—13241 年；中期在 5947 年—6253 年，與上一次測定的時間大致相同；這一次增加了中晚期測定，時間在 2771 年—5422 年。晚期岩畫由于有西夏文字及題記爲证，也就知道時間在距今不足 1000 年。

這一次所測的麗石黄衣都是已死亡的麗石黄衣，因此，在測年中是比較準確的。另外麗石黄衣都附着于岩畫之上，岩畫測年更可靠。這些都是以前用麗石黄衣測定年代時所没有的。但是，有一個問題縈懷難忘，就是爲什麽這些麗石黄衣都幾乎同時死亡了？是什麽原因，是地理環境的變化、是氣候的變化、是污染，還是别的什麽原因？總之，這是一個自然之謎，也是一個科學之謎。

用麗石黄衣進行岩畫年代的測定，不僅僅測算出了岩畫的年代，其重要性還在于爲建立起岩畫斷代標尺，做了開創性的工作。可以説，如今賀蘭山與北山所有重要岩畫點的岩畫，在斷代上都已有了一個具體的年代斷定，爲今後岩畫的研究奠定了基礎。由此可見，用麗石黄衣測定賀蘭山與北山岩畫的科學價值是難以估量的。過去人們苦苦探索的斷代難題，總算找到了一個較爲理想和有效的方法。

在研究麗石黄衣測年方法上，以上衹是一種統計結果，因此在測年應用時，時間上不能無限外推。如果有一個已知年代的直徑在 800mm 的地衣，這樣大的麗石黄衣是特少見到的。但由于麗石黄衣的壽命有限，是否可以活到 13000 多年，實事求是地説並没有把握。因此，麗石黄衣測年也有它的局限性。

通過麗石黄衣的研究無疑爲岩畫研究開闢了一條嶄新的道路，對于我國中温帶廣大地區的岩畫研究有着指導意義，對其它地區的岩畫研究有着重要的參考價值。

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①②③ 謝新生、蕭振敏：《中國北部地衣測年研究》，地震出版社，1991 年版。

④ 謝新生、蕭振敏：《地衣測年法研究及其在陝西若干地質事件中的應用》，《科學通報》1989 年 24 期 P. 1896—1897。

The Application of Lichenometry in the Age Determination of Da Mai Di Rock Arts

by Li Xiangshi　Shu Xihong

Lichens, which in Chinese means "beautiful clothes covering the earth" literally, actually is not fabric nor earthy as its Chinese equivalent may imply, but a plant genus spreading throughout the world with many species under its category and thus multi-colored. There are almost 200 genuses, i. e., 2000 species known in China, and about 500 genuses, i. e., 26000 species known in the whole world. They embellish the earth with bright colors and are found on rocks, trees and ancient architectures etc. They welcome the passage of time, century by century, with extraordinary vigor and therefore have seen the great changes of the earth and the transformation of human beings from barbarian life to civilized society, so they are the true "witness" of history.

Lichen is so special that it is the compound of two creatures. That is to say, it is the commensal of green or cyan algoid cells and achromatic fungi. Although fungi accrete with algae, the former actually are in the dominant position. The combination of fungi and algae is inter-dependent and reciprocal: the symbiotic fungi are dependent on the organic nutrient (i. e., dextrose and polyhydric alcohol) provided by the photosynthesis of algae, while some secretion of the symbiotic fungi can enhance the photosynthesis of algoid cells conversely and thus being beneficial to the survival of the symbiotic algae. Furthermore, the algae are wrapped by the interwoven fungus and are thus protected and fixed and, therefore, are more impervious to the destruction of nature or some other harmful substances. Most importantly, it is the tissue of fungi that appropriately decreases luminance so that it can be beneficial to the growth of the symbiotic algae, the decrease of water evaporation of the inner algoid cells, and the improvement of the resistant ability to high temperature, low temperature and aridity.

Lichen has many multi-colored life forms, special inner structure and incomparable vitality. The main chemical substances of lichen are nucleic acid, protein, provitamin A, polyhydric alcohol, nomadic amino acid, vitamin, lichen starch and usnic acid etc.

The organics, which is vital to the growth of lichen, are mainly from the photosynthesis of its symbiotic algae. It is because of the low rate of photosynthesis (compared to some advanced plants) and the very little organics provided to the symbiotic fungi that lichen grows very slowly.

Lichen has the following features:

1. Resistance to aridity: Although lichen, like many other plants, needs water to survive, the mount of water it needs is very small. The proportion of water of some lichens in the dry circumstances can be from 2.0% to 14.5%, which clearly illustrates its ability to resist severe aridity.

2. Insensitivity to temperature: Although lichen, like many other plants, needs to be under a certain range of temperature, it has the unparallel resistant ability. It can resist torridity of very high temperature from 50 to 69℃. On the other hand, it does not have a high requirement for low temperature. It can survive even

under the frigid circumstances of -183 to -268℃. Therefore, lichens are spread over the wide areas in north China and even the plateau with the altitude of thousands of meters.

Geological Age Determination: the Study and Principle of Lichenometry

R. E. Beschel, the Austrian scholar, initiated the application of lichenometry to the chronology of Holocene glaciers and icebergs in 1950. Since then, the method has been applied to geology, landform research, meteorology, glaciology, ancient architecture, rock arts chronology and archaeology, etc and has solved many problems, which cannot be dealt with otherwise.

The theoretical foundation of lichenometry used as a measure in the determination of age is that when the glaciers moved back, the deposits of ice formed and fixed, and lichen was spread over it. The coverage of ice became larger and larger with the passage of time, so we can determine the age of the icebergs or things like them according to the diameter or the acreage of the largest lichen on its surface. Only the lichens that meet the following requirements are suitable for being used in chronology: regular growth and form, prolonged life-span, wide coverage, no selection to the chemical features of the base that the lichens live on, and no special requirements to the temperature, amount of water and altitude etc, so among the thousands of lichens, those can be used in lichenometry are very few. After the screening of scholars, the number of different kinds of lichens that can be used in lichenometry is about 40, and Xanthoria elegans (Link) Th. Fr is the most commonly used in China[1].

We can determine the age of lichens with naked eye. Young Xanthoria elegans (Link) Th. Fr is buff or dark yellow, and is circular or elliptical in form with very clear verge, while the old Xanthoria elegans (Link) Th. Fr is heavily populated in the center and becomes thinner as it expands from the center and is almost brown, while the dead Xanthoria elegans (Link) Th. Fr is dark brown. We can see the purple algoid cells, elliptically symmetrical spores and the separated fungi with the aid of microscope. Because of the difference in the natural geographical environment of the lichens being measured and the difference in the rate of growing of lichens, the result of lichenometry is also different. Till now, the oldest age determined by lichenometry is within the Holocene, about 10000 years. According to E. Anati, the ex-chairman of International Rock Arts Committee, the result they got by lichenometry in Australia is several ten thousand years, but we don't know what kind of lichen and which method they used. The lichenometry (Xanthoria elegans (Link) Th. Fr. used) of the determination of the age of Da Mai Di rock arts revealed the age of about 13241 years.

Mr. Wang Weibin, the initiator using lichenometry as a measure of age determination in China, adopted Xanthoria elegans (Link) Th. Fr. in the chronology of rock arts in his essay, named *The Research of the Cycle of Recrudescence of the Earthquake in Xinjiang*, completed in June, 1985. Later in the summer of 1987, Mr. Xie Xinsheng and Xiao Zhenmin of Institute of Research of Lithosphere Stress, a branch of National Bureau of the Research of Earthquake respectively adopted the same method in the age determination of Altaic rock arts in Xinjiang and the Hongguozi Gou of Helan Mount in Ningxia. I have co-operated with them in the research in Ningxia and learned a lot. Later, when I was doing this project, they directly provided me with much information and constant warm support.

Xanthoria elegans (Link) Th. Fr. is scale in form. Its exterior is orange or orange-red. The part, which is exposed to the highlight of ultraviolet radiation, is rusty red, while the shady part is olivine. Compared to the growth circumstances of the exposure part, the humidity and illumination of the shady part are more suitable for the growth of lichen and the photosynthesis of algae, so the algae can provide more organics as nutrient to fungi. The center of the lichen is usually impending. The bottom is in the color of light white and has no rhizoid. The apothecium is very dense and in a circular shape with the diameter from 0.5mm to 2mm.

When met with potassium hydroxide (a kind of alkali), the apothecium will turn into amaranth and contain the acid of Xanthoria elegans (Link) Th. Fr.. The outer part of the lichen clings to the base. It lives on the surface of all kinds of rocks and cannot be avulsed in the form of cracks②.

There are several kinds of lichens in the area of Helan Mount and Bei Mount in Ningxia. After careful investigation, we found that the amount of Xanthoria elegans (Link) Th. Fr. in Helan Mount is relatively small. The growth of lichens here has obvious differences. They usually live on hills with the altitude of 1300 to 1500 meters. Xanthoria elegans (Link) Th. Fr. can live on many kinds of rocks and are not selective to the chemical nature of the rock. During our investigation, we usually found that the center or the verge part of Xanthoria elegans (Link) Th. Fr. is usually impending. This indicates that the relationship between lichen and rock is only adherent but not reciprocal. Lichen does not need the base to provide nutrient. Mr. Chen Changdu, a Chinese scholar, believes that lichen is chemo-autotrophic and absorbs nutrient from the air and the decomposition of its own remains. The larger ones among Xanthoria elegans (Link) Th. Fr. are usually joined to one piece or one body. The center part (the place on which grow apothecium) of some of them are usually dead, while the remaining part is in ring form. The bigger the lichen and the longer the time since when it was dead, the narrower the width of the ring.

The General Mode of the Age Determination Using Xanthoria elegans (Link) Th. Fr. in Northern China

Xanthoria elegans (Link) Th. Fr., which can live on all kinds of rocks in Northern China under all kinds of circumstances, has extensive use value and boasts monumental scientific significance in age determination.

1. Xanthoria elegans (Link) Th. Fr. prefers weak illumination. It grows very well on the shady part or the base exposed to the sun, which has little evaporation.

2. Xanthoria elegans (Link) Th. Fr. prefers the circumstances, which enjoy greater humidity. It grows well near waters. Since northern China, especially the west-eastern part of China, is relatively arid, it has not yet reached saturation. Therefore, the more humid the circumstance is, the better it grows.

3. After the comparison among the diameters of Xanthoria elegans (Link) Th. Fr. in regions that have different temperature, we found that the average temperature has an influence on its growth, but the influence is not as strong as humidity.

Since Xanthoria elegans (Link) Th. Fr.'s age has something to do with the climate, we made a gradual regression analysis on its diameter and surface as following:

$$T(x_1, x_2, x_3, x_4, x_5) = + A_1 x_1 + A_2 x_2 + A_3 x_3 + A_4 x_4 + A_5 x_5$$

In the formula above:

x_1 stands for the annual average temperature in the vicinity of the place where the lichen grows.

x_2 stands for the annual accumulative temperature above 0℃.

x_3 stands for the annual accumulative temperature above 10℃.

x_4 stands for the annual average atmospheric pressure with water as its criteria.

x_5 stands for the diameter (D) or surface (S) of Xanthoria elegans (Link) Th. Fr..

T stands for the function of the age of Xanthoria elegans (Link) Th. Fr..

Tht result is as following:

$$T(x_4, x_5 = D) = 242.1324 - 65.2438x_4 + 12.9098D, K = 13.5\%.$$

$$T(x_4, x_5 = S) = 343.1940 - 28.9404x_4 + 0.0885S, K = 14.6\%.$$

K stands for fractional error.

The two formulae mentioned above indicate that the growth of Xanthoria elegans (Link) Th. Fr. only has a close relationship with time and average atmospheric pressure with water as its criteria.

According to the research about Xanthoria elegans (Link) Th. Fr. in *The Research into Lichenometry in Northern China* written by Xie Xinsheng and Xiao Zhenmin, its growth mode has the following parameters[③]:

1. Base. The growth of Xanthoria elegans (Link) Th. Fr. does not have physiological relationship with the chemical nature of the base and does not need the base to provide any nutrient. Instead, under suitable circumstances, fungi can accrete with algae reciprocally. Therefore, the chronological mode can exclude the base.

2. Temperature. Lichen can live in all kinds of areas from frigidity to torridity. Lichen almost lives in every corner where creature can live. Botanists think that the influence of annual average accumulative temperature to plants is greater than that of annual average temperature, so we take accumulative temperature as one of the parameters in the growth mode of lichen.

3. Humidity. Water is a must to the metabolism of all creatures. Lichen absorbs water in the air to grow. Water from rain does not influence lichen greatly, especially in the northern China which is always arid, so water in the air is of particular importance to the growth of lichen. Therefore, we consider it as one of the parameters.

4. Diameter and surface of the lichen. In order to determine the age, we take the time of growth of lichen as dependent variable and its diameter and surface as independent variables. These are the other parameters.

The Regional Growth Mode of Xanthoria elegans (Link) Th. Fr. in Different Natural Areas in Northern China

To sum up the above, the growth of Xanthoria elegans (Link) Th. Fr. has a close connection with the climate. If we divide northern China, which is vast in land and complicated in climate, into four natural areas in accordance with Map of natural Metes and Bounds in China, the diameter mode, i. e., T(D), and the surface mode, i. e., T(S) of Xanthoria elegans (Link) Th. Fr. in the four areas are listed as follows:

1. The growth mode of Xanthoria elegans (Link) Th. Fr. in sub-temperate and semi-humid zone:

$$T(D) = 0.1142D^{1.894}, K = 17\%. \quad (1)$$

$$T(S) = 38.2590 + 0.0838S, K = 13\%. \quad (2)$$

2. The growth mode of Xanthoria elegans (Link) Th. Fr. in medium-temperate and arid zone:

$$T(D) = 2.8609D^{1.304}, K = 12.3\%. \quad (3)$$

$$T(S) = 254.7117 + 0.0934S, K = 17\%. \quad (4)$$

3. The growth mode of Xanthoria elegans (Link) Th. Fr. in medium-temperate and humif zone:

$$T(D) = 0.1663D^{1.884}, K = 20\%. \quad (5)$$

$$T(S) = 74.6639 + 0.1061S, K = 20\%. \quad (6)$$

4. The growth mode of Xanthoria elegans (Link) Th. Fr. in medium-temperate and semi-arid zone:

$$T(D) = 0.9155D^{1.491}, K = 20\%. \quad (7)$$

$$T(S) = 63.5375 + 0.0902S, K = 16\%. \quad (8)$$

In the modes mentioned above, D stands for its diameter, S stands for its surface, K stands for fractional error and T stands for the function of its age.

Among all the modes mentioned above, mode 2 and 4 are suitable for the lichenometry using Xanthoria elegans (Link) Th. Fr. in some places of northern China where we have climate information. Helan Mount is located in medium-temperate and arid zone of China, which is from 1000 to 1500 meters in height and also consists of vast areas including the eastern and western part of Inner Mongolia, the basin of the Yellow River and the Alashan Plateau. The amount of precipitation here is from 50 to 400 mm annually. The accumulative temperatures above 10℃ is in the vicinity from 2600 to 3000℃.

According to the data provided by Mr. Xie and Mr. Xiao, I have found some relatively big Xanthoria elegans (Link) Th. Fr. at the Mailujing rock art spot, near the north side of Hongguozi Gou of Helan Mount. All these Xanthoria elegans (Link) Th. Fr. grow on granite. They are in the shape of ellipse or circle. The shapes are comparatively regular and are easy to measure. During our investigation, we got the macroaxis (b) and brachyaxis (c), thus the diameter: $D = \sqrt{ab}$, then we conduct our calculation④.

Lichenometry Using Xanthoria elegans (Link) Th. Fr. in Da Mai Di Rock Arts

In October 1990, during the investigation of Da Mai Di ro = arts, the Antique Managing Committee of the Autonomous Region firstly got four groups of Xanthoria elegans (Link) Th. Fr. numbered from 1st to 4th. Considering some calculative errors, I proofread them and list them as following:

1st group: macroaxis 640mm, brachyaxis 220mm, diameter 375.2mm, surface 110564.5mm^2.
2nd group: macroaxis 420mm, brachyaxis 340mm, diameter 377.9mm, surface 112161.5mm^2.
3rd group: macroaxis 510mm, brachyaxis 390mm, diameter 446mm, surface 156228.3mm^2.
4th group: macroaxis 710mm, brachyaxis 330mm, diameter 484mm, surface 183984.2mm^2.

In May and June 2003, the Second Northwest University of Nationalities (SNWUN) conducted a more conscientious investigation of these rock arts and got six groups of dead Xanthoria elegans (Link) Th. Fr. that attach to rock arts, numbered from 5th to 10th, as listed below (age included):

5th group: macroaxis 500mm, brachyaxis 300mm, diameter 387.3mm, surface 117810.7mm^2.
6th group: macroaxis 450mm, brachyaxis 360mm, diameter 402.5mm, surface 127239.4mm^2.
7th group: macroaxis 630mm, brachyaxis 600mm, diameter 614.8mm, surface 296864mm^2. 5
8th group: macroaxis 420mm, brachyaxis 310mm, diameter 360.8mm, surface 102240.5mm^2.
9th group: macroaxis 310mm, brachyaxis 150mm, diameter 215.6mm, surface 36507.9mm^2.
10th group: macroaxis 800mm, brachyaxis 640mm, diameter 715.5mm, surface 402076.9mm^2.

	Macro-axis	Brach-yaxis	Diameter	Surface	Age in Arid Areas	Age in Arid Areas + A	Age in Semi-arid Areas − A	Age in Semi-arid Areas	Age in Arid Areas + B	Age in Semi-arid Areas − B
1	640	220	375.2	110564.5	6506.4	7306.7	5706.1	6307.9	7569.5	5046.3
2	420	340	377.9	112161.5	6567.5	7375.3	5759.7	6375.7	7650.8	5100.6
3	510	390	446.0	156228.3	8151.5	9154.1	7148.9	8162.4	9794.9	6529.9
4	710	330	484.0	183984.2	9068.6	10184.0	7953.2	9220.7	1064.8	7376.6
5	500	300	387.3	117810.7	6781.4	7615.5	5947.3	6613.6	7936.3	5290.9
6	450	360	402.5	127239.4	7130.5	8007.6	6253.4	7004.3	8405.2	5603.4
7	630	600	614.8	296864.0	12388.3	13912.1	10864.5	13172.3	15806.8	10537.8
8	420	310	360.8	102240.5	6182.7	6943.2	5422.2	5950.4	7140.5	4760.3
9	310	150	215.6	36507.9	3159.2	3547.8	2770.6	2761.4	3313.7	2209.1
10	800	640	715.5	402076.9	15097.8	16954.8	13240.8	16515.1	19818.1	13212.1

Due to the tremendous changes in Nature, including some geographical and climate changes, the natural environment will also change. This cannot be reversed for human will and wish. Furthermore, the very unique climate and geographical conditions of Da Mai Di at the north part of Weining, Ningxia, strongly influence the growth of Xanthoria elegans (Link) Th. Fr.. Therefore, we conducted two more groups concerning age, i. e., age in arid areas and age in semi-arid areas, in order to approach the real natural conditions.

We suggest that when looking at the data collected in October 1990, we should take "Age in Semi-arid Areas-A" as the major parameter. The oldest age should be within 7149 and 7953 years. The medium age should be within 5706 and 5760 years.

The scale of the date collected in May and June 2003 is larger than the former one, so the determination of age will be more precise. The age measured this time is much older than last time. The oldest age should be within 10865 and 13241 years. The medium age should be within 5947 and 6253 years. It is almost the same as last time. This time, we added the so-called medium-later period. It is within 2771 and 5422 years. The determination of the latest rock art is relied on the Tangut scripts and epigraph. The latest rock art is no more than 1000 years old.

The Xanthoria elegans (Link) Th. Fr. measured this time are all dead ones, so the determination is more precise. Furthermore, all the Xanthoria elegans (Link) Th. Fr. attach to rock arts, so the lichenometry of rock arts is more reliable. These two points are unique in this determination. But there is still one more question waiting to be solved: why do all these Xanthoria elegans (Link) Th. Fr. died almost at the same time? Is it because of the change of climate? Or the change of geographical environment? Or environmental pollution? Or some other unknown reasons? In a word, this is not only a mystery in nature, but also a mystery in scientific research.

The significance of our job is not only to reach the achievement of knowing the age of rock arts, but also to make a pioneering task using lichenometry in the age determination of rock arts. We can say that we know the rough age of almost all the rock arts in the important spots at Helan Mount and Bei Mount. This has laid a solid foundation for further research. The scientific value of using lichenometry in the age determination of rock arts is incredible. We have found a comparatively ideal and effective method concerning the problems, which had puzzled our forerunners.

However, all the above are only statistic results. When we use lichenometry in age determination, we cannot suppose the age infinitely. If we have got a piece of lichen with the diameter of 800mm (although this is very rare), the age should be about 13000 years according to calculative rules. But Xanthoria elegans (Link) Th. Fr.'s life is limited, whether it can survive so long is still a question. Therefore, the lichenometry using Xanthoria elegans (Link) Th. Fr. also has its limitations.

Lichenometry using Xanthoria elegans (Link) Th. Fr. blazed a brand new trail for the research of rock arts. It would have great instructive meaning to the rock arts research in the vast temperate zone in China. It would also benefit the research in other parts of our country a lot.

Translated by Liu Mingming

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① Xie Xinsheng & Xiao Zhenmin, Zhongguo Beibu Diyi Cenian Yanjiu 中国北部地衣测年研究 *The Research into Lichenometry in Northern China*: Earthquake Research Press: 1991

② *Ibid.*

③ *Ibid.*

④ Xie Xinsheng & Xiao Zhenmin, "Diyi Cenianfa Yanjiu ji qi zai Shanxi Ruogan Dizhi Shijian zhong de Yingyong" Kexue Tongbao 科学通报 *Science Newspaper*: 1989 (24)

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